Editorial Board

Editor
Norman G. Miller
University of San Diego

Associate Editors
Kwame Addae-Dapaah
National University of Singapore

Nico B. Rottke
European Business School

Robert Simons
Cleveland State University

Michel Boudrias
University of San Diego

Helen Neill
University of Nevada–Las Vegas

Isaac Megbolugbe
Johns Hopkins University

Steven Bourassa
University of Louisville

Andrew J. Nelson
RREEF Real Estate

Gary Pivo
University of Arizona

Sofia Dermisi
Roosevelt University

Darren Prum
Florida State University

Tim Dixon
Oxford Brookes University

Richard Reed
Deakin University

Frank Fuerst
University of Reading

Karl-Werner Schulte
University of Regensburg

Angela Guggemos
Colorado State University

Ron Throup
University of Denver

Rebecca Henn
University of Michigan

Grant Thrall
University of Florida

Jerry Jackson
Texas A&M University

John Kilpatrick
Greenfield Advisors LLC

Dan Kohlhepp
Johns Hopkins University

Richard Loope
Arizona State University

Nils Kok
Maastricht University

Bing Wang
Harvard University

Steve Laposa
Colorado State University

Elaine Worzala
Clemson University
Contents

ix  Preface
1  Dynamics of Green Rentals over Market Cycles: Evidence from Commercial Office Properties in San Francisco and Washington DC  
   Prashant Das, Alan Tidwell, and Alan Ziobrowski
23  Residential Land Values and Walkability  
   Stephanie Yates Rauterkus and Norman G. Miller
44  The Political Economy of Green Industrial Warehouses  
   David M. Harrison and Michael J. Seiter
68  Greening the Regulatory Landscape: The Spatial and Temporal Diffusion of Green Building Policies in U.S. Cities  
   Constantine E. Kontokosta
91  Explaining LEED Concentration: Effects of Public Policy and Political Party  
   Eugene Choi and Norman G. Miller
109  Valuing Green Home Designs: A Study of ENERGY STAR® Homes  
   Bryan Bloom, MaryEllen C. Nobe, and Michael D. Nobe
127  The Demand for Green Housing Amenities  
   Kimberly R. Goodwin
142  The Role of Dual-pane Windows and Improvement Age in Explaining Residential Property Values  
   Ramya Rajajagadeesan Aroul and J. Andrew Hansz
162  Green Mark Certification: Does the Market Understand?  
   Kwame Addae-Dapaah and Su Jen Chieh
192  The Process for Adopting an Energy Efficiency Code in Existing Homes: A Case Study of Boulder, Colorado’s SmartRegs Program  
   Laura Barrett, Scott Glick, and Caroline Clevenger
211  Does Sustainability Pay Off for European Listed Real Estate Companies? The Dynamics between Risk and Provision of Responsible Information  
   Marcelo Cajias and Sven Bienert
232  Facility Sustainment and Firm Value: A Case Study Based on Target Corporation  
   Robert Beach
254  The Cost of LEED—An Analysis of the Construction Costs of LEED and Non-LEED Banks  
   Chad Mapp, MaryEllen C. Nobe, and Brian Dunbar
274  Creative Construction: The Capacity for Environmental Innovation in Real Estate Development Firms  
   William B. Bradshaw II
312  Sustainability and Graduate Business Education: An Analysis of the Need, Best Efforts to Date, and Curriculum Recommendations  
   Marnie L. Abramson
The Board of Directors of the American Real Estate Society extends its deep appreciation to:

- **University of San Diego**, Burnham Moores Real Estate Center for its support of the editorial functions of the American Real Estate Society;
- **Florida Gulf Coast University**, for its support of the editorial functions of the American Real Estate Society;
- **Florida International University**, for its support of the Director of Publications functions of the American Real Estate Society; and
- **Kennedy Wilson**, for its support of the Executive Director functions of the American Real Estate Society.

**2011 Membership**

Academic ($135), Professional ($300), Academic Library ($600), Corporate Library ($600), Student or Retired Academic ($85), Corporate ($600), Sponsor ($1,500), Regent ($3,000) and President’s Council ($6,000). **Additional membership options are available. See the 2011 Membership Form in the back of the journal.** Checks should be made payable to ARES and correspondence should be addressed to: Diane Quarles, Clemson University, College of Business & Behavioral Science, Dept. of Finance, 424 Sirrine Hall, Clemson, SC 29634-1323. Phone: 864-656-1373; Fax: 864-656-7519. Website: www.ARESnet.org or equarle@clemson.edu.

The *Journal of Sustainable Real Estate* (1949-8276) is published annually by the American Real Estate Society at Clemson University, School of Business and Behavioral Science, Department of Finance, 424 Sirrine Hall, Clemson, SC 29634-1323. Postmaster, please send address changes to: Diane Quarles, Clemson University, School of Business and Behavioral Science, Department of Finance, 424 Sirrine Hall, Clemson, SC 29634-1323. Changes of address, claims and all correspondence dealing with subscriptions should be sent to Diane Quarles, Manager of Member Services, Clemson University, School of Business and Behavioral Science, Department of Finance, 424 Sirrine Hall, Clemson, SC, 29634-1323. Phone 864-656-1373, Fax 864-656-7519 or email equarle@clemson.edu. For more information, visit our website: www.ARESnet.org.
2011 American Real Estate Society

President’s Council

Altus Group
Appraisal Institute
CCIM Institute
Cornerstone Real Estate Advisers, Inc.

CoStar Group
Counselors of Real Estate (CRE)
Institutional Real Estate, Inc.
Prudential Real Estate Investors

Regents

Argus
Blackrock Financial Management
Charles River Associates
Dearborn Real Estate Education
Freddie Mac
LaSalle Investment Management
National Association of Real Estate Investment Trusts (NAREIT)
National Association of Realtors® (NAR)
National Investment Center for the Seniors Housing & Care Industry (NIC)
NYU Schack Institute of Real Estate
Richard H. Pennell Center for Real Estate Development–Clemson University
Real Capital Analytics
UBS

Sponsors

Bailard, Inc.
Burnham-Moores Center for Real Estate–University of San Diego
CBRE Econometric Advisors
Cengage Learning
Clarion Associates, Inc.
Colvin Institute of Real Estate Development
Dividend Capital Research LLC
Emerald Group Publishing Limited
GIC Real Estate Pte., Ltd.
Graduate School of Real Estate Studies–KonKuk University
Jerome Bain Real Estate Institute at Florida International University
Johns Hopkins Carey Business School
Kennedy Wilson
National Association of Industrial and Office Properties (NAIOP)
National Multi Housing Council (NMHC)
Real Estate Center at DePaul University
## 2011 Fellows of the James R. Webb American Real Estate Society

### Endowed International Scholar Sponsorship
Arthur L. & Helen Beckett Schwartz

### Endowed Doctoral Sponsorships
Youguo, Lucy, Michelle, and Mia Liang
Glenn R. and Jan H. Mueller
Theron R. and Susan L. Nelson
Michael J. and Vicky L. Seiler

### Benefactors
<table>
<thead>
<tr>
<th>Marc A. Louargand</th>
<th>Karl-Werner Schulte</th>
</tr>
</thead>
<tbody>
<tr>
<td>Commercial Real Estate Advisers</td>
<td>University of Regensburg</td>
</tr>
<tr>
<td>Stephen A. Pyhrr</td>
<td>John E. Williams</td>
</tr>
<tr>
<td>Kennedy Wilson</td>
<td>Morehouse College</td>
</tr>
</tbody>
</table>

### Distinguished Fellows
| Joseph D. Albert       | Christopher A. Manning           |
| James Madison University | Loyola Marymount University     |
| John D. Benjamin       | Margaret McFarland               |
| American University–Emeritus | University of Maryland        |
| Marsha Courchane       | Norman G. Miller                 |
| Charles River Associates | University of San Diego        |
| Bart Danielsen         | Nico B. Rottke                   |
| North Carolina State University | European Business School |
| Jan A. DeRoos          | Seungwoo Woo Shin                |
| Cornell University     | Konkuk University                |
| Don Dorechester        | Robert A. Simons                 |
| Cushman & Wakefield    | Cleveland State University       |
| Paul R. Goebel         | Michael C. Truebestein           |
| Texas Tech University  | University of Reading           |
| David Harrison         | Zhong Y. Tong                    |
| Texas Tech University  | U.S. Department of the Treasury  |
| Forrest E. Huffman     | Richard Wincott                  |
| Temple University      | Altus Group                      |
| Alex Klatskin          | Elaine M. Worzala                |
| Forsgate Industrial Partners | Clemson University        |
| Mark L. Levine         |                                  |
| University of Denver   |                                  |

### Fellows
| Randy I. Anderson       | Charles Carter                   |
| University of Central Florida | Haint Blue Realty, LLC        |
| John S. Baen            | Karl E. Case                     |
| University of North Texas | Wellesley College              |
| Edward A. Baryl        | Lijian Chen                      |
| East Tennessee State University | UBS Realty Investors, LLC   |
| Donald H. Bleich       | Ping Cheng                       |
| California State University–Northridge | Florida Atlantic University    |
| Steven C. Bourassa      | James W. Coleman                 |
| University of Louisville | Wright State University        |
| M. Gordon Brown        | Glenn E. Crellin                 |
| Urban Land Institute   | Washington State University    |
| Todd A. Canter         | Charles G. Dannis               |
| LaSalle Investment Management | Crosson Dannis Inc.          |
Karen G. Davidson
Davidson & Associates/UCLA Extension

Geoffrey Doehrmann
Institutional Real Estate Inc.

David H. Downs
Virginia Commonwealth University

Donald R. Epley
University of South Alabama

Andrew C. Florance
CoStar Group Inc.

Dan W. French
University of Missouri–Columbia

Karen M. Gibler
New York University

Hany Guirguis
Manhattan College

Otis E. Hackett
University of St. Thomas

Thomas W. Hamilton
Pennybacker Capital, LLC

David J. Hardaway
University of North Carolina–Chapel Hill

Mingjun Huang
Property and Portfolio Research, Inc.

Thomas O. Jackson
Texas A&M University

Aart Hordijk
Real Estate Council

Michael J. Highfield
Florida A&M University–Emeritus

William G. Hardin, III
Florida International University

Jack Harris
Texas A&M University

Ken H. Johnson
Florida International University

Ronald W. Kaiser
Bailard, Inc.

John Kilpatrick
Greenfield Advisors, LLC

Steven P. Laposa
Colorado State University

Joseph B. Lipscomb
Texas Christian University

Emil Malizia
University of North Carolina–Chapel Hill

John F. McDonald
Roosevelt University

Willard McIntosh
Abu Dhabi Investment Authority

Graeme Newell
University of Western Sydney

Joseph L. Pagliari, Jr.
University of Chicago

David R. Parker
University of South Australia

Ruojue Peng
Property and Portfolio Research

Rudy R. Robinson, III
Austin Valuation Consultants

Mauricio Rodriguez
Texas Christian University

Stephen E. Roulac
Roulac Global Places LLC

Ronald C. Rutherford
University of South Florida

Sean P. Salter
Middle Tennessee State University

David Scribner, Jr.
Baruch College

G. Stacy Sirmans
Florida State University

Thomas M. Springer
Clemson University

Mark A. Sunderman
University of Memphis

Stephen F. Thode
Lehigh University

Grant I. Thrall
University of Florida

Ronald L. Throupe
University of Denver

Raymond Y.C. Tse
Hong Kong Institute of Real Estate

Ko Wang
Baruch College/CUNY

H. Shelton Weeks
Florida Gulf Coast University

Margot B. Weinstein
MW Leadership Consultants

Anthony Welch
Sarasota Capital Strategies

Daniel T. Winkler
University of North Carolina–Greensboro

Kimberly Winson-Geideman
University of North Texas

Larry E. Wofford
University of Tulsa

Zhonghua (George) Wu
Florida International University

Charles H. Wurtzebach
DePaul University

David Wyman
Clemson University

Melinda L. Yarling
Casey Key, FL

James Young
University of Auckland

Leonard V. Zumpano
University of Alabama
<table>
<thead>
<tr>
<th>Name</th>
<th>Company/Institution</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ray Anderson</td>
<td>Interface Global</td>
</tr>
<tr>
<td>Scott Anders</td>
<td>University of San Diego</td>
</tr>
<tr>
<td>Grant Austin</td>
<td>Greenfield Advisors</td>
</tr>
<tr>
<td>Aaron Binkley</td>
<td>AMB Property Corporation</td>
</tr>
<tr>
<td>Stuart Brodsky</td>
<td>GE Real Estate</td>
</tr>
<tr>
<td>John Crews</td>
<td>Jones Lang LaSalle</td>
</tr>
<tr>
<td>Dale Dekker</td>
<td>Dekker/Perich/Sabatini</td>
</tr>
<tr>
<td>Brian Dunbar</td>
<td>Colorado State University</td>
</tr>
<tr>
<td>Richard Epstein</td>
<td>RNL Design</td>
</tr>
<tr>
<td>Andrew Florance</td>
<td>CoStar Group, Incorporated</td>
</tr>
<tr>
<td>Doug Gatlin</td>
<td>U.S. Green Building Council</td>
</tr>
<tr>
<td>Lydia Jacobs-Horton</td>
<td>Procter &amp; Gamble</td>
</tr>
<tr>
<td>Kent Jeffreys</td>
<td>International Council of Shopping Centers</td>
</tr>
<tr>
<td>David Jellison</td>
<td>Liberty Property Trust</td>
</tr>
<tr>
<td>Stephen Kapp</td>
<td>Siemens Industry Inc.</td>
</tr>
<tr>
<td>Charles B. Leitner III</td>
<td>Greenprint Foundation</td>
</tr>
<tr>
<td>David Lorenz</td>
<td>Lorenz Property Advisors</td>
</tr>
<tr>
<td>Marc Louargand</td>
<td>Commercial Real Estate Advisers</td>
</tr>
<tr>
<td>L. Hunter Lovins</td>
<td>Natural Capitalism Solutions (NCS)</td>
</tr>
<tr>
<td>Asieh Mansour</td>
<td>CBRE</td>
</tr>
<tr>
<td>Scott Muldavin</td>
<td>The Muldavin Company, Inc.</td>
</tr>
<tr>
<td>David Pogue</td>
<td>CBRE</td>
</tr>
<tr>
<td>Mark Robinson</td>
<td>Momentum Bay Associates LP</td>
</tr>
<tr>
<td>Jay Spivey</td>
<td>CoStar</td>
</tr>
<tr>
<td>Leanne Tobias</td>
<td>Malachite LLC</td>
</tr>
<tr>
<td>Cathy Turner</td>
<td>New Buildings Institute (NBI)</td>
</tr>
<tr>
<td>B. Alan Whitson</td>
<td>RPA</td>
</tr>
<tr>
<td>Sally Wilson</td>
<td>CBRE</td>
</tr>
<tr>
<td>Jim Young</td>
<td>Realcomm</td>
</tr>
<tr>
<td>Jerry Yudelson</td>
<td>Yudelson Associates</td>
</tr>
</tbody>
</table>
Preface

We are pleased to present the third volume of the *Journal of Sustainable Real Estate*. We continue to believe that electronic journals will prove superior to hard copy journals in several ways and we remind authors of the possibilities such journals present. First, authors may use color in graphs and charts, although many authors have yet to take advantage of the benefits of color. Second, you may embed links as a way to present additional materials and resources as long as they are not selling a product or service. For example, you can insert a video commentary by the authors or some experts on the topic of the paper.

While we continue to publish once per year, we will likely move to a format where we accept, edit, and publish papers within a given year’s volume as they are processed so that the lag for early submissions to publication will not be as long.

We continue to benefit from the financial support of CoStar for this publication. Since its inception, CoStar has been the sole sponsor of this journal without any editorial oversight. Not only has CoStar supported the journal but some of the papers on sustainable real estate would not be possible without the data provided by CoStar. We greatly appreciate this unconditional and continuous support.

In this volume we start with a paper on the dynamics of green office rentals by Das, Tidwell, and Ziobrowski. The authors show that, while green rental premiums exist, these premiums vary with market conditions. Next, we have a paper on walkability and residential values by Rauterkus and Miller, which suggests that well-located properties near amenities in denser urban areas tend to show less price volatility than those areas that are more car-dependent, suggesting that price risk for consumers and lenders may be lowered with more attention paid to locational risk. The third paper is one of the first studies on green industrial property by Harrison and Seiler. The authors find that green premiums are not universal but correlated with the political environment of the region. Continuing this theme of politics and regulation, the next two papers, one by Kontokosta and the other by Choi and Miller, both provide evidence that politics and regulation vary by region and can provide a push or pull in the case of incentives spurring the rate of sustainable development or renovation observed in each region or state.

Next, we have a series of five papers that deal with residential property. Starting with one on green home design by Bloom, Nobe, and Nobe, followed by one on the demand for green amenities by Goodwin, and another dealing with specific insulation features by Aroul and Hansz. Next, we move to Singapore and explore the ability of the market to understand and value certifications by Addae-Dapaah and Chieh, which is followed by a case study in Colorado on adopting energy efficiency building codes by Barrett, Glick, and Clevenger.

We also have two papers that take the perspectives of public corporations. The first paper is an exploration of the trade-offs between risk-taking and socially responsible investing for European public companies by Cajias and Bienert. The second is on facility maintenance and firm value based on a case study of Target corporation by Beach.

Next, we have two papers related to construction costs. The first, by Mapp, Nobe, and Dunbar, focuses on a comparison of LEED and non-LEED bank construction
costs, while the second, by Bradshaw, is on the capacity of development firms to absorb environmental innovations.

Our last paper, but not the least, and one of the most valuable for educators is by Marnie Abramson on Sustainability and Graduate Business Education. This is a must read for all those concerned about integrating sustainability into their curriculum.

We thank all of you who read, discuss, disseminate and submit new papers to this journal.

Norman G. Miller, Senior Editor
University of San Diego, Burnham-Moores Center for Real Estate
nmiller@sandiego.edu

Myla Lorenzo-Wilson, Managing Editor
University of San Diego, Burnham-Moores Center for Real Estate
mwilson@sandiego.edu

Robert Simons, North American Associate Editor
Cleveland State University
r.simons@csuohio.edu

Kwame Addae-Dapaah, Asian-Pacific Editor
National University of Singapore
rstka@nus.edu.sg

Nico B. Rottke, European Editor
European Business School
rottke.ebs@rem-institute.org.
Dynamics of Green Rentals over Market Cycles: Evidence from Commercial Office Properties in San Francisco and Washington DC

Authors
Prashant Das, Alan Tidwell, and Alan Ziobrowski

Abstract
This study examines the rental rate dynamics of green commercial office properties in the San Francisco and Washington DC metropolitan areas. We match the list of U.S. Green Building Council (USGBC)-certified commercial office properties in the two areas with property-level temporal and non-temporal data derived from USGBC and CoStar for the period 2007:Q1 to 2010:Q1. We find that, similar to previous studies, green office properties enjoy rental rate premiums over comparable non-green buildings. However, we also find the premiums to be dynamic instead of constant. Our models suggest that green property rents may provide a hedge in down markets.

Recognition of the adverse effects of urban sprawl, changing consumer preferences, and a heightened awareness of environmental concerns has contributed to the growth of the green building design and construction movement in the United States. Nelson (2007) suggests that public concern about global warming, the environment, and sustainability have provided a major impetus to the increased activity in this realm. For example, the number of commercial office building applications filed for Leadership in Energy and Environmental Design (LEED) labeling,1 awarded by U.S. Green Building Council (USGBC), has increased substantially in recent years—from less than 50 in 2000 to above 8,000 in 2009 according to January 2010 USGBC data. Another source of demand for green commercial office properties comes from U.S. government agencies who, in 2000, built 42% of all commercial office properties that were candidates for USGBC green labeling.

The literature establishes a “premium” on various performance measures that green (or “Eco-labeled”) properties enjoy over their non-green counterparts. For example, Fuerst and McAllister (2009) used OLS and quantile regression models to conclude that LEED-labeled and ENERGY STAR-labeled offices have 8% and 3% higher occupancy rates respectively while controlling for age, height, building class, and quality. Dermisi (2009) analyzed a dataset of 351 buildings across 36 states gathered during 2009 using OLS, maximum likelihood spatial error regression and fixed effects regression methods, and finds that the ENERGY STAR designation increases the market and assessed values of office properties substantially. The effect of LEED ratings is also a function of geographic
aggregation. Similarly, Eichholtz, Kok, and Quigley (2009), Miller, Pogue, Gough, and David (2009), and Fuerst and McAllister (2011) establish a premium on rental rates and sale prices enjoyed by green buildings compared to similar non-green counterparts. However, most of these studies are cross-sectional in nature and overlook the variations over time. Our study examines how the rental rate premium varies over time in a dynamic market cycle. In addition, we focus on LEED-certified buildings rather than broader based “eco-labeled” buildings. Our analysis suggests that the green premium is higher during down markets compared to up markets. The results are robust when we perform a cross-sectional analysis of three specific quarters. In addition, we find leasing activity and vacant area to be significant predictors of the rental rate of green properties. To our knowledge, these variables have not been recognized as determinants of rental rates in any other study.

The additions from our study to the body of knowledge are as follows. Green rental premiums are dynamic and vary across market cycles. Green rental office properties may offer a hedge to owners in down markets due to an increased premium. Total leasing activity, rental rate change in the previous quarter, and vacant square footage are significant explanatory variables for the hedonic modeling of green rentals. Real estate analysts, lenders, and corporate real estate professionals dealing in green commercial office properties may be able to make a more accurate estimate of future rental patterns. This may not be true for comparable non-green properties.

The remaining paper is organized as follows. We begin with a survey of literature that has two parts: literature on green buildings and literature on rental rate modeling. The literature synthesis is followed by a description of the data. In the third section, we discuss the research procedures, which are followed by the fourth section in which we empirically analyze the data and present the results of the analysis. The fifth section concludes.

**Literature Review**

**Green Properties**

Empirical studies examining the financial performance of green buildings are a relatively new paradigm of academic research, primarily the result of historical data paucity. Thus, several researchers had to resort to the typology of “eco-labeled” properties as compared to “green” properties. A number of studies have established the distinction between the rental rate (or value) pattern of green properties compared with those of non-green properties including Miller, Spivey, and Florance (2008), Eichholtz, Kok, and Quigley (2009), and Fuerst and McAllister (2009, 2011).

Wiley, Benefield, and Johnson (2008) and Dermisi (2009) conclude that LEED certification has a strong positive effect on a property’s assessed value and market value. Wiley, Benefield, and Johnson (2008) and Fuerst and McAllister (2009) also find that green buildings enjoy higher occupancy rates. Jackson (2009)
concludes that LEED-labeled and ENERGY STAR-rated buildings yield very high internal rates of return (IRR) and that the probability of a lower IRR for such buildings is very low. However, Jaffee, Stanton, and Wallace (2010) contend that the ENERGY STAR label does not contribute to property prices after controlling for key asset pricing factors of expenses, income, and capitalization rates.

The boundary between “green” and “energy-efficient” buildings has been blurred in several studies, as LEED- and ENERGY STAR-certified properties are treated equally as “green” or “eco-labeled.” While ENERGY STAR certification is primarily based on the criteria of energy efficiency, the LEED-certified buildings offer additional efficiencies such as water efficiency, waste reduction, environmentally preferred materials, sustainability, etc. Thus, LEED-certified buildings fulfill the criteria of resource efficiency as defined by the U.S. Environmental Protection Agency (EPA). In this study, we focus on LEED-labeled properties which, we argue, is a closer proxy for “green” properties as opposed to a more generic group of “eco-labeled” properties.

The paradigm of green real estate research has enjoyed international exploration. For example, Brounen and Kok (2010) found that, in the Netherlands, homebuyers are willing to pay a premium for homes that are labeled as more energy efficient, or “green.” Alternatively, Yoshida and Sugiura (2011) study 1,504 projects in Tokyo between 2002 and 2010 and report that green condominiums are priced 5%–10% lower as the higher maintenance costs are capitalized by the buyers. Chegut, Eichholtz, and Kok (2010) analyze the 78 BREEAM3-certified offices in the United Kingdom and report a 16%–20% premium on the rental rates of eco-certified properties. Deng, Li, and Quigley (2011) analyze 36,512 transactions in the Singapore housing market and conclude that the “Green Mark4” labeling offers a 4% premium on the price. In Australia, IPD (2011) reports that the “Green Star5”-labeled properties offer a 400 basis point spread on the return and a negative 40 basis point cap rate spread with respect to non-labeled properties.

These studies generally establish green real estate as a financially advantageous proposition. However, this broad notion of financial benefits is less than adequate for prudent investment decisions. The understanding of variables that drive changes in the property market rental rates and thus values is posited to be critical (Geltner and Mei, 1995). So far, little attention has been paid to the determinants of rental rate variability in green real estate. Our research argues that the rental rates of green properties may be driven in part by a different set (or, at least, a different set of relative effect sizes) of variables. Also, there is no strong reason to believe that the rental premium of green buildings remains the same across different stages of market cycles. Understanding the variation of the premium over market cycles is therefore critical for investment decisions.

Rental Rate Modeling

Case and Shiller (1989) contend that price movement in individual properties is not sufficiently explained by market-wide factors. Plazzi, Torous, and Valkanov (2008) suggest that the cross-sectional differences in property characteristics can affect rental rate changes, even if market-wide economic shocks propagate
uniformly across the properties. A large amount of research has examined the effects of cross-sectional variables on the rental rate of real property. Dunse and Jones (1998) establish the physical characteristics of the building, locational features, and contract terms as prime determinants of rental rates. Clapp (1980) finds that taller buildings enjoy higher rental rate premiums. Slade (2000), however, finds a quadratic relationship such that rents increase at a decreasing rate with respect to floor height. Shilton (1994) finds that building height and size are highly correlated. Frew (1988), Sivitanidou (1995), Bollinger and Ihlanfeldt (1998), and Fuerst and McAllister (2009) identify building age as a strong predictor, such that rental rates diminish with building age. Clapp (1980), Brennan and Colwell (1984), Colwell and Sivitanidou (1995), Trefzger (1998), and Slade (2000) advocate a log-linear \( \ln(\text{Rent/SF}) \) model for rental rates while regressing rental rates against a set of independent variables (e.g., lease term, location, distance from a landmark, etc.). Fuerst and McAllister (2009) include some novel continuous and indicator independent variables (e.g., lease type, lot size, geographic coordinates, asking rent, etc.) in studying the occupancy rate of eco-labeled buildings.

In most rental rate studies, the set of explanatory variables has differed depending on the study. Although these studies provide insights about the determinants of rental rates in terms of building characteristics, most of them are cross-sectional in nature. Thus, they do not describe the amount of variability defined by time-based explanatory variables including vacant area and leasing activity. In addition, the existing body of knowledge lacks studies that explore whether the pattern of rental rate change is uniform across properties of varying temporal and non-temporal characteristics. In other words, we did not find any studies that explore the determinants of rental rate change over time as a function of the physical characteristics of offices, as well as time-based variables such as vacant square feet and leasing activity. Moreover, most of the studies examining rental rate dynamics are more than ten years old. The increasing popularity of green buildings along with the recent availability of sufficient green building data make this study timely and relevant.

**Data and Methodology**

We examine the rental rate dynamics of green commercial office properties in the San Francisco and Washington DC areas using data derived from USGBC and CoStar for the period 2007:Q1 to 2010:Q1 (Exhibit 1). The choice of the property-type and the locations are driven by several factors. Green labeling has been more popular among commercial office properties as opposed to some other property types such as residential. Thus, selecting commercial offices as the property type affords us a larger sample size. In addition, explanatory variables of our models require the attributes of a property to be collected from two different sets of data, namely, CoStar and the USGBC. We chose San Francisco and Washington DC because they offer the largest sample of green rental office buildings that are also identifiable by us in the CoStar data set. The matching of the properties in the two data sets is a tedious, manual process. We conducted the matching process
**Exhibit 1 | Summary of the Characteristics of the Sample Properties**

<table>
<thead>
<tr>
<th></th>
<th>Min.</th>
<th>Max.</th>
<th>Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Panel A: Green Property Quarters (2010:Q1)</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total gross rent ($/sq. ft./yr.)</td>
<td>12.00</td>
<td>75.52</td>
<td>36.56</td>
</tr>
<tr>
<td>Number of stories</td>
<td>2</td>
<td>48</td>
<td>11.00</td>
</tr>
<tr>
<td>Year built</td>
<td>1924</td>
<td>2009</td>
<td>1998</td>
</tr>
<tr>
<td>Washington DC</td>
<td>60%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Downtown</td>
<td>15%</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Panel B: Non-Green Property Quarters (2010:Q1)</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total gross rent ($/sq. ft./yr.)</td>
<td>12.00</td>
<td>155.82</td>
<td>37.00</td>
</tr>
<tr>
<td>Number of stories</td>
<td>2</td>
<td>48</td>
<td>9.36</td>
</tr>
<tr>
<td>Year built</td>
<td>1924</td>
<td>2009</td>
<td>1990</td>
</tr>
<tr>
<td>Washington DC</td>
<td>61%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Downtown</td>
<td>19%</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Notes: This table describes the green properties included in our analyses and the criteria on which the control sample of non-green properties was selected.

for 10 leading metros based on the number of green office properties as suggested by the USGBC data set. Metropolitan areas other than the two included in our sample offered a smaller number of matched green properties, particularly early in the sample. The final dataset consists of property information collected from the two metropolitan areas yielding a combined 53 green office properties (60% from Washington DC), with an average rental rate of $36.56/sq. ft./year. These properties were built between 1924 and 2009 and ranged in height from 2 to 48 floors. We apply these green building characteristics as constraints in the CoStar database to obtain a control sample of similar but “non-green” properties, and select 70 of these properties as a control group. In order to maintain a balance of total number of properties from the two metros, we select a larger number (i.e., 60%) of the control sample properties from San Francisco. In total, we have an aggregate of 123 unique office properties, providing a total of 1,256 property-quarter observations.

The dataset is further stratified into various sub-samples based on their green status or across time for robustness checks. The data are divided into four samples: panel data (including all available properties-quarters) and cross-sectional data (for three individual quarters: 2007:Q4, 2008:Q4, and 2009:Q4). We collect rental data on commercial office properties in the San Francisco market and the Washington DC Metropolitan Statistical Area for the time period between 2007: Q1 and 2010:Q1. Rental rates and property-specific characteristics are obtained from CoStar. As the rental rate data from CoStar are available on a quarterly basis only and the event of earning green status by a property may fall in the middle of a quarter, we assign
the green status to a property if the date of the awarding of the green status falls in the first half of a quarter. The CoStar database is a repository of information for both temporal and non-temporal property-specific attributes. Moreover, it also provides rich aggregated information at the metro area level. An examination of the overall metro area data allows us to label each quarter as an “up market” or “down market,” depending on the direction of average market rental rate change with respect to the previous quarter.

Exhibit 2 suggests that the metro-area wide trends in San Francisco and Washington DC differed slightly. Therefore, in our sample, the market conditions (“up” vs. “down” markets) can vary by both time and location. To analyze the quarterly change in the rental rate of a property, we need the rental rate data on a property in at least two consecutive quarters. This leads to a reduction in our sample size as a property’s rental data is available on CoStar for those quarters only when it was listed for rent. However, for these “valid” quarters of interest, CoStar provides sufficient data on our variables of interest, such as vacant square feet and leasing activity. In addition, several fixed effect variables, such as number of stories and age, are also made available by CoStar.

Not all quarters of a “green” property qualify as green since they might not have been labeled as green by USGBC in that quarter. Our unit of analysis is property-quarters as opposed to property. This allowed us to assign different “green” (versus “non-green,” through an indicator variable) status to a property based on the time period.

**Variables**

We focus on the effects of “green” status on the change in rental rates across time. However, as discussed earlier (Case and Shiller, 1989), the dynamics of this change may not be satisfactorily explained by market-wide factors only, suggesting the inclusion of idiosyncratic characteristics of office properties. These characteristics exhibit both cross-sectional and temporal variations requiring “panel” analysis. Although fragmented, the extant literature provides useful insights into the research questions that are central to this paper. Varying perspectives adopted by earlier studies assisted us in identifying a comprehensive approach towards answering our research questions. In addition to introducing some new explanatory variables in our model (such as leasing activity, vacant square feet, etc.), we also include the variables established by the existing literature (e.g., building age, size, height, and location). A number of variables are highly correlated, such as downtown location and parking ratio, leasable area and building height, etc. Because we are employing temporal data, the “time” variable is also included in our random-effects model to control for the inflation effect. The existing literature also provides insights into the functional form of the relationship that the independent variables share with the dependent variable. Thus, we include log-linear transformations of rental rate, leasing activity and vacancy and quadratic forms of building age and height. We also derive insights from the literature for transforming the new variables introduced by us in the model, such as leasing activity.
Panel Data

Earlier real estate studies have addressed similar research questions analyzing panel data sets. Bourassa, Haurin, Haurin, Hoesli, and Sun (2009) analyze time series data from three cities to estimate the price increase of individual properties with respect to the market. They find that if market conditions change, then the property characteristics affect the price path relative to the market. Plazzi, Torous, and Valkanov (2008) modeled the dispersion of rental growth rate as a time series over the cross section of metropolitan areas and conclude that negative economic shocks have a larger effect on cross-sectional dispersion.

The idiosyncratic cross-sectional features of the properties have mostly been recognized as responsible for “unobserved” heterogeneity in the fixed-effects models. As in most studies, these characteristics have not been recorded; the analysis of differences over time in price (rental rate in our case) has been analyzed to remove the unobserved effects from the model. Among others, Case and Quigley (1991) recommend the method proposed by Bailey, Muth, and Nourse (1963) where the fixed property characteristics are standardized with reference to themselves confining the analysis to properties those that have been repeatedly sold. Repeat sales in such studies are analogous to repeat listings in our study. This solution can be understood as in Equation (1):

Let

$$R_{it} = \beta_0 + \sum_{j=1}^{j'} \beta_{j} X_{jut} + \sum_{k=1}^{k'} \beta_{k} Z_{ki} + \delta t + \epsilon_{it},$$

(1)
where $R$ is the rental rate of a property, indexed by time $t$ and property $i$. $X_j$ is the $j^{th}$ temporal (time-dependent) characteristic of the property, $Z_k$ is the $k^{th}$ cross-sectional characteristic of the property, $\delta$ is the effect of time, and $\varepsilon_i$ is a disturbance term assumed to satisfy the usual regression model. Considering the previous equation, we can explain the rental rate at time $(t-1)$ as follows:

$$R_{i(t-1)} = \beta_0 + \sum_{j=1}^{j'} \beta_j X_{ji(t-1)} + \sum_{k=1}^{k'} \beta_k Z_{ki} + \delta(t - 1) + \varepsilon_{i(t-1)}. \quad (2)$$

Subtracting Equation (2) from Equation (1), we find:

$$\Delta R_i = \sum_{j=1}^{j'} \beta_j \Delta X_{ji} + \delta + \varepsilon_i - \varepsilon_{i(t-1)}. \quad (3)$$

It is evident from Equation (3), that the unobserved effects may be eliminated from the regression model by analyzing the difference. The first difference fixed effect model eliminates the issue of “unobserved heterogeneity” from the model caused by the limitations of the dataset. Dougherty (2007) discusses some other issues with such models. First, the intercept term ($\beta_0$), which is fixed for individual properties, disappears from the model. Second, several degrees of freedom are lost while differencing the rental rate of two consecutive terms. Third, if the disturbance term $\varepsilon_i$ satisfies the regression model assumptions, the differencing may give rise to autocorrelation due to the $\{\varepsilon_i - \varepsilon_{i(t-1)}\}$ term (on the contrary, if $\varepsilon_i$ itself is subject to autocorrelation, the first difference estimator could be acceptable). Further, the interpretation of such models is limited to only those explanatory variables that are temporal in nature. In other words, the effects of non-temporal characteristics of a property are discounted while analyzing the change over time. For example, the model remains silent about the effect of variation in height (or age, location, and so on) on the change in their rents (or prices) over time. On the contrary, it may be possible that, say, the rents of taller buildings rise (or fall) faster over time. Dougherty (2006) explains the benefits of using “Random Effects Regression” in order to include the non-temporal effects in the model. The Random Effects model provides a capability to apply regression to the model without having to eliminate the non-temporal effects; and the equation is similar to Equation (1).

In our analyses, we start with the first difference models followed by random effect models. In the latter case, however, we treat the quarterly rental rate level as the dependent variable instead of the change in rental rate over a quarter. Due to the availability of cross-sectional characteristics of office buildings, we include the non-temporal characteristics of the office buildings from our sample in the
model. We, therefore, analyze our model both ways (i.e., including and excluding the non-temporal characteristics independent variables).

**Empirical Analysis**

We examine multiple models and multiple samples to study the effects of green buildings on rental dynamics. We begin the analysis with a first difference model. First, we find the effect of green status (vs. absence of it) on the rental rate changes over time through a statistical randomization approach. This allows us to include a richer set of independent variables in our model, keeping them uniform over our subsamples made up of green and non-green properties. Second, we explore the first difference model of the rental rate, controlling for the “green” attribute through sampling. That is, we split our sample of first differences into two subsamples of green and non-green properties. Due to the constant nature of the change (over time) of the “green” dummy variable in the subsamples, we lose the interaction term leading to Model Ib.

**The First Difference Model**

**Model Ia**

\[
\Delta \text{LnTGR}_i = f(\Delta \text{UpMarket}_i, \Delta \text{LnTGR}_{i(t-1)}, \Delta \text{LnTLA}_i, \Delta \text{LnVac}_i, \\
\Delta \text{Green}_i, \Delta \text{UpMarket}_i \times \text{Green}_i).
\]

**Model Ib**

\[
\Delta \text{LnTGR}_i = g(\Delta \text{UpMarket}_i, \Delta \text{LnTGR}_{i(t-1)}, \Delta \text{LnTLA}_i, \Delta \text{LnVac}_i).
\]

Where \(\Delta\) signifies the change in a variable with respect to the previous quarter. \(\text{Green}\) and \(\text{UpMarket}\) are indicator variables denoting the green status (= 1 if a property is green) and the up-market scenario (= 1 if the average market rent in the sample increased from the previous quarter). \(\text{TGR}\) is total gross rent ($/sq. ft./yr.), \(\text{TLA}\) is total leasing activity (sq. ft.), and \(\text{Vac}\) is total property vacancy (sq. ft.) in a given quarter.

\(\Delta V_i\) signifies the quarterly change in the variable \(V\), from the \((t-1)\) quarter to the \(t\) quarter for property \(i\). To examine differential performance, we divide our first-difference sample into three groups of properties-quarters: data points with (1) both consecutive properties-quarters designated as green, (2) no consecutive properties-quarters designated as green, and (3) only the latter properties-quarters designated as green signifying the transition from non-green to green. In these analyses, we omit the green status indicator variable (and, thus, its interaction with the up-market indicator variable) for the sake of intuitive comparison between the three groups; this results in two models (Ia & Ib) for the first-difference regression.
Random Effects Model

Model II

\[ \ln\text{TGR}_{it} = h(\text{Green}_{it}, DC_{t}, \text{UpMarket}_{t}, t, \ln\text{TGR}_{it-1}, \ln\text{TLA}_{it}, \ln\text{Vac}_{it}, \text{YrBlt}_{i}, \text{Stories}_{i}, \text{Stories}^2_{i}, \text{Downtown}_{i}, \text{Green}_{it} \times \text{UpMarket}_{t}), \]

where \(i\) and \(t\) index individual properties and time (quarter) respectively; and

\[ \text{Green}_{it} = 1 \text{ if the property is LEED certified; } 0 \text{ otherwise;} \]
\[ DC_{t} = 1 \text{ if the property is located in Washington DC; } 0 \text{ otherwise;} \]
\[ \text{UpMarket}_{it} = 1 \text{ if the market trend of the metro area is witnessing an up-market; } 0 \text{ otherwise;} \]
\[ t = \text{Time period in quarters such that } 2001:Q1 = 1, 2009:Q4 = 2, \text{ and so on;} \]
\[ \text{TGR}_{it} = \text{Total gross rent in $/sq. ft./year;} \]
\[ \ln\text{TLA}_{it} = \text{Natural log of total leasing activity in sq. ft.;} \]
\[ \ln\text{Vac}_{it} = \text{Natural log of total vacancy in sq. ft.;} \]
\[ \text{YrBlt}_{i} = \text{The year in which the property was first built (indicating its age);} \]
\[ \text{Stories}_{i} = \text{Number of stories in the property;} \]
\[ \text{Downtown}_{i} = 1 \text{ if the property } i \text{ is located in the downtown; } 0 \text{ otherwise;} \text{ and} \]
\[ \text{Green}_{it} \times \text{UpMarket}_{t} = 1 \text{ if the property is classified as green and in an up market.} \]

Results

First Difference Models

The first-difference model eliminates the non-temporal explanatory variables from Model Ia. To further examine the differences across green and non-green property-quarters, we control for the green status through sampling in Model Ib. The descriptive statistics for the three groups are shown in Exhibits 3–4.

As the Exhibit 3 suggests, the data points for the green property-quarters have a generally even distribution of up-market (56%) and down-market scenarios. In our sample, the quarterly rental change of green properties has ranged between \(-36\%\) and \(40\%\). On an average, the quarterly rental change has been \(0.07\\%\). Exhibit 4 suggests that the proportion of properties going through a transition in the market cycle over two consecutive quarters (\(\Delta\text{UpMarket} \neq 0\)) is almost half (48%) while the remaining portion belongs to the properties that did not witness any
### Exhibit 3 | Descriptive Statistics for the First-Difference Model of the Data Points Wherein Both Consecutive Quarters are Designated as “Green”

<table>
<thead>
<tr>
<th></th>
<th>N</th>
<th>Min.</th>
<th>Max.</th>
<th>Mean</th>
<th>Std. Dev.</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\Delta \ln TGR$ (Dependent)</td>
<td>126</td>
<td>-0.44</td>
<td>0.47</td>
<td>0.001</td>
<td>0.08</td>
</tr>
<tr>
<td>$\Delta \ln TGR_{(t-1)}$</td>
<td>126</td>
<td>-0.44</td>
<td>0.77</td>
<td>0.001</td>
<td>0.10</td>
</tr>
<tr>
<td>$\Delta \ln TLA$</td>
<td>126</td>
<td>-11.51</td>
<td>11.51</td>
<td>-0.64</td>
<td>5.16</td>
</tr>
<tr>
<td>$\Delta \ln Vac$</td>
<td>126</td>
<td>-1.01</td>
<td>1.08</td>
<td>0.004</td>
<td>0.18</td>
</tr>
</tbody>
</table>

Freq. Percent

$\Delta UpMarket \neq 0$

70 55.6

Notes: “$\Delta$” signifies the change in a variable with respect to the previous quarter. TGR, TLA, Vac, and UpMarket represent the total gross rent ($/sq. ft./yr.), total leasing activity (sq. ft.), total vacancy (sq. ft.) and up-market indicator (= 1 when the market exhibits upward trend from the previous quarter) respectively of a properties in a quarter. Data collected from a sample of those properties which were designated as green in two consecutive quarters from the San Francisco and Washington DC markets for the period between 2007:Q1 to the date of data collection in 2010:Q1.

### Exhibit 4 | Descriptive Statistics for the First-Difference Model of the Data Points Wherein Neither of the Two Consecutive Quarters are Designated as “Green”

<table>
<thead>
<tr>
<th></th>
<th>N</th>
<th>Min.</th>
<th>Max.</th>
<th>Mean</th>
<th>Std. Dev.</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\Delta \ln TGR$ (Dependent)</td>
<td>1,069</td>
<td>-0.53</td>
<td>0.57</td>
<td>-0.003</td>
<td>0.10</td>
</tr>
<tr>
<td>$\Delta \ln TGR_{(t-1)}$</td>
<td>1,069</td>
<td>-1.27</td>
<td>1.15</td>
<td>0.01</td>
<td>0.15</td>
</tr>
<tr>
<td>$\Delta \ln TLA$</td>
<td>1,069</td>
<td>-11.90</td>
<td>11.99</td>
<td>-0.02</td>
<td>5.61</td>
</tr>
<tr>
<td>$\Delta \ln Vac$</td>
<td>1,069</td>
<td>-11.46</td>
<td>11.72</td>
<td>0.13</td>
<td>2.23</td>
</tr>
</tbody>
</table>

Freq. Percent

$\Delta UpMarket \neq 0$

512 47.9

Notes: “$\Delta$” signifies the change in a variable with respect to the previous quarter. TGR, TLA, Vac, and UpMarket represent the total gross rent ($/sq. ft./yr.), total leasing activity (sq. ft.), total vacancy (sq. ft.) and up-market indicator (= 1 when the market exhibits upward trend from the previous quarter) respectively of a properties in a quarter. Data collected from a sample of those properties which were designated as green in two consecutive quarters from the San Francisco and Washington DC markets for the period between 2007:Q1 to the date of data collection in 2010:Q1.
changes to the market cycle. Comparing this data with the green properties (Exhibit 3) suggests that in our sample, on average, while the green rentals appreciated by 0.07% on quarterly basis, the non-green properties actually witnessed a negative change of 0.03%.\(^{11}\)

Exhibit 5 suggests that the 38 properties that changed their status from non-green to green in our sample actually saw the rental rates shrink by 0.8% on average. For the properties-quarters undergoing a transition from non-green to green status, the overall sample size is small. Moreover, the first difference of market-scenario (up-market) is an under-represented variable.

Exhibit 6 describes the results of the first-difference models (Ia and Ib) with $\Delta LnTGR$ as the dependent variable. The model (Ia) with the complete panel data is statistically insignificant and explains only 0.02% of the variability. The regression analyses (Model Ib) when run separately for non-green and transition properties also turn out to be insignificant. However, despite a relatively smaller sample size (125), our hedonic model for green office rentals (Exhibit 6) is substantially more efficient ($R^2 = 18.9\%$) compared to all other first-difference models. Moreover, only the green sample yielded statistically significant explanatory variables.

It is evident that the first-difference model is meaningful only when applied to green properties. All temporal variables (total leasing activity, total vacancy, and quarterly rental change in the previous quarter) pertaining to green properties in a quarter are statistically significant. As expected, changes to the rental rate in green properties are significant and positively related to changes in the leasing
### Exhibit 6 | First Difference Regression Model

<table>
<thead>
<tr>
<th></th>
<th>Model Ia</th>
<th></th>
<th>Model Ib</th>
<th></th>
<th>Non-Green Properties Only</th>
<th>Transition Properties Only</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>All Properties</td>
<td></td>
<td>Green Properties Only</td>
<td></td>
<td>Non-Green Properties Only</td>
<td>Transition Properties Only</td>
</tr>
<tr>
<td>$\delta$</td>
<td>-0.002</td>
<td>0.002</td>
<td>-0.003</td>
<td></td>
<td>-0.01</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(0.391)</td>
<td>(0.722)</td>
<td>(0.334)</td>
<td></td>
<td>(0.477)</td>
<td></td>
</tr>
<tr>
<td>$\Delta\text{Green}^a$</td>
<td>-0.006</td>
<td>N/A</td>
<td>N/A</td>
<td></td>
<td>N/A</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(0.697)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$\Delta\text{UpMarket}_t$</td>
<td>-0.001</td>
<td>0.007</td>
<td>-0.001</td>
<td></td>
<td>0.02</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(0.878)</td>
<td>(0.685)</td>
<td>(0.884)</td>
<td></td>
<td>(0.567)</td>
<td></td>
</tr>
<tr>
<td>$\Delta\text{Green} \times \text{UpMarket}$</td>
<td>0.002</td>
<td>N/A</td>
<td>N/A</td>
<td></td>
<td>N/A</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(0.905)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$\Delta\ln\text{TGR}_{t-1}$</td>
<td>-0.004</td>
<td>-0.194***</td>
<td>0.003</td>
<td></td>
<td>0.047</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(0.818)</td>
<td>(0.003)</td>
<td>(0.879)</td>
<td></td>
<td>(0.430)</td>
<td></td>
</tr>
<tr>
<td>$\Delta\ln\text{TLA}$</td>
<td>0.001</td>
<td>0.002*</td>
<td>0.001</td>
<td></td>
<td>-0.003</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(0.202)</td>
<td>(0.055)</td>
<td>(0.249)</td>
<td></td>
<td>(0.243)</td>
<td></td>
</tr>
<tr>
<td>$\Delta\ln\text{Vac}$</td>
<td>0.001</td>
<td>-0.156***</td>
<td>0.001</td>
<td></td>
<td>0.189</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(0.526)</td>
<td>(0.000)</td>
<td>(0.475)</td>
<td></td>
<td>(0.204)</td>
<td></td>
</tr>
<tr>
<td>$R^2$</td>
<td>0.002</td>
<td>0.189</td>
<td>0.002</td>
<td></td>
<td>0.084</td>
<td></td>
</tr>
<tr>
<td>Adj. $R^2$</td>
<td>-0.002</td>
<td>0.163</td>
<td>-0.002</td>
<td></td>
<td>-0.027</td>
<td></td>
</tr>
<tr>
<td>$F$</td>
<td>0.422</td>
<td>7.070***</td>
<td>0.487</td>
<td></td>
<td>0.759</td>
<td></td>
</tr>
</tbody>
</table>

**Notes:** The dependent variable is $\Delta\ln\text{TGR}$, the first difference of the natural log of total gross rent with respect to the previous quarter. “All Properties” denotes the regression results of the following model:

$$\Delta\ln\text{TGR} = f(\Delta\text{UpMarket}, \Delta\ln\text{TGR}_{t-1}, \Delta\ln\text{TLA}, \Delta\ln\text{Vac}, \Delta\text{Green}, \Delta\text{UpMarket}, \times \text{Green})$$

Columns 3–5 denote the regression result run on the same sample where the green status is being controlled for by sampling such that the first sample consists of green-only, the second of non-green only, and the third of the only properties-quarters witnessing a transition from non-green to green status, where $\Delta$ signifies the change in a variable with respect to the previous quarter. Green and UpMarket are indicator variables denoting the green status ($= 1$ if a properties is green) and Up-Market scenario ($= 1$ if the average market rent in the sample increased from the previous quarter), TGR is total gross rent ($$/sq. ft./yr.)

TLA is total leasing activity (sq. ft.) and Vac is total property vacancy (sq. ft.) in a given quarter. Columns 3–5 describe the results of the first different regression model wherein the first differences of the green status and its interaction with the UpMarket variables have been omitted. P-values are in parentheses. Total degrees of freedom for column 2 = 1,255, for column 3 = 125, for column 5 = 1,068, and for column 6 = 37.

*Significant at $< 0.1$

**Significant at $< 0.05$.

***Significant at $< 0.005$. 
activity. However, they are significantly yet negatively related to their own previous value and changes in vacant area. This suggests that a positive change in the rental rate in green buildings usually follows a negative movement in the rental rate showing signs of elasticity. Our model suggests that these explanatory variables are unique to modeling green rental rates and are insignificant for non-green samples.

**Random Effects Model**

For Model II, we first analyze the panel data that includes all property-quarters for the time period between 2007:Q1 and 2010:1. Exhibit 7 describes the data used in the random-effects panel data analysis for the complete period of analysis. While the data suggests an even distribution of the location (Washington DC: 51% vs. San Francisco: 49%) and the market cycle (up-market: 49% vs. down-market: 51%), the proportions of green (13%) versus non-green (77%) properties and downtown (19%) versus non-downtown (81%) locations are not comparable.

As a robustness check, we analyze the same model for three individual quarters, thus stratifying the sample into cross-sectional data. Evidently, in the period-specific cross-sectional sub-samples, the unit of analysis shifts to property from property-quarters as in the panel-data. We choose three quarters at yearly intervals (2009:Q4, 2008:Q4, and 2007:Q4). This selection covers the overall sample evenly across time, and also incorporates periods of different market cycles (up-markets and down-markets). Moreover, one of these quarters (2009:Q4) allows us to model both up-markets and down-markets in a single set of cross-sectional data, which
is described in Exhibit 8. This is possible as the two metro areas for that quarter were witnessing opposite concurrent market cycles. The descriptive statistics for these samples are presented in Exhibits 9–11.

The descriptive statistics (Exhibit 9) reveals that there is approximately equal representation from both San Francisco and Washington DC, as well as from the up-market and down-market scenarios. The proportion of green properties is relatively small (13%) in the panel data. However, it is clear that the majority of green properties appear in the cross-sectional analysis during the period of 2009: Q4.

Among the cross-sectional sub-samples, the 2007:Q4 set has only one green property. This further supports our decision to include rental data no earlier than 2007 to avoid under-sampling green properties. Breaking up of the panel data into cross-sectional samples is employed only for a greater understanding of the phenomenon; however, we draw our conclusions from the panel data analysis. For the control variables, we have also been able to sample a satisfactory range of observations. Almost all of our observations are Class A office properties. The only exception is a Class B green property in San Francisco; thus, building-class may not be a significant explanatory variable in our sample.

Exhibit 8 presents the regression results for Model I. Time is a meaningful independent variable for panel data only as the remaining models are cross-sectional. Hence the time variable is omitted from the quarter-specific regression models. Also, during 2009:Q4, only Washington DC was witnessing an up-market, hence the variable DC was perfectly collinear with the UpMarket variable, leading to zero tolerance. The data redundancy is removed by avoiding the DC variable and retaining the UpMarket variable so as to retain the interaction-term (Green * UpMarket) in the model. In the other two quarters, both markets were witnessing either upward (2007:Q4) or downward (2008Q4) trends.

During down-markets, green buildings had nearly a 2.4% higher rental rate, controlling for other factors. This number is the coefficient of the Green variable when the up-market indicator variable is assigned a value of zero, thus signifying the premium of green properties over non-green properties during the down-market scenarios. During up-markets, the premium on green buildings is calculated by adding the coefficients of the Green indicator and its interaction term with the UpMarket indicator. Thus, during the up-markets, the premium enjoyed by green properties over non-green properties shrinks to 0.1%; however, the coefficient of the interaction term (−0.023) is insignificant. The amount of vacant square feet in a building (LnVac) is an insignificant explanatory variable of rental rates during the respective quarter, although it tends to have a negative coefficient in most cases. Higher leasing activity (LnTLA), as suggested by the panel data, seems to increase the bargaining power of property owners. Controlling for other factors, there is an insignificant difference between the rental rate dynamics of commercial office properties in San Francisco and Washington DC. The effect of building height had contrasting effects during the up-market and down-market scenarios (columns 2 & 3 of Exhibit 8). Also, a significant quadratic term of building height (stories) in one of the samples supports Slade’s (2000) finding that the effect of
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Intercept</td>
<td>0.003</td>
<td>-2.010</td>
<td>1.045</td>
<td>-0.920</td>
</tr>
<tr>
<td></td>
<td>(0.994)</td>
<td>(0.128)</td>
<td>(0.516)</td>
<td>(0.545)</td>
</tr>
<tr>
<td>Green</td>
<td>0.024**</td>
<td>-0.073**</td>
<td>0.067**</td>
<td>-0.004</td>
</tr>
<tr>
<td></td>
<td>(0.024)</td>
<td>(0.021)</td>
<td>(0.012)</td>
<td>(0.951)</td>
</tr>
<tr>
<td>UpMarket</td>
<td>0.030*</td>
<td>0.011</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td></td>
<td>(0.000)</td>
<td>(0.588)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Green * UpMarket</td>
<td>-0.023</td>
<td>0.082*</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td></td>
<td>(0.155)</td>
<td>(0.089)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>t</td>
<td>-0.004***</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td></td>
<td>(0.000)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>LnTGRt1</td>
<td>0.966***</td>
<td>0.982***</td>
<td>0.942***</td>
<td>0.987***</td>
</tr>
<tr>
<td></td>
<td>(0.000)</td>
<td>(0.000)</td>
<td>(0.000)</td>
<td>(0.000)</td>
</tr>
<tr>
<td>LnTLA</td>
<td>0.002**</td>
<td>0.004*</td>
<td>0.002</td>
<td>-0.002</td>
</tr>
<tr>
<td></td>
<td>(0.009)</td>
<td>(0.078)</td>
<td>(0.350)</td>
<td>(0.211)</td>
</tr>
<tr>
<td>LnVac</td>
<td>-0.001*</td>
<td>0.000</td>
<td>0.000</td>
<td>-0.001</td>
</tr>
<tr>
<td></td>
<td>(0.065)</td>
<td>(0.872)</td>
<td>(0.873)</td>
<td>(0.503)</td>
</tr>
<tr>
<td>DC</td>
<td>-0.004</td>
<td>N/A</td>
<td>0.026</td>
<td>-0.037**</td>
</tr>
<tr>
<td></td>
<td>(0.538)</td>
<td></td>
<td>(0.167)</td>
<td>(0.045)</td>
</tr>
<tr>
<td>Downtown</td>
<td>0.011</td>
<td>0.063**</td>
<td>0.024</td>
<td>0.005</td>
</tr>
<tr>
<td></td>
<td>(0.165)</td>
<td>(0.009)</td>
<td>(0.347)</td>
<td>(0.847)</td>
</tr>
<tr>
<td>Stories</td>
<td>-0.001</td>
<td>-0.008**</td>
<td>0.008**</td>
<td>0.003</td>
</tr>
<tr>
<td></td>
<td>(0.165)</td>
<td>(0.035)</td>
<td>(0.026)</td>
<td>(0.522)</td>
</tr>
<tr>
<td>SqStories</td>
<td>0.000</td>
<td>0.000*</td>
<td>0.000***</td>
<td>0.000</td>
</tr>
<tr>
<td></td>
<td>(0.180)</td>
<td>(0.100)</td>
<td>(0.003)</td>
<td>(0.439)</td>
</tr>
<tr>
<td>YrBlt</td>
<td>0.000</td>
<td>0.001</td>
<td>0.000</td>
<td>0.001</td>
</tr>
<tr>
<td></td>
<td>(0.701)</td>
<td>(0.107)</td>
<td>(0.563)</td>
<td>(0.503)</td>
</tr>
<tr>
<td>R²</td>
<td>0.946</td>
<td>0.968</td>
<td>0.965</td>
<td>0.965</td>
</tr>
<tr>
<td>Adj. R²</td>
<td>0.945</td>
<td>0.964</td>
<td>0.961</td>
<td>0.960</td>
</tr>
</tbody>
</table>

Notes: This table lays out the results of the following regression model:

\[
\ln TGR_t = \beta_0 + \beta_1 \text{Green}_t + \beta_2 \text{UpMarket}_t + \beta_3 t + \beta_4 \ln TGR_{t-1} + \beta_5 \ln TLA_t + \beta_6 \ln Vac_t + \beta_7 YrBlt_t + \beta_8 \text{Stories}_t + \beta_9 \text{Stories}^2_t + \epsilon_t.
\]

Green is an indicator variable that assumes a value of 1 if a property is green in a quarter. UpMarket is an indicator variable that assumes a value of 1 if the average market rent increased over the previous quarter; else 0. \( t \) signifies the serial number of a quarter such that 2007:Q1 is coded as 9, 2007:Q2 as 10 and so on. TGR stands for total gross rent ($/sq. ft./yr.) of a building. TLA signifies total leasing activity (sq. ft.) of a building. Vac stands for total vacancy in a building (sq. ft.). DC, an indicator variable assumes a value of 1 if a properties is located in Washington DC metro, zero otherwise. Downtown is a location variable that assumes a value of 1 if a properties is located in a downtown. Stories represents the number of stories in a building. YrBlt specifies the original construction year of a building. All data are recorded for a property in a specific quarter. \( P \)-values are in parentheses. Total degrees of freedom for column 2 = 1,255, for column
taller buildings reverts in sign after a certain height of the building is achieved. However, our study suggests that this effect is faint. We find building age to have a statistically insignificant effect on the rental rates. As expected, the rental rate of the previous quarter is large and statistically significant.

Our analysis has certain limitations. The explanatory variables are insignificant in absence of the lagged dependent variables, which exhibit autocorrelation. There may be potential endogeneity issues between the dependent variable and some explanatory variables such as total leasing activity and vacant area. In addition, panel data analysis has its own limitations. On the other hand, the effect of cross-sectional differences in properties such as age, height, and location may have differing effects on the rental rate changes over time, which cannot be examined.
### Exhibit 10 | Descriptive Statistics for 2008:Q4

<table>
<thead>
<tr>
<th></th>
<th>N</th>
<th>Min.</th>
<th>Max.</th>
<th>Mean</th>
<th>Std. Dev.</th>
</tr>
</thead>
<tbody>
<tr>
<td>TGR(^1)</td>
<td>100</td>
<td>18</td>
<td>156</td>
<td>41.91</td>
<td>22.03</td>
</tr>
<tr>
<td>TLA(^2)</td>
<td>100</td>
<td>0</td>
<td>95,000</td>
<td>5,592.46</td>
<td>12,951.59</td>
</tr>
<tr>
<td>Vac(^3)</td>
<td>100</td>
<td>0</td>
<td>126,961</td>
<td>26,894.75</td>
<td>33,701.40</td>
</tr>
<tr>
<td>Stories(^4)</td>
<td>100</td>
<td>2</td>
<td>48</td>
<td>9.43</td>
<td>8.167</td>
</tr>
<tr>
<td>YrBlt(^5)</td>
<td>100</td>
<td>1957</td>
<td>2009</td>
<td>1992</td>
<td>12.05</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>Freq.</th>
<th>Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Green(^6)</td>
<td>11</td>
<td>11</td>
</tr>
<tr>
<td>UpMarket(^7)</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>DC(^8)</td>
<td>52</td>
<td>52</td>
</tr>
<tr>
<td>Downtown(^9)</td>
<td>17</td>
<td>17</td>
</tr>
</tbody>
</table>

Notes: 1: total gross rent ($/sq. ft./yr.), 2: total leasing activity (sq. ft.), 3: vacant properties (sq. ft.), 4: number of stories, 5: year of original construction, 6: equals 1 if green, else 0; 7: equals 1 if the average market rent increased from the previous quarter, 8: equals one if located in Washington DC, and 9: equals one if located in downtown. All statistics for a commercial office properties in a quarter.

### Exhibit 11 | Descriptive Statistics for 2007:Q4

<table>
<thead>
<tr>
<th></th>
<th>N</th>
<th>Min.</th>
<th>Max.</th>
<th>Mean</th>
<th>Std. Dev.</th>
</tr>
</thead>
<tbody>
<tr>
<td>TGR(^1)</td>
<td>84</td>
<td>22.41</td>
<td>96</td>
<td>40.84</td>
<td>14.15</td>
</tr>
<tr>
<td>TLA(^2)</td>
<td>84</td>
<td>0</td>
<td>45,000</td>
<td>4,823.77</td>
<td>9,456.38</td>
</tr>
<tr>
<td>Vac(^3)</td>
<td>84</td>
<td>0</td>
<td>124,839</td>
<td>24,650.36</td>
<td>32,899.19</td>
</tr>
<tr>
<td>Stories(^4)</td>
<td>84</td>
<td>2</td>
<td>39</td>
<td>9.51</td>
<td>7.52</td>
</tr>
<tr>
<td>YrBlt(^5)</td>
<td>84</td>
<td>1955</td>
<td>2009</td>
<td>1992</td>
<td>11.92</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>Freq.</th>
<th>Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Green(^6)</td>
<td>1</td>
<td>1.2</td>
</tr>
<tr>
<td>UpMarket(^7)</td>
<td>84</td>
<td>100</td>
</tr>
<tr>
<td>DC(^8)</td>
<td>44</td>
<td>52.4</td>
</tr>
<tr>
<td>Downtown(^9)</td>
<td>14</td>
<td>16.7</td>
</tr>
</tbody>
</table>

Notes: 1: total gross rent ($/sq. ft./yr.), 2: total leasing activity (sq. ft.), 3: vacant properties (sq. ft.), 4: number of stories, 5: year of original construction, 6: equals 1 if green, else 0; 7: equals 1 if the average market rent increased from the previous quarter, 8: equals one if located in Washington DC, and 9: equals one if located in downtown. All statistics for a commercial office properties in a quarter.
through fixed-effects models. In addition, the first-difference models are not as efficient as the random-effects models as our results suggest. To address these limitations of methodology, we ran several robustness checks. The issues with the panel data are addressed by breaking up our sample into smaller, cross-sectional samples. The issues of the fixed-effects model are addressed by also running a random effects model.

**Conclusion**

In line with previous studies, we find that green office properties enjoy a rental rate premium. We also find evidence that green premiums are not static. Instead they tend to stabilize rental rates across various real estate market conditions thus offsetting some of the negative effects of down-markets. The green premium is counter-cyclical: positive and significant in down-markets, but substantially reduced in up-markets. This finding confirms Eichholtz, Kok, and Quigley (2011), who also report that the recent downturns in the property markets have not significantly degraded the financial performance of green buildings relative to those of comparable non-green properties. In addition, if green properties witnessed a positive rental rate percentage change from a previous quarter, it tends to offset the intrinsic pattern of the increase by a negative percentage while controlling for other factors. Quarterly changes in the property-specific temporal variables explain approximately 19% of the variability in the changes of commercial office property rental rates, resulting in a significant explanatory model. In contrast, the model examining quarterly changes in the property-specific temporal variables in non-green properties only explained 0.2% of rental rate variability. Thus, our hedonic models for rental rates are more efficient for green properties compared with non-green properties.

It is, however, critical to point out that our sample includes a time period in which the economy was going through an unusual phase of severe economic crisis. This might have influenced the pattern of green commercial office rental rates asymmetrically compared with comparable non-green office properties. It is also possible that with time, as more green developments are constructed, the issue of limited supply of green properties may become moot as the market reaches equilibrium and the dynamic nature of green premiums may diminish.

**Endnotes**

1 In this paper, we use LEED-labeled as synonymous to “green” properties.
2 Green building is defined as “the practice of creating and using healthier and more resource-efficient models of construction, renovation, operation, maintenance and demolition”; From the US EPA website: http://www.epa.gov/greenbuilding/.
3 BREEAM stands for BRE Environmental Assessment Method administered by Building Research Establishment in the U.K.
4 “Green Mark” is a green labeling used in Singapore for newly constructed and rehabilitated buildings.
“Green Star” is a green rating system administered by the Green Building Council of Australia.

For example, green ratings for residential real estate were instituted very recently by the USGBC.

For a more detailed discussion on this issue, see Wang and Zorn (1999).

Calculated as $100 \times (e^{0.47} - 1)\%$.

Calculated as $100 \times (e^{0.007} - 1)\%$.

Calculated as $100 \times (e^{-0.003} - 1)\%$.

This information is relevant only to our sample. In fact, there were several other green properties available in that quarter, but we failed to find their information in the CoStar database.

Calculated as $100 \times (e^{0.024} - 1)\%$.

During the up-markets, the coefficient of the green premium (on $\ln TGR$) can be calculated as $0.024 - 0.023 = 0.001$.

Calculated as $100 \times (e^{0.001} - 1)\%$.

References


*We are thankful to USGBC and CoStar for providing us with the data. Sincere thanks to David Harrison, Patrick McAllistor, Edward Coulson, the anonymous reviewers of the JOSRE, Julian Diaz III, Edward Rigdon, Subhashish Samaddat, and Arun Rai for valuable insights, comments or suggestions.*
Residential Land Values and Walkability

Authors
Stephanie Yates Rauterkus and Norman G. Miller

Abstract
We examine 5,603 property transactions in Jefferson County, Alabama that take place between 2004 and 2008. Using OLS regressions, we estimate the extent to which differences in walkability, as measured by Walk Score™, can explain the variability in land values. We find that after controlling for population growth and lot size, land values generally increase with walkability and that this result is stable over time. However, we find evidence that this impact reverses as neighborhoods become more car-dependent. This car dependency increases as the distance from the central business district increases. We consider the implications of our findings on mixed-use developments in what we believe is the first study to address walkability in this context of sustainable development.

Residential land values differ greatly by location. We consider the impact that walkability has on these differences. Walkability is a measure of how friendly a neighborhood is to walking to commonly demanded consumption amenities, such as work, schools, etc. Walker-friendly neighborhoods have significant health, economic, and environmental benefits because, as noted by Lehman and Boyle (2007), it is easier for residents to get the daily exercise recommended by the Surgeon General and the Centers for Disease Control and Prevention (CDC) to combat obesity and a number of other health-related risk factors. Walkable neighborhoods are a housing intervention thought to have a positive impact on public health via minimizing carbon footprints. Also, neighborhoods where residents can walk to stores, schools, and jobs are thought to promote a healthier, pedestrian lifestyle. The environmental benefits from walkable neighborhoods derive from a decrease in motor vehicle usage, which in turn cuts down on harmful emissions polluting the air. This decrease in motor vehicle traffic can also provide an economic benefit to residents because the disposable income ordinarily allocated toward auto expenses can be used for other necessities. Neighborhoods, such as mixed-use developments, that offer these various health, convenience, and environmental benefits are considered to be more sustainable over time.

The aim of this paper is to determine to what extent the benefits of walkable neighborhoods are reflected in land values. We focus on land values as opposed to overall home values in order to remove some of the non-location ‘noise’ in our analyses. That is, we wish to determine the degree to which specific location-related elements impact value as opposed to improvements. In order to isolate that effect, we attempt to ignore, as much as possible, valuation factors that could be easily replicated at another location. A home, for example, could be constructed...
in the same manner in virtually any location in the country meeting space and zoning requirements. Neighborhood amenities, services, and other location-related value factors may not be easily transported and are the focus of our study. Miller (1982) organized the determinants of residential property value into five broad categories: physical attributes, location, financial factors, transaction costs, and inflation relative to market price. This paper focuses on the location-based factors, particularly given the walkability characteristics of that location. Of Miller’s three location-based subcategories (fiscal, transportation costs, and economic externalities), walkability fits in the category of economic externalities. The author included issues such as air quality, race, public facilities, noise, and public housing that affect the quality of life within a neighborhood. Walkability is akin to public facility access, but (to our knowledge) has not yet been studied in the context of residential land values.

We hypothesize that walkability matters. We expect that land values are higher in neighborhoods that are easily accessible to services and that this impact may be muddied in certain areas when overall home values are studied as opposed to the land itself. This is because in lower income neighborhoods, the structures in place are smaller with fewer bedrooms and bathrooms and are therefore less valuable than the structures that are typical of higher income neighborhoods.

The paper is organized as follows. Section two provides a review of the existing literature in the area of property valuation with an emphasis on land values versus home values. Section three describes the data and methodology. Section four presents the results. And section five provides conclusions and policy implications.

Review of the Literature

Studies of land values have focused on the specific factors in the built environment that impact land values. Exhibit 1 summarizes much of what has been reported regarding these factors. Certain characteristics, when present in a neighborhood, have been found to enhance property values while others have been found to be value-reducing. With regard to population change, initially it was not clear if there was a correlation between realized or forecasted growth and land values. Mertzke (1926) studied 37 Wisconsin cities with a population of 5,000 or more and determined that there was little correlation between land values and changes in population. However, later studies by Capozza and Helsley (1989) and Guntermann (1997) confirmed that the price of land in rapidly growing cities reflects a premium based on future growth expectations. Thus, a forward-looking versus backward-looking approach to population change is key in valuation. With changes in population, access to public transportation becomes important as well, especially as one considers locations farther from the central city. Hayes (1957), Benson, Hansen, Schwartz, and Smersh (1998), and Bond, Bond, Seiler, and Seiler (2002) and more recently Giuliano, Gordon, Pan, and Park (2010) studied the value related to water features. Giuliano et al., however, found that lot size, home size, and proximity to the coast were more important than accessibility. Besides general accessibility, proximity to amenities and favorable topography have also been shown to increase land values. Several papers such as Do and Grudnitski
Exhibit 1 | Empirical Evidence of the Impact of Location Features on Land Values

<table>
<thead>
<tr>
<th>Location Features</th>
<th>Value Adding</th>
<th>Value Destroying</th>
<th>Indeterminate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rail Stations</td>
<td>Hayes (1957)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Water-Based Features</td>
<td>Hayes (1957); Benson, Hansen, Schwartz, and Smersh (1998); Bond, Seiler, and Seiler (2002); Giuliano, Gordon, Pan, and Park (2010)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Proximity to Urban Areas, Malls and Roads</td>
<td>Hayes (1957); Kaltas, Bosch, and McGuirk (2008)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Proximity to Industrial Areas</td>
<td>Hayes (1957); Asabere and Huffman (1991); McMillen and McDonald (2002)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Parcel Size</td>
<td>Kaltas, Bosch and McGuirk (2008)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Golf Courses</td>
<td>Do and Grudnitski (1995)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note: This table presents the findings of existing literature in the area of land valuation.

(1995), Benson, Hansen, Schwartz, and Smersh (1998), and Bond, Seiler, and Seiler (2002) have examined the impact of amenities on residential property values. These studies, however, study the value that a specific amenity such as water views or golf course access adds. Pivo and Fisher (2011) also consider neighborhood amenities and use Walk Score™, which takes into consideration all amenities within one mile of a given property.

Walk Score scores locations on a 100-point scale with respect to the ease with which one could live without a car. Thus, locations scoring 90 points or better are dubbed a “Walker’s Paradise” while locations scoring under 25 points are labeled as “Car-Dependent.” The scoring algorithm awards the most points for amenities within 0.25 miles of the given location based on data from Google (for mapping), Education.com (for school listings), Open Street Map (for additional mapping resources), and Localeze (for business listings). There are some limitations of Walk Score in that while it attempts to approximate walkability, not all factors are included in its algorithm, such as street design, safety, topography, and weather. That is, the Walk Score is strictly based on the distance between a location and all amenities within a one-mile radius. Also, the distances used are “as the crow flies” distances as opposed to the actual distance walked along street grids. In effect, Walk Score assumes that residents can walk to each amenity using...
a straight path. In addition, Walk Score does not consider proximity to public transit. A new metric, Transit Score, does account for access to public transportation, but Birmingham is not currently one of the cities where Transit Scores are available.\(^2\)

However, while a “Street Smart” Walk Score is in production that will consider intersection density, block length, and other walking issues, Carr, Dunsiger, and Marcus (2010) test the validity and reliability of Walk Score for estimating access to objectively measured walkable amenities. They find significant correlations between Walk Score and all categories of aggregated walkable destinations within a one-mile buffer of their sample addresses and conclude that Walk Score is a reliable and valid measure of estimating access to walkable amenities.

Pivo and Fisher (2011) find that proximity to amenities, hence, walkability increases value, but their focus is on commercial real estate values. Cortright (2009) studies 15 metro areas including Chicago, San Francisco, Sacramento, Austin, and Charlotte where the value of Walk Score was greatest and uses Walk Score to determine its impact on house values. The author finds that homes that rank as above-average in walkability command premiums of $4,000 to $34,000 over homes in less walkable neighborhoods.

Several other studies have used Walk Score data in various ways. For example, Rauterkus, Thrall, and Hangen (2010) use Walk Score data to show that walkability is associated with a lower mortgage default probability. They argue that walkable neighborhoods allow residents to spend less on vehicle-related expenses, thereby making their housing costs more affordable. Rogers, Halstead, Gardner, and Carlson (2011) use a case study set in New Hampshire to argue that walkable neighborhoods improve quality of life by generating and maintaining social capital. That is, their survey of New Hampshire residents indicates that respondents living in more walkable neighborhoods reported higher social capital as well as a better quality of life than those in less walkable neighborhoods.

Hayes (1957) found that land values decrease with proximity to industrial areas. Asabere and Huffman (1991) found that this decrease in value is 58% when considering lots that were actually zoned for industrial use versus those that were not. McMillen and McDonald (2002) found support for this finding with their own result that residential zoning led to higher land value growth rates than commercial zoning after a new zoning ordinance in Chicago in 1923. In some areas, however, parcel value per unit declines with increasing parcel size (Kaltsas, Bosch, and McGuirk, 2008).

Our study focuses on residential versus commercial land values. Because we ignore structure values by focusing only on land values, we are left to consider factors unique to the neighborhood that may have an impact on land values. Prior literature has suggested that these locational issues include forecasted population change, access to public transit, water-based features, proximity to urban and industrial areas, parcel size, and amenities. Our primary focus is on the value added by neighborhood amenities and we measure the proximity to amenities by using Walk Score. We then move the discussion of amenity value to a broader
discussion of sustainability. That is, does walkability add value? We control for factors known to impact land values by including these factors in our robustness tests.

Data and Methodology

Our study location is Jefferson County Alabama, which includes the Birmingham-Hoover Metropolitan Statistical Area (MSA). Jefferson County had a population of 658,466 in 2010 according to the U.S. Census Bureau and is the most populated county in Alabama. We obtained data from the Jefferson County Tax Commissioner on all property sales in the county from January 2004 to December 2008. This data includes information related to the property sale, as well as characteristics of the property, such as lot size and land value, along with characteristics of the existing structure. Our key variables of interest are land value and Walk Score as we are attempting to estimate the degree to which walkability, as measured by Walk Score, explains variation in land values. In order to isolate the explanatory power of walkability, we control for other factors known to affect land values, such as lot size and population growth.

Exhibit 2 is a heat map of the study data depicting the variability in land values per square foot across ZIP Codes. This map shows that land values are the highest in the neighborhoods of Mountain Brook, Avondale, and Vestavia Hills, near the
airport and near two universities. These three neighborhoods have the highest median income levels in the county. Mountain Brook and Avondale are two of the oldest communities in the county, with many homes listed on the historical register.

For each property, we obtain its Walk Score. As noted previously, higher scores are indicative of more walkable locations and therefore should generally correlate with more walkable neighborhoods, whereas locations with scores below 50 are considered to be car-dependent. After mapping the property addresses to obtain geographic coordinates for each location, we apply the Walk Score algorithm to obtain the Walk Score for each location. Again, the Walk Score algorithm awards points based on the distance to the closest amenity in each category and no points are awarded for amenities located more than one mile from the subject address.5

Given the nature of the Walk Score methodology, we had concerns about whether it measured only proximity to amenities and not true walkability. We argue that population density would be an appropriate proxy for proximity. Throughout our analysis, we substituted population density for Walk Score. While we found similar results at times, the findings were not identical, which indicates that Walk Score measures something other than strictly population density.6

Exhibit 3 is a map of the study data depicting the variability in Walk Scores across ZIP Codes, along with sales transactions for the sample period of 2004 to 2008. Each pushpin on the map represents a sale, while the background color on the
**Exhibit 4 | Descriptive Statistics: Entire Sample**

<table>
<thead>
<tr>
<th></th>
<th>Mean</th>
<th>Median</th>
<th>Min.</th>
<th>Max.</th>
<th>Std. Dev.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Land Value ($)</td>
<td>60,192</td>
<td>35,700</td>
<td>2,200</td>
<td>1,318,300</td>
<td>69,390</td>
</tr>
<tr>
<td>Total Land Area (ft.²)</td>
<td>19,774</td>
<td>14,962</td>
<td>1,400</td>
<td>1,812,912</td>
<td>41,121</td>
</tr>
<tr>
<td>Land Value per Square Foot ($)</td>
<td>4.94</td>
<td>2.48</td>
<td>0.04</td>
<td>62.18</td>
<td>6.43</td>
</tr>
<tr>
<td>Population Growth (%)</td>
<td>0.61</td>
<td>0.00</td>
<td>-3.20</td>
<td>7.00</td>
<td>1.53</td>
</tr>
<tr>
<td>Walk Score</td>
<td>26.94</td>
<td>23.00</td>
<td>0.00</td>
<td>94.00</td>
<td>20.32</td>
</tr>
<tr>
<td>Land Leverage (%)</td>
<td>30.65</td>
<td>32.00</td>
<td>0.00</td>
<td>177.14</td>
<td>17.52</td>
</tr>
<tr>
<td>Sale Price ($)</td>
<td>179,872</td>
<td>150,000</td>
<td>20,000</td>
<td>1,750,000</td>
<td>119,878</td>
</tr>
</tbody>
</table>

*Notes: This table summarizes the sample of data used in the study. We examine 5,603 properties in Jefferson County, Alabama that were sold between 2004 and 2008.*

map is darkest in areas where the Walk Score is highest and the background color is lightest in areas where the Walk Score is lowest. Walk Scores are generally low with the highest values near the universities and in the neighborhood of Homewood, which is one of the most walkable neighborhoods in all of Alabama. In addition, the map appears to indicate that sales transactions are more prevalent in the more walkable neighborhoods as opposed to the less dense areas to the north and east.

Exhibit 4 provides the descriptive statistics for the sample. Our sample includes 5,603 properties. The average (median) land value is $60,192.61 ($35,700). These land values are reported separately from total sales price by the county tax assessor. The median land value is in line with average land value data from the Lincoln Institute. The Lincoln Institute reports that from 2004 to 2008 (our sample period), the average land value in Alabama was $44,314. The average (median) lot size in our sample is 19,774.65 (14,962.89) square feet. This equates to average lot sizes of just under half an acre. The ratio of land values to lot sizes results in average (median) land values per square foot of $4.94 ($2.48). We use population growth from 2000 to 2009 at the Census tract level (estimated by ESRI) as a proxy for future growth. This measure was found by Capozza and Helsley (1989) and Guntermann (1997) to be positively related to land value increases. Overall, population growth across our sample neighborhoods was minimal, as indicated by a median value of 0.00.

We use the exact locations of the properties in our sample to obtain Walk Score by creating a batch file containing the longitude and latitude coordinates for every property. We then upload this file to the Walk Score file server and use ColdFusion programming to request and download the corresponding Walk Scores. The average (median) Walk Score for the properties in our sample is 26.94 (23.00), indicating that the average property is located in a car-dependent neighborhood due to the fact that only a few amenities are within walking distance. According to Walk Score, the 53 largest cities in Alabama have an average Walk Score of
Exhibit 5  |  Walk Score Frequency

<table>
<thead>
<tr>
<th>Walk Score Range</th>
<th>Category Description</th>
<th>Frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td>90–100</td>
<td>Walker’s Paradise (Hoboken, NJ)</td>
<td>2</td>
</tr>
<tr>
<td>70–89</td>
<td>Very Walkable (New York, NY)</td>
<td>183</td>
</tr>
<tr>
<td>50–69</td>
<td>Somewhat Walkable (Los Angeles, CA)</td>
<td>620</td>
</tr>
<tr>
<td>25–49</td>
<td>Somewhat Car Dependent (Phoenix, AZ)</td>
<td>1,954</td>
</tr>
<tr>
<td>0–24</td>
<td>Car Dependent (Port St. Lucie, FL)</td>
<td>2,844</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>5,603</td>
</tr>
</tbody>
</table>

Notes: This table reports the frequency of Walk Scores in the sample data within specific bands. In the Category Description column, examples are given (in parentheses) of cities outside of Alabama where the average Walk Score places it in the given category.

31, while one of the most walkable cities, Homewood, Alabama, lies within our sample area and has a Walk Score of 55. We edited the Walk Score values by adding 0.5 to all observations before taking log transformations. This eliminated the problem of taking log transformations of observations with zero values. Further, adding this constant uniformly across all observations does not alter the statistical significance of the results.

In order to gain a better understanding of the frequency distribution of Walk Scores across the various categories of walkability as defined by Walk Score, we created dummy variables corresponding to each category. This distribution is reported in Exhibit 5.

The average (median) sale price of the properties in our sample is $179,872.50 ($150,000.00). We use this value along with land values to compute land leverage, as in Bostic, Longhofer, and Redfearn (2007). Bostic et al. proposed that houses with a greater amount of land leverage—the ratio of a property’s land value to total property value—will have relatively more volatile prices. This hypothesis is based on the argument that when unbundling property values into the components of land and structure values, land value is the ultimate source of house price appreciation and thus the main driver of property values and volatility. Their empirical analysis using data from Wichita, Kansas showed evidence of a positive relation between house price volatility and land leverage. In our sample, average (median) land leverage is 30.65% (25.31%).

Exhibit 6 describes the correlations between our key variables. While our dependent variable in our primary regression analysis is lnvalpsqft and lnLandLeverage in our robustness checks, our concern here is the extent to which our independent variables (lnWalkScore, PopGrowth, and lnLotSize) are correlated.

We hypothesize that the more walkable a neighborhood, the greater the land values in that neighborhood. This walkability accounts for neighborhood amenities and speaks to the value of neighborhood design and sustainability. As an anchor for
Exhibit 6 | Correlation Matrix

<table>
<thead>
<tr>
<th></th>
<th>Invalpsqft</th>
<th>InWalkScore</th>
<th>PopGrowth</th>
<th>InLotSize</th>
<th>InLandLeverage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Invalpsqft</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>InWalkScore</td>
<td>0.3271</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(0.0000)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>PopGrowth</td>
<td>−0.0120</td>
<td>−0.3843</td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(0.3697)</td>
<td>(0.0000)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>InLotSize</td>
<td>−0.5785</td>
<td>−0.2390</td>
<td>−0.0933</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>(0.0000)</td>
<td>(0.0000)</td>
<td>(0.0000)</td>
<td>(0.0000)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>InLandLeverage</td>
<td>0.5949</td>
<td>0.3328</td>
<td>−0.1598</td>
<td>0.0749</td>
<td>1</td>
</tr>
<tr>
<td>(0.0000)</td>
<td>(0.0000)</td>
<td>(0.0000)</td>
<td>(0.0000)</td>
<td>(0.0000)</td>
<td></td>
</tr>
</tbody>
</table>

Notes: This table presents the correlation coefficients for the key variables with p-values shown in parentheses. There are 5,603 observations. Invalpsqft is the natural logarithm of the land value per square foot of the property. InWalkScore is the natural log of the property’s Walk Score. PopGrowth is the population growth percentage since the 2000 Census. InLotSize is the natural logarithm of the size of the parcel. InLandLeverage is the natural logarithm of the ratio of the land value to the sale price.

In our discussion, we use the Girardet (1999) definition of a sustainable city. He defines a sustainable city as one that is “organized so as to enable all its citizens to meet their own needs and to enhance their well-being without damaging the natural world or endangering the living conditions of other people, now or in the future.” We argue that walkability allows for sustainability because easy access to amenities makes it easier for citizens to meet their own needs. We estimate the impact of walkability on land values using an OLS regression of the following form:

\[
\text{Residential land value} = f(\text{walkability, population change, parcel size}) \quad (1)
\]

\[
\text{Land Leverage} = f(\text{walkability, population change, parcel size}) \quad (2)
\]

We anticipate that land value will increase with walkability and population change and decrease with parcel size. We expect these results to hold across our alternative specification using land leverage as the dependent variable.

For robustness, we divide our sample based on Walk Score. We divide the sample into two halves: observations above and below the median value. Exhibit 7 summarizes the subsamples relative to Walk Score. Total land value and land value per square foot are lower for properties whose Walk Score is at or below the median. Land area, population growth, and travel time to work are greater for
### Exhibit 7 | Descriptive Statistics: Walk Score Subsamples

<table>
<thead>
<tr>
<th></th>
<th>Mean</th>
<th>Median</th>
<th>Min</th>
<th>Max</th>
<th>Std. Dev.</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Panel A:</strong> Observations at or Below the Mean Walk Score ((N = 2,844))</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total Land Value ($)</td>
<td>47,954.22</td>
<td>34,300.00</td>
<td>2,200.00</td>
<td>968,000.00</td>
<td>53,414.72</td>
</tr>
<tr>
<td>Total Land Area (ft.²)</td>
<td>24,590.07</td>
<td>16,015.31</td>
<td>1,610.22</td>
<td>1,812,912.00</td>
<td>55,735.39</td>
</tr>
<tr>
<td>Land Value per Square Foot ($)</td>
<td>3.36</td>
<td>2.11</td>
<td>0.04</td>
<td>54.14</td>
<td>4.24</td>
</tr>
<tr>
<td>Population Growth (%)</td>
<td>1.17</td>
<td>0.70</td>
<td>-3.20</td>
<td>7.00</td>
<td>1.72</td>
</tr>
<tr>
<td>Walk Score</td>
<td>10.49</td>
<td>11</td>
<td>0</td>
<td>23</td>
<td>7.76</td>
</tr>
<tr>
<td>Travel Time (minutes)</td>
<td>26.77</td>
<td>27.20</td>
<td>15.70</td>
<td>43.80</td>
<td>4.33</td>
</tr>
<tr>
<td><strong>Panel B:</strong> Observations Above the Median Walk Score ((N = 2,759))</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total Land Value ($)</td>
<td>72,808.05</td>
<td>39,000.00</td>
<td>3,400.00</td>
<td>1,318,300.00</td>
<td>80,780.26</td>
</tr>
<tr>
<td>Total Land Area (ft.²)</td>
<td>14,810.88</td>
<td>12,664.02</td>
<td>1,400.09</td>
<td>213,865.10</td>
<td>13,560.15</td>
</tr>
<tr>
<td>Land Value per Square Foot ($)</td>
<td>6.57</td>
<td>3.39</td>
<td>0.15</td>
<td>62.18</td>
<td>7.75</td>
</tr>
<tr>
<td>Population Growth (%)</td>
<td>0.03</td>
<td>-0.10</td>
<td>-3.10</td>
<td>7.00</td>
<td>1.01</td>
</tr>
<tr>
<td>Walk Score</td>
<td>43.89</td>
<td>42</td>
<td>25</td>
<td>94</td>
<td>14.49</td>
</tr>
<tr>
<td>Travel Time (minutes)</td>
<td>22.74</td>
<td>22.50</td>
<td>10.40</td>
<td>41.80</td>
<td>4.72</td>
</tr>
<tr>
<td><strong>Panel C:</strong> Difference in Samples (Panel A–Panel B)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total Land Value ($)</td>
<td>-24,853.80***</td>
<td>-4,700.00</td>
<td>-1,200.00</td>
<td>-350,300.00</td>
<td>-27,365.50</td>
</tr>
<tr>
<td>Total Land Area (ft.²)</td>
<td>9,779.19***</td>
<td>3,351.30</td>
<td>210.12</td>
<td>1,599,046</td>
<td>42,175.24</td>
</tr>
<tr>
<td>Land Value per Square Foot ($)</td>
<td>-3.20***</td>
<td>-1.29</td>
<td>-0.11</td>
<td>-8.04</td>
<td>-3.51</td>
</tr>
<tr>
<td>Population Growth (%)</td>
<td>1.14***</td>
<td>0.80</td>
<td>-0.10</td>
<td>0.00</td>
<td>0.72</td>
</tr>
<tr>
<td>Walk Score</td>
<td>-33.39***</td>
<td>-31.00</td>
<td>-25.00</td>
<td>-71.00</td>
<td>-6.73</td>
</tr>
<tr>
<td>Travel Time (minutes)</td>
<td>4.03***</td>
<td>4.70</td>
<td>5.30</td>
<td>2.00</td>
<td>-0.39</td>
</tr>
</tbody>
</table>

Notes: This table summarizes the sample of data used in the study. We examine 5,603 properties in Jefferson County, Alabama that were sold between 2004 and 2008 and divide the sample based on the median Walk Score in the full sample. All observations with a Walk Score at or below 23 are placed in one subsample. All observations with a Walk Score above this value are placed in a separate subsample. *The difference between the mean values across the two samples is significant at the 10% level. **The difference between the mean values across the two samples is significant at the 5% level. ***The difference between the mean values across the two samples is significant at the 1% level.

Properties whose Walk Score is above the median. These differences are all highly significant.

### Results

Exhibit 8 plots the data in our full sample. The data appear to follow a log-linear pattern consistent with other walkability studies such as Cortright (2009) and Pivo and Fisher (2011).
We estimate OLS regressions in order to determine the linkage between land values and Walk Score. The results of our regression analysis are presented in Exhibit 7. All of our explanatory variables are significant. Both Walk Score and population growth increase with land values while lot sizes decrease with land values. This result indicates that walkability does enhance land values. The results from our control variables (population growth and lot sizes), consistent with Capozza and Helsley (1989) and Guntermann (1997), show that population growth does tend to be value increasing as an influx of residents to an area drives up property demand and therefore prices. Lot sizes in our sample decline as land values increase, consistent with Colwell (1990) and Kaltsas, Bosch, and McGuirk (2008). This may be because developers attempt to maximize cash flows by carving valuable land into smaller lots, thereby increasing population density. Buyers must then travel further away from the central business district to purchase larger lots. These lots, in turn, may be less valuable with regard to price per square foot of land. These results are consistent across our subsamples. However, the significance differs somewhat, as evidenced by the \( t \)-statistics. To gain a better understanding of the impact of Walk Scores on land values in walkable neighborhoods versus car-dependent neighborhoods, we re-estimated these models using the full sample and dummy variables indicating which Walk Score range each property falls in according to the categories discussed and listed previously in Exhibit 5. The results of this analysis are shown in Exhibit 9. All of the dummy
### Exhibit 9 | Land Value Regression Results

<table>
<thead>
<tr>
<th></th>
<th>Model 1</th>
<th>Model 2</th>
<th>Model 3</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Panel A: Full Sample</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Intercept</td>
<td>0.4387 (15.88***)</td>
<td>9.3051 (45.65***)</td>
<td>16.2998 (88.23***</td>
</tr>
<tr>
<td>lnWalkScore</td>
<td>0.2310 (25.91***)</td>
<td>0.0381 (4.30***)</td>
<td>0.0394 (5.42***)</td>
</tr>
<tr>
<td>lnTravelTime</td>
<td>-2.6126 (−43.80***</td>
<td>-2.7871 (−62.49***</td>
<td></td>
</tr>
<tr>
<td>lnLotSize</td>
<td>-0.6505 (−55.63***</td>
<td></td>
<td></td>
</tr>
<tr>
<td>PopGrowth</td>
<td>0.1287 (20.96***)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>lnStructAge</td>
<td>-0.1029 (−13.76***</td>
<td></td>
<td></td>
</tr>
<tr>
<td>F-statistic</td>
<td>671.28***</td>
<td>1,409.55***</td>
<td>1,995.86***</td>
</tr>
<tr>
<td>Adj. R²</td>
<td>0.1070</td>
<td>0.3346</td>
<td>0.6428</td>
</tr>
<tr>
<td>N</td>
<td>5,603</td>
<td>5,603</td>
<td>5,544</td>
</tr>
<tr>
<td><strong>Panel B: Low Walk Score Subsample (Walk Score Less than 24)</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Intercept</td>
<td>0.5700 (21.34***)</td>
<td>6.1885 (17.73***)</td>
<td>14.3428 (55.62***</td>
</tr>
<tr>
<td>lnWalkScore</td>
<td>0.1328 (11.37***)</td>
<td>0.0510 (4.16***)</td>
<td>0.0403 (4.94***)</td>
</tr>
<tr>
<td>lnTravelTime</td>
<td>-1.6707 (−16.14***</td>
<td>-2.0123 (−30.01***</td>
<td></td>
</tr>
<tr>
<td>lnLotSize</td>
<td>-0.7069 (−51.98***</td>
<td></td>
<td></td>
</tr>
<tr>
<td>PopGrowth</td>
<td>0.0960 (15.03***</td>
<td></td>
<td></td>
</tr>
<tr>
<td>lnStructAge</td>
<td>-0.1049 (−13.18***</td>
<td></td>
<td></td>
</tr>
<tr>
<td>F-statistic</td>
<td>129.29***</td>
<td>200.78***</td>
<td>1,056.78***</td>
</tr>
<tr>
<td>Adj. R²</td>
<td>0.0435</td>
<td>0.1232</td>
<td>0.6532</td>
</tr>
<tr>
<td>N</td>
<td>2,844</td>
<td>2,844</td>
<td>2,804</td>
</tr>
<tr>
<td><strong>Panel C: High Walk Score Subsample (Walk Score Greater than 23)</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Intercept</td>
<td>-3.2975 (−15.59***</td>
<td>8.6499 (24.65***</td>
<td>15.0670 (41.97***</td>
</tr>
<tr>
<td>lnWalkScore</td>
<td>1.2424 (22.06***)</td>
<td>0.4429 (8.91***)</td>
<td>0.3502 (8.22***)</td>
</tr>
<tr>
<td>lnTravelTime</td>
<td>-2.8868 (−38.92***</td>
<td>-3.0315 (−48.47***</td>
<td></td>
</tr>
<tr>
<td>lnLotSize</td>
<td>-0.5577 (−27.83***</td>
<td></td>
<td></td>
</tr>
<tr>
<td>PopGrowth</td>
<td>0.1706 (12.87***)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>lnStructAge</td>
<td>-0.1133 (−7.88***)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>F-statistic</td>
<td>486.71***</td>
<td>1,134.45***</td>
<td>885.66***</td>
</tr>
<tr>
<td>Adj. R²</td>
<td>0.1500</td>
<td>0.4511</td>
<td>0.6176</td>
</tr>
<tr>
<td>N</td>
<td>2,759</td>
<td>2,759</td>
<td>2,740</td>
</tr>
</tbody>
</table>

Notes: This table presents the results of OLS regressions to explain the variability of land values across properties in Jefferson County, Alabama. *t*-statistics are shown in parentheses. The dependent variable in each model is \( \ln(val_{psqft}) \) which is the log transformation of the land value per square foot.

* The difference between the mean values across the two samples is significant at the 10% level.
** The difference between the mean values across the two samples is significant at the 5% level.
*** The difference between the mean values across the two samples is significant at the 1% level.
Exhibit 10 | Land Value Alternative Subsample Results

<table>
<thead>
<tr>
<th></th>
<th>Model 1</th>
<th>Model 2</th>
<th>Model 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intercept</td>
<td>2.7935 (4.41*** )</td>
<td>10.0995 (16.97*** )</td>
<td>17.0015 (38.11*** )</td>
</tr>
<tr>
<td>InWalkScore</td>
<td>0.1390 (11.60*** )</td>
<td>0.0198 (1.78* )</td>
<td>0.0248 (2.91*** )</td>
</tr>
<tr>
<td>InTravelTime</td>
<td>-2.3852 ( -38.27*** )</td>
<td>-2.6137 ( -56.29*** )</td>
<td></td>
</tr>
<tr>
<td>InLotSize</td>
<td></td>
<td>-0.6394 ( -55.00*** )</td>
<td></td>
</tr>
<tr>
<td>PopGrowth</td>
<td></td>
<td>0.1257 (20.59*** )</td>
<td></td>
</tr>
<tr>
<td>InStructAge</td>
<td></td>
<td>-0.1074 ( -14.49*** )</td>
<td></td>
</tr>
<tr>
<td>VeryWalkable</td>
<td>-1.0570 ( -1.67** )</td>
<td>-0.9354 ( -1.66* )</td>
<td>-0.8684 ( -2.11** )</td>
</tr>
<tr>
<td>SomewhatWalkable</td>
<td>-1.5050 ( -2.38** )</td>
<td>-1.2155 ( -2.16** )</td>
<td>-1.1257 ( -2.75** )</td>
</tr>
<tr>
<td>SomewhatCarDependent</td>
<td>-2.1931 ( -3.47*** )</td>
<td>-1.5347 ( -2.73*** )</td>
<td>-1.3467 ( -3.29*** )</td>
</tr>
<tr>
<td>CarDependent</td>
<td>-2.2346 ( -3.54*** )</td>
<td>-1.5147 ( -2.69*** )</td>
<td>-1.3449 ( -3.28*** )</td>
</tr>
<tr>
<td>F-statistic</td>
<td>247.64***</td>
<td>504.38***</td>
<td>1,155.18***</td>
</tr>
<tr>
<td>Adj. R²</td>
<td>0.1804</td>
<td>0.3503</td>
<td>0.6521</td>
</tr>
<tr>
<td>N</td>
<td>5,603</td>
<td>5,603</td>
<td>5,544</td>
</tr>
</tbody>
</table>

Notes: This table reports the results of an alternative method for creating subsamples of the dataset based on Walk Score. Dummy variables (Paradise, VeryWalkable, SomewhatWalkable, SomewhatCarDependent, and CarDependent) are created in conjunction with the five categories of Walk Scores and included in the models. The dependent variable in all models is lnvalpsqft.

* The difference between the mean values across the two samples is significant at the 10% level.
** The difference between the mean values across the two samples is significant at the 5% level.
*** The difference between the mean values across the two samples is significant at the 1% level.

variables in these alternative specifications are negative and statistically significant. In addition, the significance of these variables increases with lower Walk Scores. This result suggests that in areas that are the most car dependent, Walk Score has the greatest impact on land values (Exhibit 10).

For robustness, we estimate our models using an alternative dependent variable. The results of this analysis are presented in Exhibit 11. Here, we substitute land value per square foot with land leverage, which is the ratio of land value to sale price. While we continue to see a positive, significant relation with Walk Score, population growth, one of our control variables, loses significance in our high Walk Score subsample. This result suggests that the degree to which total property values are driven by land values is not related to population growth in highly walkable neighborhoods. This may be because the highly walkable neighborhoods tend to be older, developed neighborhoods closer to the CBD and population growth tends to cause more development in the outer areas of a city, as has been the case in Birmingham, Alabama. In addition, the adjusted R-squared values are lower for the low Walk Score sample than the high Walk Score sample and the full sample. This may be because when examining only a sample of properties
### Exhibit 11 | Land Leverage Regression Results

<table>
<thead>
<tr>
<th></th>
<th>Model 1</th>
<th>Model 2</th>
<th>Model 3</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Panel A: Full Sample</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Intercept</td>
<td>$-1.6468 (-115.91^{***})$</td>
<td>$2.4558 (22.70^{***})$</td>
<td>$1.4559 (11.35^{***})$</td>
</tr>
<tr>
<td>lnWalkScore</td>
<td>$0.1193 (26.03^{***})$</td>
<td>$0.0301 (6.39^{**})$</td>
<td>$0.0286 (5.68^{**})$</td>
</tr>
<tr>
<td>lnTravelTime</td>
<td>$-1.2089 (-38.18^{***})$</td>
<td>$-1.2393 (-40.03^{***})$</td>
<td></td>
</tr>
<tr>
<td>lnLotSize</td>
<td></td>
<td></td>
<td>$0.0716 (13.79^{**})$</td>
</tr>
<tr>
<td>lnStructAge</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>F-statistic</td>
<td>677.35</td>
<td>1,155.69^{***}</td>
<td>596.05^{***}</td>
</tr>
<tr>
<td>Adj. R²</td>
<td>0.1079</td>
<td>0.2919</td>
<td>0.3493</td>
</tr>
<tr>
<td>N</td>
<td>5,603</td>
<td>5,603</td>
<td>5,544</td>
</tr>
</tbody>
</table>

|                  |                          |                          |                          |
| **Panel B: Low Walk Score Subsample (Walk Score Less than 24)** |                          |                          |                          |
| Intercept        | $-1.5869 (-123.52^{***})$ | $0.7986 (4.71^{**})$    | $0.2685 (1.41)$           |
| lnWalkScore      | $0.0713 (12.70^{***})$   | $0.0366 (6.14^{**})$    | $0.0238 (3.95^{**})$    |
| lnTravelTime     | $-0.7093 (-14.11^{**})$  | $-0.7368 (-14.88^{**})$  |                         |
| lnLotSize        |                          |                          | $0.0446 (4.44^{**})$   |
| lnStructAge      |                          |                          |                          |
| F-statistic      | 161.20^{***}             | 185.73^{***}             | 123.94^{***}            |
| Adj. R²          | 0.0537                   | 0.1150                   | 0.1799                   |
| N                | 2,844                    | 2,844                    | 2,804                    |

|                  |                          |                          |                          |
| **Panel C: High Walk Score Subsample (Walk Score Greater than 23)** |                          |                          |                          |
| Intercept        | $-3.1513 (-26.95^{**})$  | $2.6405 (12.82^{***})$  | $0.6406 (2.68^{**})$    |
| lnWalkScore      | $0.5289 (16.99^{***})$   | $0.1413 (4.85^{**})$    | $0.1914 (6.75^{**})$    |
| lnTravelTime     | $-1.3994 (-32.14^{***})$ | $-1.4032 (-33.74^{***})$ |                         |
| lnLotSize        |                          |                          | $0.1703 (12.78^{**})$   |
| lnStructAge      |                          |                          |                          |
| F-statistic      | 288.52^{***}             | 714.88^{***}             | 381.52^{***}            |
| Adj. R²          | 0.0947                   | 0.3411                   | 0.4099                   |
| N                | 2,759                    | 2,759                    | 2,740                    |

Notes: This table presents the results of OLS regressions to explain the variability of land values across properties in Jefferson County, Alabama. $t$-statistics are shown in parentheses. The dependent variable in each model is $\ln\text{LandLeverage}$, which is the log transformation of the ratio of land value to sale price.

* The difference between the mean values across the two samples is significant at the 10% level.
** The difference between the mean values across the two samples is significant at the 5% level.
*** The difference between the mean values across the two samples is significant at the 1% level.
## Exhibit 12 | Land Leverage Alternative Subsample Results

<table>
<thead>
<tr>
<th></th>
<th>Model 1</th>
<th>Model 2</th>
<th>Model 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intercept</td>
<td>-0.3959 (−1.20)</td>
<td>3.0076 (9.48***)</td>
<td>1.9379 (6.24***)</td>
</tr>
<tr>
<td>lnWalkScore</td>
<td>0.0727 (11.67***)</td>
<td>0.0172 (2.90***)</td>
<td>0.0129 (2.18***)</td>
</tr>
<tr>
<td>lnTravelTime</td>
<td>−1.1112 (−33.45***)</td>
<td>−1.1369 (−35.15***)</td>
<td></td>
</tr>
<tr>
<td>lnLotSize</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>PopGrowth</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>lnStructAge</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>VeryWalkable</td>
<td>−0.6248 (−1.90*)</td>
<td>−0.5682 (−1.89*)</td>
<td>−0.5737 (−2.00***)</td>
</tr>
<tr>
<td>SomewhatWalkable</td>
<td>−0.8623 (−2.63***)</td>
<td>−0.7275 (−2.43***)</td>
<td>−0.7132 (−2.50***)</td>
</tr>
<tr>
<td>SomewhatCarDependent</td>
<td>−1.1477 (−3.50***)</td>
<td>−0.8410 (−2.81***)</td>
<td>−0.8368 (−2.94***)</td>
</tr>
<tr>
<td>CarDependent</td>
<td>−1.1934 (−3.63***)</td>
<td>−0.8580 (−2.86***)</td>
<td>−0.8724 (−3.06***)</td>
</tr>
<tr>
<td>F-statistic</td>
<td>220.45***</td>
<td>406.95***</td>
<td>349.61***</td>
</tr>
<tr>
<td>R²</td>
<td>0.1638</td>
<td>0.3030</td>
<td>0.3614</td>
</tr>
<tr>
<td>N</td>
<td>5,603</td>
<td>5,603</td>
<td>5,544</td>
</tr>
</tbody>
</table>

**Notes:** This table reports the results of an alternative method for creating subsamples of the dataset based on Walk Score. Dummy variables (Paradise, VeryWalkable, SomewhatWalkable, SomewhatCarDependent, and CarDependent) are created in conjunction with the five categories of Walk Scores and included in the models. The dependent variable in all models is lnLandLeverage.

*The difference between the mean values across the two samples is significant at the 10% level.

**The difference between the mean values across the two samples is significant at the 5% level.

***The difference between the mean values across the two samples is significant at the 1% level.

located in car-dependent neighborhoods, factors such as school quality drive land values that are not incorporated in our models.

We estimate the same alternative models as in the land value specifications. The results of that analysis are presented in Exhibit 12. Similarly, we find evidence of a stronger significance in more car-dependent areas. That is, Exhibit 11 indicated that in strictly car-dependent areas, other factors besides walkability, travel time to work, lot size, population growth, and structural age influence land values. These results indicate that when comparing areas of varying levels of walkability, land values decline as car dependency strengthens.

To further examine differences between walkable neighborhoods and car-dependent neighborhoods, we estimate our regression model on a subsample of data from a walkable neighborhood and on a subsample of data from a car-dependent neighborhood. ZIP Code 35071 covers Gardendale, Alabama. This neighborhood has a very low population density at 264 people per square mile as of 2010 according to the U.S. Census. ZIP Code 35209 covers Homewood, Alabama, which is much more densely populated at 2,921 people per square mile as of 2010 according to the U.S. Census. Homewood is also one of the most walkable neighborhoods in Alabama.
### Exhibit 13 | ZIP Code Regression Results

<table>
<thead>
<tr>
<th>Panel A: Dependent Variable is $lnval_{psqft}$</th>
<th>ZIP Code 35071</th>
<th>ZIP Code 35209</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intercept</td>
<td>9.5311 (16.24***)</td>
<td>4.5892 (5.43***)</td>
</tr>
<tr>
<td>$lnWalkScore$</td>
<td>0.1533 (1.38)</td>
<td>0.5574 (4.08***)</td>
</tr>
<tr>
<td>PopGrowth</td>
<td>0.2118 (3.58***)</td>
<td>-0.0930 (-2.71***)</td>
</tr>
<tr>
<td>$LnLotSize$</td>
<td>-0.9544 (-29.25***)</td>
<td>-0.4458 (-6.30***)</td>
</tr>
<tr>
<td>F-statistic</td>
<td>329.05***</td>
<td>25.90***</td>
</tr>
<tr>
<td>$R^2$</td>
<td>0.9481</td>
<td>0.2691</td>
</tr>
<tr>
<td>$N$</td>
<td>58</td>
<td>215</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Panel B: Dependent Variable is $lnLandLeverage$</th>
<th>ZIP Code 35071</th>
<th>ZIP Code 35209</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intercept</td>
<td>-2.0841 (-3.12***)</td>
<td>-4.3020 (-7.77***)</td>
</tr>
<tr>
<td>$lnWalkScore$</td>
<td>0.3722 (2.94***)</td>
<td>0.1869 (2.09**)</td>
</tr>
<tr>
<td>PopGrowth</td>
<td>0.1249 (1.85*)</td>
<td>-0.0678 (-3.02**)</td>
</tr>
<tr>
<td>$LnLotSize$</td>
<td>-0.0638 (-1.72*)</td>
<td>0.3298 (7.12***)</td>
</tr>
<tr>
<td>F-statistic</td>
<td>6.97***</td>
<td>19.18***</td>
</tr>
<tr>
<td>$R^2$</td>
<td>0.2792</td>
<td>0.2143</td>
</tr>
<tr>
<td>$N$</td>
<td>58</td>
<td>215</td>
</tr>
</tbody>
</table>

Notes: This table presents the results of OLS regressions to explain the variability of land values across properties in specific ZIP Codes in Jefferson County, Alabama. In ZIP Code 35071, the mean Walk Score is 16.44; in ZIP Code 35209, the mean Walk Score is 59.64. t-statistics are shown in parentheses.

*The difference between the mean values across the two samples is significant at the 10% level.
**The difference between the mean values across the two samples is significant at the 5% level.
***The difference between the mean values across the two samples is significant at the 1% level.

We find that in Gardendale, walkability does not explain the variability in land values while walkability is positive and significant in our Homewood regression. Also, we find that population growth increases with land values and land leverage in walkable neighborhoods but decreases with land values and land leverage in walkable neighborhoods. We argue that this result is because changes in land value due to population growth tend not to affect walkable neighborhoods. This is because when there is a significant increase in population, new residents tend to gravitate toward outlying areas where more land and housing is available than the walkable communities near the CBD.

In our land leverage models, we find that lot size decreases but loses some of its explanatory power when walkability is low and increases with land leverage when walkability is high. We argue that this result is because lot sizes tend to be much smaller in walkable neighborhoods near the CBD where land is limited. Here, larger lots sell at a premium. These ZIP Code-level findings are somewhat
### Exhibit 14 | Two Stage Regression Results

<table>
<thead>
<tr>
<th></th>
<th>Dependent Variable = ( \ln \text{salesprice} )</th>
<th>Dependent Variable = Residuals</th>
<th>Dependent Variable = ( \ln \text{salesprice} )</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intercept</td>
<td>10.4670 (121.83***                      )</td>
<td>0.2035 (−14.44***              )</td>
<td>9.7868 (108.51***                      )</td>
</tr>
<tr>
<td>( \ln \text{StructAge} )</td>
<td>−0.1261 (−22.11***                      )</td>
<td>–0.1688 (−28.41***              )</td>
<td></td>
</tr>
<tr>
<td>( \ln \text{SqFt} )</td>
<td>0.1925 (21.00***                      )</td>
<td>0.2458 (26.48***              )</td>
<td></td>
</tr>
<tr>
<td>PopChange</td>
<td>0.0310 (6.37***                      )</td>
<td>0.0480 (10.01***              )</td>
<td></td>
</tr>
<tr>
<td>( \ln \text{WalkScore} )</td>
<td>0.0733 (16.14***                      )</td>
<td>0.1043 (19.44***              )</td>
<td></td>
</tr>
<tr>
<td>( F )-statistic</td>
<td>409.85***</td>
<td>260.64***</td>
<td>422.82***</td>
</tr>
<tr>
<td>( R^2 )</td>
<td>0.1816</td>
<td>0.0449</td>
<td>0.2339</td>
</tr>
<tr>
<td>( N )</td>
<td>5,544</td>
<td>5,544</td>
<td>5,544</td>
</tr>
</tbody>
</table>

Notes: This table presents the results of OLS regressions to explain the variability of housing prices in Jefferson County, Alabama. \( t \)-statistics are shown in parentheses.

* The difference between the mean values across the two samples is significant at the 10% level.
** The difference between the mean values across the two samples is significant at the 5% level.
*** The difference between the mean values across the two samples is significant at the 1% level.

Inconsistent with our initial results from the full sample and suggest that while walkability matters, the extent to which it has an impact on land value differs in walkable communities versus car-dependent ones (Exhibit 13).

Due to the possibility of biases in the assessor valuations of land values, we consider the impact of walkability using (full) sales prices that include structures and land. We estimate a two-stage regression where the first regression takes the following form:

\[
\text{Sales price} = f(\text{age, square footage, population change}) + \varepsilon. \quad (3)
\]

We hypothesize that these traditional housing value factors do not fully explain housing prices because they do not consider walkability. Therefore, the second stage of our regression takes the following form:

\[
\varepsilon = f(\text{walkability}). \quad (4)
\]

The results of our regressions are shown in Exhibit 14. These results indicate that market prices increase with home size and population change but decrease as the age of the home increases. Further, walkability does appear to explain some of the remaining variability in housing prices.
## Exhibit 15 | Tests for Structural Changes

<table>
<thead>
<tr>
<th></th>
<th>2005 Sales</th>
<th>2006 Sales</th>
<th>2007 Sales</th>
<th>2008 Sales</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intercept</td>
<td>9.8928 (52.06***)</td>
<td>9.8769 (59.79***)</td>
<td>9.7484 (52.20***)</td>
<td>9.7230 (35.35***)</td>
</tr>
<tr>
<td>lnWalkScore</td>
<td>0.1174 (10.54***)</td>
<td>0.0906 (9.04***)</td>
<td>0.1044 (9.62***)</td>
<td>0.1323 (7.66*** )</td>
</tr>
<tr>
<td>lnStructAge</td>
<td>−0.1726 (−13.46***)</td>
<td>−0.1687 (−15.29***)</td>
<td>−0.1860 (−15.42***)</td>
<td>−0.1938 (−9.40***)</td>
</tr>
<tr>
<td>lnSqFt</td>
<td>0.2314 (11.79***)</td>
<td>0.2389 (14.04***)</td>
<td>0.2618 (13.58***)</td>
<td>0.2655 (9.38*** )</td>
</tr>
<tr>
<td>PopGrowth</td>
<td>0.0340 (3.36***)</td>
<td>0.0565 (6.46*** )</td>
<td>0.0438 (4.38*** )</td>
<td>0.0420 (2.80*** )</td>
</tr>
<tr>
<td>F-statistic</td>
<td>85.24***</td>
<td>134.66***</td>
<td>107.88***</td>
<td>42.25***</td>
</tr>
<tr>
<td>$R^2$</td>
<td>0.2105</td>
<td>0.2784</td>
<td>0.2515</td>
<td>0.2281</td>
</tr>
<tr>
<td>N</td>
<td>1,284</td>
<td>1,401</td>
<td>1,289</td>
<td>577</td>
</tr>
</tbody>
</table>

**Notes:** This table presents the results for individual regressions by transaction year. *t*-statistics are shown in parentheses. The dependent variable in each model is $\lnsalesprice$.

* The difference between the mean values across the two samples is significant at the 10% level.
** The difference between the mean values across the two samples is significant at the 5% level.
*** The difference between the mean values across the two samples is significant at the 1% level.
After establishing a relationship between housing prices and walkability, that is, that housing prices marginally increase with walkability, we aim to determine if this relationship is constant over time. Recalling that our data covers the five-year period from 2004 to 2008, we estimate our model separately for each year and then conduct a Chow test to test for structural changes. That is, we test for parameter drift. The results of the regressions and the Chow test ($F = 5.82$) indicate that the coefficients do change over time. This suggests that it is possible that the degree to which walkability influences housing prices changes over time. Exhibit 15 presents the results.

These regressions show that the relationship between walkability and housing prices is fairly stable over the sample period.

**Conclusion**

We examine land values and Walk Scores for a sample of properties in Jefferson County, Alabama. Our aim in this analysis was to determine whether or to what extent, the benefits of walkable neighborhoods are reflected in land values. We find evidence that land values increase with walkability as measured by Walk Scores. The relation appears to be strongest in the most walkable neighborhoods, where Walk Score is above average for the MSA. In our data, these neighborhoods are found closer to the central business district (CBD), in older communities, and around universities. We argue that neighborhoods that are farther away from the CBD are not expected to be walkable and thus walkability is not a factor in land value. When we examine the degree to which property values are driven by land values, we again find that walkability matters. That is, land leverage also increases with walkability. We find similar results when using sales prices as opposed to land values.

The policy implications of these findings relate to initiatives to promote mixed-use developments and sustainable communities. Neighborhoods that include a mixture of retail/commercial and residential properties potentially provide features and benefits that promote the general well-being of the residents. These findings suggest that walkability adds value from a financial perspective, which may be attractive to developers and policymakers considering investment in mixed-use developments. Zoning that encourages mixed-use land developments will certainly result in higher land values and lower carbon footprints for such communities. Inner city developments in established older neighborhoods with better access to multiple amenities and work are more of a challenge to developers because of the parcel accumulation challenges and the lack of scale but certainly offer the potential for high walkability scores and positive incremental land value. Municipalities seeking higher property tax revenues should encourage such inner city mixed-use development by easing regulatory hurdles or speeding up the permitting process.
Endnotes

1 We define consumption amenities according to Weissbourd, Bodoni, and He (2009) as related to the range of consumption options available to neighborhood residents, such as retail services, museums, dining, etc.

2 There are currently 114 cities with Transit Scores. These are cities where the public transit agencies make their data available in an open format.

3 This time period was selected because it was the most recent data available at the time of the study.

4 We do not have data regarding whether or not the properties are attached or detached.

5 For specific information about the Walk Score Algorithm methodology, see www.walkscore.com/rankings/ranking-methodology.shtml.

6 In our analysis, population density was not consistently, positively correlated with land values as in the results shown here. We hypothesize that this lack of consistency with the Walk Score results indicates that Walk Score measures more than proximity despite the fact that Walk Scores are generally higher in more heavily populated areas. The full results of this analysis are not reported in the paper but are available upon request.

References


Stephanie Yates Rauterkus, University of Alabama at Birmingham, Birmingham, AL 35294-4460 or Srauter@uab.edu.

Norman G. Miller, University of San Diego, San Diego, CA 92110 or nmiller@sandiego.edu.
The Political Economy of Green Industrial Warehouses

Authors
David M. Harrison and Michael J. Seiler

Abstract
Empirical research into the effects of environmental certification on commercial real estate properties routinely finds evidence of both significant rental rate and occupancy rate premiums accruing to owners of LEED and/or ENERGY STAR certified properties. Interestingly, however, the underlying determinants and drivers of such premia remain largely unexplored. This investigation expands our understanding of environmental certification and valuation effects by examining a previously unexplored property type: industrial warehouse facilities. Using a sample of 20,172 industrial properties, we find “green” certification plays an important, but contingent, role within this sector. Specifically, “green” warehouses in politically conservative areas rent at a significant discount relative to their non-certified counterparts, while similar properties in politically liberal areas rent at a significant premium. These results provide further evidence on the importance of political ideology to real estate decision-making, and offer the first insight into the importance of environmental certification within the industrial warehouse sector.

Do investments in environmental certification create value for owners and managers of commercial real estate properties? Over the past decade, this and related questions have garnered increased attention from practitioners, academicians, and public policy makers, with preliminary empirical evidence tending to support the view that environmental responsibility is viewed favorably by the marketplace. From a practical perspective, the continuing evolution of new technologies and industrial processes have allowed firms to more efficiently measure, monitor, and mitigate their environmental impact, while the development and increased visibility of independent, third-party environmental performance and assessment benchmarks such as Leadership in Energy and Environmental Design (LEED) certification and the ENERGY STAR designation provide firms with a transparent and tangible certification of best practices, which they can use to demonstrate the efficacy of their commitment to such environmental initiatives to their key interested stakeholders.\(^1\)

While concerned citizens, government regulators, and political activists may well regard environmental stewardship as a worthy goal regardless of the direct pecuniary implications for the firm’s bottom-line, profit-maximizing real estate professionals may not inherently share these same goals. For example, Izzo (2000) examines the cognitive moral development of realtors and finds only one in four believe they should act to promote the general welfare rather than their own
self-interest. Similarly, Velthouse and Kandogan (2006) find finance, insurance, and real estate professionals possess a relatively low regard for aggregate ethics, with the industry ranking eighth out of the nine sectors studied. As such, for environmental certification initiatives to be truly sustainable in a competitive, capitalistic marketplace they likely must provide positive financial returns (or at least not impose prohibitive costs). Emerging empirical evidence suggests this may well be the case, and if this trend continues, suggests profit-maximizing managers would be well served to strongly consider the pursuit of such environmental certification. On the other hand, while the emerging evidence on the financial returns to investments in environmental stewardship appear promising, the literature has yet to fully identify and explore the direct mechanisms through which such green premia are derived. Are the gains primarily from improved energy efficiency, enhanced workplace productivity, or strengthened relationships with key constituents such as consumers, suppliers, and/or governmental authorities? Are these benefits uniform across space and asset markets, or do they vary with the economic vitality, visibility, and political ideology of individual market segments? Clearly, the answers to these questions offer direct insight into the long-run vitality and sustainability of environmental certification initiatives. As such, this investigation will examine the distributional and valuation consequences of environmental certification on a unique set of industrial warehouse facilities. Specifically, we will explore whether economics or ideology drive rental rates and capacity utilization at such facilities. To the best of our knowledge, this is the first direct study of the economic effects of political ideology on environmental certification and the valuation effects of industrial warehouse facilities.

The remainder of this paper is organized as follows. Section two reviews the limited existing literature on the economic consequences of green building certification. Section three motivates and describes our key focal hypotheses, describes our sample data, and details the methodological approaches we employ throughout our empirical tests. The results are presented in section four, while the final section summarizes our results, discusses their implications, and concludes.

Previous Literature

The academic literature on green building, environmental certification and design, and their related valuation consequences is expanding rapidly. This growth is perhaps most easily exemplified by the emergence of a variety of new specialty journals dedicated to the examination and discussion of such issues. For example, the Journal of Green Building began publication in 2006, followed in 2009 by the Journal of Sustainable Real Estate, the Green Building Journal in 2010, and the Canadian Journal of Green Building and Design in 2011. Together, these outlets, as well as their more mainstream economics, finance, and real estate counterparts, have begun the long process of enhancing our understanding of the dynamics of this market segment. In the discussion below, we highlight the key findings from this literature that inform the valuation of environmentally-certified commercial properties.
Benefits of Sustainable Design

One of the most obvious sources of value creation in “green” building construction and design derives from enhanced energy efficiency. For example, the United States General Services Administration (GSA, 2009) reports the implementation of simple energy conservation strategies could save the federal government nearly $60 million dollars per year. With respect to formal environmental certification platforms, Watson (2009) reports LEED certification is associated with a 25% reduction in energy consumption, Choi (2009) finds LEED certified operations reduce building energy consumption costs by roughly 30%, and Goering (2009) estimates energy cost savings of 20%–35% for typical green building projects. These savings have also been shown to influence observable market outcomes, as Laquatra (1986), Dinan and Miranowski (1989), and Brounen and Kok (2011) all demonstrate energy efficiency is capitalized into real estate transaction prices. Clearly, enhanced energy efficiency is a major potential benefit to the adoption of green construction and design.

Environmentally-friendly facilities may also offer strategic benefits not directly related to energy consumption. For example, Miller, Pogue, Gough, and Davis (2009) report non-trivial gains in employee productivity accruing to firms operating in green buildings. Specifically, they report workers in such facilities take nearly three fewer sick days per year, which translates into a direct productivity advantage in excess of 1%. Additionally, environmentally-certified facilities may allow firms to more effectively brand and market their operations to an environmentally conscious set of customers and other stakeholders. Supporting this contention, Vyas and Cannon (2008) find green building initiatives are generally driven by ideology, marketing, and/or providence rather than explicit profit considerations. Finally, regulatory considerations suggest green buildings, and the firms they house, may be strategically positioned to capitalize on a commercial real estate marketplace that is being forced to become more environmentally conscious. At the local level, numerous municipalities (e.g., Austin, San Francisco, etc.) have adopted ordinances mandating increased environmental efficiency, while at the federal level Executive Order #13423 mandates annual energy consumption reductions by federal agencies of 3% per year until 2015.3 Failure to comply with these guidelines may significantly delay, or even derail, the permitting process and thus impair the firm’s or agency’s ability to do business. Firms proactively adopting “green” building design may be better positioned to capitalize on opportunities created, or challenges presented, by this constantly evolving regulatory process. These indirect benefits may be particularly important for the industrial warehouse sector, as the branding related benefits of environmental certification may well be difficult to capture for property types with limited direct customer interactions.

Concerns Regarding Sustainable Design

While “green” building and design offers the above potential benefits, it also faces a number of barriers to its continued growth and adoption. Foremost among these concerns are cost perceptions. While Davis Langdon (2007) and Miller (2010)
argue that the costs associated with LEED certification are trivial, most developers do not appear to share this opinion. Specifically, survey results by Jackson (2009) find the vast majority of developers believe “green” initiatives increase construction costs more than 5%, while more than two in five developers believe such initiatives increase costs more than 10%. Similarly, Addae-Dapaah, Hiang, and Shi (2009) find building users in Singapore consistently cite increased costs as a major deterrent to leasing green buildings. Supporting these industry perceptions, Reed, Bilos, Wilkinson, and Schulte (2009) and Watson (2009) note the certification process is costly, time consuming, and fraught with uncertainty. Specifically, LEED certification costs frequently exceed $100,000, with the typical process taking roughly two years to complete and characterized by an attrition rate of 25%–30%.

Additional obstacles confronting the growth of the green building sector include concerns related to maintenance and monitoring, litigation, performance reliability, and transparency. First, with respect to maintenance and monitoring, D’Arelli (2008) observes that most environmental certification designations require ongoing compliance with performance standards to retain certification. This inherently increases long-run monitoring costs, but also creates potential agency conflicts between building owners and users with differing utility from environmental certification. Such conflicts may well increase costs, or limit flexibility, for both existing and future users of certified space. Extending this line of reasoning, Shimizu (2010) and Yoshida and Sugiura (2010) argue that green buildings face higher expected maintenance expenses, as repair costs are generally proportional to a structure’s initial investment outlay. As “green” buildings are more expensive to construct, they will likely be more expensive to maintain as well. On a related note, the reliability of green development materials, processes, and products is also an open question for debate. Addae-Dapaah, Hiang, and Shi (2009) report three-quarters of building users in Singapore find uncertain reliability a critical roadblock to the adoption of green initiatives within the building sector, while more than 80% of their survey respondents expressed a “lack of faith” in the long-run effectiveness of such projects. Similarly, Jones and Vyas (2008) present case study evidence from Florida suggesting energy savings from green initiatives may well decay at substantially faster rates than generally assumed in typical valuation models. To the extent such rapid decay is generalizable to the broader green building marketplace, the promised benefits of green building initiatives may not be fully realizable.

Turning to liability issues, a number of authors note the increased litigation risk and uncertainty surrounding green building projects. For example, what legal exposure is created by aggressive brokers and leasing agents who promise tenants green amenities that fail to materialize? What recourse do building owners and managers have against architects, engineers, and/or developers who fail to attain the desired level of certification or energy efficiency on a given structure? In practice, these questions remain largely unresolved. Finally, transparency of certification may be differentially important across property type sectors or geographic markets. As noted above, Vyas and Cannon (2008) argue that many sustainability initiatives are driven by marketing and branding. Outside of the
direct, tangible benefits of reduced energy consumption, enhanced employee productivity, or strategic risk reduction, transparent and visible certification offers the potential for enhanced marketing through a “plaque-in-the-lobby” effect. Interestingly, most previous studies of the valuation effects of environmental certification have focused on commercial office buildings. While these facilities serve as a useful laboratory for answering many questions, the interactive nature of such space leads to a potential confounding attribution of the root cause of observed rental premiums. Are higher rents on certified properties due to enhanced energy efficiency, branding effects, or something else entirely? Furthermore, if such premia are based (even in part) on reputational capital effects, are the results generalizable to alternative property types, such as warehouse facilities, where space branding is of more limited import. With respect to the current investigation, if green rental premiums are attributable to the branding of space, why would industrial warehouse facilities (which typically exhibit only limited public interaction) benefit? Alternatively, if energy efficiency drives green premia, such effects may well be more pronounced within the industrial sector. We explore these issues in more depth below.

Does the Market Value Environmental Certification?

While the literature is expanding rapidly, only a limited number of peer-reviewed publications have directly examined the rental and vacancy rate implications of environmental certification. Early studies in this area have tended to support the notion that the market values environmental certification positively. One of the first such studies was Miller, Spivey, and Florance (2008). Using a sample of CoStar listed office buildings, they document both significant rental and occupancy rate premiums for environmentally-certified structures. Lease rates were 5%–10% higher for certified structures than for their control sample (within their multivariate context), while occupancy rates were 3%–4% higher. Wiley, Benefield, and Johnson (2010) offer a similar analysis using a national sample of Class A office space, and document substantially larger effects. They find an ENERGY STAR rental premium of 7%–9%, a LEED rental premium of 15%–17%, and positive occupancy rate differentials of 10%–11% and 16%–18% for ENERGY STAR and LEED certified structures, respectively, relative to their non-certified counterparts. Next, Pivo and Fisher (2010) report a 5.2% increase in rents and 1.3% increase in occupancy rates for responsible property investments, while internationally Yoshida and Shimizu (2010) find green condos in Japan command a 5% price premium and Zheng, Wu, Kahn, and Deng (2011) report a 9.1% price premium for green projects in Beijing. Continuing, Fuerst and McAllister (2011) examine a sample of 1,031 LEED (197) and/or ENERGY STAR (834) certified properties along with over 15,000 control units. They document 4%–5% lease rate premiums, and 25%–26% sales price premiums, for environmentally-certified structures relative to their control group. Finally, in perhaps the most detailed and technical analysis of green premiums to date, Eichholtz, Kok, and Quigley (2010) find environmentally-certified buildings enjoy a 3% rental premium over non-certified structures in terms of nominal rent, a 6% premium in effective rents, and a 16% sales price premium. Furthermore, the authors obtain detailed energy consumption usage for a subset of the buildings in their sample, and are able to
document a direct linkage between the observed green premium and the energy efficiency of the structure.

While these seminal works all appear to document a positive relationship between environmental certification and market outcomes, a handful of emerging investigations offer somewhat contradictory results. For example, while Deng, Li, and Quigley (2010) document an average green premium of 14% accruing to Green Mark certified properties in Singapore. This result is heavily clustered and concentrated within the higher grades of gold and platinum certification. Basic Green Mark certification does not appear to provide significant valuation effects. Similarly, while Yoshida and Sugiura (2010) report green condominiums in Tokyo trade, on average, at a premium, they argue this result is entirely attributable to other dimensions of unit quality. After controlling for age and unit quality, they find green units under the Tokyo Green Building Program (TGBP) trade at significant discounts of 6%–11%. Consistent with our discussion above, the authors attribute this finding to an expected increase in future maintenance costs for green structures relative to their non-certified peers. Finally, Jaffee, Stanton, and Wallace (2010) conclude ENERGY STAR labeling does not influence real estate valuation after asset pricing models have been properly specified. Together, these results suggest further inquiry into the valuation consequences of environmental certification is clearly needed to identify the causal linkages between environmental amenities and property valuation.

**Data and Methodology**

Although the preliminary evidence from the literature on the valuation of environmental certification for commercial real estate properties generally documents positive returns, surprisingly little work has been published that attempts to explain either cross-sectional or inter-temporal variation in such green premiums. We note two important findings from the published studies: economic geography and political ideology appear to matter. With respect to geography, Dermisi (2009) observes that the influence of LEED ratings on both assessed and market value is contingent upon the level of geographic aggregation employed throughout the analysis. Furthermore, Jaffee, Stanton, and Wallace (2010) document substantial geographic clustering in the location of ENERGY STAR labeled buildings. These authors also note that both energy prices and weather expectations, which influence the anticipated cost of energy consumption, materially influence observable market rents and are location contingent. Thus, economic geography considerations appear to materially influence environmental certification processes, decisions, and valuation.

Turning to political ideology, a cursory examination of green building initiatives to date suggests such practices are neither controversial nor ideologically motivated. For example, May and Koski (2007) report that of the 15 states that have adopted regulations mandating public facilities comply with environmental building standards, eight were governed by democrats and seven were governed by republicans at the time the regulations were adopted. Furthermore, these initiatives appear to have garnered wide-spread, bi-partisan support, with six of
the twelve legislative bodies voting on such measures passing the mandates unanimously. The narrowest margin of victory they report occurred in the Washington state senate, where a two-thirds (32–16) majority favored environmental standards being applied to the construction and major renovation of state-funded buildings. In total, state legislative bodies have voted overwhelmingly (800–47) in favor of the enactment of such initiatives.

On the other hand, a closer examination of the political dimensions of environmental building certifications and regulations raises important questions. For example, if such initiatives truly enjoy overwhelming bi-partisan support, why have only 15 states enacted such requirements? Similarly, while seven of those 15 states did have republican governors at the time of adoption, only two of those states voted republican in the 2008 U.S. presidential election. Additionally, we note the findings of two recent papers examining the impact of political ideology on environmental building certification outcomes. First, Brounen and Kok (2011) find that the choice of adopting green energy labels in Holland, known as Energy Performance Certificates (EPCs), may well be driven by ideological beliefs, as adoption rates dropped along with public sentiment regarding green initiatives, and rose in direct relation to the number of “green” party voters in the local region during the 2006 national elections. Similarly, Harrison and Seiler (2011) examine environmental certification premiums in U.S. office markets and find green premiums to be relatively modest at less than 2% in politically conservative, “red,” or republican counties, while similar premiums were nearly 6% in politically liberal, “blue,” or democratic counties. As such, we posit that geographic and ideological considerations may well influence the valuation of green warehouse facilities, and explicitly examine these possibilities in the empirical work that follows.

The empirical analysis proceeds along two dimensions. First, using data from CoStar on industrial warehouse facility rents and occupancy rates, we extend previous analyses of environmental certification premiums to the industrial warehouse sector. Second, after evaluating the existence and significance of green premiums within this sector, we explore whether such premiums vary systematically with the political ideology of the local market area.

The empirical specifications require information along five key dimensions. First, information on individual property rents and occupancy rates—the core dependent variables employed throughout our investigation—were obtained from CoStar. Second, related information regarding each warehouse facility’s physical attributes and environmental certification status were also obtained from CoStar. Specifically, we identify the typical floor size of each site, whether each facility has a crane, one or more loading docks, drive-in capabilities, power and sewer facilities, onsite access to railroad transportation, and the facility’s parking ratio, which is defined as the number of parking spaces per 1,000 ft2 of gross leasable area. Ex ante, we hypothesize that average size and the presence of cranes, docks, drive-ins, power, sewer, and rail access all proxy for the intensity of onsite industrial activity, and thus should be inversely related to market rents. Similarly, we hypothesize increased parking ratios are inversely related to the intensity of onsite industrial activity, or alternatively stated proxy for light industrial usage at
the facility. As such, we anticipate parking ratios to be directly related to observed market rents for the warehouse facilities within the sample.

Third, we next employ an array of metrics to control for the socioeconomic and demographic environment in which each facility is located. Specifically, following Jaffee, Stanton, and Wallace’s (2010) finding that weather influences energy consumption and thus market rents, we collect information from the National Climactic Data Center (NCDC) on both the average heating degree days, and cooling degree days, for each warehouse location using a 65°F basis. We also obtain information from the U.S. Census Bureau on the racial diversity, educational attainment, median household income, and population density for each facility’s home county. We offer no prediction as to the expected coefficient on the racial diversity metric, but anticipate rents to increase with population, density, and the fraction of high school graduates in the county (as semi-skilled labor becomes increasingly available), decrease with the fraction of college graduates in the county (as the market place moves from “blue collar” to “white collar” employment industrial facilities may become less desirable), and increase along with household incomes (as the ability to pay increases). Similarly, we obtain county-level estimates of unemployment rates from the Bureau of Labor Statistics (BLS), and again anticipate a negative relationship between market rents and this inverse economic vitality index.

Fourth, our focal political ideology metrics are based upon voting results from the 2008 U.S. presidential election. Specifically, using county-level vote counts from the Federal Elections Commission (FEC), we first define the percent Democratic vote as the number of votes received by Barack Obama in the county divided by the total number of votes for president cast in the county. Second, we define a “blue” or democratic county as any county in which Barack Obama received more votes than his republican challenger (John McCain). Given the current ideological composition of the two major parties in the United States, we anticipate that both our Blue County and percent Democratic vote share metrics will be positively related to the environmental consciousness of the local citizenry, and thus positively associated with observable green premiums. Finally, as a robustness check, we examine whether our results are dependent upon the regulatory environment faced by the firm. As such, we control for the commercial electric rate in each jurisdiction, as well as for the existence of state-sponsored tax credits, grant programs, or property tax incentives specifically dedicated to encourage environmentally-conscious development. Information on electric rates was obtained from the U.S. Energy Information Association (EIA), while information on state and local government-sponsored environmental initiatives was obtained from the North Carolina Solar Center’s Database of State Incentives for Renewables & Efficiency (DSIRE). Ex ante, we expect both higher energy costs and the existence of government provided financial incentives to increase observable green premiums.

Empirical Analysis

Exhibit 1 provides descriptive statistics for the key variables. We find that for the facility attributes, industrial warehouse rents averaged $6.36 per square foot, while
## Exhibit 1 | Descriptive Statistics

<table>
<thead>
<tr>
<th>Variable</th>
<th>Mean</th>
<th>Std. Dev.</th>
<th>Min.</th>
<th>Max.</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Dependent Variables</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rental Rate</td>
<td>6.358</td>
<td>3.743</td>
<td>0.18</td>
<td>144</td>
</tr>
<tr>
<td>Occupancy Rate</td>
<td>56.069</td>
<td>40.175</td>
<td>0</td>
<td>100</td>
</tr>
<tr>
<td><strong>Facility Attributes</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Floor Size (ft²)</td>
<td>52,767</td>
<td>92,750</td>
<td>1</td>
<td>4,000,000</td>
</tr>
<tr>
<td>Have Cranes (yes = 1)</td>
<td>0.033</td>
<td>0.180</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Have Docks (yes = 1)</td>
<td>0.520</td>
<td>0.500</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Have Drive-ins (yes = 1)</td>
<td>0.828</td>
<td>0.377</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Have Power (yes = 1)</td>
<td>0.233</td>
<td>0.423</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Have Sewer (yes = 1)</td>
<td>0.169</td>
<td>0.375</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Rail Access (yes = 1)</td>
<td>0.361</td>
<td>0.480</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Parking Ratio</td>
<td>1.875</td>
<td>0.902</td>
<td>0.02</td>
<td>10</td>
</tr>
<tr>
<td><strong>Socio-Economic &amp; Demographic Environment</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Heating Degree Days</td>
<td>4,509</td>
<td>2,018</td>
<td>475</td>
<td>9,030</td>
</tr>
<tr>
<td>Cooling Degree Days</td>
<td>1,283</td>
<td>769</td>
<td>195</td>
<td>3,158</td>
</tr>
<tr>
<td>Population (millions)</td>
<td>2.171</td>
<td>2.479</td>
<td>0.004</td>
<td>9.862</td>
</tr>
<tr>
<td>% Caucasian</td>
<td>76.04</td>
<td>12.59</td>
<td>25.40</td>
<td>98.40</td>
</tr>
<tr>
<td>% High School Grads</td>
<td>81.16</td>
<td>6.01</td>
<td>59.00</td>
<td>94.90</td>
</tr>
<tr>
<td>% College Grads</td>
<td>27.03</td>
<td>7.05</td>
<td>8.50</td>
<td>52.90</td>
</tr>
<tr>
<td>Unemployment Rate</td>
<td>4.72</td>
<td>1.25</td>
<td>2.40</td>
<td>18.0</td>
</tr>
<tr>
<td>Median HH Income ($,000s)</td>
<td>53.915</td>
<td>8.818</td>
<td>32.660</td>
<td>100.744</td>
</tr>
<tr>
<td>Density (000's of people / m²)</td>
<td>1.516</td>
<td>2.357</td>
<td>0.006</td>
<td>31.730</td>
</tr>
<tr>
<td><strong>Regulatory Incentives for “Green” Projects</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Electric Rates (per kWh)</td>
<td>11.03</td>
<td>3.38</td>
<td>6.76</td>
<td>26.31</td>
</tr>
<tr>
<td>Tax Credits (yes = 1)</td>
<td>0.310</td>
<td>0.462</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Grant Programs (yes = 1)</td>
<td>0.481</td>
<td>0.500</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Property Tax Incentives (yes = 1)</td>
<td>0.818</td>
<td>0.386</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td><strong>Political Economy of Environmental Certification</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>“Green” Certified (yes = 1)</td>
<td>0.003</td>
<td>0.055</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Percent Democratic</td>
<td>57.85</td>
<td>11.29</td>
<td>21.58</td>
<td>88.95</td>
</tr>
<tr>
<td>“Blue” County (yes = 1)</td>
<td>0.757</td>
<td>0.429</td>
<td>0</td>
<td>1</td>
</tr>
</tbody>
</table>

Notes: This table presents descriptive statistics on the average rental rates, occupancy rates, and market share for environmentally certified industrial warehouse facilities. Information on the corresponding facility attributes, socioeconomic and demographic environment, regulatory incentives for green projects, and political ideology of the local market area are also reported.

Utilization rates averaged 56.07%. Relatively few (only 674 or 3.3%) of the warehouses have cranes, slightly more than 1 in 3 (36.1%) have direct rail access, and just over half (52.0%) have onsite loading docks. The typical facility has slightly under 2 parking spaces (1.88) per 1,000 square feet of gross leasable area. For the socioeconomic and demographic characteristics, the average county has more heating than air conditioning needs, a population in excess of 2,000,000 people, and is roughly three-quarters (76.0%) white. Over 80% of county residents...
have completed a high school education, while 27% have completed college. Sample counties were characterized by 2007 estimated median household incomes of nearly $54,000, and relatively low unemployment rates of 4.72%, though both numbers exhibit substantial variation around their reported means. Politically, Barack Obama received a majority of the vote share in counties that were home to 75.7% of our sample observations. Similarly, the typical home county for a warehouse facility gave 57.9% of their votes to Barack Obama. This number is five full percentage points higher than the 52.9% of the popular vote he actually received, and underscores the overrepresentation of urban areas within the sample. Finally, with respect to direct financial incentives to pursue green building initiatives, commercial electric rates averaged 11.03 cents per kilowatt hour across sample counties, while 31%, 48%, and 82% of sample counties, respectively, were located in jurisdictions with tax credits, grant programs, or property tax incentives available to help defray the costs of green building initiatives.

Next, we begin our analysis of the importance of political ideology on observable market outcomes by bifurcating the sample across red and blue county definitions. Exhibit 2 provides sample means for all key variables of interest segmented by republican leaning “red” counties and democratic leaning “blue” counties. Of note, both rents and capacity utilization rates appear to be substantively higher in “blue” counties than in “red” counties. Warehouses in “blue” counties are marginally more likely to have cranes, loading docks, and access to both power and sewer facilities on site, while warehouses in “red” counties are more likely to have direct rail access and higher parking ratios. “Blue” counties tend to be characterized by increased heating degree days, while “red” counties tend to be characterized by increased cooling degree days. Total degree days, and hence expected energy consumption, appear similar across “red” and “blue” counties. Not surprisingly, “blue” counties tend to be more heavily populated, denser, and more ethnically diverse than their “red” counterparts. Somewhat surprisingly, democratic leaning counties are characterized by lower high school graduation rates, but higher college graduation rates than their republican leaning counterparts.

Turning to our environmental certification metrics, industrial warehouse facilities in “blue” counties are 2.5 times (0.35% vs. 0.14%) more likely to be ENERGY STAR and/or LEED certified than comparable facilities located in “red” counties. This finding is entirely consistent with the notion that political ideology materially influences environmental decision making.

Finally, examining the regulatory environment attributes reveals further differences. Specifically, electric rates appear to be lower in “red” counties, while these same jurisdictions are also more likely to have tax credits available to help offset the cost of green development. On the other hand, “blue” counties are characterized by an increased likelihood of both grant programs and property tax incentives available to incentivize green initiatives. The results in Exhibit 2 suggest industrial property market outcomes and attributes vary markedly with the political ideology of the local market area.

Exhibit 3 presents the correlation coefficients between each pair of variables. Most of the explanatory variables exhibit relatively low correlations; only six variable
**Exhibit 2 | Descriptive Statistics by “Blue” County versus “Red” County**

<table>
<thead>
<tr>
<th>Variable</th>
<th>“Blue” County Mean</th>
<th>“Red” County Mean</th>
<th>T-stat of Difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rental Rate (per ft²)</td>
<td>6.569</td>
<td>5.699</td>
<td>14.23***</td>
</tr>
<tr>
<td>Occupancy Rate (%)</td>
<td>57.03</td>
<td>53.06</td>
<td>6.03***</td>
</tr>
<tr>
<td>Dependent Variables:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Floor Size</td>
<td>52,796</td>
<td>52,675</td>
<td>0.08</td>
</tr>
<tr>
<td>Have Cranes (yes = 1)</td>
<td>0.036</td>
<td>0.024</td>
<td>4.00***</td>
</tr>
<tr>
<td>Have Docks (yes = 1)</td>
<td>0.535</td>
<td>0.474</td>
<td>7.41***</td>
</tr>
<tr>
<td>Have Drive-ins (yes = 1)</td>
<td>0.830</td>
<td>0.821</td>
<td>1.44</td>
</tr>
<tr>
<td>Have Power (yes = 1)</td>
<td>0.243</td>
<td>0.203</td>
<td>5.81***</td>
</tr>
<tr>
<td>Have Sewer (yes = 1)</td>
<td>0.180</td>
<td>0.136</td>
<td>7.19***</td>
</tr>
<tr>
<td>Rail Access (yes = 1)</td>
<td>0.351</td>
<td>0.393</td>
<td>−5.37***</td>
</tr>
<tr>
<td>Parking Ratio</td>
<td>1.858</td>
<td>1.928</td>
<td>−4.70***</td>
</tr>
<tr>
<td>Socio-Economic &amp; Demographic Environment:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Heating Degree Days</td>
<td>4,662</td>
<td>4,036</td>
<td>19.06***</td>
</tr>
<tr>
<td>Cooling Degree Days</td>
<td>1,160</td>
<td>1,664</td>
<td>−41.57***</td>
</tr>
<tr>
<td>Population (000,000’s)</td>
<td>2.331</td>
<td>1.670</td>
<td>16.34***</td>
</tr>
<tr>
<td>% Caucasian</td>
<td>73.37</td>
<td>84.35</td>
<td>−57.25***</td>
</tr>
<tr>
<td>% High School Grads</td>
<td>80.74</td>
<td>82.46</td>
<td>−17.62***</td>
</tr>
<tr>
<td>% College Grads</td>
<td>27.75</td>
<td>24.78</td>
<td>26.10***</td>
</tr>
<tr>
<td>Unemployment Rate</td>
<td>4.87</td>
<td>4.26</td>
<td>30.21***</td>
</tr>
<tr>
<td>Median HH Income ($,000)</td>
<td>54.302</td>
<td>52.711</td>
<td>11.02***</td>
</tr>
<tr>
<td>Density (000’s of people/m²)</td>
<td>1.820</td>
<td>0.571</td>
<td>33.14***</td>
</tr>
<tr>
<td>Regulatory Incentives for “Green” Projects:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Electric Rates (cents per kWh)</td>
<td>11.396</td>
<td>9.904</td>
<td>27.34***</td>
</tr>
<tr>
<td>Tax Credits</td>
<td>0.236</td>
<td>0.541</td>
<td>−41.87***</td>
</tr>
<tr>
<td>Grant Programs</td>
<td>0.537</td>
<td>0.308</td>
<td>28.38***</td>
</tr>
<tr>
<td>Property Tax Incentives</td>
<td>0.854</td>
<td>0.708</td>
<td>23.29***</td>
</tr>
<tr>
<td>Political Economy of Environmental Certification:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>“Green” Certified (%)</td>
<td>0.354</td>
<td>0.143</td>
<td>2.34**</td>
</tr>
<tr>
<td>Percent Democratic</td>
<td>62.33</td>
<td>43.90</td>
<td>140***</td>
</tr>
<tr>
<td>“Blue” County</td>
<td>1</td>
<td>0</td>
<td>—</td>
</tr>
</tbody>
</table>

Notes: This table presents descriptive statistics for sample facilities segregated by political ideology. “Blue” counties are defined as those in which Barack Obama received more votes than John McCain during the 2008 U.S. presidential election. Information on the corresponding facility attributes, socioeconomic and demographic environment, regulatory incentives for “green” projects, and political ideology of the local market area are also reported. Blue county: n = 15,271; red county: n = 4,901.

* Significant at 90%.
** Significant at 95%.
*** Significant at 99%.
### Exhibit 3 | Correlation Coefficients

<table>
<thead>
<tr>
<th>a) Rent/ft²</th>
<th>b) % Leased</th>
<th>c) Floor Size</th>
<th>d) Cranes</th>
<th>e) Docks</th>
<th>f) Drive-ins</th>
<th>g) Power</th>
<th>h) Sewer</th>
<th>i) Rail</th>
<th>j) Parking</th>
<th>k) HD Days</th>
<th>l) CD Days</th>
<th>m) Population</th>
<th>n) % White</th>
<th>o) % HS Grad</th>
<th>p) % BA Grad</th>
<th>q) % Unemp.</th>
<th>r) Med. Inc.</th>
<th>s) Density</th>
<th>t) Elec. Rates</th>
<th>u) Tax Credits</th>
<th>v) Grant</th>
<th>Programs</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.0</td>
<td>0.08</td>
<td>-0.22</td>
<td>-0.09</td>
<td>-0.27</td>
<td>-0.00</td>
<td>-0.12</td>
<td>-0.04</td>
<td>-0.05</td>
<td>0.14</td>
<td>-0.10</td>
<td>-0.00</td>
<td>0.22</td>
<td>-0.01</td>
<td>-0.05</td>
<td>0.08</td>
<td>0.10</td>
<td>0.21</td>
<td>0.10</td>
<td>-0.04</td>
<td>-0.04</td>
<td>-0.19</td>
<td>0.04</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>a)</td>
<td>b)</td>
<td>c)</td>
<td>d)</td>
<td>e)</td>
<td>f)</td>
<td>g)</td>
<td>h)</td>
<td>i)</td>
<td>j)</td>
<td>k)</td>
<td>l)</td>
<td>m)</td>
<td>n)</td>
<td>o)</td>
<td>p)</td>
<td>q)</td>
<td>r)</td>
<td>s)</td>
<td>t)</td>
<td>u)</td>
<td>v)</td>
<td>w)</td>
</tr>
<tr>
<td>0.04</td>
<td>-0.01</td>
<td>0.13</td>
<td>0.10</td>
<td>0.04</td>
<td>-0.01</td>
<td>0.13</td>
<td>0.04</td>
<td>-0.01</td>
<td>-0.01</td>
<td>0.04</td>
<td>0.04</td>
<td>-0.01</td>
<td>0.04</td>
<td>-0.01</td>
<td>0.04</td>
<td>-0.01</td>
<td>-0.01</td>
<td>0.01</td>
<td>-0.01</td>
<td>0.04</td>
<td>-0.04</td>
<td>0.04</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>w)</td>
<td>x)</td>
<td>y)</td>
<td>z)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0.04</td>
<td>-0.01</td>
<td>0.13</td>
<td>0.10</td>
<td>0.04</td>
<td>-0.01</td>
<td>0.13</td>
<td>0.04</td>
<td>-0.01</td>
<td>-0.01</td>
<td>0.04</td>
<td>0.04</td>
<td>-0.01</td>
<td>0.04</td>
<td>-0.01</td>
<td>0.04</td>
<td>-0.01</td>
<td>-0.01</td>
<td>0.01</td>
<td>-0.01</td>
<td>0.04</td>
<td>-0.04</td>
<td>0.04</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>x)</td>
<td>y)</td>
<td>z)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>-0.01</td>
<td>0.13</td>
<td>0.10</td>
<td>0.04</td>
<td>0.04</td>
<td>-0.01</td>
<td>0.13</td>
<td>0.04</td>
<td>-0.01</td>
<td>-0.01</td>
<td>0.04</td>
<td>0.04</td>
<td>-0.01</td>
<td>0.04</td>
<td>-0.01</td>
<td>0.04</td>
<td>-0.01</td>
<td>-0.01</td>
<td>0.01</td>
<td>-0.01</td>
<td>0.04</td>
<td>-0.04</td>
<td>0.04</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>y)</td>
<td>z)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0.10</td>
<td>0.04</td>
<td>0.10</td>
<td>0.04</td>
<td>0.04</td>
<td>-0.04</td>
<td>0.10</td>
<td>0.04</td>
<td>-0.04</td>
<td>-0.04</td>
<td>0.10</td>
<td>0.04</td>
<td>-0.04</td>
<td>0.10</td>
<td>-0.04</td>
<td>0.04</td>
<td>-0.04</td>
<td>-0.04</td>
<td>0.04</td>
<td>-0.04</td>
<td>0.10</td>
<td>-0.04</td>
<td>0.04</td>
</tr>
</tbody>
</table>
pairs exhibit correlation coefficients in excess of 0.50, with all of these relationships following expected sign patterns. Specifically, the number of heating degree days and cooling degree days are negatively related ($\rho = -0.85$), heating degree days and state level grant programs supporting green building initiatives are directly related ($\rho = 0.52$), the two educational attainment metrics of high school and college graduation rates are positively related ($\rho = 0.59$), and the Percent Democratic vote share variable is negatively related to the percentage of Caucasian residents within a county ($\rho = -0.56$) while positively related to both population density ($\rho = 0.50$) and “Blue County” status ($\rho = 0.70$).

Exhibit 4 presents the results from four alternative OLS specifications regressing industrial warehouse facility rents per square foot against vectors of facility attributes, socio-economic and demographic market conditions, and location-specific political ideology metrics. Consistent with a priori expectations, rents are directly related to capacity utilization and inversely related to the intensity of onsite industrial activity across all four model specifications. Similarly, and again in-line with expectations, warehouse rents per square foot appear to be inversely related to expected energy consumption, college graduation rates, and unemployment rates, while directly related to local area population and density levels, high school graduation rates, and local area income levels across all four models.

Turning to our focal political ideology metrics, somewhat surprisingly we find environmental certification of industrial warehouses is associated with a reduction in market rents of approximately $1.35 per ft². Given the sample average rent of $6.36, these results suggest a “green” discount of approximately 20% for industrial properties located in “red” counties. Further analysis also reveals rents to be systematically higher in democratic leaning, politically liberal, “blue” counties. Finally, and perhaps most interestingly, we also interact our political ideology Blue County and environmental “Green Certified” metrics. This interaction term is consistently positive and suggests that while environmentally certified industrial warehouse rents may be discounted in politically conservative, republican leaning, “red” counties, such facilities rent at premiums of nearly 10% in politically liberal, democratic leaning, “blue” counties. The results presented in Exhibit 4 provide strong support for the notion that democratic leaning counties place a higher premium on environmental certification than their more conservative, republican leaning counterparts.

Exhibit 5 presents the results of our parallel analysis that examines capacity utilization rates within industrial warehouse properties. While we retain all previously examined facility attributes and location-specific socioeconomic and demographic characteristics for control purposes, we offer no ex ante predictions as to their expected empirical signs. Rather, we focus on the interplay between the environmental certification and political ideology metrics. As with our rental rate results, we find large disparities in the demand for green industrial warehouse facilities across the political ideology spectrum. The results in Exhibit 5 suggest capacity utilization rates for environmentally certified industrial properties in “red” counties are roughly 23% lower than those observed at non-certified facilities in similar locations. Interestingly, in “blue” counties, capacity utilization
Exhibit 4 | Determinants of Industrial Warehouse Rents

<table>
<thead>
<tr>
<th>Variables</th>
<th>I</th>
<th>II</th>
<th>III</th>
<th>IV</th>
</tr>
</thead>
<tbody>
<tr>
<td>Facility Attributes</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>% Leased</td>
<td>0.007</td>
<td>0.007</td>
<td>0.007</td>
<td>0.007</td>
</tr>
<tr>
<td></td>
<td>(12.40***)</td>
<td>(12.50***)</td>
<td>(12.30***)</td>
<td>(11.50***)</td>
</tr>
<tr>
<td>Floor Size (000's of ft²)</td>
<td>-0.005</td>
<td>-0.005</td>
<td>-0.005</td>
<td>-0.005</td>
</tr>
<tr>
<td></td>
<td>(-9.15***)</td>
<td>(-9.13***)</td>
<td>(-9.16***)</td>
<td>(-9.17***)</td>
</tr>
<tr>
<td>Have Cranes (yes = 1)</td>
<td>-0.730</td>
<td>-0.836</td>
<td>-0.741</td>
<td>-0.619</td>
</tr>
<tr>
<td></td>
<td>(-8.62***)</td>
<td>(-9.80***)</td>
<td>(-8.72***)</td>
<td>(-7.42***)</td>
</tr>
<tr>
<td>Have Docks (yes = 1)</td>
<td>-1.495</td>
<td>-1.475</td>
<td>-1.493</td>
<td>-1.354</td>
</tr>
<tr>
<td></td>
<td>(-27.80***)</td>
<td>(-27.40***)</td>
<td>(-27.70***)</td>
<td>(-25.20***)</td>
</tr>
<tr>
<td>Have Drive-ins (yes = 1)</td>
<td>-0.359</td>
<td>-0.349</td>
<td>-0.359</td>
<td>-0.444</td>
</tr>
<tr>
<td></td>
<td>(-4.90***)</td>
<td>(-4.74***)</td>
<td>(-4.90***)</td>
<td>(-6.10***)</td>
</tr>
<tr>
<td>Have Power (yes = 1)</td>
<td>-0.507</td>
<td>-0.474</td>
<td>-0.506</td>
<td>-0.573</td>
</tr>
<tr>
<td></td>
<td>(-9.16***)</td>
<td>(-8.57***)</td>
<td>(-9.13***)</td>
<td>(-10.50***)</td>
</tr>
<tr>
<td>Have Sewer (yes = 1)</td>
<td>-0.265</td>
<td>-0.231</td>
<td>-0.264</td>
<td>-0.201</td>
</tr>
<tr>
<td></td>
<td>(-10.50***)</td>
<td>(-4.32***)</td>
<td>(-4.88***)</td>
<td>(-3.76***)</td>
</tr>
<tr>
<td>Rail Access (yes = 1)</td>
<td>-0.058</td>
<td>-0.068</td>
<td>-0.058</td>
<td>0.008</td>
</tr>
<tr>
<td></td>
<td>(-1.10)</td>
<td>(-1.28)</td>
<td>(-1.10)</td>
<td>(0.16)</td>
</tr>
<tr>
<td>Parking Ratio</td>
<td>0.397</td>
<td>0.388</td>
<td>0.396</td>
<td>0.380</td>
</tr>
<tr>
<td></td>
<td>(14.2***)</td>
<td>(13.7***)</td>
<td>(14.1***)</td>
<td>(13.6***)</td>
</tr>
<tr>
<td>Socioeconomic &amp; Demographic Environment</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Heating Degree Days (000s of days)</td>
<td>-0.467</td>
<td>-0.443</td>
<td>-0.466</td>
<td>0.166</td>
</tr>
<tr>
<td></td>
<td>(-15.20***)</td>
<td>(-14.70***)</td>
<td>(-15.10***)</td>
<td>(3.02***)</td>
</tr>
<tr>
<td>Cooling Degree Days (000s of days)</td>
<td>-0.824</td>
<td>-1.062</td>
<td>-0.819</td>
<td>0.956</td>
</tr>
<tr>
<td></td>
<td>(-11.8***)</td>
<td>(-14.5***)</td>
<td>(-11.7***)</td>
<td>(6.88***)</td>
</tr>
<tr>
<td>Population (000,000's)</td>
<td>0.202</td>
<td>0.260</td>
<td>0.207</td>
<td>0.116</td>
</tr>
<tr>
<td></td>
<td>(13.00***)</td>
<td>(17.10***)</td>
<td>(12.90***)</td>
<td>(6.60***)</td>
</tr>
<tr>
<td>% Caucasian</td>
<td>0.025</td>
<td>0.004</td>
<td>0.025</td>
<td>-0.010</td>
</tr>
<tr>
<td></td>
<td>(6.81***)</td>
<td>(1.44)</td>
<td>(6.70***)</td>
<td>(-2.30***)</td>
</tr>
<tr>
<td>% High School Grads</td>
<td>0.046</td>
<td>0.049</td>
<td>0.049</td>
<td>-0.008</td>
</tr>
<tr>
<td></td>
<td>(5.46***)</td>
<td>(5.79***)</td>
<td>(5.84***)</td>
<td>(-0.80)</td>
</tr>
<tr>
<td>% College Grads</td>
<td>-0.070</td>
<td>-0.055</td>
<td>-0.071</td>
<td>-0.021</td>
</tr>
<tr>
<td></td>
<td>(-14.40***)</td>
<td>(-11.30***)</td>
<td>(-14.50***)</td>
<td>(-3.94***)</td>
</tr>
<tr>
<td>Unemployment Rate</td>
<td>-0.416</td>
<td>-0.420</td>
<td>-0.415</td>
<td>-0.493</td>
</tr>
<tr>
<td></td>
<td>(-15.40***)</td>
<td>(-15.00***)</td>
<td>(-15.30***)</td>
<td>(-14.10***)</td>
</tr>
<tr>
<td>Median HH Income ($,000)</td>
<td>0.082</td>
<td>0.077</td>
<td>0.082</td>
<td>0.055</td>
</tr>
<tr>
<td></td>
<td>(25.90***)</td>
<td>(23.10***)</td>
<td>(25.80***)</td>
<td>(17.40***)</td>
</tr>
<tr>
<td>Density (000's of people / m²)</td>
<td>0.207</td>
<td>0.258</td>
<td>0.212</td>
<td>0.196</td>
</tr>
<tr>
<td></td>
<td>(13.6***)</td>
<td>(17.2***)</td>
<td>(13.7***)</td>
<td></td>
</tr>
<tr>
<td>Political Economy of Environmental Certification</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>&quot;Green&quot; Certified (yes = 1)</td>
<td>-1.339</td>
<td>-1.392</td>
<td>-1.305</td>
<td>-0.627</td>
</tr>
<tr>
<td></td>
<td>(-2.96***)</td>
<td>(-2.59***)</td>
<td>(-2.84***)</td>
<td>(-1.64*)</td>
</tr>
<tr>
<td>Percent Democratic</td>
<td>0.060</td>
<td>—</td>
<td>0.055</td>
<td>0.010</td>
</tr>
<tr>
<td></td>
<td>(13.20***)</td>
<td>(9.81***)</td>
<td>(1.59)</td>
<td></td>
</tr>
</tbody>
</table>
Determinants of Industrial Warehouse Rents

\[ \text{Exhibit 4 (continued)} \]

<table>
<thead>
<tr>
<th>Variables</th>
<th>I</th>
<th>II</th>
<th>III</th>
<th>IV</th>
</tr>
</thead>
<tbody>
<tr>
<td>“Blue” County</td>
<td>—</td>
<td>0.668</td>
<td>0.142</td>
<td>0.502</td>
</tr>
<tr>
<td></td>
<td>(11.2**)</td>
<td>(1.86*)</td>
<td>(5.98***)</td>
<td></td>
</tr>
<tr>
<td>“Blue” County × “Green” Certified</td>
<td>1.844</td>
<td>1.984</td>
<td>1.799</td>
<td>1.039</td>
</tr>
<tr>
<td></td>
<td>(3.03***)</td>
<td>(2.92***)</td>
<td>(2.93***)</td>
<td>(1.88*)</td>
</tr>
<tr>
<td>Intercept</td>
<td>–0.490</td>
<td>3.672</td>
<td>–0.579</td>
<td>3.783</td>
</tr>
<tr>
<td></td>
<td>(–0.55)</td>
<td>(4.87***)</td>
<td>(–0.65)</td>
<td>(3.26***)</td>
</tr>
</tbody>
</table>

Geographic Controls

<table>
<thead>
<tr>
<th>F(k, N – k – 1: k = 23/25/26/33)</th>
<th>No</th>
<th>No</th>
<th>No</th>
<th>Yes</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>261.48</td>
<td>256.92</td>
<td>251.11</td>
<td>212.43</td>
</tr>
<tr>
<td>Prob &gt; F</td>
<td>0.0000</td>
<td>0.0000</td>
<td>0.0000</td>
<td>0.0000</td>
</tr>
<tr>
<td>R²</td>
<td>0.2474</td>
<td>0.2420</td>
<td>0.2475</td>
<td>0.2649</td>
</tr>
</tbody>
</table>

Notes: This table investigates the determinants of market rents on industrial warehouse facilities. Rents are modeled as a function of the facility’s attributes, socioeconomic and demographic environment, and the political ideology of the county in which each facility is located. All models employ robust standard errors using White’s correction. The number of observations in all models is 20,172.

Notes: The numbers inside the parentheses are \( t \)-statistics.

* Significant at 90%.
** Significant at 95%.
*** Significant at 99%.

Rates at environmentally certified facilities remain lower than those observed for non-certified properties in similar locations, though the approximate 2.5% reduction in occupancy is dramatically smaller than the 23% observed for the “red” county locations. While the reduced occupancy rates for environmentally certified warehouse facilities noted in Exhibit 5 are entirely consistent with the rental rate discounts previously reported for similar properties, it may also be explained by the vintage of these projects. As noted by Miller (2010), a sizable proportion of environmentally certified projects have been brought to market relatively recently. As a result, such facilities may well have disproportionately entered their lease-up phases during periods of economic turmoil and financial hardship. As a result, the higher observed vacancy rates for environmentally certified facilities may be due, in part, to temporal dependence and economic considerations rather than exclusively ideological considerations.

If political ideology influences observable industrial property market outcomes, do policy innovations mitigate these results? Exhibit 6 explores this possibility by augmenting our full model specification of determinants of industrial warehouse per square foot rents with four additional financial incentives derived from public policy related innovations within the commercial property market. First, column 1 adds commercial electric rates to the existing model specification. Throughout most of the U.S., commercial electric power and capacity is supplied to industrial warehouse facilities through either publicly owned corporations or heavily
### Exhibit 5 | Determinants of Industrial Warehouse Occupancy Rates

<table>
<thead>
<tr>
<th>Variables</th>
<th>I</th>
<th>II</th>
<th>III</th>
<th>IV</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Facility Attributes</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rent (per ft²)</td>
<td>1.048</td>
<td>1.053</td>
<td>1.046</td>
<td>0.972</td>
</tr>
<tr>
<td></td>
<td>(8.64***)</td>
<td>(8.72***)</td>
<td>(8.65***)</td>
<td>(8.03***)</td>
</tr>
<tr>
<td>Floor Size (000's of ft²)</td>
<td>0.052</td>
<td>0.052</td>
<td>0.052</td>
<td>0.053</td>
</tr>
<tr>
<td></td>
<td>(9.85***)</td>
<td>(9.85***)</td>
<td>(9.85***)</td>
<td>(9.97***)</td>
</tr>
<tr>
<td>Have Cranes (yes = 1)</td>
<td>-4.520</td>
<td>-4.709</td>
<td>-4.625</td>
<td>-4.197</td>
</tr>
<tr>
<td></td>
<td>(-2.53***)</td>
<td>(-2.63***)</td>
<td>(-2.58***)</td>
<td>(-2.33**)</td>
</tr>
<tr>
<td>Have Docks (yes = 1)</td>
<td>4.333</td>
<td>4.379</td>
<td>4.351</td>
<td>4.508</td>
</tr>
<tr>
<td></td>
<td>(6.67***)</td>
<td>(6.75***)</td>
<td>(6.70***)</td>
<td>(6.95***)</td>
</tr>
<tr>
<td>Have Drive-ins (yes = 1)</td>
<td>4.646</td>
<td>4.652</td>
<td>4.640</td>
<td>4.593</td>
</tr>
<tr>
<td></td>
<td>(5.86***)</td>
<td>(5.87***)</td>
<td>(5.85***)</td>
<td>(5.78***)</td>
</tr>
<tr>
<td>Have Power (yes = 1)</td>
<td>-4.226</td>
<td>-4.181</td>
<td>-4.215</td>
<td>-3.902</td>
</tr>
<tr>
<td></td>
<td>(-5.78***)</td>
<td>(-5.73***)</td>
<td>(-5.77***)</td>
<td>(-5.33***)</td>
</tr>
<tr>
<td>Have Sewer (yes = 1)</td>
<td>4.003</td>
<td>4.045</td>
<td>4.013</td>
<td>4.554</td>
</tr>
<tr>
<td></td>
<td>(5.57***)</td>
<td>(5.64***)</td>
<td>(5.59***)</td>
<td>(6.36***)</td>
</tr>
<tr>
<td>Rail Access (yes = 1)</td>
<td>-5.088</td>
<td>-5.092</td>
<td>-5.083</td>
<td>-5.331</td>
</tr>
<tr>
<td></td>
<td>(-8.39***)</td>
<td>(-8.40***)</td>
<td>(-8.38***)</td>
<td>(-8.82***)</td>
</tr>
<tr>
<td>Parking Ratio</td>
<td>-0.865</td>
<td>-0.888</td>
<td>-0.877</td>
<td>-0.656</td>
</tr>
<tr>
<td></td>
<td>(-2.70***)</td>
<td>(-2.78***)</td>
<td>(-2.74***)</td>
<td>(-2.04**)</td>
</tr>
<tr>
<td><strong>Socio-Economic &amp; Demographic Environment</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Heating Degree Days (000s of days)</td>
<td>2.290</td>
<td>2.327</td>
<td>2.301</td>
<td>8.172</td>
</tr>
<tr>
<td></td>
<td>(6.79***)</td>
<td>(6.92***)</td>
<td>(6.82***)</td>
<td>(11.4**)</td>
</tr>
<tr>
<td>Cooling Degree Days (000s of days)</td>
<td>2.212</td>
<td>2.030</td>
<td>2.255</td>
<td>14.444</td>
</tr>
<tr>
<td></td>
<td>(2.54**)</td>
<td>(2.41**)</td>
<td>(2.59***)</td>
<td>(8.20**)</td>
</tr>
<tr>
<td>Population (000,000's)</td>
<td>0.062</td>
<td>0.162</td>
<td>0.113</td>
<td>-0.051</td>
</tr>
<tr>
<td></td>
<td>(0.35)</td>
<td>(0.94)</td>
<td>(0.64)</td>
<td>-0.26</td>
</tr>
<tr>
<td>% Caucasian</td>
<td>0.061</td>
<td>0.039</td>
<td>0.059</td>
<td>-0.025</td>
</tr>
<tr>
<td></td>
<td>(1.67*)</td>
<td>(1.30)</td>
<td>(1.61)</td>
<td>-0.62</td>
</tr>
<tr>
<td>% High School Grads</td>
<td>-0.636</td>
<td>-0.604</td>
<td>-0.604</td>
<td>-0.614</td>
</tr>
<tr>
<td></td>
<td>(-5.87***)</td>
<td>(-5.46***)</td>
<td>(-5.46***)</td>
<td>(-4.99***)</td>
</tr>
<tr>
<td>% College Grads</td>
<td>0.287</td>
<td>0.295</td>
<td>0.280</td>
<td>0.216</td>
</tr>
<tr>
<td></td>
<td>(4.42***)</td>
<td>(4.71***)</td>
<td>(4.30***)</td>
<td>(2.98**)</td>
</tr>
<tr>
<td>Unemployment Rate</td>
<td>-2.543</td>
<td>-2.534</td>
<td>-2.533</td>
<td>-3.223</td>
</tr>
<tr>
<td></td>
<td>(-7.31***)</td>
<td>(-7.28***)</td>
<td>(-7.28***)</td>
<td>(-7.44***)</td>
</tr>
<tr>
<td>Median HH Income ($,000)</td>
<td>0.219</td>
<td>0.208</td>
<td>0.213</td>
<td>0.146</td>
</tr>
<tr>
<td></td>
<td>(5.31***)</td>
<td>(5.08***)</td>
<td>(5.15***)</td>
<td>(3.34***)</td>
</tr>
<tr>
<td>Density (000's of people/m²)</td>
<td>-0.238</td>
<td>-0.146</td>
<td>-0.188</td>
<td>-0.390</td>
</tr>
<tr>
<td></td>
<td>(-1.44)</td>
<td>(-0.89)</td>
<td>(-1.11)</td>
<td>(-2.19**)</td>
</tr>
<tr>
<td><strong>Political Economy of Environmental Certification</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>“Green” Certified (yes = 1)</td>
<td>-23.268</td>
<td>-23.020</td>
<td>-22.945</td>
<td>-22.631</td>
</tr>
<tr>
<td></td>
<td>(-1.73*)</td>
<td>(-1.72*)</td>
<td>(-1.71*)</td>
<td>(-1.57)</td>
</tr>
<tr>
<td>Percent Democratic</td>
<td>0.094</td>
<td>—</td>
<td>0.053</td>
<td>0.065</td>
</tr>
<tr>
<td></td>
<td>(2.03**)</td>
<td>(0.97)</td>
<td>(1.05)</td>
<td></td>
</tr>
</tbody>
</table>
regulated monopolistic enterprises. As such, the electric rate setting process frequently includes a non-trivial political component, with varying degrees of public input, supervision, and control.\textsuperscript{15} To the extent that democratic regions are systematically characterized by higher electric rates, a finding entirely consistent with the univariate results presented in Exhibit 2 and the positive correlation coefficients between both Blue County status and Percent Democratic vote share with electric rates shown in Exhibit 3, the observed relationship between green rental discounts, premiums, and political ideology may be an artifact of expected cost savings accruing through enhanced energy efficiency. The results reported in Column 1 of Exhibit 6 are inconsistent with this conclusion. Specifically, while electric rates are positively related to observed market rents, after controlling for the cost of commercial electricity (per kWh) the “Green Certification” metric remains strongly negative, while the Blue County (political ideology) x “Green Certified” interaction term remains strongly positive. These results are also consistent with the contentions of Zheng, Wu, Kahn, and Deng (2011), who posit electric rates and trends alone, both in the U.S. and China, are unlikely to be sufficient to spur widespread adoption of energy-efficient technologies.

Column 2 of Exhibit 6 alters our regulatory innovation framework by adding three variables designed to identify those jurisdictions that have tax credits, grant programs, or property tax incentives available to foster the development and expansion of green building initiatives. All else the same, such governmental
### Exhibit 6 | Do Economic Incentives Explain “Green” Rental Disparities?

<table>
<thead>
<tr>
<th>Variables</th>
<th>I</th>
<th>II</th>
<th>III</th>
<th>IV</th>
</tr>
</thead>
<tbody>
<tr>
<td>Facility Attributes</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>% Leased</td>
<td>0.007</td>
<td>0.007</td>
<td>0.007</td>
<td>0.007</td>
</tr>
<tr>
<td></td>
<td>(11.30***)</td>
<td>(12.60***)</td>
<td>(11.40***)</td>
<td>(11.30***)</td>
</tr>
<tr>
<td>Floor Size (000's of ft²)</td>
<td>-0.005</td>
<td>-0.004</td>
<td>-0.005</td>
<td>-0.005</td>
</tr>
<tr>
<td></td>
<td>(-9.16***)</td>
<td>(-9.33***)</td>
<td>(-9.29***)</td>
<td>(-9.16***)</td>
</tr>
<tr>
<td>Have Cranes (yes = 1)</td>
<td>-0.649</td>
<td>-0.648</td>
<td>-0.614</td>
<td>-0.596</td>
</tr>
<tr>
<td></td>
<td>(-7.71***)</td>
<td>(-7.68***)</td>
<td>(-7.29***)</td>
<td>(-7.16***)</td>
</tr>
<tr>
<td>Have Docks (yes = 1)</td>
<td>-1.413</td>
<td>-1.437</td>
<td>-1.399</td>
<td>-1.339</td>
</tr>
<tr>
<td></td>
<td>(-26.3***)</td>
<td>(-26.6***)</td>
<td>(-26.0***)</td>
<td>(-24.8***)</td>
</tr>
<tr>
<td>Have Drive-ins (yes = 1)</td>
<td>-0.392</td>
<td>-0.393</td>
<td>-0.403</td>
<td>-0.450</td>
</tr>
<tr>
<td></td>
<td>(-5.39***)</td>
<td>(-5.36***)</td>
<td>(-5.53***)</td>
<td>(-6.19***)</td>
</tr>
<tr>
<td>Have Power (yes = 1)</td>
<td>-0.524</td>
<td>-0.529</td>
<td>-0.526</td>
<td>-0.565</td>
</tr>
<tr>
<td></td>
<td>(-9.54***)</td>
<td>(-9.58***)</td>
<td>(-9.59***)</td>
<td>(-10.3***)</td>
</tr>
<tr>
<td>Have Sewer (yes = 1)</td>
<td>-0.179</td>
<td>-0.196</td>
<td>-0.147</td>
<td>-0.159</td>
</tr>
<tr>
<td></td>
<td>(-3.34***)</td>
<td>(-3.57***)</td>
<td>(-2.70***)</td>
<td>(-2.95***)</td>
</tr>
<tr>
<td>Rail Access (yes = 1)</td>
<td>-0.019</td>
<td>-0.024</td>
<td>-0.004</td>
<td>0.026</td>
</tr>
<tr>
<td></td>
<td>(-0.36)</td>
<td>(-0.46)</td>
<td>(-0.09)</td>
<td>(0.50)</td>
</tr>
<tr>
<td>Parking Ratio</td>
<td>0.377</td>
<td>0.384</td>
<td>0.378</td>
<td>0.380</td>
</tr>
<tr>
<td></td>
<td>(13.60***)</td>
<td>(13.70***)</td>
<td>(13.60***)</td>
<td>(13.60***)</td>
</tr>
<tr>
<td>Socioeconomic &amp; Demographic Environment</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Heating Degree Days (000s of days)</td>
<td>-0.247</td>
<td>-0.326</td>
<td>-0.182</td>
<td>0.199</td>
</tr>
<tr>
<td></td>
<td>(-6.95***)</td>
<td>(-8.95***)</td>
<td>(-4.58***)</td>
<td>(3.38***)</td>
</tr>
<tr>
<td>Cooling Degree Days (000s of days)</td>
<td>-0.334</td>
<td>-0.659</td>
<td>-0.293</td>
<td>0.888</td>
</tr>
<tr>
<td></td>
<td>(-4.26***)</td>
<td>(-9.09***)</td>
<td>(-3.69***)</td>
<td>(6.19***)</td>
</tr>
<tr>
<td>Population (000,000’s)</td>
<td>0.180</td>
<td>0.185</td>
<td>0.175</td>
<td>0.121</td>
</tr>
<tr>
<td></td>
<td>(11.30***)</td>
<td>(11.50***)</td>
<td>(11.00***)</td>
<td>(6.82***)</td>
</tr>
<tr>
<td>% Caucasian</td>
<td>0.027</td>
<td>0.020</td>
<td>0.026</td>
<td>-0.045</td>
</tr>
<tr>
<td></td>
<td>(7.95***)</td>
<td>(5.38***)</td>
<td>(7.41***)</td>
<td>(-0.11)</td>
</tr>
<tr>
<td>% High School Grads</td>
<td>0.065</td>
<td>0.044</td>
<td>0.056</td>
<td>0.013</td>
</tr>
<tr>
<td></td>
<td>(7.72***)</td>
<td>(5.03***)</td>
<td>(6.46***)</td>
<td>(1.33)</td>
</tr>
<tr>
<td>% College Grads</td>
<td>-0.058</td>
<td>-0.053</td>
<td>-0.048</td>
<td>-0.021</td>
</tr>
<tr>
<td></td>
<td>(-12.3***)</td>
<td>(-9.78***)</td>
<td>(-9.21***)</td>
<td>(-3.80***)</td>
</tr>
<tr>
<td>Unemployment Rate</td>
<td>-0.471</td>
<td>-0.415</td>
<td>-0.464</td>
<td>-0.503</td>
</tr>
<tr>
<td></td>
<td>(-17.4***)</td>
<td>(-15.1***)</td>
<td>(-16.7***)</td>
<td>(-14.6***)</td>
</tr>
<tr>
<td>Median HH Income ($,000)</td>
<td>0.059</td>
<td>0.074</td>
<td>0.058</td>
<td>0.048</td>
</tr>
<tr>
<td></td>
<td>(19.00***)</td>
<td>(23.30***)</td>
<td>(18.40***)</td>
<td>(14.90***)</td>
</tr>
<tr>
<td>Density (000's of people/m²)</td>
<td>0.192</td>
<td>0.223</td>
<td>0.201</td>
<td>0.201</td>
</tr>
<tr>
<td></td>
<td>(12.60***)</td>
<td>(14.30***)</td>
<td>(12.90***)</td>
<td>(12.30***)</td>
</tr>
<tr>
<td>Regulatory Incentives for “Green” Projects</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Electric Rates (cents per kWh)</td>
<td>0.174</td>
<td>—</td>
<td>0.162</td>
<td>0.074</td>
</tr>
<tr>
<td></td>
<td>(15.2***)</td>
<td>(12.8***)</td>
<td>(4.26***)</td>
<td></td>
</tr>
<tr>
<td>Tax Credits</td>
<td>—</td>
<td>-0.141</td>
<td>-0.104</td>
<td>-0.218</td>
</tr>
<tr>
<td></td>
<td>(-2.30***)</td>
<td>(-1.72)</td>
<td>(-3.01***)</td>
<td></td>
</tr>
</tbody>
</table>
Do Economic Incentives Explain “Green” Rental Disparities?

<table>
<thead>
<tr>
<th>Variables</th>
<th>I</th>
<th>II</th>
<th>III</th>
<th>IV</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grant Programs</td>
<td>—</td>
<td>–0.727</td>
<td>–0.348</td>
<td>–0.252</td>
</tr>
<tr>
<td></td>
<td>(–10.4***)</td>
<td>(–4.77***)</td>
<td>(–2.87***)</td>
<td></td>
</tr>
<tr>
<td>Property Tax Incentives</td>
<td>—</td>
<td>0.194</td>
<td>–0.112</td>
<td>–0.121</td>
</tr>
<tr>
<td></td>
<td>(2.79***)</td>
<td>(–1.51)</td>
<td>(–1.26)</td>
<td></td>
</tr>
<tr>
<td>Political Economy of Environmental Certification</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>“Green” Certified (yes = 1)</td>
<td>–0.997</td>
<td>–1.080</td>
<td>–0.938</td>
<td>–0.610</td>
</tr>
<tr>
<td></td>
<td>(–2.34***)</td>
<td>(–2.33***)</td>
<td>(–2.11***)</td>
<td></td>
</tr>
<tr>
<td>Percent Democratic</td>
<td>0.057</td>
<td>0.048</td>
<td>0.052</td>
<td>0.020</td>
</tr>
<tr>
<td></td>
<td>(10.1***)</td>
<td>(8.04***)</td>
<td>(8.62***)</td>
<td>(3.22***)</td>
</tr>
<tr>
<td>“Blue” County</td>
<td>0.090</td>
<td>0.255</td>
<td>0.178</td>
<td>0.427</td>
</tr>
<tr>
<td></td>
<td>(1.19***)</td>
<td>(3.20***)</td>
<td>(2.25**)</td>
<td>(5.18***)</td>
</tr>
<tr>
<td>“Blue” County × “Green” Certified</td>
<td>1.534</td>
<td>1.599</td>
<td>1.490</td>
<td>1.077</td>
</tr>
<tr>
<td></td>
<td>(2.65***)</td>
<td>(2.62***)</td>
<td>(2.51**)</td>
<td>(1.94*)</td>
</tr>
<tr>
<td>Intercept</td>
<td>–4.405</td>
<td>–0.151</td>
<td>–3.494</td>
<td>1.113</td>
</tr>
<tr>
<td></td>
<td>(–5.06***)</td>
<td>(–0.16)</td>
<td>(–3.78***)</td>
<td>(0.91)</td>
</tr>
</tbody>
</table>

Geographic Controls

<table>
<thead>
<tr>
<th></th>
<th>No</th>
<th>No</th>
<th>No</th>
<th>Yes</th>
</tr>
</thead>
<tbody>
<tr>
<td>F(k, N – k – 1: k = 23/25/26/33)</td>
<td>252.92</td>
<td>230.01</td>
<td>228.00</td>
<td>190.29</td>
</tr>
<tr>
<td>Prob &gt; F</td>
<td>0.0000</td>
<td>0.0000</td>
<td>0.0000</td>
<td>0.0000</td>
</tr>
<tr>
<td>R²</td>
<td>0.2595</td>
<td>0.2522</td>
<td>0.2607</td>
<td>0.2669</td>
</tr>
</tbody>
</table>

Notes: This table investigates the determinants of market rents on industrial warehouse facilities. Specifically, rents are modeled as a function of the facility’s attributes, socioeconomic and demographic environment, regulatory incentives in place to support “green” initiatives, and the political ideology of the county in which each facility is located. All models employ robust standard errors using White’s correction. The number of observations in all models is 20,172. Notes: The numbers inside the parentheses are t-statistics.

* Significant at 90%.
** Significant at 95%.
*** Significant at 99%.

Interventions would be expected to reduce the cost of environmental initiatives, thus making green development more financially viable, while simultaneously driving up market rents and certification premiums. Somewhat surprisingly, even after the inclusion of controls for these governmental initiatives, the coefficient estimate on the “Green” Certification metric remains strongly negative and statistically significant. Similarly, while tax incentives and grant programs would appear to facilitate the transfer of financial resources into the commercial property market and thus increase observable market rents, two of the three policy innovation control variables exhibit unexpectedly negative coefficient sign estimates.16 Nevertheless, our core result that environmental certification detracts from industrial warehouse rents in “red” counties, and enhances market rents on similar facilities in “blue” counties, remains qualitatively unchanged.
Finally, Columns 3 and 4 in Exhibit 6 control for the effects of both commercial electric rates and government policy innovations simultaneously. Once again, our results remain qualitatively robust to the inclusions of these additional model parameters. These results provide solid evidence of a statistically significant and economically meaningful relationship between the political ideology of location specific industrial warehouse property markets and the market valuation associated with green (ENERGY STAR or LEED) certification.

Conclusion

In this paper, we examined whether industrial warehouse facility rents and utilization rates are materially influenced by either environmental certification or political ideology. In contrast to the previous literature, we find rental rate discounts of nearly 20% accruing to environmentally-certified warehouse facilities located in politically conservative, republican leaning, “red” counties. On the other hand, we find rental rate premiums of approximately 8% accruing to environmentally-certified warehouse facilities located in politically liberal, democratic leaning, “blue” counties. Similarly, when examining occupancy or utilization rates for the sample properties, we again find non-trivial performance shortfalls accruing to environmentally-certified industrial properties in “red” counties. Our empirical findings suggest that vacancy rates are roughly 22%–23% higher for environmentally-certified properties in “red” counties than for non-certified properties in similar locations. Vacuum rates for “green” warehouses in “blue” counties also exceed those found for similarly located non-certified properties, although the magnitude of the differential is markedly lower at approximately 2%–3%. Finally, these results appear robust to the inclusion of an array of facility attributes, socioeconomic and demographic controls, and regulatory innovations.

Our findings are strongly supportive of the notion that non-pecuniary factors, including but potentially not limited to the political ideology of the local market area, may materially influence the market valuation of environmental amenities within industrial property markets. Therefore, we urge extreme caution to real estate professionals, governmental policymakers, and academic researchers when generalizing the results of environmental valuation studies to new property type sectors, geographic markets, or chronological time periods.

Endnotes

1 The U.S. Green Building Council first introduced LEED certification in 1998. To date, more than 5 billion square feet of commercial real estate projects, across all 50 states and in more than 90 countries, have been involved in the USGBC’s certification process. For further details, see U.S. Green Building Council (2009). Similarly, the ENERGY STAR label, which is jointly administered by the U.S. Environmental Protection Agency (EPA) and the Department of Energy (DOE), was extended to industrial warehouse facilities in 2004. To qualify for such designation, a warehouse must score within the
top 25% of all such facilities in the marketplace on a comprehensive energy consumption audit. For complete details, see U.S. Environmental Protection Agency (2009).

2 Mining and construction, another industry category relevant to green business professionals, finished last in terms of aggregate ethics.

3 See Tinker, Kreuter, Burt, and Bame (2006), Woods (2008), and Simons, Choi, and Simons (2009) for further details regarding local, state, and federal regulations designed to enhance environmental and energy efficiency.

4 Additional evidence on the cost of energy efficiency may be found in Goldman, Hopper, and Osborn (2005) and Pivo and Fisher (2010). Together, they report the cost of a typical energy efficiency retrofit at approximately $1.39 per ft², or approximately 0.6% of value.

5 See Bray and McCurry (2006) for an examination and discussion of the unintended consequences of rigid compliance with the LEED scoring system.

6 See, for example, Anderson (2008), Butters (2008), D’Arelli (2008), Del Percio (2008), Lemieux (2008), and Seifert (2008).

7 See Vandell and Lane (1989) and Jaffee, Stanton, and Wallace (2010) for further discussion of reputational capital effects surrounding certified commercial real estate building design and the “plaque-in-the-lobby” effect.

8 The two adopting states voting for John McCain over Barack Obama in the 2008 presidential election were Arkansas and Arizona. Neither state should be classified as reliably republican. For example, Arkansas favored the democratic candidate in two of the previous five presidential elections, while Arizona favored home state candidate John McCain by less than 200,000 votes.

9 Throughout this investigation, and consistent with the reporting practices of the Federal Elections Commission (FEC), we employ county-level aggregation for all political ideology voting metrics.

10 The NCDC is operated under the auspices of the National Oceanic and Atmospheric Administration (NOAA). Heating (cooling) degree days represent aggregate deviations from a temperature-neutral standard. They are computed as the average daily (or alternatively low and high) temperatures minus a predefined constant, and then aggregated across a desired observation interval. In the context of the current investigation, we employ an industry standard benchmark of 65°F as our baseline temperature. Thus, suppose location X has an average daily temperature of 52°F on January 1. In order to elevate the temperature within the facility to the 65°F benchmark would require 13 heating degree days worth of energy consumption. Similarly, an average temperature of 91°F on July 1 would generate 26 cooling degree days of energy consumption. Long-run average heating degree days and cooling degree days are then collected and annualized for each location within our sample.


12 Results obtained using the natural log of rent per square foot as the dependent variable yield qualitatively identical results.

13 We do note that the sign on our energy consumption and racial diversity metrics change in Column 4. This is likely due to the strong correlations between geographic location, energy consumption, and the racial composition of each market area. Fixed effects for the eight NCREIF sub-regions are included in model IV as geographic controls. Not surprisingly, the Pacific West (AK, HI, CA, OR, and WA) and Northeast (CT, ME, MA, NH, NJ, NY, PA, RI, and VT) exhibit the highest rents.
Consider, for example, the results provided in model I. Given the OLS model specification, the coefficient estimates represent marginal effects and may be interpreted directly as the price impact per square foot of the attribute. Thus, as the interaction term coefficient premium available in “blue” counties (1.844) exceeds the raw green certification discount coefficient (−1.339), we may estimate the green premium as (1.844 − 1.339) $0.505 per square foot for warehouses in “blue” counties. Given an average industrial warehouse sample rent of $6.36 per square foot, this translates into a green premium of ($0.505/$6.36) 7.9% in “blue” counties.

See Bonardi, Holburn, and Vanden Bergh (2006) for a discussion on related regulatory issues.

Interestingly, while the existence of both property tax incentives and grant programs to support green building initiatives are positively correlated with the Blue County variable, the magnitudes of these relationships are relatively small (ρ = 0.16 and ρ = 0.20, respectively). Furthermore, the correlation between “blue” county status and the availability of tax credits for green building initiatives is actually negative (ρ = −0.28).

References


This paper is the winner of the 2011 American Real Estate Society (ARES) manuscript prize in Industrial Real Estate. We thank the NAIOP Research Foundation for their generous support of this award. The authors also wish to thank seminar participants at the 2011 American Real Estate Society annual meetings and the 2010 Clemson University Valuation Colloquium, as well as two anonymous referees, for their helpful and insightful comments on a previous version of this research.

David M. Harrison, Texas Tech University, Lubbock, TX 79409-2101 or david.m.harrison@ttu.edu.

Michael J. Seiler, Old Dominion University, Norfolk, VA 23529-0223 or mseiler@odu.edu.
Greening the Regulatory Landscape: The Spatial and Temporal Diffusion of Green Building Policies in U.S. Cities

Author: Constantine E. Kontokosta

Abstract

This paper explores the determinants of green building policy adoption and the spatial and temporal diffusion of such policies. This research builds substantially on previous work by employing an original, robust database of green building policies created by the author for 200 cities in the United States—the Green Building Regulation Database (GBRD)—and a hazard rate model to determine the effect of a range of variables on policy adoption. The results indicate that economic, political, and climate factors, such as the number of patents issued per capita, carbon emissions per capita, and the existing policy landscape, are significant predictors of green building policy adoption. Cities categorized as policy innovators and early adopters of green building policies tend to have lower carbon emissions per capita, are better educated, and have more restrictive land use regulations.

There has been an exponential increase in the number of green buildings constructed in the United States over the past decade. The emergence of various eco-labeling systems, such as the U.S. Green Building Council’s (USGBC) Leadership in Energy and Environmental Design (LEED) rating system and the U.S. Environmental Protection Agency’s (EPA’s) ENERGY STAR program, have served to heighten awareness of the environmental and social impacts of new construction, both within the real estate industry and among the general public. By 2010, there were more than 2,000 LEED-certified properties in the U.S., with an annual rate of growth of approximately 50% since 2000. Spurred by new regulations and financial incentives, in addition to growing market demand, real estate owners and developers have begun to shift design standards for new buildings to meet a minimum standard of energy and resource efficiency, although obstacles remain to the widespread integration of green practices (Hoffman and Henn, 2008).

Despite the increased awareness and understanding of the benefits of sustainable design, the adoption of green building policies—codes, statutes, or plans that require, incentivize, or otherwise encourage sustainable buildings—has occurred incrementally. To date, there have been relatively few cities that have adopted such policies, resulting in substantial opportunity to enact and improve new green building programs. The policies that have been adopted, such as Local Law 86 in
New York City and Chapter 13C of the San Francisco Building Code, tend to vary significantly with respect to the type and size of buildings affected and, most importantly, the measure of sustainability used (Simons, Choi, and Simons, 2009). While a vast majority of city-level policies utilize the LEED rating system, emerging alternatives and a growing demand for performance-based metrics may shift policy structures in the future.

This paper explores the determinants of green building policy adoption and the spatial and temporal diffusion of such policies. The research builds substantially on previous work by employing an original, robust database of green building policies created by the author for 200 U.S. cities—the Green Building Regulation Database (GBRD)—and a hazard rate model to determine the effect of a range of political, economic, social, climate, and regulatory variables on policy adoption. Supplemental data for the work comes from such sources as the CoStar Group, the U.S. Census, the Bureau of Economic Analysis, the Wharton Land Use Regulation Database, and the U.S. Patent and Trademark Office. The article concludes with a discussion of the implications for public policy and green building market transformation.

Green Building Policies in the United States

For much of the world, the need to reduce carbon emissions to mitigate or reverse climate change is widely accepted and the scale of emissions attributed to the buildings sector is well known (Huovila, Juusela, Melchert, and Pouffary, 2007; Metz et al., 2007). In the U.S., buildings have become the focus of energy efficiency and carbon reduction strategies, particularly because energy efficiency measures in buildings can result in a positive “double bottom line” outcome by reducing carbon and adding value to the underlying real estate asset (Miller, Spivey, and Florance, 2008; Dermisi, 2009; Fuerst and McAllister, 2009, 2011a, 2011b; Eichholtz, Kok, and Quigley, 2010). Buildings are an attractive target for policymakers tasked with climate change mitigation as efficiency measures at the property-level are relatively low-cost, less politically charged, and can have a more immediate impact than comprehensive changes to land use patterns and transportation networks (Gonzalez, 2005; Metz et al., 2007; Wheeler, 2008).

Today, much of the innovation in green building policies is occurring at the city or municipal level, where, in most parts of the U.S., authority over building and zoning codes resides. Green building policies encompass a wide range of interventions through building and zoning codes, tax incentives, and subsidies, among others. These policies can shape the market by (1) leading by example (e.g., through requirements for municipal buildings), (2) raising building and design standards, (3) setting targets and measurable goals, and (4) incentivizing exemplary performance. Critical to the success of any of these policy interventions is ongoing performance data that can be measured, openly distributed, and used as a yardstick to evaluate progress toward established energy or carbon reduction goals. The drive toward greater transparency in energy performance information has the tremendous potential to shift markets and affect the decision-making processes of both tenant and owner. New York City’s Greener, Greater Buildings
Plan, for instance, although criticized for dropping the mandatory retrofit component, should play a significant role in changing behavior by providing an additional metric for evaluation of investment alternatives. Similar energy performance disclosure requirements are proliferating in cities across the U.S., such as San Francisco, Seattle, and Washington, D.C., amid growing awareness of the need for transparent energy use data (Burr, Keicher, and Leipziger, 2011).

Public policy approaches to green buildings tend to fall into one of two categories: voluntary incentives and mandatory standards (King and King, 2005). Voluntary incentive programs take on a number of forms, including tax abatements, density bonuses, expedited permitting, and technical assistance. Mandatory standards and regulations are, by definition, more binding and can have differing effects depending on policy structure and regulatory context. Certain regulations can limit or delay industry acceptance of sustainable design and construction and the market penetration of energy-efficient buildings. For example, regulatory barriers in the form of outdated zoning, building, and environmental regulations can restrict innovation in Smart Growth planning policies and green building technology, design, and construction (Downs, 2005; Simons, Choi, and Simons, 2009). Furthermore, differing regulations and codes across local municipalities (in New York State, for example, there are more than 932 towns, 62 cities, and 553 incorporated villages, each with its own authority over zoning laws) create friction in the planning, design, and development of green projects, thus adding costs and delays that limit the financial feasibility of such efforts (Choi, 2010).

On the other hand, regulations can act as an important mandate for a threshold level of sustainable design and development. For example, New York City requires that all municipal buildings meet certain requirements to achieve LEED Silver ratings and the Town of Babylon (New York) recently adopted legislation requiring all commercial properties greater than 4,000 square feet to achieve LEED certification. Similar examples can be found across the U.S., and government regulations have been widely (and effectively) used in many parts of Europe for decades (the cities of Stuttgart and Freiburg in Germany provide excellent examples). Properly structured green building policies (Porter and van der Linde, 1995) can raise the standard for energy-efficient construction, encourage innovative design and material solutions, and accelerate the market penetration of green buildings (Newell, Jaffe, and Stavins, 1999).

Policy Diffusion Mechanisms

The study of the diffusion of innovations, which includes policy innovations, began in earnest in the 1940s and 1950s. During this time, various disciplines approached the question of how ideas spread from the perspective of an innovation relevant to their specific area of study, with the work of two rural sociologists, Bryce Ryan and Neal Gross (1943), emerging as an influential contribution to the field. In 1962, Everett Rogers wrote what is widely considered the first theoretical synthesis of the process of diffusion, identifying four main elements—innovation, communication, time, and social system—common to all diffusion processes (Rogers, 1962, 2003). Within this framework, Rogers developed five categories of
Exhibit 1 | Adoption S-Curve

Adapted from Rogers (2003).

adopters, based on a normal distribution of adoption as a function of time (shown in Exhibit 1).

Innovators are those who are first to adopt a new innovation and can be viewed as opportunistic, seeking out new ideas that are, by definition, relatively high risk as a result of significant uncertainty surrounding their effectiveness. Policy innovators [also referred to as public entrepreneurs (Schneider and Teske, 1992)] must have strong communication networks, a sophisticated understanding of the problem to be addressed, and the ability to analyze alternative innovative, cutting-edge solutions (Polsby, 1984; Mintrom, 1997; Rogers, 2003). To be successful, policy innovators must have significant political capital and influence in order to convince (or compel) a wide range of actors of the potential opportunity from adopting the policy in question. There is evidence of this process in New York City, where the Bloomberg Administration, supported by relatively high approval ratings,1 was successful in advancing several greenhouse gas reduction and energy efficiency policies, such as PlaNYC 2030 and, most recently, the Greener, Greater Buildings Plan. Of course, policy innovators take risks, and the failure of a new policy to produce expected outcomes exposes these innovators to political repercussions.

While Rogers (1962, 2003) outlines the critical elements of the process of diffusion, the mechanisms by which new ideas spread can be grouped into four dominant explanatory categories (Simmons, Dobbin, and Garrett, 2008; Shipan and Volden, 2008; Meseguer and Gilardi, 2009). The first mechanism is coercion, where policies enacted at the regional, state, or national government level, or through a court-ordered mandate, impose pressure on local governments to follow suit. The second mechanism, emulation, occurs when policies are adopted because they represent social or political values that are independent of the primary function of the policy itself. Diffusion by emulation is predicated on one city
adopting a certain policy enacted in another city in order to become more like that city in some way (e.g., to achieve similar economic or social characteristics). Third, competition encourages the diffusion of policies as governments compete for resources either by adopting similar policies to other municipalities or by attempting to pre-empt other municipalities with more effective and efficient policies. Finally, diffusion through the learning process occurs when one city (or, more specifically, decision-makers in that city) seeks a solution to a local problem by adopting a policy that has been successful elsewhere (Berry and Baybeck, 2005). Learning requires that the adopting municipality (1) is aware of other municipalities’ policies through communication channels, (2) evaluates policies with respect to some measure of effectiveness, (3) modifies or adapts the policy to local political, economic, social, and cultural conditions, and, finally, (4) adopts the policy.

Often, decision-makers lack the requisite time or expertise to fully evaluate alternative policy options and rely on a variety of heuristics to identify viable policy solutions [Simon, 1985; see also Scott (2008) for more on institutional theory]. These include the representiveness heuristic, which bases the evaluation of success on expectations or rhetoric rather than analysis of actual outcomes; the availability heuristic, which suggests a higher likelihood of adopting a policy that has a geographically proximate successful example; and the heuristic of anchoring, which encourages the adoption of a policy with little adaptation to local context and needs (Weyland, 2007; Meseguer and Gilardi, 2009). It is the heuristic of anchoring that often reinforces the convergence of policy structure across differing jurisdictional frameworks.

Data and Study Area

The Green Building Regulation Database

Green building policy diffusion in the U.S. is explored here by analyzing the adoption of mandatory and incentive-based green building programs. Previous attempts to assemble data on green building policies have been limited by methodology [e.g., cursory web searches as in Simons, Choi, and Simons (2009) and Choi, (2010)] and breadth and depth of information gathered (e.g., Retzlaff, 2009). The GBRD created for this research catalogues the presence, type, structure, and year of adoption of building regulations and codes, incentives, and sustainability plans for 200 U.S. cities covering 44 states. Cities were selected from Core Based Statistical Areas with populations greater than 200,000 and based on the availability of relevant CoStar market data. From the full sample of 200 cities, CoStar data were available for 178 cities. For each city included in this analysis, the following information was gathered:

Green Building Standards: Design standards relating to the attainment of an eco-label certification (such as LEED); the applicability of the standard with respect to building size, type, and ownership (public or private); whether the standard was mandatory; the type and level of certification required; and the year adopted.
**Green Building Incentive**: Any incentives relating to green building construction, including expedited permitting, fee reductions, etc.; the applicability of the incentive with respect to building size, type, and ownership (public or private); the type and level of certification required to qualify for the incentive; and the year adopted.

**Sustainability Plan**: Any planning initiative or climate action plan that affects buildings, the type of real estate implicated, and the year adopted.

**Energy Conservation and Renewable Energy**: Any incentive or requirement for energy conservation programs and/or renewable energy systems in buildings.

The GBRD was developed using a three-step methodology. First, an online review of municipal planning, building, and sustainability agencies was conducted to determine the presence of the green building policies described above. Second, if a policy was indicated, the applicable building code, zoning code, or local law was reviewed to collect the required policy information. Finally, where sufficient or complete information could not be gathered (such as year of policy adoption, for instance), a survey of the relevant municipal planning, building, or sustainability official was conducted by phone and email. This process was conducted between January 2010 and February 2011.

State-level policies are also included in the database. While a number of studies have examined state adoption of environmental policies (Clark and Allen, 2004), there has been relatively limited discussion of green building regulations enacted at the state level (May and Koski, 2007). However, state green building policies can provide both an impetus to similar action at the local level and a complementary policy environment across different levels of government that may accelerate the adoption of green building practices. The state policies included here represent green building and energy efficiency regulations and incentives (tax incentives, subsidies, grants, municipal loans/bonds). This information was collected from the Database of State Incentives for Renewables and Efficiency, a project of the North Carolina Solar Center and the Interstate Renewable Energy Council.

Additional data were collected from numerous sources, including the U.S. Census, the Bureau of Labor Statistics, the Bureau of Economic Analysis, and the CoStar Group. Carbon dioxide (CO₂) emissions data as of 2002 were extracted from the NASA/DOE funded North American Carbon Program. These data are available at the county level and broken down by building type and per capita measures. For this analysis, county-level emissions data are aggregated by city. Carbon emissions per capita are used as a measure of the environmental impact of a city and the degree to which carbon reduction actions are warranted.

Data on “utility patents” by city of issuance were collected from the U.S. Patent and Trademark Office. Utility patents are those issued for the invention of a new and useful process, machine, manufacture, or composition of matter, or a new and useful improvement thereof (U.S. Code Title 35). Although patents have some limitations as a measure of innovation (Acs, Anselin, and Varga, 2002), it is expected that cities with higher numbers of utility patents are more receptive and conducive to technological change and shifts in building practices.
To examine the role of regulatory context in green building policy diffusion, the Wharton Residential Land Use Regulation Index (WRLURI) is included in the model as a measure of the restrictiveness of other land use regulation in the jurisdiction. The WRLURI was created through a survey of over 2,000 municipalities and provides a snapshot of the extent of land use regulations affecting residential development in a particular jurisdiction (Gyourko, Saiz, and Summers, 2008). It is expected that municipal governments with more restrictive land use regulations may be more willing to intervene in real estate markets to promote green building. Similarly, municipalities with more restrictive regulations may also be more likely to adopt mandatory green building policies rather than voluntary, incentive-based structures. A complete summary of variable data sources is provided in Exhibit 2.

The Current Landscape of Green Building Policies: Evidence from the GBRD

The GBRD database reveals a burgeoning landscape of green building policies across the U.S., with approximately one-quarter of all cities surveyed adopting some form of green building standard for either privately- or publicly-owned buildings (Exhibit 3). The most common metric used is the LEED rating system, and over three-quarters of cities with a green building policy make LEED certification, typically at the Silver level, a requirement for publicly and/or privately-owned buildings. More than half of the green building policies apply to buildings of 5,000 square feet or more.

There is, however, a wide variation in the stringency of these requirements. For example, Chapter 13C of the San Francisco Building Code, adopted in 2008, requires that all commercial buildings over 25,000 square feet and all residential buildings greater than 5 units and 75 feet in height must achieve LEED Silver certification.² This policy represents one of the most ambitious code mandates affecting privately-owned buildings. In the city of Pittsburgh, an amendment to the Pittsburgh Code approved in 2006 allows for a 20% floor-area ratio (FAR) bonus for commercial projects that achieve LEED New Construction or Core & Shell certification.³ This policy represents an example of a robust incentive-based policy. Of course, such bonus and incentive schemes are not without their challenges in implementation.⁴

In general, cities that adopt green building policies tend to be larger, both in terms of population and office market size, and have a population that is healthier, more active, better educated, and younger (Exhibits 4 and 5).⁵ These cities are more dense, have lower carbon footprints, and lower average temperatures. There also appears to be a vertical relationship between policies enacted at the state level and those adopted by cities. Data from the GBRD reveal that almost all cities with green building standards are in states with at least some incentives for energy efficient buildings or renewable energy systems, typically in the form of tax incentives or grant programs. This lends support to coercion and learning as mechanisms of diffusion, as cities are influenced, and supported, by state policies. Competition also appears to play an important role in the spread of green building policies, particularly as cities are increasingly framing competition in terms of
### Exhibit 2 | Variable Data Sources

<table>
<thead>
<tr>
<th>Variable</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Real Estate Market</strong></td>
<td></td>
</tr>
<tr>
<td>Age of Structures, Median</td>
<td>U.S. Census</td>
</tr>
<tr>
<td>% LEED Certified, sq. ft., 2004</td>
<td>USGBC/CoStar</td>
</tr>
<tr>
<td>% Urbanized</td>
<td>U.S. Census</td>
</tr>
<tr>
<td><strong>Socioeconomic</strong></td>
<td></td>
</tr>
<tr>
<td>% Population between 22 and 34 Years of Age</td>
<td>U.S. Census</td>
</tr>
<tr>
<td>Population, 1995 (per 1,000,000 persons)</td>
<td>U.S. Census</td>
</tr>
<tr>
<td>Education, % Bachelors Degree or Higher, 2000</td>
<td>U.S. Census</td>
</tr>
<tr>
<td>Per Capita Income, 1995, (000s)</td>
<td>Bureau of Economic Analysis</td>
</tr>
<tr>
<td>Per Capita Income, % Growth 1995–2005</td>
<td>Bureau of Economic Analysis</td>
</tr>
<tr>
<td><strong>Economic</strong></td>
<td></td>
</tr>
<tr>
<td>GMP per Capita, 2000, per 100,000</td>
<td>Bureau of Economic Analysis</td>
</tr>
<tr>
<td>GMP per Capita, % Growth 2000–2008</td>
<td>Bureau of Economic Analysis</td>
</tr>
<tr>
<td>Government Employment, % of Total, 2000</td>
<td>Bureau of Labor Statistics</td>
</tr>
<tr>
<td>Total # of Patents, 1999 (00s)</td>
<td>U.S. Patent and Trademark Office</td>
</tr>
<tr>
<td><strong>Political/Regulatory</strong></td>
<td></td>
</tr>
<tr>
<td>Non-profit Organizations, per 10,000 pop., 2000</td>
<td>Urban Institute National Center for Charitable Statistics</td>
</tr>
<tr>
<td>Sustainability Plan Previously Adopted</td>
<td>GBRD</td>
</tr>
<tr>
<td>Green Building Policy, State</td>
<td>DSIRE</td>
</tr>
<tr>
<td>Land Use Regulation Index</td>
<td>Wharton Residential Land Use Regulation Database</td>
</tr>
<tr>
<td>Democratic Mayor</td>
<td>U.S. Census and U.S. Conference of Mayors</td>
</tr>
<tr>
<td><strong>Climate</strong></td>
<td></td>
</tr>
<tr>
<td>CO₂ Emission per Capita, metric tons</td>
<td>NASA/Department of Energy</td>
</tr>
<tr>
<td>Climate Zone 2</td>
<td>ASHRAE</td>
</tr>
<tr>
<td>Climate Zone 3</td>
<td>ASHRAE</td>
</tr>
<tr>
<td>Climate Zone 4</td>
<td>ASHRAE</td>
</tr>
<tr>
<td>Climate Zone 5</td>
<td>ASHRAE</td>
</tr>
<tr>
<td>Climate Zone 6</td>
<td>ASHRAE</td>
</tr>
<tr>
<td>Climate Zone 7</td>
<td>ASHRAE</td>
</tr>
<tr>
<td>Temporal-Spatial Control</td>
<td></td>
</tr>
<tr>
<td># of Previous Adopters in State</td>
<td>GBRD</td>
</tr>
</tbody>
</table>

carbon reduction targets and climate change mitigation in an effort to improve quality of life and attract firms and residents (Rogerson, 1999). Energy efficiency in buildings has emerged as a new economic development strategy that is predicated on fostering innovation and creating new investment, employment, and R&D opportunities.

**Empirical Strategy**

Using data from the GBRD, this paper examines the political/regulatory, environmental, economic, and social determinants of green building policy...
adoption and diffusion across U.S. cities. In particular, the focus of this empirical analysis is to better understand the mechanisms by which green building policies have spread—both temporally and spatially—across the country over the past decade.

Determinants of policy adoption and diffusion are analyzed here using a Cox proportional hazards model with a binary dependent variable for the adoption of a green building standard (Cox, 1972; Berry and Berry, 1990; Rincke, 2007; Shipan and Volden, 2008). The hazards model allows for both time invariant and time-varying covariates, which accounts for changes in municipal-level characteristics over the study timeframe. Therefore, the likelihood of adopting a green building policy is given as a function of a range of factors using annual data for the year preceding the year of adoption. It also allows for the analysis of censored data, when the event in question (in this case the adoption of a green building policy) occurs before or after the study period. In the Cox proportional hazards model, the hazard is assumed to be:

\[
h(t) = h_0(t)\exp\{\beta_1 x_1 + \cdots + \beta_k x_k + g(t)(\gamma_1 z_1 + \cdots + \gamma_m z_m)\},
\]

where \((z_1, \ldots, z_m)\) are the time-varying covariates. The hazard function is the conditional probability of a municipality adopting a green building regulation
### Exhibit 4 | Descriptive Statistics

<table>
<thead>
<tr>
<th>Category</th>
<th>With Green Building Policy</th>
<th>No Green Building Policy</th>
<th>Diff. (Mean)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total RBA</td>
<td>Mean: 488,000,000</td>
<td>Mean: 130,000,000</td>
<td>Mean: 358,000,000</td>
</tr>
<tr>
<td></td>
<td>Std. Dev: 621,000,000</td>
<td>Std. Dev: 183,000,000</td>
<td></td>
</tr>
<tr>
<td>LEED Bldgs. (as of 2010)</td>
<td>Mean: 39.9</td>
<td>Mean: 6.4</td>
<td>Mean: 33.5</td>
</tr>
<tr>
<td></td>
<td>Std. Dev: 45.7</td>
<td>Std. Dev: 10.0</td>
<td></td>
</tr>
<tr>
<td>Population Density (per sq. mi.)</td>
<td>Mean: 2,619</td>
<td>Mean: 1,904</td>
<td>Mean: 715</td>
</tr>
<tr>
<td></td>
<td>Std. Dev: 1,144</td>
<td>Std. Dev: 622</td>
<td></td>
</tr>
<tr>
<td>Carbon Footprint (metric tons per capita)</td>
<td>Mean: 2.27</td>
<td>Mean: 2.6</td>
<td>Mean: -0.3</td>
</tr>
<tr>
<td></td>
<td>Std. Dev: 0.57</td>
<td>Std. Dev: 0.4</td>
<td></td>
</tr>
<tr>
<td>% Urban</td>
<td>Mean: 86.5%</td>
<td>Mean: 80.7%</td>
<td>Mean: 5.8%</td>
</tr>
<tr>
<td></td>
<td>Std. Dev: 10.0%</td>
<td>Std. Dev: 9.4%</td>
<td></td>
</tr>
<tr>
<td>% 25–34 Years Old</td>
<td>Mean: 19.1%</td>
<td>Mean: 17.8%</td>
<td>Mean: 1.3%</td>
</tr>
<tr>
<td></td>
<td>Std. Dev: 1.7%</td>
<td>Std. Dev: 2.1%</td>
<td></td>
</tr>
<tr>
<td>GDP per capita, % Growth 2001–2008</td>
<td>Mean: 9.4%</td>
<td>Mean: 8.3%</td>
<td>Mean: 1.1%</td>
</tr>
<tr>
<td></td>
<td>Std. Dev: 6.8%</td>
<td>Std. Dev: 7.8%</td>
<td></td>
</tr>
<tr>
<td>Population, 1995</td>
<td>Mean: 2,136,532</td>
<td>Mean: 633,126</td>
<td>Mean: 1,503,406</td>
</tr>
<tr>
<td>Population, % Growth 1995–2005</td>
<td>Mean: 16.3%</td>
<td>Mean: 10.7%</td>
<td>Mean: 5.6%</td>
</tr>
<tr>
<td></td>
<td>Std. Dev: 12.8%</td>
<td>Std. Dev: 10.7%</td>
<td></td>
</tr>
<tr>
<td>Per Capita Income, 1995</td>
<td>Mean: 24,289</td>
<td>Mean: 21,666</td>
<td>Mean: 2,623</td>
</tr>
<tr>
<td></td>
<td>Std. Dev: 3,783</td>
<td>Std. Dev: 3,354</td>
<td></td>
</tr>
<tr>
<td>Per Capita Income, % Growth 1995–2005</td>
<td>Mean: 53.2%</td>
<td>Mean: 49.7%</td>
<td>Mean: 3.5%</td>
</tr>
<tr>
<td></td>
<td>Std. Dev: 8.9%</td>
<td>Std. Dev: 9.0%</td>
<td></td>
</tr>
<tr>
<td>% with Asthma</td>
<td>Mean: 7.8%</td>
<td>Mean: 8.3%</td>
<td>Mean: -0.5%</td>
</tr>
<tr>
<td></td>
<td>Std. Dev: 1.3%</td>
<td>Std. Dev: 1.5%</td>
<td></td>
</tr>
<tr>
<td>% Exercise Regularly</td>
<td>Mean: 78.0%</td>
<td>Mean: 77.3%</td>
<td>Mean: 4.4%</td>
</tr>
<tr>
<td></td>
<td>Std. Dev: 3.6%</td>
<td>Std. Dev: 4.4%</td>
<td></td>
</tr>
<tr>
<td>% Obese Population (BMI &gt;30)</td>
<td>Mean: 22.0%</td>
<td>Mean: 23.6%</td>
<td>Mean: -1.6%</td>
</tr>
<tr>
<td></td>
<td>Std. Dev: 2.7%</td>
<td>Std. Dev: 3.4%</td>
<td></td>
</tr>
<tr>
<td>% in State with Green Building Tax Incentive</td>
<td>Mean: 44.0%</td>
<td>Mean: 45.3%</td>
<td>Mean: -1.3%</td>
</tr>
<tr>
<td></td>
<td>Std. Dev: 50.1%</td>
<td>Std. Dev: 50.0%</td>
<td></td>
</tr>
<tr>
<td>Employment, Construction, % of Total 2001</td>
<td>Mean: 6.3%</td>
<td>Mean: 6.1%</td>
<td>Mean: 0.2%</td>
</tr>
<tr>
<td></td>
<td>Std. Dev: 1.3%</td>
<td>Std. Dev: 1.5%</td>
<td></td>
</tr>
<tr>
<td>Employment, Government, % of Total 2001</td>
<td>Mean: 14.4%</td>
<td>Mean: 15.1%</td>
<td>Mean: -0.7%</td>
</tr>
<tr>
<td></td>
<td>Std. Dev: 4.9%</td>
<td>Std. Dev: 5.6%</td>
<td></td>
</tr>
<tr>
<td>% with Bachelors Degree or Higher</td>
<td>Mean: 28.2%</td>
<td>Mean: 23.1%</td>
<td>Mean: 5.1%</td>
</tr>
<tr>
<td></td>
<td>Std. Dev: 6.0%</td>
<td>Std. Dev: 5.3%</td>
<td></td>
</tr>
<tr>
<td>Average Electricity Price</td>
<td>Mean: 11.5</td>
<td>Mean: 11.0</td>
<td>Mean: 0.5</td>
</tr>
<tr>
<td></td>
<td>Std. Dev: 3.4</td>
<td>Std. Dev: 2.7</td>
<td></td>
</tr>
<tr>
<td>Average Annual Temperature (Fahrenheit)</td>
<td>Mean: 54.3</td>
<td>Mean: 56.6</td>
<td>Mean: -2.3</td>
</tr>
<tr>
<td></td>
<td>Std. Dev: 7.8</td>
<td>Std. Dev: 9.0</td>
<td></td>
</tr>
<tr>
<td>% with Republican Mayor</td>
<td>Mean: 16.3%</td>
<td>Mean: 20.3%</td>
<td>Mean: -4.0%</td>
</tr>
<tr>
<td></td>
<td>Std. Dev: 37.3%</td>
<td>Std. Dev: 40.6%</td>
<td></td>
</tr>
</tbody>
</table>

Note: The values in the table are year 2000 values unless otherwise indicated.
Independent sample $t$-test performed to analyze difference in means.

* Significant at the 90% confidence level.
** Significant at the 95% confidence level.
*** Significant at the 99% confidence level.

within the study period. Robust standard errors are estimated to account for heteroscedasticity and uncorrected serial correlation over time or space. The explanatory variables are categorized into real estate market factors, socioeconomic characteristics, political/regulatory, and climate variables. Spatial controls are also included to test for spatial correlation.

The equation estimated here is given by:

$$h_i(t) = h_0(t) \exp\{RE + SE + ECON + POL + CLIMATE + SPATIAL\}.$$

where $h_0$ is the baseline hazard function; $RE$ is a set of real estate market variables, including percentage of urban area, median age of structures, and the proportion of LEED certified space prior to policy adoption; $SE$ is a vector of socioeconomic characteristics of city $i$ including population, education, and income variables; $ECON$ represents economic conditions described through gross municipal product, employment, and patent variables; $POL$ is a set of political and regulatory measures, including the number of environmental non-profit organizations, the presence of a municipal sustainability plan, state-level green building policies, the political party affiliation of the mayor, and a measure of the restrictiveness of local policies.
land use regulations; CLIMATE includes a variable for the carbon emissions per capita and a series of dummy variables for the climate zone of city i; and SPATIAL is temporal-spatial control variable for the number of cities in the same state that adopted a green building policy prior to city i.

Results

Hazard Rate Model

The results of the hazard rate model (Exhibit 6) reveal that regulatory, economic, and climate variables are clear predictors of green building policy adoption. The results are robust to different model specifications, including stratifying the model by climate zone to account for the varying significance of adoption drivers in different climate contexts. The first column of Exhibit 6 reports the coefficients for each variable, followed by the robust standard error. The third column displays the hazard rate.

A city that previously adopted a sustainability or climate action plan is more likely to adopt a green building policy. This is a logical progression: a city analyzes its current environmental impact and energy consumption, identifies targets for carbon and energy use reduction, and outlines strategies to achieve those goals. The green building policy, then, is the implementation of part of the sustainability plan for the city. This process has been reflected in the path of adoption in cities like San Francisco and New York. While the adoption of a sustainability plan may share certain predicators with the adoption a green building policy, there is substantial difference in scope, legislative process, and relevant stakeholders. Of course, city sustainability plans are often criticized for their lack of specific implementation strategies and evaluation metrics (Wheeler, 2008), but despite this they often represent an important first step in taking action against climate change.

The finding above is supported by the positive, statistically significant coefficient for carbon emissions per capita. Cities with higher per capita emissions are more likely to adopt a green building policy, reflecting what may be a rational public policy response to an actual or perceived problem. It follows that cities that have developed a sustainability plan know and understand the source of their carbon emissions and, consequently, take action to curb emissions in buildings. This finding also supports pre-emption as a motivation by city officials, who recognize that carbon emissions may become regulated by higher levels of government in the future and thus decide to act to avoid regulations being imposed on them (e.g., the narrow defeat of the proposed American Clean Energy and Security Act of 2009). In other words, cities may see that action will need to be taken to reduce emissions and decide to proactively address the issue by creating their own green building policy. For instance, San Francisco’s green building policy is more restrictive than the recently adopted CalGreen green building code in California, which gives city officials greater control over green building design requirements.

The measure of innovation included in the model—patents per capita—is significant, indicating that cities with a greater number of patents issued are more
### Exhibit 6 | Hazards Model Regression Results

<table>
<thead>
<tr>
<th>Variable</th>
<th>Coeff.</th>
<th>Robust Std. Error</th>
<th>Hazard Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Real Estate Market</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Age of Structures, Median</td>
<td>-0.026</td>
<td>0.069</td>
<td>0.974</td>
</tr>
<tr>
<td>% LEED Certified sq. ft., 2004</td>
<td>0.000</td>
<td>0.000</td>
<td>1.000</td>
</tr>
<tr>
<td>% Urbanized</td>
<td>0.679</td>
<td>2.751</td>
<td>1.971</td>
</tr>
<tr>
<td><strong>Socioeconomic</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>% Population between 22 and 34 Years of Age</td>
<td>2.089</td>
<td>16.891</td>
<td>8.074</td>
</tr>
<tr>
<td>Population, 1995 (per 1,000,000 persons)</td>
<td>-0.003</td>
<td>0.156</td>
<td>0.999</td>
</tr>
<tr>
<td>Education, % Bachelors Degree or Higher, 2000</td>
<td>3.988</td>
<td>5.376</td>
<td>53.969</td>
</tr>
<tr>
<td>Per Capita Income, 1995 (000s)</td>
<td>-0.008</td>
<td>0.151</td>
<td>0.999</td>
</tr>
<tr>
<td>Per Capita Income, % growth 1995–2005</td>
<td>-3.221</td>
<td>2.836</td>
<td>0.040</td>
</tr>
<tr>
<td><strong>Economic</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>GMP per Capita, 2000, per 100,000</td>
<td>4.530</td>
<td>6.420</td>
<td>1.045</td>
</tr>
<tr>
<td>GMP per Capita, % growth 2000–2008</td>
<td>0.143</td>
<td>3.627</td>
<td>1.154</td>
</tr>
<tr>
<td>Government Employment, % of Total, 2000</td>
<td>4.229</td>
<td>5.281</td>
<td>68.665</td>
</tr>
<tr>
<td>Total # of Patents per capita, 1999</td>
<td>0.001</td>
<td>0.000</td>
<td>1.001***</td>
</tr>
<tr>
<td><strong>Political / Regulatory</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Non-profit organizations, per 10,000 pop., 2000</td>
<td>0.116</td>
<td>0.167</td>
<td>1.123</td>
</tr>
<tr>
<td>Sustainability Plan previously adopted</td>
<td>1.953</td>
<td>0.896</td>
<td>7.046**</td>
</tr>
<tr>
<td>Green Building Policy, State</td>
<td>-0.621</td>
<td>1.067</td>
<td>0.538</td>
</tr>
<tr>
<td>Land Use Regulation Index</td>
<td>0.186</td>
<td>0.295</td>
<td>1.204</td>
</tr>
<tr>
<td>Democratic Mayor</td>
<td>0.240</td>
<td>0.483</td>
<td>1.271</td>
</tr>
<tr>
<td><strong>Climate</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CO₂ Emission per Capita, Metric Tons</td>
<td>0.052</td>
<td>0.019</td>
<td>1.054***</td>
</tr>
<tr>
<td>Climate Zone 2</td>
<td>-1.201</td>
<td>1.217</td>
<td>0.301</td>
</tr>
<tr>
<td>Climate Zone 3</td>
<td>-2.014</td>
<td>1.184</td>
<td>0.133*</td>
</tr>
<tr>
<td>Climate Zone 4</td>
<td>-1.205</td>
<td>1.598</td>
<td>0.300</td>
</tr>
<tr>
<td>Climate Zone 5</td>
<td>-1.970</td>
<td>1.377</td>
<td>0.139</td>
</tr>
<tr>
<td>Climate Zone 6</td>
<td>-1.579</td>
<td>1.496</td>
<td>0.206</td>
</tr>
<tr>
<td>Climate Zone 7</td>
<td>-1.204</td>
<td>1.378</td>
<td>0.300</td>
</tr>
<tr>
<td><strong>Spatial</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td># of Previous Adopters in State</td>
<td>0.191</td>
<td>0.199</td>
<td>1.211</td>
</tr>
</tbody>
</table>

Notes: The number of observations is 120. The log likelihood is −154.693 and the Wald $\chi^2$ is 155.36.

* Significant at the 10% level.
** Significant at the 5% level.
*** Significant at the 1% level.

likely to adopt a green building policy. On average, cities with a green building policy had approximately 33% more patents per capita than cities without such a policy. Innovative cities may be more receptive to incentives for resource-efficient design, and may be more likely to link innovation in green building technologies, systems, and design to economic competitiveness. Although cities have historically been loci of innovation (Glaeser, 2011), what is notable in the case of climate change is that a relatively small number of citizens are willing to bear the
costs of carbon reductions that will, by definition, have a global impact (Engel and Orbach, 2008).

Equally interesting from the perspective of better understanding the diffusion of green building policies are the variables that are not significant. Most notable are the variables for the mayor’s political party affiliation, the density of environmental non-profit organizations, and the climate zone of the city. Although it might be assumed that a democratic mayor (and the electorate that would vote for them) would be more likely to consider climate change an important issue, the results show no significant variation across political parties (Dunlap, Xiao, and McCright, 2001; Shipan and Lowry, 2001). This suggests that either there is some convergence on the issue of building energy efficiency across parties or the motivations differ among democrats, republicans, and independents, but the resultant approach is still to enact green building policies. Along these lines, the number of environmental organizations does not appear to play a role in green building policy diffusion. It is possible that it is not the number of non-profit organizations, but their capabilities and political capital that is important. For instance, the USGBC has been a primary change agent in the market transition to more energy efficient buildings. It is conceivable that the power of the USGBC and its national reach have been more influential in framing public policy around green buildings than local advocacy groups.

Finally, the climate zone of the city is not a significant factor in policy adoption and diffusion, except for climate zone 3, which is negative and marginally significant at the 90% level. There are eight climate zones in the U.S., categorized according to the number of heating degree days (hdd) or cooling degree days (cdd) per year, as well the average humidity in the region. Climate zones 1 and 7 represent extremes in terms of cooling and heating requirements, respectively, with zone 1 averaging more than 9,000 cdd and zone 7 averaging between 9,000 and 12,600 hdd. The results of the analysis presented here show that the climate zone of the city does not influence the likelihood of adopting a green building policy, although cities in climate zone 3, one of the most temperate climate environments where heating and cooling demands are relatively low, are somewhat less likely to adopt. In some ways, the insignificance of the climate zones is counterintuitive. One would expect that cities with extreme temperatures (and thus greater cooling or heating loads and energy demands) would be more likely to prioritize and regulate building energy efficiency. On the other hand, it is conceivable that cities in the extreme climate zones (or, more specifically, building owners in these climate zones) have greater economic incentive to design and construct energy-efficient buildings and therefore do not require a green building policy to shift design standards (as building codes may already be more stringent). However, the data reveal no significant differences in the mean number of ENERGY STAR or LEED certified properties in the extreme climate zones.

The coefficient for percent LEED certified square footage in 2004 is also not significant. This suggests that the amount of LEED certified buildings in a city does not affect the likelihood of adopting a green building policy. In cities with more LEED certified space, it would be expected that the local real estate community, including contractors and design professionals, is more familiar with
green building practices and thus less opposed to green building regulation. This might occur because as awareness and understanding of green building design increases, additional costs associated with green building should decrease. In the same vein, elected officials may have the opportunity to see the benefits of sustainable design and thus better understand the potential for public policy to shift construction standards and achieve energy efficiencies and carbon reductions in buildings. However, the results indicate that this variable is not a predictor of policy adoption, suggesting that policymakers are influenced by other factors, such as policies in other cities.

Mandatory vs. Voluntary Policies: Empirical Evidence

A second model specification was estimated to determine the factors that influence whether a city adopts a mandatory policy. For the sample of 49 cities that adopted some form of policy (full data are available for 41 of these cities), the results indicate significant positive coefficients for carbon emissions, democratic and independent mayors, and land use regulations. Cities with higher carbon emissions per capita were more likely to adopt a mandatory policy. This may be a response to a greater perceived need to address carbon reductions through efficiencies in the buildings sector. Cities with democratic or independent mayors were more likely to institute a mandatory green building program. This is expected, as there is a historical tendency for democrats and independents (albeit less so) to favor policy solutions that involve government intervention.

Most interestingly, cities with more restrictive land use regulations (as measured by the WRLURI) are significantly more likely to adopt a mandatory green building policy. This finding suggests that cities that favor regulatory responses to control development and possible negative externalities also favor regulatory strategies to address climate change and energy efficiency in buildings. One concern here is if existing land use regulations raise the cost of construction (Mayer and Somerville, 2000; Quigley and Rosenthal, 2005), an additional green building requirement may further increase costs (Kats, 2003; Langdon 2007, 2010) and create a disincentive for more efficient buildings and innovative technological and design approaches.

Diffusion over Time

The number of municipal green building policies has expanded dramatically over the past ten years. Through the end of the year 2000, only Seattle, Washington and Austin, Texas had adopted a green building policy. Both cities enacted regulations that required municipal buildings to achieve certain prescribed sustainable design standards. Since 2000, the growth in municipal green building policies has been exponential, with a sharp increase beginning in 2006, coinciding with high-profile policy adoptions in New York and Washington, DC. Exhibit 7 shows the cumulative hazard estimate of the expected number of policy adoptions in the GBRD sample beginning in the year 2000.

The trajectory of municipal green building policy adoption mirrors the overall pace of market transformation, evidenced by the expansion in the number of
LEED certified buildings across the U.S., which has grown from 667,600 square feet certified in the year 2000 to approximately 500 million square feet certified in 2010 (USGBC).

Looking at descriptive statistics by time of adoption reveals interesting texture across adopter categories within the sample. Exhibit 8 shows the pre-adoption data
for population, education, patents, LEED certified space, and carbon emissions per capita, broken down by Roger’s (2003) categories of innovation adopters. Policy “innovators” and “early adopters” (i.e., those earliest to adopt a new innovation) are better educated, have a higher number of patents per capita, have more LEED certified space as of 2004, and lower carbon emissions per capita. This suggests that policy innovators are, in fact, innovative in other capacities and share different motivations for green building policy adoption. These innovator cities are better educated, which is consistent with previous research on diffusion (Rogers, 2003). In addition, these cities do not appear to be responding to a crisis in terms of their own carbon emissions; instead, it is possible that these cities view building energy efficiency as an opportunity to stimulate economic activity and increase competitiveness, key factors in the competition mechanism of diffusion (Porter and van der Linde, 1995). These cities, which include Portland, San Francisco, and Seattle, also tend to have a greater concern for environmental quality and protection, suggesting that green building policies are viewed as an additional tool to protect the natural environment. The “early majority” cities, on the other hand, may be motivated by a fear that carbon reduction requirements may be imposed on them by higher levels of government, and are therefore acting to pre-empt the intervention (the coercion mechanism). Based on interviews with various city building officials, cities that adopt policies later are also looking to the innovators and early adopters and either learning from their policy decisions or trying to emulate those cities to replicate some desirable city characteristics. It should be noted, of course, that when looking at the entire set of U.S. cities, the 41 presented here may all be considered innovators should the pace of green building policy diffusion continue.

When looking at policy structure, innovators and early adopters were more likely to introduce policies that applied only to municipal or publicly-owned buildings and that have both mandatory standards and incentives. Innovators and early adopters were also much more likely to have more restrictive land use regulations (Exhibit 9). The WRLURI is normalized at 0, with positive values indicating higher levels of regulation and negative values representing a less restrictive regulatory environment (Gyourko, Saiz, and Summers, 2008).

Green building policies adopted recently have tended to focus more on privately-owned buildings, in addition to municipal facilities. This transition is consistent with market transformation over the past ten years in green building design and construction. In the infancy of the green building movement in the U.S., cities were reluctant to impose green building mandates on the private sector due to cost premiums associated with more efficient systems, sustainable materials, and greater design integration [for historical cost impacts, see Kats (2003)]. However, as costs have decreased over time due to increased knowledge and demand for green buildings, combined with a greater appreciation of the urgency of climate change mitigation, cities have looked to shape markets by influencing design and investment decisions through policy requirements. This transition can be seen in individual cities through policy amendments over time. For example, the city of Portland, Oregon has revised its green building policies twice since initially adopting a standard for publicly-owned buildings in 2001. In 2005, Portland
instituted a series of incentives for privately-owned buildings that achieved LEED Silver certification. Most recently, in 2009, Portland adopted a “feebate” program for commercial and multi-family residential buildings, and instituted an energy disclosure requirement for existing buildings. These amendments and revisions reflect the policy trajectory of several U.S. cities with respect to green building over the past decade.

**Policy Implications and Conclusions**

Government policies are critical to the expeditious and large-scale deployment of innovative energy-efficient building technologies, materials, and design and construction practices. Green building policies can be used both to create a baseline standard for building energy performance and to encourage new innovations in product and process that can result in greater efficiencies over time. While the potential exists for policies to shift markets toward more sustainable building practices, only a small percentage of cities have adopted robust green building policies. As has been shown here, the cities that have tend to have higher carbon emissions per capita, an environment that encourages innovation, and a sustainability plan in place. Policies of “early adopter” cities focused initially on municipal and city-owned buildings, which allowed the public sector to lead the private markets by increasing awareness and lowering the costs associated with green building practices.

Discerning the mechanism of green building policy diffusion is in many ways more challenging than establishing the determinants of policy adoption. Often, a combination of the four mechanisms presented here—coercion, emulation, competition, and learning—are at work simultaneously. There does not appear to
be evidence to suggest that the coercion mechanism is driving green building policy diffusion, since the presence of a state green building policy did not affect local policy adoption. However, it is possible that cities are anticipating changes to federal regulations that may impact their policies in the future, and therefore pre-empting possible future mandates.7

With respect to the learning mechanism, while cities may be learning about policy options from one another, their managers are not making rational decisions based on policy evaluation studies, since there has been only limited work in this area until recently (Simons, Choi, and Simons, 2009; Choi, 2010; Fuerst, Kontokosta, and McAllister, 2011). Interviews conducted with officials in Chicago and Portland revealed that cities are exchanging ideas on policy structure and development, but there are still information limitations on actual policy impact.

Competition and emulation mechanisms may be more useful in explaining the early stages of green building policy development over the past decade. Those cities earliest to adopt green building policies recognized the importance of environmental responsibility in the built environment and had the means through a higher-income, well-educated, and innovative population to enact policies to encourage and require greater efficiency in buildings. Those cities that followed the earliest adopters (2000 to 2006) may have been driven by a desire to remain competitive, in terms of job creation, infrastructure investment, and environmental impact, with the early adopters (e.g., Boston, Chicago, and Los Angeles following New York City and San Francisco). Likewise, many cities also may have been driven to enact policies to follow the lead of larger cities without necessarily competing with them (e.g., Cleveland, Ohio, Madison, Wisconsin, and Dallas, Texas).

The findings presented here suggest a number of ways to encourage and accelerate the adoption and diffusion of green building policies. First, cities need to understand their carbon footprint. A city that quantifies its carbon emissions can establish baselines that can be used to measure changes over time. A city’s carbon emissions can also be used to benchmark performance against other cities and to create a mechanism for higher levels of government to incentivize or penalize cities based on their relative impact.

Second, cities should develop a sustainability or climate action plan to guide green building policy decision-making. All but five of the cities with a sustainability plan adopted before 2007 currently have a green building policy in place. While most sustainability plans are not enacted into law, they provide an important foundation for understanding the city’s current environmental impact and opportunities and strategies to reduce it. The findings presented here indicate that a sustainability plan is a significant predictor of green building policy adoption.

Third, cities that provide a platform for innovation, measured as the number of patents issued per capita, are more likely to adopt green building policies. This suggests that these cities recognize the potential of sustainable buildings to catalyze innovation in building technology, construction processes, and real estate capital markets. Therefore, creating an urban environment where innovation can occur and thrive is an important component of policy adoption.
Finally, while not discussed in the empirical findings, there is a need for continued communication between cities regarding green building policies. Interviews conducted as part of the development of the GBRD revealed numerous cities, including Portland, Chicago, and Washington DC, learned about and shaped their green building policies based on actions in other cities. Open communication channels between cities and stakeholders can facilitate learning, which will serve to refine green building policy interventions over time.

Several questions remain to be explored. First, it is necessary to determine the optimal mix of incentives and regulations—“carrots and sticks”—that balance efficiency goals with constrained municipal budgets. While regulations raise the baseline level of construction and design standards, they can also raise costs and, in the aggregate, limit new development and constrain innovation. Incentives may encourage developers to pursue more sustainable projects, but they are typically only effective when designed to offset the costs associated with sustainable design and to respond to non-capital costs, such as administrative hurdles and knowledge exchange. Second, the potential exists for regulations to create a market mindset of “teaching to the test,” where developers build to the required standard (e.g., LEED Silver), but have little incentive to exceed the mandate. Regulations may also focus the market too closely on one rating system or set of design criteria, thus incentivizing the attainment of a particular certificate at the cost of encouraging innovative solutions to achieve performance goals. Therefore, the effect of various policy interventions and structures on green building market penetration must be explored.

Endnotes

1 The NY1-Marist Poll reported that approximately two-thirds of registered New York City voters rated Mayor Bloomberg as doing an “excellent” or “good” job in office, from October 2005 to October 2008.

2 San Francisco Building Code 2007, Chapter 13C “Green Building Requirements.”

3 Pittsburgh Code, Title Nine, Zoning Chapter 915.04.F “Sustainable Development Bonuses.”

4 Density bonuses, for example, can be limited due to infrastructure constraints, local community opposition to larger buildings, and a concern for architectural character.

5 For example, cities with any green building standard had lower rates of asthma and adult obesity and residents were more likely to regularly exercise (data provided by the Department of Health and Human Services, Centers for Disease Control and Prevention).

6 No cities in the database are located in Climate Zone 8.

7 Pre-emption of state or federal policies by local regulations typically will only hold when the local policy is more restrictive (Diller, 2007). Of course, cities may pre-empt state and federal policies in an effort to stimulate local market transformation and build regional competitive advantage.

References


The author would like to thank NYU graduate students Stephanie Mendez, Joe Stampone, and Jared Rodriguez for their assistance in data collection.
Explaining LEED Concentration: Effects of Public Policy and Political Party

Authors
Eugene Choi and Norman G. Miller

Abstract
This study investigates the factors that influence the spatial concentration of Leadership in Energy and Environmental Design (LEED) certified buildings in the United States. We examine the effects of green building standards at the state level and compare these to the effects of financial incentives supported by the Energy Policy Act of 2005 on the concentration of LEED certified buildings. We find that political party has a significant effect on LEED concentration as well as economic growth rates. Federal level economic incentives seem to dominate state level requirements for more sustainable buildings that encourage new LEED certification efforts.

The penetration of sustainable “green buildings” into the market is a trend of great interest. Here we will focus on the penetration success of Leadership in Energy and Environmental Design (LEED) certified buildings.1 Green buildings provide two general benefits: (1) more efficiency and productivity for occupants and owners of property and (2) an improved, or at least, less harmed environment for society.

The cost to build to LEED standards has come down to the point that for office properties there is little or no added direct cost to achieve silver certification (from the basic levels of certified, silver, gold, and platinum) as of 2010 (Langdon, 2007; Budny, 2009; and Katz, 2009). For other property types and for office property in less experienced markets,2 some cost premiums may continue and for this reason landlords considering upgrades to LEED Existing Building Operations and Maintenance (EBOM) or considering LEED New Construction (NC) programs may still need convincing that sustainable investments have reasonable payoffs or significant social benefits. With respect to increased efficiency or rent and value differentials, there is a growing body of evidence suggesting positive economic benefits from higher rents to faster absorption, higher occupancy rates, lower operating expenses, higher residual values, as well as greater occupant productivity (e.g., Miller, Spivey, and Florance, 2008; Eichholtz, Kok, and Quigley, 2009, 2011; Fuerst and McAllister, 2009; Miller and Pogue, 2009; Chau, Tse, and Chung, 2010; Pivo, 2010; and Miller, Pogue, Saville, and Tu, 2010).

Some authors have focused on energy and water efficiency (Pan, Yin, and Huang, 2008; Newsham, Mancini, and Birt, 2009; Blengini and Shields, 2010; Chau, Tse, and Chung, 2010), while others have addressed indoor air quality (Paul and Taylor,
or the reduction in toxic wastes generated from human construction (James and Yang, 2005; Blengini and Shields, 2010; Chau, Tse, and Chung, 2010). In the past decades, we have experienced the rapid growth of green buildings in the United States as a percentage of new buildings but it will take many years for green buildings to become mainstream since we typically build no more than about 2% of the stock in any one year or significantly renovate no more than 3%. The U.S. Green Building Council (USGBC) has simulated green building movements in the U.S. and in many countries around the world. The USGBC continues to allow LEED to evolve based on market feedback and has started to make the rating system more localized. Many scholars have documented the economics of green buildings looking for investment justification, yet we have found much variation in terms of sustainable investment around the U.S. There is a paucity of empirical studies to explain the spatial concentration of LEED certified buildings in some cities and states. Although corporate social responsibility and that it may be the ‘right-thing-to-do’ from a societal point of view, the growth rate of green efforts is also subject to mandates and incentives by the federal, state, county, and local governments (Retzlaff, 2009; Choi, 2010).

Local regulations are more able to adapt to the unique water and temperature conditions of the region or to address other environmental concerns such as congestion and pollution (Retzlaff, 2009; Simons, Choi, and Simons, 2009; Choi, 2010). Public sustainability activism is also more likely to affect local and regional policies (Theaker and Cole, 2001; Retzlaff, 2009). To conduct empirical research, however, a small government such as municipality as a unit of analysis is challenging for several reasons. The greatest challenge is the small sample of data as of 2010 by which to do local government research. In addition, it is almost impossible to quantify all the various policy instruments at the municipal level to enumerate their effects on the growth of green buildings when these policies vary significantly by metro market. Therefore, we concluded that a state-based analysis is the most suitable approach to use for a lengthy panel dataset.

This study measures the effect of green building standards (GBS) at the state levels adopted either by executive order or by legislative proceeding on the spatial concentration of LEED certified buildings. In addition, the effects from the Energy Policy Act of 2005 are analyzed in the empirical model since this legislation provided financial incentives that increased private investment in green development. We collected data from CoStar for the top 20 U.S. states based on having the most cumulative LEED certified buildings. Using a 10-year panel approach, we controlled for a number of demand and supply factors shown to be significant in the literature. We also examined the role of the governing party in the empirical models as we have observed very strong opposition to green development requirements by members of the Republican Party. We use the Location Quotient (LQ) of LEED certified buildings, defined below, as a proxy for the spatial concentration of LEED.

The remainder of this paper is organized as follows. In Section 2, we present a literature review focusing on factors that stimulate green building designations, along with hypotheses. In Section 3, we provide justifications of our empirical
framework, and in Section 4 we describe the variables included in our empirical models. In Section 5, we explain our estimation results and significant findings and in Section 6, we summarize and conclude.

Literature Review and Hypotheses

Literature Review

Government policies including regulations and incentives have been pointed out as the main driving force for the spatial concentration of green buildings in the U.S. by previous studies (Retzlaff, 2009; Simons, Choi, and Simons, 2009; Choi, 2010; Qi, Shen, Zeng, and Jorgel, 2010).

We examine the impact of the Energy Policy Act of 2005 (hereafter EPAct 2005) as the federal law signed by President George W. Bush in August 2005. This law contains substantial incentives for the use of renewable energy efficiency for all sectors of energy demand and supply: Section 1331 of this law enacted Section 179D of the Internal Revenue Code and established incentives for energy-efficiency measures in commercial buildings. The intent of Section 1331 is to encourage energy efficiency in commercial buildings through tax incentives. To qualify for the full tax deductions, the energy-efficient property must produce at least 50% energy and power cost savings (Deru and Crawley, 2007). The significance of this law is that higher green design and development costs for new commercial building construction can be offset by such incentives. The major concern about this law, however, is the limited time availability for tax deductions. EPAct 2005 authorized tax deductions for a period of two years starting January 1, 2006 and ending December 31, 2007. However, the Tax Relief and Health Care Act of 2006 extended tax deductions for an additional year (Deru and Crawley, 2007).

At the state level, many state governments have adopted GBS in various forms through executive order or legislation since 2000 as mandates for public facilities. The provisions of state GBS mainly includes mandates for adherence to LEED provisions for new public facilities, and for renovation projects for public facilities (May and Koski, 2007). This kind of public policy aims at influencing the private sectors, especially those wishing to secure public sector tenants. Such policies have been called ‘Leading by Example’ (Simons, Choi, and Simons, 2009). California, for example, adopted GBS through both legislative proceeding and executive order in 2004. GBS in California aims at reduction in grid-based energy usage in favor of renewal generation for state buildings to at least 20% of 2003 levels by 2015; and all new and renovated buildings must achieve a minimum equivalent “Silver” rating on the LEED scale. Ohio, for another example, adopted GBS through executive order in 2007, and it aims at energy use reduction of 15% from fiscal year 2007 as a baseline by fiscal year 2011 in buildings owned or leased by state agencies, boards, and commissions while other requirements vary by building type.9

Exhibit 1 depicts the conceptual model that explains possible effects of public policies on the spatial concentration of green buildings. EPAct 2005 and GBS in
each state have different effects on green building concentration. EPAct 2005 had a direct effect on green building construction in the private sector because it provided tax incentives to developers. On the other hand, GBS has had an indirect effect on private commercial buildings. It includes mandates for public buildings or public tenancies, and boosts diffusion from the public sectors to the private sectors.

There has been modest related empirical study investigating the effects from public policies on the spatial concentration of green buildings. Choi (2010) tested the effects of municipal policies on the number of commercial green buildings including LEED certified buildings and ENERGY STAR labeled buildings at the central city levels. He classified green building policies into regulatory policies and incentive-based policies. Then he divided incentive-based policies into three sub-policies: administrative incentives, financial policies, and technical support. His results indicated that at the municipal level, regulatory policy has been a strong tool to promote green office building developments, as expected, but incentive-based policies have not been very effective. Qi, Shen, Zeng, and Jorgel (2010) tested the effects of regulations on green building designations. They collected data from a questionnaire sent to contractors in the construction industry in China. They found significant relationships between government regulations and business adoption of green construction practices.

Simons, Choi, and Simons (2009) qualitatively explored the effects of public policies on the growth of green commercial office buildings. They searched policies at both the state and city level through various methods, such as website research and interviews with public officials. They found that many local municipalities in California have adopted green building codes that were mandated for public funding of projects. They also noted that some financial incentives were established but phased out quickly when budget concerns were not as predictable as had been hoped. This is not unlike Las Vegas, which initiated enormous property tax breaks for green development and then quickly pulled back when it became apparent that the response would be overwhelming. City Center, an 8 million square foot mixed-use development responded within the window of opportunity and remains one of the largest LEED Gold certified developments in
the U.S. as a result of such incentives. Chicago not only encourages LEED design and green roofs for all new public buildings, but also works with existing building owners and operators to incorporate ENERGY STAR efficiencies in rehabilitation projects. Simons, Choi, and Simons (2009) concluded that the most common form of local public policy is to require LEED certification for all public buildings. Several states call this “Lead by Example” and specify that government buildings and/or school buildings be LEED certified, ENERGY STAR rated, or both. They also pointed out that starting with publicly financed new buildings such as schools is the best way to “Lead by Example” and gain knowledge about the green building process.

Hypotheses

Based on the above understanding and explanation of the potential effects of public policies including GBS, which is a regulation for green building mandates and EPAct 2005, which guarantees financial incentives for commercial developers, the following null hypotheses can be introduced:

Null Hypothesis 1: There is no effect of EPAct 2005 on the spatial concentration of LEED certified buildings. Alternatively, a positive coefficient will suggest an impact on LEED concentration.

Null Hypothesis 2: There is no effect of states’ green building standards on the spatial concentration of LEED certified buildings. Alternatively, a positive sign will suggest that building code regulations matter in the inducement of LEED certified building.

In addition, as May and Koski (2008) argued, the magnitude of effects of GBS can vary based on whether GBS has been adopted by legislative proceeding or adopted by executive order. Therefore, Null Hypothesis 2 is divided into two different null hypotheses:

Null Hypothesis 2-1: There is no effect of GBS adopted by legislative proceeding on the spatial concentration of LEED certified buildings. Alternatively, the state level legislative proceedings do have an effect on LEED concentration.

Null Hypothesis 2-2: There is no effect of GBS adopted by executive order on the spatial concentration of LEED certified buildings. Alternatively, the state level regulation enacted by executive order (governor’s decree) has an effect on LEED concentration.

Other Drivers

In addition to the effect of public policies on the spatial concentration of green buildings, previous literature indicates several other drivers influence green building designations: real estate market conditions, local demand and the role of governors.

Real estate market and investment premiums have affected the decision to go for green building designations. Previous studies on rents or the sales prices of green
buildings are important because rent or sales price premiums for green office buildings indicate that markets can price the benefits of investment in ENERGY STAR and LEED certification (Simons, Choi, and Simons, 2009). In other words, developers or building owners can derive acceptable returns for green investment.

Dermisi (2009) examined the effect of LEED ratings and certification levels on assessed value and market value, while controlling for other internal and external factors. She found that ENERGY STAR designations increase assessed values and market values substantially while the effect of LEED rating/level on assessed and market values can be differentiated based on the level of geographic aggregation. Wiley, Benefield, and Johnson (2010) investigated the relationship between energy-efficient design including both LEED certified buildings and ENERGY STAR labeled buildings and the leasing/sales markets for commercial real estate. Their model considered lease rates and occupancy in simultaneous equilibrium. In their economic model, selling price is determined by both rents and occupancy: therefore the impact of efficient design on commercial sales activities should be distributed through the leasing market. Considering Class A office buildings, they found that “green” buildings achieve superior rents and sustain significantly higher occupancy. Similar results were found by Miller, Spivey, and Florance (2008) and in updates since then.

Local economic condition is used as a proxy of local demand for green buildings, or all buildings for that matter. Healthier economies can afford better quality buildings (Allen and Potiowsky, 2008). Buyers and tenants who consider public perception and those who think “it is the right thing to do” are more likely to act on this social responsibility goal when economies are strong (Simons, Choi, and Simons, 2009). Under this assumption, it is logical that if a local economy is growing, more buildings tend to be green.

May and Koski (2008) point out that while the green-building movement has gained considerable momentum in the past decade, the fact remains that by early 2006 only 15 states had adopted requirements that state facilities be constructed to green building standards. Their theorizing and analyses about state adoption of the requirements point to the actions of governors because governors promote the agenda of their party and the interest groups that support or contribute to the party.

**Hypothesis Summary**

We investigate the impact of the following factors on LEED building concentration with the expected effect:

- The EPAct of 2005 with tax inducements (positive).
- State level green building code requirements (positive).
- State level legislation enacted via support from the general legislative body (positive).
- State level legislation enacted via an executive order (positive).
- The political party of the governor of the state (positive for Democratic Party membership).
Empirical Framework

The primary objective of this study is to determine the effectiveness of EPAct 2005 and state level GBS on the spatial concentration of LEED certified buildings in the U.S. To enumerate the effects of policies on the LEED concentration, we use a 10-year panel of data that allows us to control for unobserved state and year heterogeneity. This is akin to a change-in-changes approach with state and year fixed effects. We control for existing differences among the states as well as exogenous factors, giving us consistent coefficient estimates. We estimate several models of the form:

\[
GREENBLDCONCENT_{it} = \alpha_i + \gamma_t + \delta R_{it} + \tau G_{it} + \theta G^2_{it} + \eta P_{it} + \beta X_{it} + \varepsilon_{it},
\]

where \(GREENBLDCONCENT\) is the LEED concentration enumerated in top 20 U.S. states, \(\alpha_i\) represents state-specific intercept, \(\gamma_t\) represents year fixed effects, \(R_{it}\) is a variable indicating gross rent of newly built offices, \(G_{it}\) is to capture a non-linear relationship between the LEED concentration and the office rent, \(G^2_{it}\) is an economic condition, which is a proxy for local demand measured by Gross Regional Domestic Products (GRDP) in the model, \(P_{it}\) represents a dummy variable indicating governors’ political party in each year. Finally, \(X_{it}\) is a measure of existence of green building policies that are EPAct 2005 or state level GBS.

Data

A Dependent Variable: The Location Quotient of LEED

We use the Location Quotient (LQ) of LEED certified office buildings as a measure of the relative concentration of LEED certified buildings. LQ is an economic analysis technique that measures the extent to which an area is specialized, relative to another area, in the production of a particular product. LQ is defined as the ratio of an industry’s share of the local economy to the industry’s share of the national economy (Klosterman, 1990). In this study, therefore, LQ calculates which U.S. states have a greater share of LEED certified office buildings compared to total office buildings in selected U.S. states. The LQ of LEED certified office buildings in each U.S. state in year \(t\) is obtained from a following function:

\[
LEED_{\text{LQ}} = \frac{LEED_{st}/OFFICE_{st}}{LEED_{nt}/OFFICE_{nt}},
\]

where \(LEED_{\text{LQ}}\) is the LEED concentration enumerated in top 20 U.S. states, \(LEED_{st}\) is the number of LEED certified office buildings in state \(s\) in year \(t\), \(OFFICE_{st}\) is the total number of office buildings in state \(s\) in year \(t\), \(LEED_{nt}\) is the number of LEED certified office buildings in the U.S. in year \(t\), and \(OFFICE_{nt}\) is the total number of office buildings in the U.S. in year \(t\).
where \( LEED_{LQ_{st}} \) is the LQ of LEED certified office buildings in U.S. states\(^{17} \) built in year \( t \), \( LEED_{st} \) is the number of LEED in a U.S. state built in year \( t \), \( LEED_{nt} \) is the number of LEED buildings in 20 U.S. states built in year \( t \), \( OFFICE_{st} \) is the number of office buildings in a U.S. state built in year \( t \), and \( OFFICE_{nt} \) is the number of office buildings in 20 U.S. states built in year \( t \). The LEED LQ allows us to identify share of LEED certified buildings as to total office buildings in 20 states. A LQ greater than 1 indicates the total office buildings with a greater share of LEED certified buildings in a U.S. state than is the case in the total 20 U.S. states. This approach is quite similar to a market penetration approach. Thirteen states have an LQ above 1.0 based on this ratio.

Exhibit 2 depicts a trend of the number of LEED certified office buildings constructed between 2000 and 2009. The data were obtained from CoStar, Inc. and include all known LEED buildings. The number of LEED office construction greatly increased between 2006 and 2007 while LEED NC growth rates decreased after 2008. This trend obviously shows a slowing in the construction of LEED certified buildings as affected by macro economic trends. Exhibit 3 depicts the LEED concentration calculated by the LQ. The overall trend of the LQ has increased since 2000.

Exhibit 4 lists the top 20 U.S. green states for office buildings. The exhibit contains the number of constructed units, the market penetration rates,\(^{18} \) and the LQ between 2000 and 2009. This data was also obtained from CoStar’s database.
In terms of LEED certified office buildings constructed between 2000 and 2009, California was the leading state with 173 LEED buildings, followed by Texas (78), Maryland (48), and Colorado (47). In terms of the market penetration rate, however, California was ranked in eighth place. Oregon was the leading state with approximately 5.85% of the market penetration, followed by Maryland (4.12%), Minnesota (3.68%), and Massachusetts (3.63%). In terms of the LQ, the ranking of the LQ was same as the ranking of the market penetration.

In selected U.S. states, on the average, 35 LEED certified office buildings were constructed between 2000 and 2009 per state, and the average market penetration rate was 1.4%. Among 20 states, 13 states have greater than 1 of the LQ value.

**Independent Variables**

Exhibit 5 lists the independent variables used in this study. To control for market conditions in the real estate market, we include the log natural of the gross rent of office buildings per square foot per year ($LNRENT$). The data were obtained from CoStar. To control for local demand of green buildings, we include the log natural of Gross Regional Domestic Products for all industry ($LNGRDP$), and these data were obtained from U.S. Bureau of Economic Analysis.

Modeling the role of governors is challenging because their roles and attitudes on green building movements cannot be easily enumerated. Thus to control for
### Exhibit 4 | Top 20 Green States

<table>
<thead>
<tr>
<th>State</th>
<th>Frequency</th>
<th>Market Penetration</th>
<th>Location Quotient</th>
</tr>
</thead>
<tbody>
<tr>
<td>California</td>
<td>173</td>
<td>Oregon</td>
<td>Oregon</td>
</tr>
<tr>
<td>Oregon</td>
<td>5.847%</td>
<td>Oregon</td>
<td>3.815</td>
</tr>
<tr>
<td>Maryland</td>
<td>48</td>
<td>Maryland</td>
<td>Maryland</td>
</tr>
<tr>
<td>Massachusetts</td>
<td>3.675%</td>
<td>Minnesota</td>
<td>Minnesota</td>
</tr>
<tr>
<td>Massachusetts</td>
<td>3.631%</td>
<td>Colorado</td>
<td>Colorado</td>
</tr>
<tr>
<td>California</td>
<td>3.417%</td>
<td>Washington</td>
<td>Washington</td>
</tr>
<tr>
<td>Texas</td>
<td>78</td>
<td>Maryland</td>
<td>Maryland</td>
</tr>
<tr>
<td>Minnesota</td>
<td>3.075%</td>
<td>Washington</td>
<td>Wisconsin</td>
</tr>
<tr>
<td>Oregon</td>
<td>3.075%</td>
<td>California</td>
<td>California</td>
</tr>
<tr>
<td>Virginia</td>
<td>2.320%</td>
<td>Michigan</td>
<td>Michigan</td>
</tr>
<tr>
<td>Massachusetts</td>
<td>2.482%</td>
<td>Illinois</td>
<td>Illinois</td>
</tr>
<tr>
<td>Missouri</td>
<td>2.302%</td>
<td>New York</td>
<td>New York</td>
</tr>
<tr>
<td>Michigan</td>
<td>32</td>
<td>Texas</td>
<td>Texas</td>
</tr>
<tr>
<td>Pennsylvania</td>
<td>31</td>
<td>Virginia</td>
<td>Virginia</td>
</tr>
<tr>
<td>Massachusetts</td>
<td>24</td>
<td>Georgia</td>
<td>Georgia</td>
</tr>
<tr>
<td>New Jersey</td>
<td>21</td>
<td>North Carolina</td>
<td>North Carolina</td>
</tr>
<tr>
<td>Arizona</td>
<td>15</td>
<td>Ohio</td>
<td>Ohio</td>
</tr>
<tr>
<td>Arizona</td>
<td>10.05%</td>
<td>Florida</td>
<td>Florida</td>
</tr>
<tr>
<td>Wisconsin</td>
<td>15</td>
<td>Arizona</td>
<td>Arizona</td>
</tr>
<tr>
<td>New Jersey</td>
<td>6</td>
<td>New Jersey</td>
<td>New Jersey</td>
</tr>
<tr>
<td>New Jersey</td>
<td>0.405%</td>
<td>New Jersey</td>
<td>New Jersey</td>
</tr>
<tr>
<td>Average</td>
<td>39.150</td>
<td>2.249%</td>
<td>1.467</td>
</tr>
<tr>
<td>Std. Dev.</td>
<td>35.210</td>
<td>1.415%</td>
<td>0.923</td>
</tr>
</tbody>
</table>

Notes: Market penetration and LQ values are 10 year averaged values. The source is CoStar, Inc.

As mentioned, EPAct 2005 was a temporary law terminated at the end of 2008. Therefore, the years of 2006, 2007, and 2008 for all 20 states were coded by “1” and other years including a year of 2009 were coded by “0.” Each state has governors’ roles in boosting the green building industry, we include a dummy variable indicating the governor’s party in each year in each state. In the model, if a governor is Republican in year of $t$, it is coded as “1” while Democrats are coded as “0.” Our hypothesis is that there should be less green in Republican-dominated states simply because the party has a clear stand on less regulation. On the other hand, we have Arnold Schwarzenegger, of California, an unusual governor who was very pro-environment and still a member of the Republican Party, so any results supporting our hypothesis would be even stronger without the presence and impact of Governor Schwarzenegger.
<table>
<thead>
<tr>
<th>Variable</th>
<th>Descriptions</th>
<th>Sources</th>
<th>Mean</th>
<th>Std. Dev.</th>
</tr>
</thead>
<tbody>
<tr>
<td>RENT</td>
<td>The average gross rent of office buildings newly constructed per SF per year.</td>
<td><a href="http://www.costar.com">www.costar.com</a></td>
<td>22.39</td>
<td>4.36</td>
</tr>
<tr>
<td>PARTY</td>
<td>A dummy variable indicating governors’ party (if Republican, it is 1).</td>
<td>Official websites of each state</td>
<td>0.45</td>
<td>0.50</td>
</tr>
<tr>
<td>EPAct 2005</td>
<td>A dummy variable indicating U.S. states under EPAct 2005 (year 2006, 2007, 2008 are 1).</td>
<td>Environmental Protection Agency</td>
<td>0.40</td>
<td>0.49</td>
</tr>
<tr>
<td>GBS</td>
<td>A dummy variables indicating U.S. states under green building standard (if a state has a green building standard, it is 1).</td>
<td>Database of State Incentives for Renewable &amp; Efficiency</td>
<td>0.39</td>
<td>0.49</td>
</tr>
<tr>
<td>GBS_E</td>
<td>A dummy variable indicating U.S. states under green building standard adopted by executive order.</td>
<td>Database of State Incentives for Renewable &amp; Efficiency</td>
<td>0.16</td>
<td>0.25</td>
</tr>
<tr>
<td>GBS_L</td>
<td>A dummy variable indicating U.S. states under green building standard adopted by legislation.</td>
<td>Database of State Incentives for Renewable &amp; Efficiency</td>
<td>0.25</td>
<td>0.43</td>
</tr>
</tbody>
</table>

Note: RENT and GRDP were included as log forms in the model.
Empirical Findings

To investigate effects of policies on the LEED market concentration, with the LQ as the dependent variable, we exploit a 10-year panel of data to control for unobserved state and year heterogeneity.

Exhibit 6 shows estimation results of Model 1 and Model 2. Model 1 was used to estimate the effects of EPAct 2005 (\textit{EPAct 2005}) and state level GBS (\textit{GBS}) on the LEED concentration and Model 2 was used to compare the magnitude of effects of \textit{GBS}_E and \textit{GBS}_L.

From the estimation results of Model 1, we found that EPAct 2005 has significantly affected the LEED concentration in the top 20 U.S. states since the \textit{EPAct of 2005} was statistically significant at the 0.01 level with a positive sign. On the other hand, we did not find any causal relationship between \textit{GBS} and the LEED concentration from the estimation of Model 1. However, we cannot...
Exhibit 7 | Estimation Results 2 [with lag period]

<table>
<thead>
<tr>
<th>Variables</th>
<th>Model 3</th>
<th></th>
<th>Model 4</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Coeff.</td>
<td>Std. Err.</td>
<td>t-Value</td>
<td>Coeff.</td>
</tr>
<tr>
<td>LNRENT</td>
<td>27.77</td>
<td>18.96</td>
<td>1.46</td>
<td>28.47</td>
</tr>
<tr>
<td>LNRENT$^2$</td>
<td>-3.77</td>
<td>2.94</td>
<td>-1.28</td>
<td>-3.90</td>
</tr>
<tr>
<td>LNGDP</td>
<td>63.49</td>
<td>15.44</td>
<td>4.11***</td>
<td>63.36</td>
</tr>
<tr>
<td>LNGDP$^2$</td>
<td>-2.16</td>
<td>0.56</td>
<td>-3.85***</td>
<td>-2.16</td>
</tr>
<tr>
<td>PARTY</td>
<td>-0.44</td>
<td>0.24</td>
<td>-1.85*</td>
<td>-0.44</td>
</tr>
<tr>
<td>EPAct 2005</td>
<td>1.24</td>
<td>0.34</td>
<td>3.64***</td>
<td>1.24</td>
</tr>
<tr>
<td>GBS</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>GBS$^E$</td>
<td>0.50</td>
<td>0.39</td>
<td>1.29</td>
<td></td>
</tr>
<tr>
<td>GBS$_E$.1</td>
<td>0.59</td>
<td>0.45</td>
<td>1.68*</td>
<td></td>
</tr>
<tr>
<td>GBS$_E$.2</td>
<td>0.67</td>
<td>0.37</td>
<td>1.81*</td>
<td></td>
</tr>
<tr>
<td>GBS$^L$</td>
<td>0.63</td>
<td>0.38</td>
<td>1.66*</td>
<td></td>
</tr>
<tr>
<td>R$^2$</td>
<td>0.69</td>
<td></td>
<td></td>
<td>0.70</td>
</tr>
</tbody>
</table>

Notes: The total sample size is 200 (20 states times 10 years); year and state were fixed in the model. The dependent variable is the change in the concentration index of LEED buildings.

* Significant at the 0.1 level.
** Significant at the 0.05 level.
*** Significant at the 0.01 level.

We conclude that $GBS$ has not affected the LEED concentration at all because the significant effects of $GBS^L$ can be offset by $GBS^E$ or vice versa. According to estimation results of Model 2, we found that if $GBS$ has been adopted by legislative proceeding, it is statistically significant at the 0.1 level with the positive sign, while if $GBS$ has been adopted by executive order, it has no impact on the LEED concentration at all.

Exhibit 7 contains estimation results of Models 3 and 4, which assume one- and two-year lag period, respectively. Under the assumption that the positive effects of $GBS$ adopted by executive order cannot be generated in a very short time period, in Model 3 we assumed a one-year lag for the $GBS$ adopted by executive order. According to estimation from Model 3, it still does not have a significant effect on the LEED concentration. In Model 4, therefore, we assume two-year lag period for $GBS$ adopted by executive order. According to estimation results of Model 4, $GBS$ adopted by executive order was statistically significant at the 0.1 level with a positive sign, meaning it has the greatest effect on the LEED concentration after two years passed from effective year of the order. However, its magnitude on the effects was smaller than EPAct 2005 and $GBS$ adopted by legislative proceeding.

We found several other meaningful results from these estimations. Although Choi (2010) concluded that incentive-based policies have smaller effects than regulatory
policies on green building designations, our findings instead suggest that the incentive-based policy, EPAct 2005, had larger effects than state level GBS. This result reflects that EPAct 2005 provided financial incentives to commercial developers directly while state level GBS does not directly support private investment.

The strongest factor affecting LEED concentration was the local economy since \( \text{LNGDP} \) has larger \( t \)-values in each model based on our estimations. A 1% change of GDP accounts for more than 60 of the LQ value of the LEED certified buildings. However we also found a non-linear relationship between the LEED concentration and GDP because \( \text{LNGDP}^2 \) was statistically significant at the 0.01 level with a negative sign. This result indicates that the increase rates of the LQ decrease by approximately 2%.

A governor’s political party was also a significant factor that affects the LEED concentration. If a governor was a Republican, the state had 0.44 less LQ value than other states governed by Democrats. Interestingly, the strongly significant effects of gross office rents on the LEED concentration were not found here; however, it was statistically significant at approximately the 0.15 level.

**Conclusion**

The main purpose of this study was to measure the effects of EPAct 2005, which provided financial incentives to commercial building developers, and compare these to the effects of state level GBS, which are mandates for public facilities, on the LEED concentration in 20 U.S. states. A 10-year panel of data was exploited to control for unobserved year and state effects. We also examined real estate market conditions, local demand, and the political party of the state governors within several empirical models. We used four different models: Model 1 estimated the effects of EPAct 2005 and state level GBS on the LEED concentration; Model 2 compared the effects of GBS adopted by executive order to the effects of GBS adopted by legislative proceeding; Model 3 assumed one-year lag period for GBS adopted by executive order; and Model 4 assumed two-year lag period for GBS adopted by executive order.

In general, we found a strong effect from EPAct 2005 and GBS adopted by legislative proceeding on the LEED concentration while EPAct 2005 showed a larger magnitude than GBS adopted by legislative proceeding. In addition, if a state adopted GBS through executive order, its effects were not generated immediately. A two-year lag period was predicted to have positive effects of GBS adopted by executive order. Based on our empirical findings local demand based on a more vigorous economy was the strongest factor affecting LEED concentration. The political party of the governor also played a role in green building industry penetration. We found that most sustainable real estate efforts to date are associated with Democratic governors.

Direct financial incentives for commercial developers are important to boosting investment in green buildings. Green buildings may cost more than traditional buildings in some markets and even the perception of higher construction cost,
along with the knowledge barrier of how to go about green building, plays as a powerful role in the decision not to invest in greener buildings. Although EPAct 2005 was terminated at the end of 2008, we recommend that federal, state, and local governments should provide financial incentives if sustainable building is to remain a priority. State level GBS works and if a state wants to spur green building efforts in a shorter time period, the state should adopt GBS through legislative proceeding as opposed to executive orders. Other incentives, such as quicker permitting may not mean much in early 2011 but they will be important as the market demand for new development returns.

**Endnotes**

1. LEED is facilitated by the United States Green Building Council (USGBC). See www.USGBC.org. ENERGY STAR is a joint program of the U.S. Environmental Protection Agency and the U.S. Department of Energy. It is a voluntary labeling program designed to identify and promote energy-efficient products to reduce greenhouse gas emissions. It is another typical label associated with green buildings. There are also green globes and many other certification systems. See Reed, Bilos, Wilkinson, and Schulte (2009) for a comparison.

2. By “less experienced” we mean where few developers, architects, contractors, and vendors are present in the local market. Lack of local experience is highly correlated with higher cost premiums to achieve LEED standards at any level.

3. Based on CoStar data, we build about 2.1% of the office stock each year but certainly lose some buildings as well to obsolescence. We renovate more but as of 2010, EBOM is just slightly ahead of NC rates of increase based on applications at the USGBC.

4. The next LEED rollout will be 2012.

5. It means that green buildings have been voluntarily practiced by building owners, investors, and designers (Retzlaff, 2009; Simons, Choi, and Simons, 2009).

6. We also recognize that in states like Illinois the Chicago market could dominate the data and in California, Los Angeles and San Francisco will represent the highest concentrations. So we do not deny that metros are a major part of the state data shown here and in some cases the state is merely a proxy for the dominant markets or market.

7. Executive order is an order issued by the state governor in our study.

8. GBS adopted by legislative proceeding mean a legislation made by the state council.

9. The tax incentives are in the form of tax deductions of up to $1.80 per square foot for energy-efficiency improvements in the interior lighting, HVAC, hot water, and building envelop.

10. A brief explanation about the case of California and Ohio was summarized from the database of State Incentives for Renewable & Efficiency (www.DSIRE.org).

11. According to Choi (2010), such policies indicate requirements for new and rehabilitated commercial buildings to meet LEED standards or the equivalent.

12. According to Choi (2010), such policies indicate priority in the building permit process, expedited development plan review, and marketing materials.

13. Similar to this are the new federal mandates. As of December 19, 2010 the Government Services Administration (GSA) is required to only acquire LEED Gold buildings if new and over 10,000 square feet or lease at least ENERGY STAR labeled buildings that are
approximately among the top 25% of the EPA benchmark distribution for energy efficiency. Source: James Nobil, GSA, Dec. 21, 2010.

14 In terms of office occupancy rates, Fuerst and McAllister (2009) found similar results. Using hedonic approach, their results suggested that occupancy rates are approximately 8% higher in LEED certified buildings and 3% higher in ENERGY STAR labeled properties. They note, however, that for ENERGY STAR labeled properties, the effects are concentrated in certain market segments.

15 See Miller, Florance, and Spivey (2010).

16 We selected the top 20 U.S. states in terms of newly built LEED buildings between 2000 and 2009, and we use these states as the unit of analysis. We selected these states because of the small number of LEED certified office buildings newly built in each year in other excluded states.

17 The LQ values were used by Cidell and Beata (2009) as a proxy for the LEED concentration.

18 The LQ of LEED certified office buildings was calculated based on 20 top states in terms of the number of LEED certified buildings constructed between 2000 and 2009.

19 The market penetration rates indicate a ratio of LEED certified buildings to total office buildings.

20 If we included Washington DC it would show the highest LQ.


22 This result is interesting because California has bucked this finding. The California Republican Party’s gubernatorial candidate for 2011 stated she would consider placing on hold some of the green mandates should she be elected. A ballot to repeal the measures known as AB32 was rejected in November of 2010.

23 This cost perception is based on surveys by the author at various talks around the U.S. in 2005–2010. When asked of experienced developers and builders who had previously worked on LEED certified projects, the direct marginal cost was always negligible to hit certified or silver levels.

References


Eugene Choi, Korea Institute of Public Administration, Seoul 135-706, Korea or echoi@kipa.re.kr.

Norman G. Miller, University of San Diego, San Diego CA 92110 or nmiller@sandiego.edu.
Valuing Green Home Designs: A Study of ENERGY STAR® Homes

Authors Bryan Bloom, MaryEllen C. Nobe, and Michael D. Nobe

Abstract A number of researchers have attempted to isolate the incremental effect of energy efficiency on home value; however, few studies have benefited from the availability of a comprehensive and continuous indicator of home energy efficiency such as the ENERGY STAR® program. This case study builds on past research by comparing original sale prices between ENERGY STAR qualified homes and non-ENERGY STAR qualified homes in Fort Collins, Colorado. Sale prices were analyzed using hedonic regression analysis. Results indicate that ENERGY STAR homes originally sold for $8.66 more per square foot than non-ENERGY STAR homes.

Homebuyers in the United States play a significant role in reducing fuel consumption and the resulting carbon emissions. “The housing sector provides a number of opportunities to address two urgent national goals—reducing greenhouse gases and U.S. foreign oil dependence,” (Fernald, 2009). Total energy consumption, including both primary energy and renewable energy, in the U.S. residential sector has averaged 18.093 quadrillion Btu between 1980 and 2005 according to the U.S. Energy Information Administration (EIA, 2010). Residential energy consumption was 15.759 quadrillion Btu in 1980; by 2005, it had increased 37% to 21.659 quadrillion Btu (EIA, 2010). In comparison, the commercial sector averaged 14.105 quadrillion Btu and the transportation sector averaged 23.249 quadrillion Btu per year between 1980 and 2005 (EIA, 2010). In 2005, the majority of residential energy consumption was for space and water heating (Elliot, Langer, and Nadel, 2006).

Beyond the impact of residential energy consumption on total U.S. energy consumption, the level of energy efficiency designed into a home also has a direct bearing on homeownership costs. According to the Consumer Expenditure Survey, 34% of homeowners’ average annual expenditures were on housing in 2009 (Bureau of Labor Statistics, 2010). Of the amount spent by homeowners on their housing, 21.5% went to pay for utilities. In comparison, 13% of household annual expenditures were on food and 16% were for transportation costs in 2009. Since housing expenditures comprise such a significant portion of the average household budget, any reduction in operating and maintaining of homes will have direct benefits to homeowners in terms of reducing the overall cost of housing. By choosing to place more value on unseen amenities such as added insulation, infiltration reduction, duct sealing, or high efficiency furnaces versus other more visible amenities (i.e., marble flooring and granite counters), homeowners can realize significant reductions in utility requirements necessary to heat and cool...
their homes (NAPEE, 2011). For example, homes designed and built to ENERGY STAR® standards are at least 15% more energy efficient than homes built to the 2004 International Residential Code, while many are 20%–30% more efficient than standard homes (“Features and Benefits”, n.d.; NAPEE, 2008). The result is both reduced homeownership costs and reductions in U.S. residential energy consumption and carbon emissions (Elliott, Langer, and Nadel, 2006; Fernald, 2009).

Although it is evident that energy-efficient homes can play a significant role in reducing U.S. energy consumption, greenhouse gas emissions, and home ownership expenses, widespread adoption and incorporation of energy-efficient designs and construction practices have been slow. Currently, energy-efficient homes only account for 21% of U.S. new home construction (2009 ENERGY STAR Qualified New Homes, 2010). Researchers have identified numerous reasons for this lack of implementation, including transaction costs, lack of information, uncertainty of energy savings, split incentives, and initial capital investment (Elliott, Langer, and Nadel, 2006; Fuller, 2009). Significant to this study are homebuilders’ perceptions that initial capital investments for increased energy efficiency will not be recaptured through energy savings or capitalization of these investments when the home is sold (Galuppo and Tu, 2010). As long as these perceptions persist among homebuilders, they will remain reluctant to invest in these systems and the residential market will continue to be a significant contributor to U.S. greenhouse gas emissions (Lande, 2008). Ultimately, the value consumers place on energy-efficient residential design either encourages or hinders further incorporation of energy-efficient features into homes (Galuppo and Tu, 2010).

Compounding this issue is the relatively short periods for which U.S. homeowners own their homes. On average, U.S. homeowners tend to sell their home every eight years (Dacquisto, Emrath, Laquatra, and Laitner, 2001; Lande, 2008). Generally, for homeowners to justify additional design and construction costs related to increasing energy efficiency from an economic standpoint, they must believe that they will recoup the added capital investments either through (1) reduced utility bills during the time they own their home, (2) an increased sales price, or (3) some combination thereof (Lande, 2008). Because payback periods for many energy efficient upgrades can easily exceed the duration homeowners typically own their homes, and little evidence exists to give them confidence that these costs will be capitalized into the sales price, many homeowners rationally conclude that added construction costs for increased energy efficiency are not economically justifiable.

Ultimately, homebuyers play a significant role in determining what role the residential sector will play in addressing U.S. energy consumption, greenhouse gas emissions, dependence on foreign oil, and home ownership costs. Through their purchasing behaviors, homebuyers either support or hinder progress within the residential sector in meeting the aforementioned objectives. If homebuyers are not willing to realize the capitalization of increased energy efficiency in the purchase of a home, builders will remain reluctant to include energy-efficient design and strategies in their projects. For energy-efficient building practices to
become more prevalent, it must be established that homebuyers are willing to pay more for energy-efficient homes, which is consistent with basic economic theory (Laquatra, Dacquisto, Emrath, and Laitner, 2002; Lande, 2008).

Incorporation of energy-efficient designs and construction techniques offer have the potential to offer immediate cash-flow benefits on monthly or yearly returns. As a result, buyers should be willing to pay more for homes with lower utility bills in anticipation of savings on future costs of operation, and consequently, sellers should attempt to charge more for homes with energy efficient features Laquatra, Dacquisto, Emrath, and Laitner, 2002). Mandell and Wilhelmsson (2011) found that homeowners are willing to pay for increased energy efficiency. Other studies, however, that have sought to provide empirical evidence that homebuyers are in fact paying more for energy-efficient homes have suffered from the challenges inherent in quantifying energy efficiency in a manner that is recognized in the marketplace (Dacquisto, Emrath, Laquatra, and Laitner, 2001). Homes are complex commodities; finding historical and observable data to support the hypothesis that energy efficiency positively impacts housing values is difficult, especially when numerous other aesthetically-pleasing features exist that presumably take precedence over utility bills. Previous research studies attempting to capture and report the incremental value of energy efficiency have not had the benefit of utilizing a comprehensive measure of home energy efficiency. Not until recently has an assessment tool existed that allows researchers to easily identify which homes are more energy efficient. When the Environmental Protection Agency (EPA) extended its ENERGY STAR rating to homes, it created an easily identifiable metric of residential energy efficiency based on a Home Energy Rating System (HERS) index. The purpose of this study is to extend previous research to approach a more accurate answer to the question of whether or not and to what extent housing markets capitalize the value of energy efficiency using ENERGY STAR labeling.

The research question guiding this study is: Do homes constructed with more energy-efficient building systems, as qualified by the ENERGY STAR labeling program, have higher market values than non-ENERGY STAR qualified homes? If so, how much more are they worth?

Based on this question, the following hypothesis was developed:

\[ H_1: \text{ENERGY STAR rated homes will have higher sales prices than comparable non-ENERGY STAR rated homes in the study area.} \]

Review of Literature

The literature review focuses on prior studies of capitalization of energy efficiency within the residential markets. Although this topic has received considerable attention in the commercial real estate sector (both in the U.S. and internationally), there has been considerably less research relevant to this study conducted in the residential section. In 2001, the EPA sponsored a comprehensive analysis of published research literature titled The Value of Energy Efficiency in Housing:
Review and Analysis of the Literature (Dacquisto, Emrath, Laquatra, and Laitner, 2001). The report presents a review of published research on the capitalization of energy efficiency in housing over a 20-year history. Their report focused primarily on using past applications of hedonic regression analysis and, to a lesser extent, willingness-to-pay surveys to determine if energy efficiency is reflected in home values.

Sopranzetti (2010) explains hedonic regression as an analytical process that allows for the deconstruction of home prices into their component parts to determine how individual components contribute to the overall value. Similarly, Meese and Wallace (1997) define hedonic regression as a way of estimating the value of a complex commodity with a bundle of attributes, such as a house, by modeling the price of that commodity as a function of the particular set of attributes it possesses. Each attribute is valued independently and contributes its individual value to the overall value of the commodity, making it easier to observe the market value of each attribute by itself. For example, appraisers can use hedonic regression to determine the value of house attributes such as structural characteristics (e.g., square footage, number of rooms, number of bathrooms, and known defects), neighborhood characteristics (e.g., quality of the school system and/or neighborhood), or location within a given market (Sopranzetti, 2010). Energy efficiency, the attribute of most interest to this study, can also be identified and included as an analysis component in hedonic regression to determine its contribution to overall home value.

Hedonic Regression Studies

The literature on hedonic house price models reviewed for this study dates back two and a half decades and includes many different methodologies. A summary of studies reviewed is provided in Appendix A. The collective results of these studies (Exhibit 1) indicate varying levels of capitalization of energy efficiency when homes are sold (Nevin and Watson, 1998; Dacquisto, Emrath, Laquatra, and Laitner, 2001); yet, the body of research as a whole suffers from challenges associated with identifying levels of residential energy efficiency. This shortcoming hinders integration of these findings into property appraisals; as a result, homebuilders are reluctant to trust that additional cost for increased energy efficiency design/construction will be capitalized in the future.

Some consistency is evident in the studies among the attributes identified for inclusion in the hedonic regression analysis (see Appendix A for a summary table), although considerable variations are also apparent and worthy of review. While all studies reviewed attempted to control for the various factors contributing to home value, all did so to a different degree. Furthermore, the studies reviewed included a wide range of sample sizes and variables in an effort to best identify the incremental market value of energy efficiency (Laquatra, 2002). An overview of the methodologies utilized in the studies is provided in Appendix B. In total, eight studies were reviewed. All but one were limited to small geographic markets and short periods of time. Sample sizes for these studies ranged from 67 to more than 15,000; the majority of studies had sample sizes between 81 and 505.
### Exhibit 1 | Key Results From Hedonic Studies

<table>
<thead>
<tr>
<th>Reference</th>
<th>Key Findings</th>
<th>R²</th>
</tr>
</thead>
<tbody>
<tr>
<td>Halvorsen (1981)</td>
<td>The 1974 spike in relative cost of fuel oil raised price differential between gas- and oil-heated houses to $761 in 1974, and up to $4,597 in the first half of 1975.</td>
<td>0.75</td>
</tr>
<tr>
<td>Corgel (1982)</td>
<td>Value of energy-efficient homes (with lower structural heat loss) was $3,248 higher than inefficient homes.</td>
<td>0.73</td>
</tr>
<tr>
<td>Johnson (1983)</td>
<td>Home value increased by about $20.73 for every $1 in annual fuel bills.</td>
<td>0.80</td>
</tr>
<tr>
<td>Longstreth (1986)</td>
<td>A one inch increase in wall insulation increased home value by $1.90 per square foot; a one inch increase in ceiling insulation increased home value by $3.37 per square foot; high quality (energy efficient) windows increased home value by $1.63 per square foot.</td>
<td>0.43</td>
</tr>
<tr>
<td>Laquatra (1989)</td>
<td>Home value increased by $2,510 for each one-point decrease in thermal integrity factor.</td>
<td>0.67</td>
</tr>
<tr>
<td>Dinan (1989)</td>
<td>Home value increased by $11.63 per $1 decrease in fuel expenditures needed to maintain a home at 65 degrees F in average heating season.</td>
<td>n/a</td>
</tr>
<tr>
<td>Horowitz (1990)</td>
<td>Home value increased by about $12.52 per $1 decrease in electric bills, consistent with home buyers discounting savings at after-tax mortgage interest rate.</td>
<td>0.86</td>
</tr>
<tr>
<td>Nevin (1998)</td>
<td>Home value increased by about $20 for every $1 reduction in annual fuel bills.</td>
<td>0.41</td>
</tr>
</tbody>
</table>

**Note:** The sources are Nevin and Watson (1996) and Dacquisto, Emrath, Laquatra, and Laitner (2001).

Additionally, some of the samples looked strictly at new or nearly-new homes, some looked only at resale values, and others looked at all sales data within a given marketplace (Dacquisto, Emrath, Laquatra, and Laitner, 2001). Following is an overview of the variables used in each study reviewed.

**Structural Variables.** Structural variables account for the physical characteristics that contribute to home value (Sopranzetti, 2010). All of the studies reviewed included square footage as a structural variable while also controlling for property age to some degree. Additional structural variables most often included in the models were number of bathrooms, lot size, fireplaces, and garages. Only two of the eight studies reviewed account for all of the aforementioned variables. In some cases, the absence of certain variables may be the result of data limitations. Nevertheless, these variables have been found to have significant effects in the other regression analyses; failure to include these variables would compromise internal validity.

**Neighborhood and Locational Variables.** Neighborhood and locational variables represent the locational quality of a property within a community (Sopranzetti, 2010). The handling of neighborhood and locational variables differed significantly across the reviewed studies. These factors are not binary variables; they are not have or have-not items. As a result, it is not easy to quantify them.
on a numerical scale, unlike size and age, making it difficult to measure the impact of their exclusion or mistreatment in a regression study. All but two of the reviewed studies included some degree of locational effects. For example, one study used distance to the central business district, while another used distance to the nearest interstate ramp. In smaller sample sizes with relatively few subdivisions, it may be easier to control for locational effects and more simplified criteria may suffice.

Energy Efficiency Variables. Energy efficiency variables represent different measures of energy conservation resulting from home design/construction. In the studies reviewed, significant differences existed on the approach used to identify energy efficiency. Some treated energy efficiency as a binary variable while others used utility bills as proxies for energy efficiency. For example, in one study energy efficiency was based solely on the type of fuel (natural gas or oil) that was used to heat the house. Another study based energy efficiency on roof temperatures as measured using infrared aerial photographs. All of these studies ignored other contributing factors to home energy efficiency, which is reflective of the difficulty inherent in identifying a single measure of energy efficiency. Because energy efficiency is clearly not a simple either-or phenomenon, it will be difficult to generalize results from studies employing this sort of methodology.

Other studies reviewed by Dacquisto, Emrath, Laquatra, and Laitner (2001) identify energy efficiency as the sum of four attributes: inches of wall insulation, inches of ceiling insulation, presence of storm windows and/or thermopane glass, and presence of wood/vinyl window frames. In these studies, separate coefficients are assigned to represent the implicit price of each of these features. A major limitation of this approach is that information on specific physical features contributing some level of energy efficiency may not be available in many data sets.

One particularly relevant study reviewed by Dacquisto, Emrath, Laquatra, and Laitner (2001) is the Laquatra (1986) study (Appendix B). Laquatra constructed a continuous variable called the “Thermal Integrity Factor” (TIF) to represent varying levels of energy efficiency. TIF assesses the annual heating load as measured in Btu per square foot of heated floor space per heating degree day, although it does not adjust for equipment efficiency, duct and distribution system losses, differences in fuel type, and energy usage for water heating, cooling, and other purposes. All of these deficiencies could result in differences in utility bills for houses with the same TIF and floor area (Dacquisto, Emrath, Laquatra, and Laitner, 2001). Application of this approach is also limited by the ability to obtain the data needed to calculate the TIF variable.

Based on the review of these studies, a minimal level of consistency can be identified with respect to which structural, neighborhood, and locational variables should be included in hedonic regression analysis of home values. Prior measures of energy efficiency, however, vary considerably. It is clear from the studies reviewed that identifying a usable measure of energy efficiency has been problematic. As a result, replication and application of study results have been limited, as evidenced by a general lack of application within the appraisal industry.
The measures of efficiency utilized in these studies were based on information that is simply not easily accessible to appraisers.

**Improving Methodology**

Despite the limitations of research investigating how housing markets capitalize the value of home energy improvements, it still remains consistent with economic theory that such a phenomenon occurs to some degree. Improved methodologies are needed to enable more reliable and implicit conclusions; hedonic regression models seem to be the most effective way of achieving these conclusions (Dacquisto, Emrath, Laquatra, and Laitner, 2001; Sopranzetti, 2010). While each regression study possesses its own set of weaknesses, the ones reviewed here do take significant steps toward employing a reliable analysis. Taken together, all of the models provide a seemingly comprehensive list of explanatory variables that should encourage future studies to include as many of them as possible. The challenge remaining is to incorporate better identifiers of energy efficiency that are also accessible to appraisers.

Since these studies were conducted, better measurements of energy efficiency have become available, such as ENERGY STAR labeling for homes, LEED for Homes, and the National Green Building Standard. Third-party ratings of homes as either green or energy efficient provides a paper trail for appraisers to incorporate into appraisals. This paper trail provides the documentation necessary to support the analysis of a high performance home and measurements of contributory value (Admoatis, 2010).

**Green Home Assessment Tools**

The green building industry has grown substantially in the last few decades. At the same time, several green home assessment tools have entered the residential market, providing consistent assessments of varying levels of energy efficiency and essentially creating a branding for energy-efficient homes that is readily identifiable. Current assessment tools for the residential market include the Environmental Protection Agency’s (EPA) ENERGY STAR rating, the U.S. Green Building Council’s LEED for Homes, and the National Association of Home Builders’ National Green Building Standard. Each of these assessment tools sets forth various criteria to ensure that the homes certified met a minimum level of increased energy efficiency compared with more common building designs and construction practices. While each assessment tool has its strengths and weaknesses, it is not the purpose of this paper to provide an in-depth review of these assessment tools and the comparable levels of energy efficiency between assessments. Rather, the purpose is to access the impact of energy efficiency branding on the ability to isolate increases in home value as a result of increased energy efficiency. Since consumers are likely to be more familiar with the ENERGY STAR rating system, which has been in existence longer than the other two rating systems, this system was chosen for use in this study.

**ENERGY STAR.** In an attempt to reduce the emission of greenhouse gases, the EPA introduced the ENERGY STAR program in 1992. The purpose of this voluntary program was to identify and promote energy-efficient products designed
to reduce greenhouse gas emissions. The ENERGY STAR label was initially listed only on items such as major appliances, office equipment, lighting, and home electronics. It has since expanded to include the construction of new homes, taking on a whole-house approach to measure energy efficiency. To qualify as ENERGY STAR labeled, a home must (a) meet the appropriate Home Energy Rating System (HERS) Index, (b) be verified and field-tested in accordance with the Residential Energy Services Network (RESNET) Standards by a RESNET-accredited provider, and (c) meet all applicable codes (“The Performance Path,” n.d.).

Methodology
A sample of 300 homes in Fort Collins, Colorado were selected to test the research question and related hypothesis guiding this study. The sample consisted of 150 ENERGY STAR qualified homes and 150 non-ENERGY STAR qualified homes. While this sample selection limits the application of the results to a broader population, it is within the range of sample size commonly utilized for similar studies. Sample homes were identified using energy rating data available through E-Star Colorado and the county assessor’s records. For each ENERGY STAR home included in the data set, a comparable home in the surrounding area was identified. To control for the considerable effect of location on home price, comparable homes were identified as close to the ENERGY STAR homes as possible based on address information. Generally comparable homes were at most 2–3 miles from the ENERGY STAR homes. It should be noted that although Fort Collins is a college town, all of the homes included in the study were in newer subdivisions that were located away from the campus community. Further, the study is delimited to single-family detached homes constructed during or after 1999 since newer homes have presumably higher levels of energy efficiency. Delimiting the study to nearly new homes also avoids the challenges of evaluating efficiency across homes of vastly different ages (Adomatis, 2010). Sales for all homes occurred between 1999 and 2005. When selecting comparable properties, it was also important to ensure that these properties were not infarct ENERGY STAR homes. To control for this, the builder name listed in the county assessor’s records was cross-checked with the list of participating ENERGY STAR builders as listed on the ENERGY STAR website.

Data and Analysis
Consistent with related literature on hedonic regression, the regression used in this study contains several independent variables (Exhibit 2). Original sale price per square foot is the dependent variable. The expected relationship between each independent variable and the dependent variable is indicated under the heading Expected Relationship (Exhibit 2). All of the model variables, with the exception of BaseFin, Quality, CovProch, and ENERGYSTAR, are scale variables. Variables appearing with a subscript “d” are considered dummy variables. These variables were measured in binary terms, whether or not a feature is present. For dummy variables, a value of 1 was given if the feature was present and 0 if the feature
### Exhibit 2 | Independent Variables and Expected Sign of Coefficient

<table>
<thead>
<tr>
<th>Variable</th>
<th>Description</th>
<th>Expected Relationship</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age</td>
<td>Age of home in years</td>
<td>−</td>
</tr>
<tr>
<td>TotalSF</td>
<td>Total finished square feet of home</td>
<td>+</td>
</tr>
<tr>
<td>LotSF</td>
<td>Size of lot in square feet</td>
<td>+</td>
</tr>
<tr>
<td>BaseSF</td>
<td>Total basement square feet</td>
<td>+</td>
</tr>
<tr>
<td>BaseFin(_d)</td>
<td>Whether or not home has finished basement</td>
<td>+</td>
</tr>
<tr>
<td>Stories</td>
<td>Number of stories</td>
<td>+ / −</td>
</tr>
<tr>
<td>Bedrooms</td>
<td>Number of bedrooms</td>
<td>+</td>
</tr>
<tr>
<td>Bathrooms</td>
<td>Number of bathrooms</td>
<td>+</td>
</tr>
<tr>
<td>Quality(_d)</td>
<td>Superior quality of construction</td>
<td>+</td>
</tr>
<tr>
<td>CovPorch(_d)</td>
<td>Whether or not home has covered porch</td>
<td>+</td>
</tr>
<tr>
<td>GarageSF</td>
<td>Total garage square feet</td>
<td>+</td>
</tr>
<tr>
<td>ENERGYSTAR(_d)</td>
<td>Whether or not home is ENERGY STAR(^\circ) qualified</td>
<td>+</td>
</tr>
</tbody>
</table>

Note: A subscript \(_d\) represents a dummy variable.

### Exhibit 3 | Regression Coefficients and \(p\)-Values

<table>
<thead>
<tr>
<th>Variable</th>
<th>Coeff.</th>
<th>(p)-Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age</td>
<td>(-3.981^{***})</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>LotSF</td>
<td>0.002***</td>
<td>.001</td>
</tr>
<tr>
<td>TotalSF</td>
<td>(-0.038^{***})</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>BaseSF</td>
<td>0.018***</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>BaseFin(_d)</td>
<td>0.395</td>
<td>.912</td>
</tr>
<tr>
<td>Stories</td>
<td>(-6.594)</td>
<td>.069</td>
</tr>
<tr>
<td>Bedrooms</td>
<td>(-0.065)</td>
<td>.969</td>
</tr>
<tr>
<td>Bathrooms</td>
<td>4.765</td>
<td>.057</td>
</tr>
<tr>
<td>Quality</td>
<td>5.830**</td>
<td>.013</td>
</tr>
<tr>
<td>CovPorch(_d)</td>
<td>(-3.141)</td>
<td>.362</td>
</tr>
<tr>
<td>GarageSF</td>
<td>0.043***</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>ENERGYSTAR(_d)</td>
<td>8.664**</td>
<td>.005</td>
</tr>
<tr>
<td>(R^2)</td>
<td>73.5%</td>
<td></td>
</tr>
</tbody>
</table>

Notes: A subscript \(_d\) represents a dummy variable.

\(^* p < .05\)

\(^{**} p < .01\)

\(^{***} p < .001\)
was absent. The variable Quality is based on the quality indicator included in the county assessor’s records.

Independent variables with a positive Expected Relationship are expected to increase house value as buyers are expected to pay more for houses with these amenities. Age, the only variable with a negative coefficient, is expected to have a negative effect on house value as buyers are expected to pay less for older homes (Exhibit 3). Number of stories does not have a predictable coefficient as the decision to buy a ranch or two-story house is presumably a decision of preference, not superiority. The quality variable is a seemingly subjective judgment of home construction, yet it is expected to be a strong indicator of home value. Quality ratings were provided within the county assessor’s data. Homes could be rated as poor, average, or good. All of the homes in the data set were rated as being either of average or good quality.

Results

The result of the regression analysis for the independent variables identified in Exhibit 2 and the dependent variable sales price was statistically significant at $p < .01$. The $R^2$ value was .735, indicating that 74% of the market valuation variation could be explained by the model. The effect size for the model was large ($r = .857$) and it had good internal reliability as evidenced by a Cronbach’s alpha of .317. The absolute coefficient ($\beta$) values for the independent variables included in the model ranged from a low of 0.018 to a high of 8.664. Independent variables with beta approaching zero essentially have minimal effect on the sales price, while variables with larger beta have a greater impact on sales price.

Almost all of the non-energy coefficients have the expected signs with the exception of TotalSF and Bedrooms; the latter of which is not statistically significant ($p = .969$). The coefficient of the ENERGYSTAR variable was statistically significant at $p < .01$. The beta of the ENERGY STAR variable is 8.664, higher than any other predictor variable.

TotalSF, one variable that would seem to be a strong predictor of home value, had a surprisingly negative coefficient, as well as a significant $p$-value. This may be because TotalSF is strongly correlated with other variables (e.g., LotSF and Quality) and that there might be a diminishing point of return for additional square footage (Nevin and Watson, 1998). Another possible reason for this result is that homebuyers that are more aware of the environmental impact of buildings may place more value on a smaller home that uses less materials and is more energy efficient. Bedrooms did not have a significant effect on sale price, even though this is typically a significant factor in residential pricing. Again, this may be due to inefficiency in recognizing collinearity. Future studies might benefit from considering and testing for collinearity and providing an approach to account for such correlation.

Two important limitations of these results were the exclusion of a location variable and the use of only ENERGY STAR rated homes. The model used in this study
did not address locational effects on home price. The data set used did not include quantifiable information on the market effect of locational variation. Instead, the researchers controlled for locational impacts by identifying comparables homes based proximity to ENERGY STAR certified homes. Had a locational variable been included in the data set, it is expected that the beta for ENERGYSTAR would be lessened but would not change from a positive to a negative relationship. Additionally, it would be expected that a significant amount of collinearity would exist between a locational variable and the ENERGYSTAR variable (and possibility AGE) since all of the homes were located in fairly new neighborhoods. It is recommended that future studies include a locational variable.

Further, employing the ENERGY STAR label and accompanying home energy rating as the determinant and measure of home energy efficiency does not take into account that homes without the ENERGY STAR label may have an equal or greater degree of energy efficiency. The purpose of focusing on ENERGY STAR homes was simplify the identification of energy efficient homes as this was identified as a significant challenge in previous studies. Additionally, identification of energy-efficient homes without third-party certification by either homebuyers or appraisers would require thorough understanding of design and construction strategies by homebuyers (or appraisers) as homes may be marketed as energy efficient when in fact they are not (Adomatis, 2010). Therefore, this study focused only on ENERGY STAR labeled homes. The purpose of this study, however, was to test the impact of third-party certification of home energy efficiency on market prices paid by consumers. In the area where this study was conducted, the results provide further support for added contributory value in the assessment of a certified energy-efficient home.

Conclusion

Although significant awareness exists on the impact of energy consumption by the U.S. residential sector, adoption of energy-efficient residential designs has been slow. Of most concern to homebuilders is the perception that the added costs related to increased energy-efficient design and construction will not be recognized when the home is sold (Galuppo and Tu, 2010). This concern has persisted even though prior studies have provided empirical evidence of consumers who recognize the contributory value of increased energy efficiency. These past studies, however, used measures of energy efficiency that were not easily replicable or recognizable by homebuyers, appraisers, or homebuilders. In recent years, several third-party certifications have become available that can be used to address this shortcoming of prior studies. Third-party certification can be used to document the incorporation of design and construction techniques (Adomatis, 2010). One well-established certification is the EPA’s ENERGY STAR labeling for homes. By incorporating ENERGY STAR certification into a hedonic regression analysis of sales prices for homes in Fort Collins, Colorado, this study provides a much needed update on homebuyers’ willingness to pay for increased energy efficiency.

The model tested in this study and which incorporated ENERGY STAR certification had an $R^2$ of 74%, consistent with the range of $R^2$ values for similar
models (see Exhibit 1), which ranged from a low of 0.41 to a high of 0.86. These results support the hypothesis that ENERGY STAR rated homes will have higher sales prices than comparable non-ENERGY STAR homes in the study area. Results indicate that ENERGY STAR homes originally sold for $8.66 more per square foot than non-ENERGY STAR homes in the study area.

This study provides additional empirical evidence that homebuyers recognize the contributory value of increased energy efficiency. There is also evidence that the use of a third-party certification such as the ENERGY STAR rating system is valued by residential consumers. As similar assessment tools of residential energy efficiency (e.g., USGBC’s LEED for Homes or the NAHB’s National Green Building Standard) become more prevalent, similar cost premiums will be found for those homes as well. Further analysis, however will be needed to verify these predictions across other residential energy assessment tools. As additional studies are conducted, their combined results should strengthen the market for energy-efficient homes that are third-party certified. This, in turn should result in an increased percentage of new homes that are designed and constructed to be more energy efficient and an overall reduction in the energy consumption of the U.S. residential sector.
## Appendix A
### Review of Hedonic Studies

<table>
<thead>
<tr>
<th>Study</th>
<th>Market Area, Time Period, and Types of Homes Included</th>
<th>Sample Size</th>
<th>Age of Homes in Sample</th>
</tr>
</thead>
</table>
## Appendix A (continued)

### Review of Hedonic Studies

<table>
<thead>
<tr>
<th>Study</th>
<th>Market Area, Time Period, and Types of Homes Included</th>
<th>Sample Size</th>
<th>Age of Homes in Sample</th>
</tr>
</thead>
</table>
Std. Dev. = 22 years |

*Note: The source is Dacquisto, Emrath, Laquatra, and Laitner (2001).*
# Appendix B

## Variables Used in Hedonic Studies

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Dependent Variable</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sales Price</td>
<td>Sales Price</td>
<td>Sales Price</td>
<td>Sales Price</td>
<td>Sales Price</td>
<td>Sales Price</td>
<td>Sales Price</td>
<td>Sales Price</td>
<td>Sales Price</td>
</tr>
<tr>
<td>Area (sf)</td>
<td>Util ($ / yr, ending)</td>
<td>Size (sf)</td>
<td>House size (sf)</td>
<td>Lot size (sf)</td>
<td>Floor area (sf)</td>
<td>Heat pump (D)</td>
<td>Unit (sf)</td>
<td>Unit size (sf)</td>
</tr>
<tr>
<td>Age (yrs)</td>
<td>Age (yrs)</td>
<td># of bathrooms</td>
<td># of stories</td>
<td>House age (yrs)</td>
<td># of bedrooms</td>
<td># of bathrooms</td>
<td># of rooms</td>
<td>Heat pump (D)</td>
</tr>
<tr>
<td># of bathrooms</td>
<td># of bathrooms</td>
<td>Ranch (D)</td>
<td>Split foyer (D)</td>
<td>Distances to central business district</td>
<td>Family room (D)</td>
<td>Family room (D)</td>
<td># of rooms</td>
<td>Heat pump (D)</td>
</tr>
<tr>
<td>2-car garage</td>
<td>2-car garage</td>
<td>Circular (D)</td>
<td>Central air conditioning (D)</td>
<td>Pupils per teacher</td>
<td>Central air conditioning (D)</td>
<td>Central air conditioning (D)</td>
<td># of rooms</td>
<td>Heat pump (D)</td>
</tr>
<tr>
<td>2-story (D)</td>
<td>2-story (D)</td>
<td>2-story (D)</td>
<td>2-story (D)</td>
<td>School year</td>
<td>2-story (D)</td>
<td>2-story (D)</td>
<td># of rooms</td>
<td>Heat pump (D)</td>
</tr>
<tr>
<td>Brick (D)</td>
<td>Brick (D)</td>
<td>Brick (D)</td>
<td>Brick (D)</td>
<td>Ceiling insulation</td>
<td>Brick (D)</td>
<td>Brick (D)</td>
<td># of rooms</td>
<td>Heat pump (D)</td>
</tr>
<tr>
<td>Cedar roof (D)</td>
<td>Cedar roof (D)</td>
<td>Cedar roof (D)</td>
<td>Cedar roof (D)</td>
<td>Wall insulation</td>
<td>Cedar roof (D)</td>
<td>Cedar roof (D)</td>
<td># of rooms</td>
<td>Heat pump (D)</td>
</tr>
<tr>
<td>Infra (D)</td>
<td>Infra (D)</td>
<td>Infra (D)</td>
<td>Infra (D)</td>
<td>Wood or vinyl window frames</td>
<td>Wood or vinyl window frames</td>
<td>Wood or vinyl window frames</td>
<td># of rooms</td>
<td>Heat pump (D)</td>
</tr>
<tr>
<td>Note: A second regression with different sample used to estimate electricity use:</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Model</td>
<td>Conservation Standards (D)</td>
<td>Floor area (sf)</td>
<td>Household size</td>
<td>Wood stove (D)</td>
<td>Electric blanket or bed heaters (D)</td>
<td>Electric water for tub / sauna (D)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Occupant Estimated Market Value</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
### Appendix B (continued)

**Variables Used in Hedonic Studies**

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Halvorsen &amp; Pollakowski (1981)</td>
<td>Sale Price</td>
<td>Fuel type used to heat home (natural gas or oil)</td>
<td>sf = square feet</td>
</tr>
<tr>
<td>Corgel, Goebel, &amp; Wade (1982)</td>
<td>Sale Price</td>
<td>Existence of either a cold roof (energy efficient) or a warm roof (not energy efficient)</td>
<td>yrs = years</td>
</tr>
<tr>
<td>Johnson &amp; Kaserman (1983)</td>
<td>Sale Price</td>
<td>Utility bills</td>
<td>D = Dummy, or indicator variable</td>
</tr>
<tr>
<td>Longstreth (1986)</td>
<td>Sale Price / Sf</td>
<td>Inches of insulation, presence of storm windows and/or thermopane glass, presence of wood/vinyl window frames</td>
<td></td>
</tr>
<tr>
<td>Laquatra (1986)</td>
<td>Sale Price</td>
<td>Thermal Integrity Factor = annual heating load for the house, measured in Btu / sf of heated floorspace / heating degree day</td>
<td></td>
</tr>
<tr>
<td>Dinan &amp; Miranowski (1989)</td>
<td>Sale Price</td>
<td>Utility bills / sf</td>
<td></td>
</tr>
<tr>
<td>Horowitz &amp; Haeri (1990)</td>
<td>Sale Price</td>
<td>Construction to meet Model Conservation Standards</td>
<td></td>
</tr>
</tbody>
</table>

The source is Dacquisto, Emrath, Laquatra, and Laitner (2001).

sf = square feet

yrs = years

D = Dummy, or indicator variable
References


The Demand for Green Housing Amenities

Author: Kimberly R. Goodwin

Abstract: Spiking oil prices over the last five years and a heightened awareness of the global warming phenomenon have placed environmentalism and sustainability into the mainstream. Consumers have these concerns in mind when making more of their purchase decisions from what they buy at the grocery store to the kind of car they drive. It only makes sense that these concerns would also factor into the home buying process. This study begins to fill the research void on this topic by examining how important green amenities are in the search for a home to purchase.

Consumers’ concerns about the environment have been increasing for the last few decades and have impacted the marketplace at an increasing rate. They have demanded more environmentally-friendly products like paper and plastic goods made from recycled material, non-toxic cleaning supplies, CFC-free aerosols, and reusable water bottles and shopping bags. In addition, not only concerns about the environmental impact of oil drilling (brought to the media forefront again by the Gulf oil spill in 2010) but also more practical concerns about the limited supply and rising cost of oil and gas are influencing consumer decisions about the type of car they purchase and how much they drive.

Consumers have also begun to take notice of the environmental impact of their homes and started to embrace practices like recycling, temperature control mechanisms, efficient landscaping and water use, and energy-efficient lights and appliances. There are television shows with a theme of green homes and green living. In fact, Discovery Communications launched a cable channel, Planet Green, with environmentalism as the core of its programming mission. You cannot deny that the green revolution has arrived.

It is interesting to note, however, that the segment of the market compelled to purchase environmentally-friendly products has not been easy to pinpoint. Roberts (1996) showed that most findings about the impact of consumers’ demographic characteristics on their environmentally conscious behavior are contradictory but that they do play a significant role. Recent work (Chan, 1999) has concluded that demographics are less important than understanding and individual’s knowledge, values, and attitudes about environmental issues. LaRoche, Bergeron, and Barbaro-Forleo (2001) show that values and behaviors are far better predictors of a willingness to pay for environmentally-friendly products. Yet, some “green” products do attract very distinct segments of the population. For example, a 2007 study by Topline Strategy found that the largest segment of Toyota Prius buyers
were over the age of 50 and had household income over $200,000. In fact, the median buyer of a Prius was 40–45 years old with a household income of $100,000–$150,000 who said the Prius was actually the least expensive car on their shopping list.

While sustainability and “green” homes are becoming more mainstream, research in this area has lagged behind the curve. Part of the reason has been a lack of data availability and another part of the reason has been a difficulty in defining “green” or “sustainable” in the residential market in particular. This study addresses the gap in the literature by investigating how concerns about sustainability and energy costs factor into a home buyer’s search process.

**Literature**

Over the last few years there have been several studies on the topic of green office space. Miller, Spivey, and Florance (2008) and Wiley, Benefield, and Johnson (2010) focused on the demand and pricing of green-labeled office buildings in the United States. Runde and Thoyre (2010) present a Sustainability Valuation Model that incorporates the concepts of sustainability and green building into appraisal. Addae-Dapaah, Hiang, and Sharon (2010) use data from Singapore to analyze the market’s perception of the benefits of green buildings and how those perceptions impact the willingness to occupy or invest in green buildings. Their study found that although respondents were aware of the benefits of green buildings, this awareness had little influence on their choice of commercial building because the benefits are seen as being too remote, uncertain, and unquantifiable.

There is a paucity of research that examines the demand for green in the residential markets. Research in this area has focused on the willingness to pay for broader environmental considerations such as air quality (Smith and Deyak, 1975; Chattopadhyay, 1999; Beron, Murdoch, and Thayer, 2001; and Brasington and Hite, 2005), clean water (Hoehn, Berger, and Blomquist, 1987), or reducing the impact of toxic waste (Kiel and McClain, 1985; Kohlhase, 1991; Nelson, Genereux, and Genereux, 1992; Hite, Chern, Hitzhusen, and Randall, 2001). Further research has included the overall willingness to pay for environmental policies (Longo, Markandy, and Petrucci, 2008; Scarpa and Willis, 2010).

There are a few studies that examine the demand for environmentally-friendly residential property features and the willingness to pay for those amenities. Cameron (1985) analyzed the demand for energy-efficient retrofits such as insulation and storm windows and found a significant sensitivity of demand to changes in investment costs, energy prices, and income. This study, however, does not address some of the more recent energy-efficient amenities. In addition, since the data is now over 15 years old, it may no longer represent the current cultural trend towards sustainability. Two recent studies look at the willingness to pay for green features in residential buildings. Banfi, Farsi, Filippini, and Jakob (2008) use a choice experiment to evaluate consumers’ willingness to pay for air renewal (ventilation) systems and insulation in Swiss residential buildings. Mandell and Wilhelmsson (2011) develop a utility function and perform an empirical hedonic
pricing analysis to determine the willingness of home buyers to pay for environmental attributes of the property in Stockholm. The study finds an overall indifference or willingness to pay for all environmental attributes. Furthermore, households stating that they perceive themselves as environmentally aware have a significantly higher willingness to pay for environmental housing attributes.

While the two studies by Banfi, Farsi, Filippini, and Jakob (2008) and Mandell and Wilhelmsson (2011) make great strides towards gaining an empirical understanding of the demand for green amenities in residential properties, it is not clear whether their findings are descriptive of the U.S. market. It is reasonable to believe that the differences in cultural beliefs and attitudes that exist between Sweden or Switzerland and the U.S. may also lead to very different valuations of green amenities in residential properties. This study adds to the literature by examining the demand for green amenities in residential properties within the U.S. Rather than generating a hedonic pricing model to value these amenities, this study seeks to identify the segment of the market factoring green amenities into their home purchase decision.

Data and Methodology

The data used in this study are from the 2009 NAR Home Buyer and Seller Survey. The survey contained responses from 9,138 survey respondents to 116 questions: some applicable to buyers only, other to sellers only, and both buyers and sellers. One question in the survey asked respondents to rank how important various energy-efficient and environmentally friendly factors were to their home search. The respondents ranked each feature as very important, somewhat important, or not important.

Ordered logit regression is used to analyze the relationship between the importance of green amenities in the respondents’ home search and a variety of identifying characteristics. The ordered logit regression model is appropriate because it allows for two or more ordered response categories of the dependent variable. The generalized regression model is:

\[
IMPORTANCE = \alpha + \beta_1\text{FAMILY} + \beta_2\text{CHILD} + \beta_3\text{AGE} \\
+ \beta_4\text{RACE} + \beta_5\text{ENGLISH} + \beta_6\text{INCOME} \\
+ \beta_7\text{LOC} + \beta_8\text{NEW} + \beta_9\text{FIRST} + \varepsilon, \quad (1)
\]

where \text{FAMILY} is a vector controlling for family status (single, married, etc.), \text{CHILD} is a vector controlling for number of children, \text{AGE} is a vector controlling for the buyer’s age, the vector \text{RACE} controls for race of the respondent, \text{ENGLISH} designates whether or not English is the primary language in the household, \text{INCOME} is a set of variables controlling for annual household income, \text{LOC} is a vector of dummy variables indicating whether the purchase was in a small town,
**Exhibit 1 | Variable Names and Definitions**

<table>
<thead>
<tr>
<th>Variable</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>SINGLEMAN</td>
<td>A dummy variable equal to 1 if the respondent is a single man.</td>
</tr>
<tr>
<td>SINGLEWOMAN</td>
<td>A dummy variable equal to 1 if the respondent is a single woman.</td>
</tr>
<tr>
<td>MARRIED</td>
<td>A dummy variable equal to 1 if the respondent is a married couple.</td>
</tr>
<tr>
<td>UNMARRIED</td>
<td>A dummy variable equal to 1 if the respondent is an unmarried couple.</td>
</tr>
<tr>
<td>CHILD0</td>
<td>A dummy variable equal to 1 if the respondent has no children.</td>
</tr>
<tr>
<td>CHILD1</td>
<td>A dummy variable equal to 1 if the respondent has 1 child.</td>
</tr>
<tr>
<td>CHILD2</td>
<td>A dummy variable equal to 1 if the respondent has 2 children.</td>
</tr>
<tr>
<td>CHILD3MORE</td>
<td>A dummy variable equal to 1 if the respondent has 3 or more children.</td>
</tr>
<tr>
<td>AGEUNDER30</td>
<td>A dummy variable equal to 1 if the respondent is under the age of 30.</td>
</tr>
<tr>
<td>AGEUNDER40</td>
<td>A dummy variable equal to 1 if the respondent is aged 30–39.</td>
</tr>
<tr>
<td>AGE40PLUS</td>
<td>A dummy variable equal to 1 if the respondent is age 40 or above.</td>
</tr>
<tr>
<td>BLACK</td>
<td>A dummy variable equal to 1 if the respondent is Black.</td>
</tr>
<tr>
<td>ASIAN</td>
<td>A dummy variable equal to 1 if the respondent is Asian.</td>
</tr>
<tr>
<td>WHITE</td>
<td>A dummy variable equal to 1 if the respondent is White.</td>
</tr>
<tr>
<td>LATIN</td>
<td>A dummy variable equal to 1 if the respondent is Latino.</td>
</tr>
<tr>
<td>OTHERRACE</td>
<td>A dummy variable equal to 1 if the respondent is any other race.</td>
</tr>
<tr>
<td>ENGLISH</td>
<td>A dummy variable equal to 1 if English is the primary language.</td>
</tr>
<tr>
<td>FIRSTHOME</td>
<td>A dummy variable equal to 1 if the respondent is purchasing a first home.</td>
</tr>
<tr>
<td>UNDER55</td>
<td>A dummy variable equal to 1 if the household income is less than $55,000.</td>
</tr>
<tr>
<td>UNDER100</td>
<td>A dummy variable equal to 1 if the household income is $55,000–$99,999.</td>
</tr>
<tr>
<td>UNDER200</td>
<td>A dummy variable equal to 1 if the household income is $100,000–$199,999.</td>
</tr>
<tr>
<td>OVER200</td>
<td>A dummy variable equal to 1 if the household income is at least $200,000.</td>
</tr>
<tr>
<td>NEWHOME</td>
<td>A dummy variable equal to 1 if the buyer purchased a new construction.</td>
</tr>
<tr>
<td>SMALLTOWN</td>
<td>A dummy variable equal to 1 if the home is in a small town.</td>
</tr>
<tr>
<td>RURAL</td>
<td>A dummy variable equal to 1 if the home is in a rural area.</td>
</tr>
<tr>
<td>URBAN</td>
<td>A dummy variable equal to 1 if the home is in a city/urban area.</td>
</tr>
<tr>
<td>SUBURB</td>
<td>A dummy variable equal to 1 if the home is in a suburb/subdivision.</td>
</tr>
<tr>
<td>RESORT</td>
<td>A dummy variable equal to 1 if the home is in a resort/recreation area.</td>
</tr>
</tbody>
</table>

an urban, rural, or resort area, **NEW** designates whether the buyer purchased a new home rather than an existing home, and **FIRST** designates whether this was a first home purchase. Detailed variable descriptions are included in Exhibit 1.

**Results**

The first question asked respondents “How important were commuting costs when searching for a home to purchase?” The average price per gallon of gas has
Exhibit 2 | Commuting Costs

<table>
<thead>
<tr>
<th>Variable</th>
<th>Coeff.</th>
<th>z-Stat.</th>
</tr>
</thead>
<tbody>
<tr>
<td>FIRSTHOME</td>
<td>0.3342***</td>
<td>6.55</td>
</tr>
<tr>
<td>NEWHOME</td>
<td>−0.1534***</td>
<td>−2.82</td>
</tr>
<tr>
<td>SINGLEWOMAN</td>
<td>0.2288***</td>
<td>3.86</td>
</tr>
<tr>
<td>UNMARRIEDCOUPLE</td>
<td>−0.0294</td>
<td>−0.40</td>
</tr>
<tr>
<td>MARRIEDCOUPLE</td>
<td>0.0676</td>
<td>0.96</td>
</tr>
<tr>
<td>CHILD1</td>
<td>0.0994*</td>
<td>1.78</td>
</tr>
<tr>
<td>CHILD2</td>
<td>0.0236</td>
<td>0.39</td>
</tr>
<tr>
<td>CHILD3MORE</td>
<td>−0.0371</td>
<td>−0.45</td>
</tr>
<tr>
<td>UNDER30</td>
<td>0.2978***</td>
<td>5.13</td>
</tr>
<tr>
<td>UNDER40</td>
<td>0.3882***</td>
<td>7.57</td>
</tr>
<tr>
<td>BLACK</td>
<td>0.0684</td>
<td>0.52</td>
</tr>
<tr>
<td>ASIAN</td>
<td>0.1465</td>
<td>1.12</td>
</tr>
<tr>
<td>WHITE</td>
<td>−0.3732***</td>
<td>−3.71</td>
</tr>
<tr>
<td>OTHERRACE</td>
<td>−0.2798</td>
<td>−1.55</td>
</tr>
<tr>
<td>ENGLISH</td>
<td>−0.3022***</td>
<td>−2.91</td>
</tr>
<tr>
<td>UNDER100</td>
<td>0.0339</td>
<td>0.67</td>
</tr>
<tr>
<td>UNDER200</td>
<td>0.0293</td>
<td>0.49</td>
</tr>
<tr>
<td>OVER200</td>
<td>−0.4084***</td>
<td>−4.10</td>
</tr>
<tr>
<td>RURAL</td>
<td>−0.2273***</td>
<td>−4.03</td>
</tr>
<tr>
<td>URBAN</td>
<td>0.0872</td>
<td>1.51</td>
</tr>
<tr>
<td>SUBURB</td>
<td>−0.1908***</td>
<td>−2.94</td>
</tr>
<tr>
<td>RESORT</td>
<td>−1.3905***</td>
<td>−7.08</td>
</tr>
<tr>
<td>Pseudo R²</td>
<td>0.0263</td>
<td></td>
</tr>
</tbody>
</table>

Notes: Exhibit 2 presents ordered logit regression results from the question: “How important were commuting costs when searching for a home to purchase?” Excluded variables are small town, single man, zero children, age over 40, Latin, and income under $55,000. Exhibit 1 provides variable definitions. There are 8,921 observations.

*Significant at the 10% level.
**Significant at the 5% level.
***Significant at the 1% level.

doubled in the last ten years, and this has resulted in a trend towards hybrid and more fuel-efficient automotive purchases. Commuting costs may also play a part in neighborhood choice as many people start to choose to locate closer to school or work than they would have previously done.

Exhibit 2 presents the ordered logit regression results related to commuting costs. Buyers under the age of 40, those purchasing a first home, those purchasing an existing home, single women, and those having only one child found commuting
costs to be a more important factor in their home search. White home buyers, those for whom English is not their first language, buyers with income over $200,000, and those buying in rural, suburban, or resort locations found commuting costs to be significantly less important to their choice of home.

These results make sense when you break this question down to be less a question about environmentalism and more a choice brought about by financial constraints. The segments of the population most likely to be constrained by an economic downturn coupled with rising commodity prices are also most likely to heavily weight the commuting costs associated with purchasing a home in a given neighborhood. For higher income households, commuting costs are a smaller percentage of their income and thus will not weigh as heavily in their home purchase decision. Those purchasing homes in rural or suburban locations may not have as far to commute as those in urban locations, and thus commuting costs may not be as important as other factors in the decision-making process. This is most evident for home buyers in resort areas, where commuting costs would be least relevant to the purchase decision.

The second question asked buyers “How important were a home’s heating/cooling costs when searching for a home to purchase?” Exhibit 3 reports the ordered logit regression results with respect to the importance of heating and cooling costs. The home’s heating and cooling costs were relatively more important for those purchasing first or new homes, buyers with one child, African Americans, and those purchasing homes in rural or suburban neighborhoods. Heating and cooling costs were less important to buyers under the age of 40, unmarried couples, Whites, and those purchasing homes in resort locations.

As expected, the heating and cooling costs of a home are more important for buyers in rural and suburban locations and less important when buying in a resort area (where the resort area is far more important than the costs of owning the home). It is interesting that those purchasing first homes and new homes are more sensitive to the heating and cooling costs of the property and have a higher expectation of efficiency for these amenities. Similar to the largest market segment for a Prius, home buyers under the age of 40 find a home’s heating and cooling costs to be less important than buyers over the age of 40. Younger buyers with less money to put down on a home may be focused more on short-term affordability, and older buyers putting more money down on a home and expecting to stay in the home longer may be willing to accept higher up-front costs in exchange for long-run savings. While there were no prior expectations set about how race influenced environmental concerns, the results show that Whites find heating and cooling costs significantly less important than Latinos, and African Americans find these costs significantly more important than any other race.

The third question asked buyers “How important were a home’s energy-efficient appliances when searching for a home to purchase?” The Environmental Protection Agency’s ENERGY STAR labeling program started to gain momentum in the early 2000s, and as of 2009 the EPA reported national awareness of the ENERGY STAR program at 75%. Now more than ever, consumers are aware of and demanding energy-efficient appliances. Exhibit 4 presents the ordered logit
regression results with respect to the importance of energy-efficient appliances. In this study, the presence of energy-efficient appliances was more important to those purchasing a first or new home, married couples, and African Americans. Energy-efficient appliances were relatively less important to unmarried couples, buyers under the age of 40, Whites, and those with household income over $100,000.

As with heating and cooling costs, home buyers under the age of 40 find a home’s energy-efficient appliances to be less important than buyers over the age of 40.
Exhibit 4 | Energy-Efficient Appliances

<table>
<thead>
<tr>
<th>Variable</th>
<th>Coeff.</th>
<th>z-Stat.</th>
</tr>
</thead>
<tbody>
<tr>
<td>FIRSTHOME</td>
<td>0.1970***</td>
<td>3.71</td>
</tr>
<tr>
<td>NEWHOME</td>
<td>1.1779***</td>
<td>20.53</td>
</tr>
<tr>
<td>SINGLEWOMAN</td>
<td>0.0701</td>
<td>1.22</td>
</tr>
<tr>
<td>UNMARRIEDCOUPLE</td>
<td>−0.2769***</td>
<td>−3.88</td>
</tr>
<tr>
<td>MARRIEDCOUPLE</td>
<td>0.1408**</td>
<td>2.00</td>
</tr>
<tr>
<td>CHILD1</td>
<td>0.1066*</td>
<td>1.88</td>
</tr>
<tr>
<td>CHILD2</td>
<td>0.0726</td>
<td>1.18</td>
</tr>
<tr>
<td>CHILD3MORE</td>
<td>0.0553</td>
<td>0.65</td>
</tr>
<tr>
<td>UNDER30</td>
<td>−0.3342***</td>
<td>−5.43</td>
</tr>
<tr>
<td>UNDER40</td>
<td>−0.2284***</td>
<td>−4.36</td>
</tr>
<tr>
<td>BLACK</td>
<td>0.3980***</td>
<td>3.14</td>
</tr>
<tr>
<td>ASIAN</td>
<td>0.1174</td>
<td>0.85</td>
</tr>
<tr>
<td>WHITE</td>
<td>−0.2600***</td>
<td>−2.73</td>
</tr>
<tr>
<td>OTHERRACE</td>
<td>0.0608</td>
<td>0.33</td>
</tr>
<tr>
<td>ENGLISH</td>
<td>−0.0421</td>
<td>−0.37</td>
</tr>
<tr>
<td>UNDER100</td>
<td>−0.0790</td>
<td>−1.56</td>
</tr>
<tr>
<td>UNDER200</td>
<td>−0.3143***</td>
<td>−5.21</td>
</tr>
<tr>
<td>OVER200</td>
<td>−0.5674***</td>
<td>−5.80</td>
</tr>
<tr>
<td>RURAL</td>
<td>0.0792</td>
<td>1.38</td>
</tr>
<tr>
<td>URBAN</td>
<td>0.0119</td>
<td>0.21</td>
</tr>
<tr>
<td>SUBURB</td>
<td>0.0511</td>
<td>0.72</td>
</tr>
<tr>
<td>RESORT</td>
<td>−0.0226</td>
<td>−0.11</td>
</tr>
<tr>
<td>Pseudo R²</td>
<td>0.0331</td>
<td></td>
</tr>
</tbody>
</table>

Notes: Exhibit 4 presents ordered logit regression results from the question: “How important were a home’s energy-efficient appliances when searching for a home to purchase?” Excluded variables are small town, single man, zero children, age over 40, Latin, and income under $55,000. Exhibit 1 provides variable definitions.

There are 8,921 observations.

* Significant at the 10% level.
** Significant at the 5% level.
*** Significant at the 1% level.

Those purchasing new and first homes again have a higher expectation that energy-efficient appliances should be included in the home. Buyers with a household income over $100,000 find energy-efficient appliances to be less important in their home search. On the surface, this goes against prior expectations. Perhaps, however, the explanation is that ENERGY STAR has so penetrated the market that these energy-efficient appliances are already being included in any property
The fourth question asked buyers “How important were a home’s energy-efficient lighting when searching for a home to purchase?” What we know now as the ENERGY STAR labeling program actually began in 1991 with the EPA’s Green Lights Program, a partnership program designed to promote efficient lighting systems in commercial and industrial buildings. As a result, energy-efficient lighting has a long history, although residential properties have only become attuned to its cost savings in recent years. Exhibit 5 reports the ordered logit regression results regarding the importance of energy-efficient lighting. The presence of energy-efficient lighting is more important to those purchasing new and first homes, as well as single women and married couples. The presence of energy-efficient lighting is less important to unmarried couples, Whites, buyers under the age of 40, and those with household income over $100,000. The results are nearly identical to the prior question about ENERGY STAR appliances, as would be expected.

The fifth question asked buyers “How important were a home’s landscaping for energy conservation when searching for a home to purchase?” The U.S. Department of Energy reports that on average, landscaping for energy efficiency provides enough energy savings to return an initial investment in less than eight years. They break down energy-efficient landscaping into five categories: climate, microclimate, shading, windbreaks, and water conservation.

Exhibit 6 reports the ordered logit regression results focused on the importance of landscaping for energy conservation. Landscaping is more important for buyers of new and first homes, as well as married couples and those buyers in suburban locations. Landscaping for energy conservation is less important for unmarried couples, buyers under the age of 40, Whites, and those with household income over $100,000.

As with prior responses, buyers of first and new homes are particularly sensitive to a variety of green home amenities, including the property’s landscaping. Also, a similar racial influence appears as in previous questions where Whites find energy-efficient landscaping less important than Latinos, and African Americans find it more important than any other race. Buyers under the age of 40 again find energy-efficient landscaping less important than buyers over the age of 40. As with other green amenities, younger buyers with less money to put down may have a preference for short-term affordability and focus less on the long-run cost savings associated with an investment in energy-efficient landscaping. Last, buyers with household income over $100,000 find energy-efficient landscaping to be less important compared to lower income households. While income was not significant in the question about heating and cooling costs, perhaps therein could lie part of the explanation since buyers with less disposable income may be more sensitive to the reduction in heating/cooling costs and water usage that “green” landscaping can provide.

The last question asked buyers “How important were a home’s green (environmentally friendly) community features when searching for a home to
### Exhibit 5 | Energy-Efficient Lighting

<table>
<thead>
<tr>
<th>Variable</th>
<th>Coeff.</th>
<th>z-Stat.</th>
</tr>
</thead>
<tbody>
<tr>
<td>FIRSTHOME</td>
<td>0.2056***</td>
<td>3.93</td>
</tr>
<tr>
<td>NEWHOME</td>
<td>0.9457***</td>
<td>16.55</td>
</tr>
<tr>
<td>SINGLEWOMAN</td>
<td>0.0955*</td>
<td>1.66</td>
</tr>
<tr>
<td>UNMARRIEDCOUPLE</td>
<td>-0.2514***</td>
<td>-3.53</td>
</tr>
<tr>
<td>MARRIEDCOUPLE</td>
<td>0.1311*</td>
<td>1.82</td>
</tr>
<tr>
<td>CHILD1</td>
<td>0.0733</td>
<td>1.29</td>
</tr>
<tr>
<td>CHILD2</td>
<td>0.0464</td>
<td>0.76</td>
</tr>
<tr>
<td>CHILD3MORE</td>
<td>0.0251</td>
<td>0.30</td>
</tr>
<tr>
<td>UNDER30</td>
<td>-0.2542***</td>
<td>-4.22</td>
</tr>
<tr>
<td>UNDER40</td>
<td>-0.1796***</td>
<td>-3.44</td>
</tr>
<tr>
<td>BLACK</td>
<td>0.1906</td>
<td>1.49</td>
</tr>
<tr>
<td>ASIAN</td>
<td>0.1501</td>
<td>1.12</td>
</tr>
<tr>
<td>WHITE</td>
<td>-0.2991***</td>
<td>-3.27</td>
</tr>
<tr>
<td>OTHERRACE</td>
<td>0.0491</td>
<td>0.30</td>
</tr>
<tr>
<td>ENGLISH</td>
<td>0.0258</td>
<td>0.24</td>
</tr>
<tr>
<td>UNDER100</td>
<td>-0.0287</td>
<td>-0.57</td>
</tr>
<tr>
<td>UNDER200</td>
<td>-0.1818***</td>
<td>-3.05</td>
</tr>
<tr>
<td>OVER200</td>
<td>-0.4143***</td>
<td>-4.13</td>
</tr>
<tr>
<td>RURAL</td>
<td>0.0154</td>
<td>0.27</td>
</tr>
<tr>
<td>URBAN</td>
<td>0.0741</td>
<td>1.34</td>
</tr>
<tr>
<td>SUBURB</td>
<td>0.0473</td>
<td>0.70</td>
</tr>
<tr>
<td>RESORT</td>
<td>0.1871</td>
<td>0.87</td>
</tr>
<tr>
<td>Pseudo R²</td>
<td>0.0222</td>
<td></td>
</tr>
</tbody>
</table>

Notes: Exhibit 5 presents ordered logit regression results from the question: “How important were a home’s efficient use of lighting (e.g., natural light, ENERGY STAR lighting) when searching for a home to purchase?”

Excluded variables are small town, single man, zero children, age over 40, Latin, and income under $55,000. Exhibit 1 provides variable definitions.

There are 8,921 observations.

* Significant at the 10% level.
** Significant at the 5% level.
*** Significant at the 1% level.

In the past few years, many new residential communities have been specifically developed as “green communities.” Each touts its own unique set of environmentally-friendly amenities, among these being proximity to mass transit rail lines, open space set aside as undeveloped property, recycling of construction waste, use of reflective roofing and solar panels, energy-efficient homes
Exhibit 6 | Landscaping for Energy Conservation

<table>
<thead>
<tr>
<th>Variable</th>
<th>Coeff.</th>
<th>z-Stat.</th>
</tr>
</thead>
<tbody>
<tr>
<td>FIRSTHOME</td>
<td>0.1311**</td>
<td>2.44</td>
</tr>
<tr>
<td>NEWHOME</td>
<td>0.4383***</td>
<td>7.73</td>
</tr>
<tr>
<td>SINGLEWOMAN</td>
<td>−0.0032</td>
<td>−0.05</td>
</tr>
<tr>
<td>UNMARRIEDCOUPLE</td>
<td>−0.2441***</td>
<td>−3.33</td>
</tr>
<tr>
<td>MARRIEDCOUPLE</td>
<td>0.1373*</td>
<td>1.91</td>
</tr>
<tr>
<td>CHILD1</td>
<td>0.0905</td>
<td>1.55</td>
</tr>
<tr>
<td>CHILD2</td>
<td>−0.0338</td>
<td>−0.53</td>
</tr>
<tr>
<td>CHILD3MORE</td>
<td>−0.0595</td>
<td>−0.67</td>
</tr>
<tr>
<td>UNDER30</td>
<td>−0.4508***</td>
<td>−7.26</td>
</tr>
<tr>
<td>UNDER40</td>
<td>−0.3132***</td>
<td>−5.79</td>
</tr>
<tr>
<td>BLACK</td>
<td>−0.0339</td>
<td>−0.25</td>
</tr>
<tr>
<td>ASIAN</td>
<td>−0.0034</td>
<td>−0.02</td>
</tr>
<tr>
<td>WHITE</td>
<td>−0.4254***</td>
<td>−4.37</td>
</tr>
<tr>
<td>OTHERRACE</td>
<td>0.1054</td>
<td>0.61</td>
</tr>
<tr>
<td>ENGLISH</td>
<td>−0.0738</td>
<td>−0.67</td>
</tr>
<tr>
<td>UNDER100</td>
<td>−0.0217</td>
<td>−0.42</td>
</tr>
<tr>
<td>UNDER200</td>
<td>−0.1378**</td>
<td>−2.22</td>
</tr>
<tr>
<td>OVER200</td>
<td>−0.3173***</td>
<td>−3.12</td>
</tr>
<tr>
<td>RURAL</td>
<td>−0.0067</td>
<td>−0.11</td>
</tr>
<tr>
<td>URBAN</td>
<td>−0.0436</td>
<td>−0.76</td>
</tr>
<tr>
<td>SUBURB</td>
<td>0.1416**</td>
<td>2.01</td>
</tr>
<tr>
<td>RESORT</td>
<td>0.0709</td>
<td>0.35</td>
</tr>
<tr>
<td>Pseudo R²</td>
<td>0.0129</td>
<td></td>
</tr>
</tbody>
</table>

Notes: Exhibit 6 presents ordered logit regression results from the question: “How important was a home’s landscaping for energy conservation when searching for a home to purchase?” Excluded variables are small town, single man, zero children, age over 40, Latin, and income under $55,000. Exhibit 1 provides variable definitions. There are 8,921 observations. *Significant at the 10% level. **Significant at the 5% level. ***Significant at the 1% level.

(incorporating energy-efficient appliances, lighting, windows, and insulation, as well as non-toxic paint and flooring products), energy-efficient landscaping utilizing recycled and reclaimed water, protected wildlife habitats, and neighborhood trail systems. Other communities are not marketed specifically as green communities but may still contain many of these same environmentally-friendly features.
### Exhibit 7 | Green Community Features

<table>
<thead>
<tr>
<th>Variable</th>
<th>Coeff.</th>
<th>z-Stat.</th>
</tr>
</thead>
<tbody>
<tr>
<td>FIRSTHOME</td>
<td>0.1160**</td>
<td>2.15</td>
</tr>
<tr>
<td>NEWHOME</td>
<td>0.4824***</td>
<td>8.53</td>
</tr>
<tr>
<td>SINGLEWOMAN</td>
<td>0.1132*</td>
<td>1.91</td>
</tr>
<tr>
<td>UNMARRIEDCOUPLE</td>
<td>-0.1810**</td>
<td>-2.48</td>
</tr>
<tr>
<td>MARRIEDCOUPLE</td>
<td>0.1444**</td>
<td>2.01</td>
</tr>
<tr>
<td>CHILD1</td>
<td>-0.0153</td>
<td>-0.26</td>
</tr>
<tr>
<td>CHILD2</td>
<td>-0.1013</td>
<td>-1.59</td>
</tr>
<tr>
<td>CHILD3MORE</td>
<td>-0.1305</td>
<td>-1.48</td>
</tr>
<tr>
<td>UNDER30</td>
<td>-0.3183***</td>
<td>-5.10</td>
</tr>
<tr>
<td>UNDER40</td>
<td>-0.1822***</td>
<td>-3.35</td>
</tr>
<tr>
<td>BLACK</td>
<td>0.2113</td>
<td>1.55</td>
</tr>
<tr>
<td>ASIAN</td>
<td>0.3337**</td>
<td>2.33</td>
</tr>
<tr>
<td>WHITE</td>
<td>-0.3406***</td>
<td>-3.39</td>
</tr>
<tr>
<td>OTHERRACE</td>
<td>0.1005</td>
<td>0.56</td>
</tr>
<tr>
<td>ENGLISH</td>
<td>-0.4521***</td>
<td>-3.74</td>
</tr>
<tr>
<td>UNDER100</td>
<td>-0.0113</td>
<td>-0.22</td>
</tr>
<tr>
<td>UNDER200</td>
<td>-0.1579**</td>
<td>-2.56</td>
</tr>
<tr>
<td>OVER200</td>
<td>-0.1685*</td>
<td>-1.67</td>
</tr>
<tr>
<td>RURAL</td>
<td>0.0606</td>
<td>1.03</td>
</tr>
<tr>
<td>URBAN</td>
<td>0.1422**</td>
<td>2.52</td>
</tr>
<tr>
<td>SUBURB</td>
<td>0.0126</td>
<td>0.18</td>
</tr>
<tr>
<td>RESORT</td>
<td>0.4272**</td>
<td>1.97</td>
</tr>
<tr>
<td>Pseudo R²</td>
<td>0.0163</td>
<td></td>
</tr>
</tbody>
</table>

**Notes:** Exhibit 7 presents ordered logit regression results from the question: "how important was a home’s green (environmentally friendly) community features when searching for a home to purchase?" Excluded variables are small town, single man, zero children, age over 40, Latin, and income under $55,000. Exhibit 1 provides variable definitions. There are 8,921 observations.

*Significant at the 10% level.
**Significant at the 5% level.
***Significant at the 1% level.

Exhibit 7 presents the ordered logit regression results with respect to the importance of green community features in the home purchase decision. Green community features were more important for those purchasing new and first homes, single women and married couples, and buyers purchasing homes in urban or resort locations. The presence of green community features was less important
for buyer under the age of 40, Whites, those who speak English as a first language, unmarried couples, and buyers with a household income over $100,000.

As with all of the prior results, buyers of new and first homes find green community features to be significant in their home search. Buyers under the age of 40 find green community features to be less important than buyers over the age of 40. Those buying homes in resort or urban areas find green community features to be more important in their search, but this may be related to the fact that these features are far more likely to be included with new developments in urban or resort locations. Also, buyers with household income over $100,000 find the presence of green community features to be significantly less important in the home search than those in lower income households.

Conclusion

Three main trends arose from the responses to all of the survey questions about the importance of green home amenities. First, buyers of new homes and first homes find green amenities to be a significantly more important part of their purchase decision than existing homeowners and those buying existing homes. Developers of new homes can capitalize on this by including green amenities in their development plans and highlighting these amenities as part of their marketing strategy. The developers will likely get the added benefit of more capital availability and more favorable terms for the property development due to the fact that the project is considered lower risk. Along those same lines, sellers who have a home for sale that is likely to appeal to the typical first-time home buyer can make their property more attractive by including more or highlighting existing energy-efficient features.

Second, buyers under the age of 40 found green amenities to be significantly less important in their home search compared to buyers over the age of 40. This result, however, should not be interpreted to mean that the younger demographic does not care about environmentalism. Rather, it seems more likely that buyers under the age of 40 may simply be placing a higher emphasis on neighborhood-specific qualities in their home search. These home buyers are at a stage in their lives where they are trying to find a neighborhood where they want to start to build a life in the community and send their children to school. It is also likely that younger home buyers have less money to put down on a home and are more constrained by short-run affordability than older home buyers who are able to accept more up-front costs for green home features that will bring long-run cost savings. In addition, this result is consistent with the market segment for the Toyota Prius. Buyers over the age of 40 are old enough to remember the oil crisis of 1973 and think of those days as they watch oil prices climb. This segment of the population may also be more likely to change their behavior and make a statement by their choice of environmentally-friendly products and green home amenities. Developers and home sellers can learn from this by not making the erroneous assumption that environmentalism is something for the younger generation.
Finally, buyers with household income over $100,000 found green amenities to be significantly less important in their home search process than lower income households. Again, this does not suggest that higher income households do not care about environmental issues or green amenities. There are many explanations for these results. One might be that heating/cooling costs and electricity are a significantly higher percentage of household income for lower income families. Therefore, they may simply be more sensitive to making a home purchase that will keep those bills as low as possible. Since those monthly utility costs are a lower percentage of income for higher income households, those families may not weigh a savings in utility costs to be as important in the home search overall. Alternatively, it is possible that some green amenities such as ENERGY STAR appliances and lighting have so penetrated the market that they are in nearly every home on the shopping list of higher income households.

Sustainability and green housing amenities are becoming more commonplace in the market every year. Yet, there is very little academic research into this area. This study adds to the small body of literature addressing demand and willingness to pay for environmentally-friendly housing features. Almost no research has been published in this area using data from the U.S., and this will be of interest as green housing amenities continue to penetrate the market and attitudes about environmentalism continue to evolve.

**Endnotes**


2 The use of solar energy is now used for more than just generating electricity. Passive solar design is also being implemented as a way to control the heating and cooling processes in a building.

**References**


Kimberly R. Goodwin, University of Southern Mississippi, Hattiesburg, MS 39406 or kimberly.goodwin@usm.edu.
The Role of Dual-pane Windows and Improvement Age in Explaining Residential Property Values

Authors Ramya R. Aroul and J. Andrew Hansz

Abstract There is a modest amount of research on the valuation impact of individual green features such as dual-pane windows. We develop and test a valuation theory for dual-pane windows. The results from a hedonic pricing model indicate a positive and statistically significant direct effect for residential transactions with improvements possessing the dual-pane window feature. However, when a dual-pane window age variable is introduced, the direct effect disappears and is replaced by an interaction effect. The supply of properties with dual-pane windows decreases with property age, which suggests that the valuation impact of the dual-pane window feature increases with property age.

With the depletion of fossil fuel reserves and increases in energy prices, energy efficiency is becoming a more prominent concern in the typical home purchase decision, particularly in regions with climates requiring substantial monthly heating and cooling expenditures. Homebuyers with differing utility functions for energy cost savings create demand for a wide array of energy-efficient options in the marketplace. In the spectrum of energy-efficient investment alternatives, insulation, weather-stripping, and dual-pane windows provide energy cost savings with relatively short payback periods, as compared to more capital intensive improvements such as solar heating (The Center for Resource Conservation, 2011). As a result, homeowners who recognize energy cost saving opportunities have upgraded their residential properties to reduce their utility bills and state and local governments have encouraged energy consumption conscious construction with efficiency requirements in municipal building codes. For example, in California, building code legislation, referred to as Title 24, has an article prescribing energy efficiency standards for new construction.

Providing further incentive, the federal government, some state and local governments, and utility companies sponsor income tax credits and rebate programs for energy efficiency improvements in residential properties. The American Recovery and Reinvestment Act (ARRA) is making the more mundane elements of residential energy efficiency improvements a national investment priority with $5 billion in funding (Committee on Appropriations, 2009).

Historically, homebuilders and brokers, who are in positions to promote and influence buyer opinions on home features, have reported difficulty in capitalizing on upgraded energy-efficient building features, particularly from price sensitive
buyers. More recently, investment in energy-efficient improvements are more attractive to residential buyers due to rising energy prices, increasing energy efficiency awareness, government income tax credits, and utility company rebates. As evidence of this consumer demand, homebuilders are now commonly including energy-efficient components as standard features, rather than options, which are emphasized in advertising campaigns; brokers are featuring green building components prominently in marketing materials.

In particular, dual-pane windows are an important feature among energy-efficient investment alternatives. Dual-pane windows provide heat transfer reduction, ultraviolet radiation protection, and noise reduction benefits over traditional single-pane windows and homeowners with dual-pane windows anticipate significant utility cost savings over single-pane windows. Despite these recognized benefits, there are no published studies that investigate the market’s recognition of the dual-pane window investment in residential property transaction prices.

In this study we are concerned with the valuation impact of dual-pane windows by asking: Is investment in dual-pane windows reflected in residential property values? With a relatively low cost to builders during construction,1 dual-pane windows have become the market standard in the new construction market. As compared to new construction, removal of old windows and installation of replacement dual-pane windows is relatively more expensive in existing improvements but utility savings and an increase in property value may offset this expense. Furthermore, the supply of properties with the dual-pane window feature diminishes with improvement age and dual-pane window investment can differentiate older properties from the housing stock of a similar vintage. Therefore, we anticipate that the valuation impact of dual-pane windows will vary between older and newer houses and we consider the relationship between dual-pane windows and improvement age with a second question: Is dual-pane window value associated with improvement age?

Our first model of residential transaction prices demonstrates a direct effect with a significant price allocation to the dual-pane window feature. In a second specification with both the direct and interaction effects, we find that the dual-pane window-age relationship is superior in modeling residential transaction prices and the direct effect is no longer statistically significant. These findings are intuitively appealing, as dual-pane windows are an expected feature by newer home consumers where dual-pane windows in older properties are relatively unique, differentiating these improvements from the existing housing stock of a similar vintage without dual-pane windows. These findings are important as this study documents market recognition of investment in an energy-efficient (green) feature (dual-pane windows), particularly with respect to older housing stock. Public and private investment in energy-efficient housing features, at least dual-pane windows, not only reduce energy consumption and utility cost, this investment may also add value to the housing stock.

The next sections provide a brief background on the window, followed by a review of extant literature and theory and hypothesis sections. Next, we present an overview of the setting and sample data, research method, and results. The paper closes with a discussion of the results and concluding remarks.
**Background**

Dual-pane windows are almost a half-century-old technology but the history of the window can be traced back to primitive holes in prehistoric cave roofs and walls. By the seventeenth century, glass pane windows were common in ordinary English homes and this construction practice was adopted by the North American colonies. By the 1950s, a well-developed American window industry produced a variety of window types ranging from pressure sealed double hung to utility windows. However, energy efficiency was not a priority in window designs and, in terms of heat transfer, these windows were not substantial improvements over early covered wall holes. It was not until the 1970s when the quieter and more energy-efficient double or dual-pane window became popular.

Also, with the Organization of Petroleum Exporting Countries (OPEC) Energy Crisis of the 1970s, the government sector started to encourage energy conservation through a variety of means including building codes. In California, the state building code requirements are commonly referred to as ‘Title 24’ of the California Energy Code. Title 24 was established in 1978 with the objective of reducing California’s energy consumption.

The dual-pane window creates a space between glass panes to provide insulation and energy efficiency properties. Insulated glazing and plastic films, referred to having “low-E” properties, provided the insulating properties of dual-pane windows. By reflecting ultraviolet and infrared radiation, low emissivity protection helps to keep heat inside during the winter and heat outside in the summer. Although single pane is standard in some markets today, dual pane is the market standard due to new construction and an active replacement window industry. Although not widely used at this time, triple- and quadruple-pane technologies are available.

**Literature Review**

The majority of the available research pertaining to the valuation of green real estate improvements focuses on commercial buildings. The findings from this research demonstrates initial evidence of rental and sale price premiums for green commercial buildings, defined as improvements with the ENERGY STAR designation and/or LEED certification (Miller, Spivey, and Florance, 2008; Fuerst and McAllister, 2009, 2011; Eichholtz, Kok, and Quigley, 2010; Wiley, Benefield, and Johnson, 2010). Despite the national interest in residential energy efficiency, a comparatively limited amount of research exists in residential markets.

In the residential market, Aroul and Hansz (2012) find evidence of price premiums for general green improvements in residential transaction prices and find a stronger price premium associated with green development in Frisco, Texas, the nation’s first municipality to implement a mandatory residential green building program. Costa and Kahn (2009) investigate energy-efficient investment by homeowners. Set in Sacramento, California and using residential transaction prices from 2003
to 2009, they find energy-efficient homes sell at a premium. Brounen and Kok (2011) present a hedonic study documenting the capitalization of residential energy efficiency in Dutch houses and find that homes with green certification labels sell at a premium.

A few studies address consumers’ valuations of specific energy-saving measures in residential buildings. Cameron (1985) analyzes the impact of energy efficiency retrofitting such as insulation and storm windows using a two-level nested logit model. Dinan and Miranowski (1989) use a hedonic price model to examine the impact of energy efficiency improvements on housing prices and find that these improvements are capitalized into residential transaction prices. Sadler (2003) investigates the attributes and preferences of residential consumer decision making and finds a strong preference for energy-efficient renovations. Consumers consider initial capital costs, annual heating/cooling costs, and comfort from energy-efficient features as important factors in energy-efficient investment decisions. Kwak, Yoo, and Kwak (2010) applies a choice experiment and find a high consumer willingness to pay for energy-saving measures (heating and cooling) in Korean residential buildings. Dastrup, Zivin, Costa, and Kahn (2010) use a large sample of San Diego single-family dwelling transactions to provide some of the first resale value pricing effects of residential solar panel investment. Using both hedonic and repeat sale index methods, they find that solar panel investment generates a price premium. Bollinger and Gillingham (2010) and Dastrup (2010) focus on the diffusion of solar panels across communities.

Due to increasing energy prices, utility cost savings, and general environmental awareness and sensitivity, investment in energy-efficient features has become important (Ciochetti and McGowan, 2010). With many potential residential green features, investment in energy-efficient dual-pane windows is a priority for many homeowners. However, research on the valuation impact of the dual-pane window feature does not exist. This study addresses this literature gap by examining and quantifying the market’s response to one of the most important and widely implemented residential green property features, dual-pane windows.

Theory and Hypotheses

Financially feasible green investment by consumers results in savings through reduced monthly utility costs that cover higher monthly mortgage payments needed to finance the initial investment in these energy-efficient features. Aroul and Hansz (2012) extend the theoretical framework of Fuerst and McAllister (2009) to develop an expected response of green improvements in residential real estate markets. In this study, we use this framework to explain the relationship between residential transaction prices and one of the most common residential green features, dual-pane windows.

Exhibit 1 diagrams the anticipated pricing response in residential real estate markets to dual-pane window investment. The demand for single-pane and dual-pane windows is given by $D_{SP}$ and $D_{DP}$ and the supply for single pane and dual-pane windows are given by $S_{SP}$ and $S_{DP}$. Assuming that single-pane and dual-pane
windows are almost perfect substitutes, an increase in the demand of dual-pane windows will result in a decrease in demand for single-pane windows. The demand increase for dual-pane windows will produce a price increase from $P_{SP}$ to $P_{DP}$ and short run supply inelasticity results in a premium $(P_{DP} - P_{SP})$ for properties with dual-pane windows.³ This relationship leads to our first research expectation that dual-pane windows will increase residential transaction prices.

Dual-pane windows, as a standard building feature in many markets today, are a relatively new construction practice and the supply of properties with this feature in the housing stock decreases as improvement age increases. Therefore, the value impact attributed to dual-pane windows could change with property age. Exhibit 1 graphically depicts the differences between improvements with and without dual-pane windows, all else being equal including the age. Exhibit 2 displays the shifts in the supply of dual-pane windows for residential improvements of various vintages. $S_{\text{Mean}}$ is the supply of houses with dual-pane windows for improvements at the mean age; $S_1$ is the supply of houses with dual-pane windows for improvements at ages less than the mean age (i.e., newer properties); and $S_2$ is
Exhibit 2 | Model of Price Premiums for Dual-Pane Windows with Varying Property Age

\[ P = \text{Price} \quad Q = \text{Quantity} \]

Note: \( D \) denotes the demand for dual-pane windows. \( S_{\text{Mean}} \) denotes the supply for dual-pane windows for properties with mean age. \( S_{1} \) and \( S_{\text{new}} \) denote the supply for dual-pane windows for properties with age lesser than mean. \( S_{\text{new}} \) is the supply for houses with zero age (i.e., newly constructed houses). An increase in supply for dual-pane windows in the newer houses will cause price to drop from \( P_{\text{Mean}} \) to \( P_{1} \) and \( P_{\text{new}} \). \( S_{2} \) and \( S_{\text{old}} \) denote the supply for dual-pane windows for properties with age greater than mean. \( S_{\text{old}} \) is the supply for oldest houses. A decrease in supply for dual-pane windows in the older houses will cause price to increase from \( P_{\text{Mean}} \) to \( P_{2} \) and \( P_{\text{old}} \).
the supply of houses with dual-pane windows for improvements at ages greater than the mean age (i.e., older properties).

Since the dual-pane window feature is becoming standard in newly constructed improvements, $S_1$ shifts to the right. This reduces a dual-pane window premium from $P_{\text{Mean}}$ to $P_1$. Conversely, the supply of improvements with dual-pane windows, original or replacement, in older improvement is relatively scarce and this special feature helps to differentiate these properties from the existing housing stock of a similar vintage. This shifts the $S_2$ supply curve to the left of $S_{\text{Mean}}$, resulting in a price increase from $P_{\text{Mean}}$ to $P_2$. As a result, we anticipate dual-pane window price premiums for older properties will be greatest since the supply of improvements with this feature diminishes with improvement age. Buyers seeking older improvements may pay premiums for these relatively scarce properties and this feature will represent a greater share of overall transaction prices.

### Setting and Sample Data

The study setting is Clovis, California in the San Joaquin Valley. Clovis has a population of around 95,000 and a total area of 23.02 square miles. This city is situated almost equal distance between Los Angeles and San Francisco and is adjacent to Fresno. Incorporated in 1912, Clovis is known as the “Gateway to the Sierras,” as it lies near the foothills of the Sierra Nevada Mountains. The major industry in the region is agriculture and agriculture-related businesses.

The subprime mortgage crisis starting in 2007 hit Central California, including the City of Clovis, very hard. As a result, declining property values and high levels of vacant and distressed properties characterized the market conditions during the sample period.

The weather in this area is conducive to studying the valuation effects of dual-pane windows. The hottest month of the year is July, with an average high of 97°F and a highest recorded temperature of 115°F. The coolest month is December, with an average low of 37°F and a lowest recorded temperature of 17°F. This climate is ideal for our study because this area experiences significant fluctuations in high and low temperatures but not so extreme to prevent the exclusion of windows in residential building designs. As opposed to some more temperate climates, residential homeowners can realize significant energy cost savings through dual-pane windows and homeowners have responded with significant investment in dual-pane windows.

The sample data consists of 3,704 brokered single-family residential sale transactions from January 1, 2008 to December 31, 2010 and collected from a local multiple listing service. This sample period is characterized by declining residential property values. A two-year period is an appropriate balance between sample size and empirical control for changing market trend and fluctuations. Exhibit 3 defines the model variables and Exhibit 4 provides descriptive statistics and a priori expectations for each control variable.

Almost 40% of the sample data consists of improvements with dual-pane windows. Some other green property features such as solar equipment (only 2%
## Exhibit 3 | Variable Descriptions

<table>
<thead>
<tr>
<th>Variable</th>
<th>Description</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>ln(salesprice)</td>
<td>Logarithm of sales price.</td>
<td>—</td>
</tr>
<tr>
<td>Dualpane</td>
<td>Equals 1 if dual-pane windows.</td>
<td>Positive</td>
</tr>
<tr>
<td>Dualpane_age</td>
<td>Interaction between age and dual-pane windows.</td>
<td>Positive</td>
</tr>
<tr>
<td>Lnsqft</td>
<td>Logarithm of square footage.</td>
<td>Positive</td>
</tr>
<tr>
<td>Age</td>
<td>Age of the property in years.</td>
<td>Negative</td>
</tr>
<tr>
<td>Agesq</td>
<td>Square of age</td>
<td>Positive</td>
</tr>
<tr>
<td>Bedrooms</td>
<td>Number of bedrooms.</td>
<td>Negative</td>
</tr>
<tr>
<td>Fireplaces</td>
<td>Number of fireplaces.</td>
<td>Positive</td>
</tr>
<tr>
<td>Story</td>
<td>Equals one if two storied.</td>
<td>Negative</td>
</tr>
<tr>
<td>Bathrooms</td>
<td>Number of bathrooms.</td>
<td>Positive</td>
</tr>
<tr>
<td>Vacant</td>
<td>Equals one if house is vacant.</td>
<td>Negative</td>
</tr>
<tr>
<td>Pool</td>
<td>Equals one if property has pool.</td>
<td>Positive</td>
</tr>
<tr>
<td>Spa</td>
<td>Equals one if property has spa.</td>
<td>Positive</td>
</tr>
<tr>
<td>Cash</td>
<td>Equals one if it is a cash transaction.</td>
<td>Negative</td>
</tr>
<tr>
<td>Tax Credit</td>
<td>Dummy variable for federal tax incentives.</td>
<td>Tax Control</td>
</tr>
<tr>
<td>Title24_2008</td>
<td>Dummy variable for Title 24 2008 revision.</td>
<td>Policy Control</td>
</tr>
<tr>
<td>Title24_2005</td>
<td>Dummy variable for Title 24 2005 revision.</td>
<td>Policy Control</td>
</tr>
<tr>
<td>Title24_2001</td>
<td>Dummy variable for Title 24 2001 revision.</td>
<td>Policy Control</td>
</tr>
<tr>
<td>Title24_1998</td>
<td>Dummy variable for Title 24 1998 revision.</td>
<td>Policy Control</td>
</tr>
<tr>
<td>Title24_1995</td>
<td>Dummy variable for Title 24 1995 revision.</td>
<td>Policy Control</td>
</tr>
<tr>
<td>Title24_1992</td>
<td>Dummy variable for Title 24 1992 revision.</td>
<td>Policy Control</td>
</tr>
<tr>
<td>Title24_1988</td>
<td>Dummy variable for Title 24 1988 revision.</td>
<td>Policy Control</td>
</tr>
<tr>
<td>Title24_1987</td>
<td>Dummy variable for Title 24 1987 revision.</td>
<td>Policy Control</td>
</tr>
<tr>
<td>Title24_1986</td>
<td>Dummy variable for Title 24 1986 revision.</td>
<td>Policy Control</td>
</tr>
<tr>
<td>Title24_1984</td>
<td>Dummy variable for Title 24 1984 revision.</td>
<td>Policy Control</td>
</tr>
<tr>
<td>Title24_1982</td>
<td>Dummy variable for Title 24 1982 revision.</td>
<td>Policy Control</td>
</tr>
<tr>
<td>Title24_1980</td>
<td>Dummy variable for Title 24 1980 revision.</td>
<td>Policy Control</td>
</tr>
<tr>
<td>Title24_1978</td>
<td>Dummy variable for Title 24 enactment.</td>
<td>Policy Control</td>
</tr>
<tr>
<td>Longitude</td>
<td>Longitude of the property.</td>
<td>Location Control</td>
</tr>
<tr>
<td>Latitude</td>
<td>Latitude of the property.</td>
<td>Location Control</td>
</tr>
<tr>
<td>ZIP_93611</td>
<td>Equals one if ZIP Code is 93611.</td>
<td>Location Control</td>
</tr>
<tr>
<td>ZIP_93612</td>
<td>Equals one if ZIP Code is 93612.</td>
<td>Location Control</td>
</tr>
<tr>
<td>ZIP_93619</td>
<td>Equals one if ZIP Code is 93619.</td>
<td>Location Control</td>
</tr>
<tr>
<td>Y2008</td>
<td>Equals one if year is 2008.</td>
<td>Year Control</td>
</tr>
<tr>
<td>Y2009</td>
<td>Equals one if year is 2009.</td>
<td>Year Control</td>
</tr>
<tr>
<td>Y2010</td>
<td>Equals one if year is 2010.</td>
<td>Year Control</td>
</tr>
</tbody>
</table>
Exhibit 3 | (continued)
Variable Descriptions

<table>
<thead>
<tr>
<th>Variable</th>
<th>Description</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Q1</td>
<td>Equals one if quarter 1.</td>
<td>Seasonality Control</td>
</tr>
<tr>
<td>Q2</td>
<td>Equals one if quarter 2.</td>
<td>Seasonality Control</td>
</tr>
<tr>
<td>Q3</td>
<td>Equals one if quarter 3.</td>
<td>Seasonality Control</td>
</tr>
<tr>
<td>Q4</td>
<td>Equals one if quarter 4.</td>
<td>Seasonality Control</td>
</tr>
</tbody>
</table>

of all transactions) and 13+ SEER ratings (only 0.5% of all transactions) are identified in the raw data. However, green features other than dual-pane windows are relatively scarce and, therefore, it is inappropriate to create unique variables for features that represent such a small portion of the sample. However, to focus on the pure influences of dual-pane windows on transaction prices, we code this variable carefully. For the dual-pane variable, we do not include transactions that indicate a green feature beyond the dual-pane window feature. For example, a transaction with solar panels or 13+ SEER rating and dual-pane windows is not included in the pure dual-pane indicator variable. The purpose of this precaution is to keep the variable of interest pure and to isolate the pricing impact of the dual-pane window feature.

The Energy Efficiency Standards for Residential and Nonresidential Buildings popularly known as the Title 24 Energy Efficiency Standards were implemented as a legislative mandate in 1978 as a measure to reduce the energy use of people in California. The standards are updated periodically to allow for possible integration of new energy efficiency technologies and methods.

The latest, 2008, Standards went into effect on January, 1, 2010 and supersede the 2005 Standards. There are two methods to comply with Title 24: the prescriptive approach and the performance approach. The prescriptive approach allows each individual building structure to meet prescribed minimum energy efficiency standards required at the time. The performance-based approach is a more detailed accounting of energy use and uses computer programs to arrive at a flexible Title 24 abiding design (Title 24 Express, 2011). In both these methods, dual-pane windows are not explicitly stated as a requirement. However, in the 2008 revision, the U-factor and Solar Heat Gain Coefficient (SHGC) requirements have been increased, making the baseline standard for windows in the prescriptive package to be dual-pane/vinyl window with Low-E, spectrally selective coating (California Legislative Coalition for Interior Design, 2010).

Exhibit 5 shows the year of enactment and revisions of Title 24, along with the number of properties in the current sample that comply with the corresponding Title 24 guidelines. We include dummy variables for all the Title 24 revisions to control for the effect of Title 24 on the choice of dual-pane windows as an energy efficiency feature.4
### Exhibit 4 | Descriptive Statistics

<table>
<thead>
<tr>
<th>Variable</th>
<th>Mean</th>
<th>Std. Dev.</th>
<th>Min.</th>
<th>Max.</th>
</tr>
</thead>
<tbody>
<tr>
<td>( \ln(\text{salesprice}) )</td>
<td>12.41</td>
<td>0.44</td>
<td>9.05</td>
<td>14.65</td>
</tr>
<tr>
<td>\text{Dualpane}</td>
<td>0.39</td>
<td>0.49</td>
<td>0.00</td>
<td>1.00</td>
</tr>
<tr>
<td>\text{Dualpane}_\text{age}</td>
<td>5.26</td>
<td>9.52</td>
<td>0.00</td>
<td>54.00</td>
</tr>
<tr>
<td>\text{Lnsqft}</td>
<td>7.59</td>
<td>0.35</td>
<td>6.30</td>
<td>9.13</td>
</tr>
<tr>
<td>\text{Age}</td>
<td>17.20</td>
<td>13.03</td>
<td>0.00</td>
<td>55.00</td>
</tr>
<tr>
<td>\text{Agesq}</td>
<td>465.71</td>
<td>624.80</td>
<td>0.00</td>
<td>3025.00</td>
</tr>
<tr>
<td>\text{Bedrooms}</td>
<td>3.55</td>
<td>0.79</td>
<td>1.00</td>
<td>7.00</td>
</tr>
<tr>
<td>\text{Fireplaces}</td>
<td>0.77</td>
<td>0.61</td>
<td>0.00</td>
<td>9.00</td>
</tr>
<tr>
<td>\text{Story}</td>
<td>0.26</td>
<td>0.44</td>
<td>0.00</td>
<td>1.00</td>
</tr>
<tr>
<td>\text{Bathrooms}</td>
<td>2.42</td>
<td>0.63</td>
<td>1.00</td>
<td>7.00</td>
</tr>
<tr>
<td>\text{Vacant}</td>
<td>0.73</td>
<td>0.45</td>
<td>0.00</td>
<td>1.00</td>
</tr>
<tr>
<td>\text{Pool}</td>
<td>0.36</td>
<td>0.48</td>
<td>0.00</td>
<td>1.00</td>
</tr>
<tr>
<td>\text{Spa}</td>
<td>0.08</td>
<td>0.26</td>
<td>0.00</td>
<td>1.00</td>
</tr>
<tr>
<td>\text{Cash}</td>
<td>0.14</td>
<td>0.35</td>
<td>0.00</td>
<td>1.00</td>
</tr>
<tr>
<td>\text{Tax Credit}</td>
<td>0.01</td>
<td>0.08</td>
<td>0.00</td>
<td>1.00</td>
</tr>
<tr>
<td>\text{Title24}_\text{2008}</td>
<td>0.01</td>
<td>0.07</td>
<td>0.00</td>
<td>1.00</td>
</tr>
<tr>
<td>\text{Title24}_\text{2005}</td>
<td>0.22</td>
<td>0.42</td>
<td>0.00</td>
<td>1.00</td>
</tr>
<tr>
<td>\text{Title24}_\text{2001}</td>
<td>0.13</td>
<td>0.34</td>
<td>0.00</td>
<td>1.00</td>
</tr>
<tr>
<td>\text{Title24}_\text{1998}</td>
<td>0.03</td>
<td>0.17</td>
<td>0.00</td>
<td>1.00</td>
</tr>
<tr>
<td>\text{Title24}_\text{1995}</td>
<td>0.05</td>
<td>0.22</td>
<td>0.00</td>
<td>1.00</td>
</tr>
<tr>
<td>\text{Title24}_\text{1992}</td>
<td>0.21</td>
<td>0.40</td>
<td>0.00</td>
<td>1.00</td>
</tr>
<tr>
<td>\text{Title24}_\text{1988}</td>
<td>0.06</td>
<td>0.23</td>
<td>0.00</td>
<td>1.00</td>
</tr>
<tr>
<td>\text{Title24}_\text{1987}</td>
<td>0.04</td>
<td>0.19</td>
<td>0.00</td>
<td>1.00</td>
</tr>
<tr>
<td>\text{Title24}_\text{1986}</td>
<td>0.02</td>
<td>0.14</td>
<td>0.00</td>
<td>1.00</td>
</tr>
<tr>
<td>\text{Title24}_\text{1984}</td>
<td>0.02</td>
<td>0.14</td>
<td>0.00</td>
<td>1.00</td>
</tr>
<tr>
<td>\text{Title24}_\text{1982}</td>
<td>0.01</td>
<td>0.09</td>
<td>0.00</td>
<td>1.00</td>
</tr>
<tr>
<td>\text{Title24}_\text{1980}</td>
<td>0.02</td>
<td>0.15</td>
<td>0.00</td>
<td>1.00</td>
</tr>
<tr>
<td>\text{Title24}_\text{1978}</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td>\text{Longitude}</td>
<td>-118.09</td>
<td>13.68</td>
<td>-119.74</td>
<td>0.00</td>
</tr>
<tr>
<td>\text{Latitude}</td>
<td>36.34</td>
<td>4.21</td>
<td>0.00</td>
<td>37.05</td>
</tr>
<tr>
<td>\text{ZIP}_93611</td>
<td>0.43</td>
<td>0.50</td>
<td>0.00</td>
<td>1.00</td>
</tr>
<tr>
<td>\text{ZIP}_93612</td>
<td>0.18</td>
<td>0.38</td>
<td>0.00</td>
<td>1.00</td>
</tr>
<tr>
<td>\text{ZIP}_93619</td>
<td>0.39</td>
<td>0.49</td>
<td>0.00</td>
<td>1.00</td>
</tr>
<tr>
<td>\text{Y2008}</td>
<td>0.31</td>
<td>0.46</td>
<td>0.00</td>
<td>1.00</td>
</tr>
<tr>
<td>\text{Y2009}</td>
<td>0.35</td>
<td>0.48</td>
<td>0.00</td>
<td>1.00</td>
</tr>
<tr>
<td>\text{Y2010}</td>
<td>0.33</td>
<td>0.47</td>
<td>0.00</td>
<td>1.00</td>
</tr>
</tbody>
</table>
Most independent control variable definitions and expectations in Exhibit 3 are intuitive but a few warrant additional explanations. The variable bedrooms measures the number of bedrooms. The expectation of a discount reflects a consumer design preference for larger bedroom after control for building size (lnsf). This market preference is evident in broker listings advertising large main bedroom and similar comments. Note that we include variables bedrooms, fireplaces, and bathrooms as continuous variables rather than creating sets of indicator variables to save degrees of freedom. This is the best approach to
incorporate information from these building characteristics while retaining model power and parsimony. Since age plays an important interaction role in the second model, we provide a distribution of housing age in Exhibit 6.

With approximately 75% one-story homes, one-story is the market standard and preference, particularly with an aging population. After controlling for property size, we anticipate two-story designs will reflect a significant price discount.

Knight (2002) finds that vacant properties are more difficult to market and may signal seller weakness. With a large portion of vacant property transactions in our sample, we anticipate a significant ‘vacant’ price discount.

With summer months in the upper 90s and sometimes higher, we anticipate a price premium for pools. Spas, also called hot tubs, are also a desirable property feature and broker marketing point.

Lusht and Hansz (1994) find a significant discount for cash buyers in a sample of residential sales in a distressed market. During the 2008 to 2010 period, mortgage qualification standards tightened and residential transaction financing was relatively difficult to obtain compared to the loose lending standards prior to the Liquidity Crisis of 2007. We anticipate cash buyers negotiate a substantial price discount during our sample period.

To control for any influences for real estate purchase tax incentives, we include an income tax incentive indicator variable that model the rollout dates of federal tax incentive programs. We include ZIP Code indicator variables as our first control for general location differences. In addition, we use longitude and latitude to control for the unique characteristics of each property in the sample (Fik, Ling, and Mulligan, 2003).

To model the dynamic market conditions, a declining market over the sample period, we use two sets of control variables: years and quarters. The year variables reflect the overall annual change in market conditions while the quarterly variables control for seasonal fluctuations in transaction prices (Goodman, 1992).
Rosen (1974) argues that individual feature and characteristics make up overall asset values. Furthermore, these feature and characteristics can be imputed from transaction prices. He has been credited as a pioneer in early hedonic pricing theory and regression-based hedonic modeling has been a dominate research paradigm in real estate research for four decades [see Cho (1996) for a survey of theoretical and empirical issues in hedonic housing price estimation and Sirmans, MacDonald, Macpherson, and Zietz (2006) for an overview of this literature]. In this tradition, we use a hedonic pricing method to estimate the marginal transaction price contribution of the dual-pane window property feature in residential property values.

We estimate the following models to determine the effect of dual-pane windows on residential prices:

\[
\begin{align*}
\ln(\text{salesprice}) &= \beta_0 + \sum \beta_i X_i + \beta_{DP} + \varepsilon \\
\ln(\text{salesprice}) &= \beta_0 + \sum \beta_i X_i + \beta_{DP} \cdot \alpha + \varepsilon
\end{align*}
\]

where \(X_i\) is a \((n \times k)\) matrix of traditional structural, site, quality, and location variables, \(DP\) is dual-pane windows, and \(\alpha\) is the age of the property. The statistical models are estimated using ordinary least squares (OLS). The dependent variable is the natural log of sale price. Sirmans, Macpherson, and Zietz (2005) discuss the advantages of using the semi-log specification in hedonic modeling. This specification allows for variation in the dollar value of each characteristic and coefficients are interpreted as the percentage change in the price per unit change in the characteristics. The semi-log specification also helps to minimize the problem of heteroscedasticity. We use Davidson and McKinnon’s (1993) heteroscedasticity-consistent standard errors.

Model 1 uses equation (1). The variable of interest is dual-pane, an indicator variable identifying all property transactions that have the dual-pane window feature. Model 1 of Exhibit 7 examines the valuation effect of dual-pane windows. With a coefficient of determination (R\(^2\)) of 87.6% and an adjusted R\(^2\) of 86.6%, the explanatory power of the model is acceptable and consistent with published hedonic research pertaining to residential transaction prices. These results demonstrate a price premium associated with the dual-pane window feature compared to the baseline of properties without dual-pane windows. After controlling for price differences associated with structure size, property qualities, and location, dual-pane windows contribute 2.99% to overall property value, which is statistically significant at the 1% level.

Model 2 uses equation (2). The variable of interest is the interaction between dual-pane windows and improvement age. Model 2 of Exhibit 7 presents the results of the interaction effect. The explanatory power measured by R\(^2\) has improved...
### Exhibit 7 | Models 1 and 2

<table>
<thead>
<tr>
<th>Variables</th>
<th>Model 1</th>
<th>Model 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Constant</td>
<td>6.759*** (0.147)</td>
<td>6.763*** (0.145)</td>
</tr>
<tr>
<td>Dualpane</td>
<td>0.030*** (0.005)</td>
<td>-0.002 (0.009)</td>
</tr>
<tr>
<td>Dualpane_age</td>
<td></td>
<td>0.002*** (0.001)</td>
</tr>
<tr>
<td>Lnsqft</td>
<td>0.784*** (0.018)</td>
<td>0.785*** (0.018)</td>
</tr>
<tr>
<td>Age</td>
<td>-0.012*** (0.003)</td>
<td>-0.013*** (0.003)</td>
</tr>
<tr>
<td>Agesq</td>
<td>9.11e-05* (4.71e-05)</td>
<td>9.63e-05** (4.67e-05)</td>
</tr>
<tr>
<td>Bedrooms</td>
<td>-0.017*** (0.005)</td>
<td>-0.017*** (0.005)</td>
</tr>
<tr>
<td>Fireplaces</td>
<td>0.045*** (0.005)</td>
<td>0.045*** (0.005)</td>
</tr>
<tr>
<td>Story</td>
<td>-0.140*** (0.007)</td>
<td>-0.140*** (0.007)</td>
</tr>
<tr>
<td>Bathrooms</td>
<td>0.064*** (0.009)</td>
<td>0.062*** (0.009)</td>
</tr>
<tr>
<td>Vacant</td>
<td>-0.077*** (0.007)</td>
<td>-0.077*** (0.007)</td>
</tr>
<tr>
<td>Pool</td>
<td>0.036*** (0.006)</td>
<td>0.0361*** (0.006)</td>
</tr>
<tr>
<td>ZIP_93611</td>
<td>-0.014 (0.062)</td>
<td>-0.012 (0.060)</td>
</tr>
<tr>
<td>ZIP_93612</td>
<td>-0.091 (0.062)</td>
<td>-0.089 (0.060)</td>
</tr>
<tr>
<td>ZIP_93619</td>
<td>0.123* (0.063)</td>
<td>0.126** (0.061)</td>
</tr>
<tr>
<td>Spa</td>
<td>0.038*** (0.011)</td>
<td>0.038*** (0.011)</td>
</tr>
<tr>
<td>Longitude</td>
<td>0.352*** (0.053)</td>
<td>0.349*** (0.053)</td>
</tr>
<tr>
<td>Latitude</td>
<td>1.140*** (0.172)</td>
<td>1.132*** (0.172)</td>
</tr>
<tr>
<td>Cash</td>
<td>-0.135*** (0.010)</td>
<td>-0.133*** (0.010)</td>
</tr>
<tr>
<td>Tax Credit</td>
<td>0.0622** (0.028)</td>
<td>0.045 (0.028)</td>
</tr>
</tbody>
</table>
Exhibit 7  | (continued)
Models 1 and 2

<table>
<thead>
<tr>
<th>Variables</th>
<th>Model 1</th>
<th>Model 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Title24_2008</td>
<td>$-0.155^{**}$</td>
<td>$-0.155^{**}$</td>
</tr>
<tr>
<td></td>
<td>(0.061)</td>
<td>(0.061)</td>
</tr>
<tr>
<td>Title24_2005</td>
<td>$-0.159^{***}$</td>
<td>$-0.160^{***}$</td>
</tr>
<tr>
<td></td>
<td>(0.054)</td>
<td>(0.053)</td>
</tr>
<tr>
<td>Title24_2001</td>
<td>$-0.103^{**}$</td>
<td>$-0.104^{**}$</td>
</tr>
<tr>
<td></td>
<td>(0.046)</td>
<td>(0.046)</td>
</tr>
<tr>
<td>Title24_1998</td>
<td>$-0.019$</td>
<td>$-0.022$</td>
</tr>
<tr>
<td></td>
<td>(0.041)</td>
<td>(0.041)</td>
</tr>
<tr>
<td>Title24_1995</td>
<td>$-0.024$</td>
<td>$-0.027$</td>
</tr>
<tr>
<td></td>
<td>(0.033)</td>
<td>(0.032)</td>
</tr>
<tr>
<td>Title24_1992</td>
<td>0.013</td>
<td>0.009</td>
</tr>
<tr>
<td></td>
<td>(0.026)</td>
<td>(0.026)</td>
</tr>
<tr>
<td>Title24_1988</td>
<td>0.002</td>
<td>$-0.003$</td>
</tr>
<tr>
<td></td>
<td>(0.024)</td>
<td>(0.024)</td>
</tr>
<tr>
<td>Title24_1987</td>
<td>$-0.023$</td>
<td>$-0.024$</td>
</tr>
<tr>
<td></td>
<td>(0.019)</td>
<td>(0.019)</td>
</tr>
<tr>
<td>Title24_1986</td>
<td>0.033</td>
<td>0.030</td>
</tr>
<tr>
<td></td>
<td>(0.024)</td>
<td>(0.024)</td>
</tr>
<tr>
<td>Title24_1984</td>
<td>$-0.061^{***}$</td>
<td>$-0.063^{***}$</td>
</tr>
<tr>
<td></td>
<td>(0.020)</td>
<td>(0.020)</td>
</tr>
<tr>
<td>Title24_1982</td>
<td>$-0.027$</td>
<td>$-0.026$</td>
</tr>
<tr>
<td></td>
<td>(0.028)</td>
<td>(0.028)</td>
</tr>
<tr>
<td>Title24_1980</td>
<td>0.017</td>
<td>0.015</td>
</tr>
<tr>
<td></td>
<td>(0.023)</td>
<td>(0.023)</td>
</tr>
<tr>
<td>Y2009</td>
<td>$-0.133^{***}$</td>
<td>$-0.132^{***}$</td>
</tr>
<tr>
<td></td>
<td>(0.007)</td>
<td>(0.007)</td>
</tr>
<tr>
<td>Y2010</td>
<td>$-0.157^{***}$</td>
<td>$-0.157^{***}$</td>
</tr>
<tr>
<td></td>
<td>(0.008)</td>
<td>(0.008)</td>
</tr>
<tr>
<td>Q1</td>
<td>0.063^{***}</td>
<td>0.063^{***}</td>
</tr>
<tr>
<td></td>
<td>(0.008)</td>
<td>(0.008)</td>
</tr>
<tr>
<td>Q2</td>
<td>0.046^{***}</td>
<td>0.045^{***}</td>
</tr>
<tr>
<td></td>
<td>(0.007)</td>
<td>(0.007)</td>
</tr>
<tr>
<td>Q3</td>
<td>0.027^{***}</td>
<td>0.027^{***}</td>
</tr>
<tr>
<td></td>
<td>(0.008)</td>
<td>(0.008)</td>
</tr>
<tr>
<td>R²</td>
<td>0.876</td>
<td>0.877</td>
</tr>
<tr>
<td>Adj. R²</td>
<td>0.866</td>
<td>0.867</td>
</tr>
</tbody>
</table>

Note: There are 3,704 observations. Robust standard errors are in parentheses.

* $p < .1$

** $p < .05$

*** $p < .01$
modestly from 87.6% to 87.7% and the adjusted $R^2$ has improved from 86.6% to 86.7%. The dual-pane window-age interaction variable is significant at the 1% level. The dual-pane window direct effect is no longer statistically significant in Model 2, showing that the dual-pane-window age interaction is a relatively superior explanation of differences in transaction prices. With each increasing year of property age, the presence of dual-pane windows increases the sales price by 0.21%.

Discussion

The objective in this study is to pursue a valuation perspective of a specific property feature, dual-pane windows. In real estate markets, it is known that cost and value are not equivalent concepts and cost does not necessarily (and maybe rarely) equal market value. We cannot report if the found pricing influence in this study is less than, greater than, or equal to any individual investment made in dual-pane windows because we are estimating a market average and do not have property-specific cost information.6

We also emphasize that any specific energy efficiency improvement from the dual-pane window feature is reliant on other building characteristics. For example, high quality and expensive dual-pane windows may result in no energy efficiencies if a house is not insulated. In this study we are isolating the valuation impact of dual-pane windows but we do recognize that an improvement’s overall level of energy efficiency is reliant on many other factors. However, inspired by a conservation movement and increasing utility bills, we do feel that residential energy consumers have become knowledgeable about basic energy efficiency principles and examples like the one above are probably an exception and not the rule in our sample.

Model 1 presents the direct effect of the dual-pane window feature on residential transaction prices. The model indicates that dual-pane windows contribute approximately 3% to residential transaction prices. Model 2 includes the interaction variable $Dualpane\_age$ to model the expected relationship between the dual-pane window feature and improvement age. This dual-pane-window age interaction effect is 0.21%, according to improvement age, and is statistically significant. Model 2 is superior to Model 1 based on a modest increase in the $R^2$ metric and the insignificance of the dual-pane window direct effect when the interaction effect is introduced into the model.

With the dual-pane-window age interaction variable, dual-pane windows have a zero or small contribution to overall transaction prices for the transaction of new or newer properties and significant contribution to the transaction prices of older properties. The oldest improvement age (55 years) indicates a prospective dual-pane window allocation of 11.55%, but we caution that we are approaching the extreme end of the model age range. An improvement age of 15, near our sample mean, would indicate a premium of 3.57% and a two-year-old improvement would have a 0.42% dual-pane window pricing allocation.
The dual-pane window-age association is expected because dual-pane windows are becoming standard in new construction. Consumers expect dual-pane windows in new improvements and builders are responding to this market demand by including this relatively low cost feature, typically as a standard amenity, in new construction. Therefore, a special allocation to transaction prices is not appropriate or should be modest in the newer home market segment. However, traditional single pane windows remain the market standard in the older market segments and properties with dual-pane windows standout from the existing housing stock. In this study, we find that buyers are paying for the dual-pane window feature at greater levels as improvement age increases.

The implications of our findings are straightforward. First, investment in dual-pane windows is recognized in the residential market place. This investment not only improves upon the energy efficiency of the American housing stock, the value created by the dual-pane window feature is being recognized in the real estate markets themselves, a benefit that is not often realized or measured. Consumers, brokers, builders, contractors, utility companies, and policymakers should be interested in the value-added impact from green building features such as dual-pane windows. Also, if markets are recognizing residential energy efficiency investment, lenders and appraisers should consider these features when evaluating collateral. Second, market recognition of the dual-pane window feature increases with improvement age. This finding should be of interest to the movement supporting investment and improvement in the American housing stock in terms of energy efficiency. Where much of the research attention has been focused on the utility cost savings of energy efficiency building feature investments, this study provides initial evidence that dual-pane window investment may contribute to overall property values, particularly as improvement age.

Conclusion

Due to consumer demand and low cost to builders, dual-pane windows have recently become the market standard in new construction in many markets. Dual-pane windows may save energy, increase property value, and differentiate older properties with this feature from the existing housing stock of a similar vintage.

In our sample, we find a positive and statistically significant direct effect for transactions with the dual-pane window feature. However, a significant dual-pane-window age interaction variable is tested, which dominates the dual-pane window pricing direct effect. The interaction between the dual-pane window feature and improvement age is a better explanation of the valuation impact of the dual-pane window feature on residential transaction prices than the dual-pane window variable alone. Because dual-pane windows are found more often in newer properties, the supply of improvements with dual-pane windows decreases according to improvement age and this feature is more important in older properties.

The contributions of these findings are as follows. First, this study introduces dual-pane windows into academic research, both the traditional residential hedonic
pricing literature and the rapidly developing green/energy efficiency literature. It is anticipated that green-building features will become common considerations in housing price research. Second, we evaluate the relationship between the dual-pane window feature and improvement age and find a significant association that explains residential transactions prices better than the dual-pane window feature alone.

These findings are important as this study documents market recognition of investment in an energy efficient (green) feature (dual-pane windows), particularly with respect to older housing stock. Investment, both public and private, in energy-efficient housing features such as dual-pane windows reduces energy consumption and utility costs and also adds value to the housing stock. Furthermore, we suspect that investment in other green features may have a similar relationship with improvement age and we encourage additional research into the valuation impact of green building features.

Endnotes

1 For new construction, labor installation costs for single- and dual-pane windows are identical and bulk purchases of dual-pane windows are only marginally more expensive as compared to single-pane windows.

2 A note on the use of the term ‘premium’ in this literature review and the remainder of the paper is appropriate. The term ‘premium’ does not refer to a costless profit. Rather, a premium refers to positive price contributions attributed to a property feature as compared to a baseline of property transactions absent the same feature.

3 The central assumption in the graph is that the supply and demand curves are different for dual-pane and non-dual-pane windows. Assuming increased costs are associated with dual-pane windows, supply is more inelastic since the home developers require increased price to offset the additional costs. Also, the demand curve for the dual-pane windows shifts outwards since the buyers of these energy-efficient windows are assumed to be prepared to pay more. The resulting equilibrium prices are therefore higher and equilibrium quantities are lower for dual-pane windows. If we extend the demand curves of both dual-pane and non-dual-pane windows to the horizontal axis, we see that they converge. This is because the marginal willingness to pay the premium by green homeowners diminishes as the supply of dual-pane increases. This implies that the dual-pane premium will fade with increasing supply. This leads to the non-parallel nature of demand and supply curves.

4 We thank two anonymous reviewers for suggesting Title 24 control variables.

5 The Journal of Real Estate Literature’s Current Journals literature classification taxonomy dedicates a unique classification to ‘hedonic theory’ literature.

6 In general, local builders report that the marginal installation cost for dual-pane windows is ‘negligible or zero’ for new construction and the added materials costs is ‘a few hundred dollars.’ For replacement dual-pane windows, cost varies widely from a couple thousand dollars up to several tens of thousands of dollars depending upon window quantity and quality. We estimate that a reasonable replacement dual-pane window cost for the typical property in our sample is around +/− $10,000.
References


Ramya R. Aroul, University of Texas, Arlington, TX 76019 or ramya.raja@gmail.com.

J. Andrew Hansz, California State University, Fresno, CA 93740 or hanz@gazarian.info.
Green Mark Certification: Does the Market Understand?

Authors
Kwame Addae-Dapaah and Su Jen Chieh

Abstract
A corollary to the green building revolution is the certification of green buildings by relevant organizations. The pertinent question is whether the market understands the certification. The paper addresses the issue via a quantitative (hedonic model) and psychographic (survey) study of the Singapore residential green building market. The results reveal that green certification commands a statistically significant premium. However, the market is confused by the different tiers of certification as evidenced by incommensurate premia for the different tiers. Furthermore, the fact that the premium varies with tenure (freehold/leasehold) and location after controlling for all other attributes may imply that the premium may not be solely attributable to green certification.

The fear of Armageddon resulting from environmental catastrophe, coupled with the perceived benefits of green building, is fuelling the green revolution. As succinctly concluded by The Ecologist (1972), sustainability is a survival imperative. The urgency emanating from this awareness has given rise to various schemes/programs to drive the green advocacy. One such program buoying the green revolution is the emergence of worldwide rating systems such as the Building Research Establishment Environmental Assessment Method (BREEAM) in the United Kingdom, Leadership in Energy and Environmental Design (LEED) and ENERGY STAR in the United States, Green Globes in the United States and Canada, Green Mark in Singapore, and BOMA-Best in Canada. These rating systems are meant to encourage environmentally and socially responsible building practices by awarding “badges” for buildings’ different degrees of “green,” as well as differentiating green from non-green buildings. Thus the rating systems are helping to promote a built environment that balances economic and social forces against the environmental imperatives of resource conservation and renewal for the world of tomorrow.

In Singapore, the Building and Construction Authority (BCA) launched the Green Mark scheme in January 2005 to promote sustainability in the built environment and raise environmental awareness among developers, designers, and builders to eventually deliver “healthier” products to end-users. Thus, Singapore became the first Asian country to adopt an eco-labeling system.

Despite the world-wide proliferation of eco-labeling systems, there are only a few studies on the impact of these rating systems on property values. These few studies, which mainly focus on the U.S., deal with commercial properties. There
is virtually no systematic body of knowledge on Asian countries. Similarly, there appears to be no study that relates eco-labeling to residential properties in Asia. Apart from Brounen and Kok’s (2011) paper that relates to the European Union, there appears to be no study on eco-labeled residential properties. Thus, the first motivation of this paper is to fill the gap in the literature relating to eco-labeling vis-à-vis property values in an Asian country, Singapore. The second motivation is to fill the gap in the literature on the impact of eco-labeling on residential property value by providing evidence from Singapore. Thirdly, the success of the rating scheme is a function of the market’s acceptance of it, which may be predicated on the market’s understanding of the ratings.

Singapore is a cosmopolitan city, which has become an important financial center in Southeast Asia. Thus, any insight into the impact of eco-labeling on property value based on a study in Singapore may have a cosmopolitan flavor that appeals to a wide audience.

In view of the above motivations, the paper is aimed at ascertaining the premium (if any) commanded by the Green Mark (GM) certification. The second objective is to determine the Singapore residential market’s understanding of the GM certification as evidenced through the premium paid for the hierarchy of ratings and the results of a survey conducted for the study. If the market understands the GM certification, any premium paid will be commensurate to the GM-tier. A higher GM-tier reflects a building that is more environmentally friendly and energy efficient than a lower GM-tier building. People may go for higher GM-tier buildings purely for an ideological reason or for the perceived economic and social benefits. Therefore, the third objective is to examine the premium-cost-ratio (PCR) for the various tiers of certification to ascertain their relative profitability. This will be followed by an incremental benefit-cost ratio (IBCR) from the perspective of the owner-occupier to see how appealing eco-labeled building is from an economic point of view.

The results of the analysis of the sales data and survey show that green certification commands a statistically significant premium. The premia for green certification extracted from the sales data and survey range from 9.61% to 27.74% and 5.47% to 6.82%, respectively. Furthermore, the results of the sales data analyses display illogical allocation of premia among the different tiers of green certification—lower tier commands a higher premium than some higher tier green certification. Moreover, it is found from the survey that out of the 33.67% of the respondents who had heard of the green certification, 83.2% were not aware of the differences among the four tiers of green certification in Singapore. As far as profitability is concerned, the results show that on the basis of the premium-cost ratio, it is more beneficial for residential property developers and investors to aim for the basic green certification rating. However, the results of the IBCR analyses show that eco-labeled private apartments are not appealing to the owner-occupier. This is consistent with the result of the survey that green features do not have much impact (with a rating score of 2.49 out of 5; 1 being minimum impact and 5 being maximum impact) on the respondents’ choice of residential units to buy.

The rest of the paper proceeds as follows. The next section is a review of the extant relevant literature. This is followed by a brief description of the GM rating,
data sourcing, and management, after which the results of the data analysis are presented and discussed. The last section contains concluding remarks.

**Literature Review**

A number of studies demonstrate the effect eco-labeling on the price of commercial offices. All the studies utilize the hedonic model and the CoStar database. Miller, Spivey, and Florance (2008) do not find any statistically significant sales price premium. However, other studies have found a rental/sales price premium for eco-labeling. Wiley, Benefield, and Johnson (2008) find a rental premium of 15%–17% for LEED and 7%–9% for ENERGY STAR (ES) certified office buildings. The premia in terms of sales price per square foot are US$130 and US$30 for LEED and ES rated office buildings, respectively. Similar results have been replicated by Fuerst and McAllister (2008) and Miller, Spivey, and Florance (2008). Furthermore, Eichholtz, Kok, and Quigley (2009) found 3% rental and 19% sales price premium for ES rated office buildings albeit no statistically significant rental/prize premium for LEED rated office buildings. Similarly, Fuerst and McAllister (2009) found a price premium of 35%/31% for ES/LEED certified office buildings. Other studies that replicate similar results are Eichholtz, Kok, and Quigley (2010), Fuerst and McAllister (2011), and Reichardt, Fuerst, Rottke, and Zietz (2012). Brounen and Kok (2011), the only study that relates to housing, found that green-labeled homes sell at 3.6% premium.

All the above studies, with exception of that by Brounen and Kok (2011), which centers on the European Union, focus on the U.S. and utilize the CoStar database. This makes this paper unique in the sense of being the first on residential properties in an Asian context. This is significant as the Asian perception of the green revolution may differ in substance from the Western perception, as evidenced by negotiations on carbon emission. While the Asian lauds the ideals of the green revolution, there is a lingering fear that a full commitment to the green revolution may scuttle the Asian economic revolution, which has firmly put Asia on the geopolitical landscape of the world. Economics takes precedence over sustainability ideals. As noted by Addae-Dapaah, Liow, and Neo (2009), location and accessibility are the primary consideration of Singaporeans in the choice of commercial buildings; green features are of secondary importance. This contrasts with the West where institutional and corporate investors think highly of and use sustainable space because of several reasons, including enhancement of public image as being socially responsible, which improves corporate financial performance (Orlitzky, 2003), increased worker productivity and retention rates of employees, and reduced employee absenteeism (Turban and Greening, 1997; Miller, Progue, Gough, and Davis, 2009) and cost savings from improved energy efficiency (Kats, 2003; Fowler and Rauch, 2008). The above rationale for consuming green space may not incentivize the Singaporean consumer of housing who, being an individual, may care less about corporate social responsibility, increased worker productivity, and even rental premium. Singaporeans buy condominiums for owner-occupation. Condominium ownership, regardless of green label, is one of the five badges of achievement. This is different from the
Green Mark Certification: Does the Market Understand?

West and thus, makes the Asian perspective of relevance to the debate on green premium.

**GM Rating Scheme in Singapore**

The Singapore GM Scheme was developed by the Building and Construction Authority (BCA) of Singapore and supported by the National Environment Agency (NEA) of Singapore in January 2005 to drive Singapore’s construction industry towards building more environment-friendly buildings. It is intended to promote sustainability in the built environment and raise environmental awareness among developers, designers, and builders and eventually deliver “healthier” products to end-users. Singapore’s Master Greenplan is aimed at 80% of all buildings in Singapore having GM certified rating by 2030. Incentives (monetary and additional floor area above GPR) are given to developers/projects that meet the requirements of GM certification (Exhibit 1). According to the Building Control amendment act 2008, all new buildings in Singapore with gross floor area (GFA) of not less than 2,000 m² must meet GM Gold rating.

There are four different ratings of GM certification: Green Mark Certified (GMC), Green Mark Gold (GMG), Green Mark Gold Plus (GMGP), and Green Mark Platinum (GMPL). Any building that is assessed under the scheme (after application has been made to that effect) is awarded a plaque according to the points scored (Exhibit 2). A maximum of 140 points is awarded in the five categories in Exhibit 1 (with an additional 20 bonus points for renewable energy).

**Methodology**

The data for the study are analyzed via the hedonic price model, which has been widely employed to explore locational and neighborhood attributes namely: quality of public schools (Haurin and Brasington, 1996; Clauretie and Neill, 2000); proximity to shopping complexes (Sirpal, 1994; Rosiers, Lagana, Theriault, and Marcel, 1996); places of worship such as churches (Carroll, Clauretie, and Jensen, 1996); hospitals (Huh and Kwak, 1997), as well as structural attributes such as floor area or size (Mok, Chan, and Cho, 1995; and Carroll, Clauretie, and Jensen, 1996). Mok, Chan, and Cho (1995) and Tse and Love (2000) also use the hedonic price model to estimate the implicit price of sea view and cemetery views, respectively.

However, finding the correct specification of the hedonic relationship requires researchers to identify both the correct list of independent variables and the true functional forms (Linneman, 1980). Some studies give primary importance to physical/structural traits such as number of rooms, bathrooms (Linneman, 1980) and age of the building (Kain and Quigley, 1970); some focus on amenities such as churches (Carroll, Clauretie, and Jensen, 1996) and schools (Clauretie and Neill, 2000) while others emphasize the role of the neighborhood traits (Goodman and Thibodeau, 1998). Ideally, all housing traits considered in valuing a property should be included in the hedonic model.
<table>
<thead>
<tr>
<th>Category</th>
<th>Point Allocation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Part 1: Energy Efficiency</td>
<td></td>
</tr>
<tr>
<td>Energy Related Requirements&lt;sup&gt;a&lt;/sup&gt;</td>
<td></td>
</tr>
<tr>
<td>RB 1-1 Thermal Performance Building Envelope—RETV</td>
<td>15</td>
</tr>
<tr>
<td>RB 1-2 Naturally Ventilated Design and Air-Conditioning System</td>
<td>22</td>
</tr>
<tr>
<td>RB 1-3 Daylighting</td>
<td>6</td>
</tr>
<tr>
<td>RB 1-4 Artificial Lighting</td>
<td>10</td>
</tr>
<tr>
<td>RB 1-5 Ventilation in Car Parks</td>
<td>6</td>
</tr>
<tr>
<td>RB 1-6 Lifts</td>
<td>1</td>
</tr>
<tr>
<td>RB 1-7 Energy Efficient Features</td>
<td>7</td>
</tr>
<tr>
<td>RB 1-8 Renewable Energy</td>
<td>20</td>
</tr>
<tr>
<td>Category Score</td>
<td>87</td>
</tr>
<tr>
<td>Part 2: Water Efficiency</td>
<td></td>
</tr>
<tr>
<td>Other Green Requirements&lt;sup&gt;b&lt;/sup&gt;</td>
<td></td>
</tr>
<tr>
<td>RB 2-1 Water Efficient Fittings</td>
<td>10</td>
</tr>
<tr>
<td>RB 2-2 Water Usage Monitoring</td>
<td>1</td>
</tr>
<tr>
<td>RB 2-3 Irrigation System and Landscaping</td>
<td>3</td>
</tr>
<tr>
<td>Category Score</td>
<td>14</td>
</tr>
<tr>
<td>Part 3: Environmental Protection</td>
<td></td>
</tr>
<tr>
<td>Other Green Requirements&lt;sup&gt;b&lt;/sup&gt;</td>
<td></td>
</tr>
<tr>
<td>RB 3-1 Sustainable Construction</td>
<td>10</td>
</tr>
<tr>
<td>RB 3-2 Sustainable Products</td>
<td>8</td>
</tr>
<tr>
<td>RB 3-3 Greenery Provision</td>
<td>8</td>
</tr>
<tr>
<td>RB 3-4 Environmental Management Practice</td>
<td>8</td>
</tr>
<tr>
<td>RB 3-5 Green Transport</td>
<td>4</td>
</tr>
<tr>
<td>RB 3-6 Stormwater Management</td>
<td>3</td>
</tr>
<tr>
<td>Category Score</td>
<td>41</td>
</tr>
<tr>
<td>Part 4: Indoor Environment Quality</td>
<td></td>
</tr>
<tr>
<td>Other Green Requirements&lt;sup&gt;b&lt;/sup&gt;</td>
<td></td>
</tr>
<tr>
<td>RB 4-1 Noise Level</td>
<td>1</td>
</tr>
<tr>
<td>RB 4-2 Indoor Air Pollutants</td>
<td>2</td>
</tr>
<tr>
<td>RB 4-3 Waste Disposal</td>
<td>1</td>
</tr>
<tr>
<td>RB 4-4 Indoor Air Quality in Wet Areas</td>
<td>2</td>
</tr>
<tr>
<td>Category Score</td>
<td>6</td>
</tr>
</tbody>
</table>
Exhibit 1 | (continued)
Residential Building Evaluation Criteria and Point Allocation

<table>
<thead>
<tr>
<th>Category</th>
<th>Point Allocation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Part 5: Other Green Features</td>
<td></td>
</tr>
<tr>
<td>Other Green Requirementsb</td>
<td></td>
</tr>
<tr>
<td>RB 5-1 Green Features &amp; Innovations</td>
<td>7</td>
</tr>
<tr>
<td>Category Score</td>
<td>7</td>
</tr>
<tr>
<td>Green Mark Score</td>
<td>155</td>
</tr>
</tbody>
</table>

Notes: The exhibit presents the framework and points allocation for the residential building evaluation criteria for the BCA GM Certification. A residential building must achieve a minimum GM score of 50 points of which 30 and 20 must come from energy related, and other green, features respectively.

a Minimum 30 points
b Minimum 20 points

Exhibit 2 | Green Mark Ratings

<table>
<thead>
<tr>
<th>Green Mark Score</th>
<th>Green Mark Rating</th>
</tr>
</thead>
<tbody>
<tr>
<td>90 and above</td>
<td>Green Mark Platinum</td>
</tr>
<tr>
<td>85 to &lt; 90</td>
<td>Green Mark Gold Plus</td>
</tr>
<tr>
<td>75 to &lt; 85</td>
<td>Green Mark Gold</td>
</tr>
<tr>
<td>50 to &lt; 75</td>
<td>Green Mark Certified</td>
</tr>
</tbody>
</table>

Notes: The exhibit presents the GM scores required for a residential building in Singapore to be awarded the respective GM Ratings. The higher the GM Rating, the more environmentally friendly and thus, more sustainable, a residential building is supposed to be.

Some studies are concerned about the collinearity between housing attributes and thus, omit a large number of housing traits (Constantine, 1994). However, this does not necessarily solve the problem. In fact, “.....the omission of variables that should be in the model only confounds the problem because the least square regressor yields consistent and efficient estimates only when the model is correctly specified. The omission of important traits on the basis of multicollinearity insures that both the standard errors and hedonic coefficients of the remaining traits are biased,” (Consumer Reports, 1996).

Thus, researchers using the hedonic pricing technique face a tradeoff, including highly correlated variables causes collinearity to reduce the precision of parameter estimates, while omission of variables that should be in the regression model may result in biased estimates. Herein may lie the wisdom in the statement of Taylor and Wilson (1964) that “To seek perfect specification for quantitative analysis of
human behavior is to seek the stars. Earth bound creatures must be content with approximate correct specification.”

According to Butler (1982), the intrinsic clustering of characteristic combinations into a relatively small number of configurations leads to considerable multicollinearity in estimates employing a generous selection of the relevant variables. He postulates that it is inevitable for any estimate of a hedonic relationship to be mis-specified as there is a need to omit some of the relevant independent variables. He finds that even severely restricted specification appears to suffer only limited coefficient biases, with a negligible impact on the explanatory and predictive powers of the equation. Similarly, Mok, Chan, and Cho (1995) favor using a smaller number of variables as they argue that biases due to missing variables are small. For example, Mok, Chan, and Cho (1995) do not include the number of rooms as an independent variable in their study since number of rooms is highly correlated with floor area.

Given that property attributes do not function independently to create value, it is inevitable that multicollinearity should exist in a hedonic model. Thus, multicollinearity in hedonic models should be welcomed so far as it is within tolerable levels. In view of this, all the property variables in Exhibit 3, which fall under the five broad categories of factors that affect property prices: structural features, neighborhood attributes, facility attributes, locational factors, time-related attributes, and environmental amenity (Nicholls and Crompton, 2005) are used in the analyses.

Furthermore, hedonic theory offers very little guidance on the correct functional form. As economic theory is ambiguous about the appropriate form, using linear and logarithmic functional forms in housing market analysis is not uncommon. Colwell, Gujral, and Coley (1985) test their hypotheses on six functional forms (Linear, Semi-Log, Exponential, Log-Linear, Inverse, and Inverse-Inverse). The Log Linear Model is selected because of the ease in interpreting the regression coefficient while its log likelihood at the 95% level of confidence is not significantly different from the maximum log likelihood given by other models. Similarly, Rosiers, Lagana, Theriault, and Beaudoin (1996) demonstrate that all tested functional forms (Linear, Semi-Log, Log-Linear, and Inverse models) yield satisfactory results although the best performance is obtained using either a log-linear or the inverse model.

Data

The repeat sales and property specific data for the study, which relate to 34 BCA certified (i.e., eco-labeled) and 34 non-certified private condominium/apartment developments in Singapore were obtained from the real estate information system (REALIS), which is a database for the Urban Redevelopment Authority of Singapore (URA). The URA transaction database (REALIS) records open market sale prices obtained from caveats lodged with Singapore Land Authority (i.e. Registrar of Title Deeds). The data are updated fortnightly on the first and sixteenth of every month. REALIS is the most reliable public database that is used
### Exhibit 3 | Variables of Hedonic Models

<table>
<thead>
<tr>
<th>Variable</th>
<th>Code</th>
<th>Description</th>
<th>Expected Sign</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Dependent Variables</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Transacted Price</td>
<td>PRICE</td>
<td>Actual selling price of property in Singapore dollars.</td>
<td>Nil</td>
</tr>
<tr>
<td><strong>Structural Features</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Floor Area</td>
<td>LNAREA</td>
<td>Floor area of property in square meters.</td>
<td>+</td>
</tr>
<tr>
<td>Floor Level</td>
<td>LEVEL</td>
<td>Floor level of property.</td>
<td>+</td>
</tr>
<tr>
<td>Age</td>
<td>LNAGE</td>
<td>From completion date to 2009</td>
<td>–</td>
</tr>
<tr>
<td>Property Type</td>
<td>PTYTYPE</td>
<td>Binary variable 1 for condominium and 0 otherwise.</td>
<td>–</td>
</tr>
<tr>
<td><strong>Facility Attributes</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>BBQ Pits</td>
<td>BBQ</td>
<td>Binary variable 1 for condominiums with BBQ pits and 0 otherwise.</td>
<td>+</td>
</tr>
<tr>
<td>Club House</td>
<td>CLUBHSE</td>
<td>Binary variable 1 for condominiums with club house / function room / multi-purpose hall facilities and 0 otherwise.</td>
<td>+</td>
</tr>
<tr>
<td>Water Features</td>
<td>WFEATURES</td>
<td>Binary variable 1 for condominiums with water features and 0 otherwise.</td>
<td>+</td>
</tr>
<tr>
<td>Swimming Pool</td>
<td>SWIM</td>
<td>Binary variable 1 for condominiums with swimming pool and 0 otherwise.</td>
<td>+</td>
</tr>
<tr>
<td>Tennis Court</td>
<td>TENNIS</td>
<td>Binary variable 1 for condominiums with tennis court and 0 otherwise.</td>
<td>+</td>
</tr>
<tr>
<td>Gymnasium</td>
<td>GYM</td>
<td>Binary variable 1 for condominiums with gymnasium and 0 otherwise.</td>
<td>+</td>
</tr>
<tr>
<td><strong>Location</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Central Region</td>
<td>CR</td>
<td>Binary variable 1 for property in CR and 0 otherwise.</td>
<td>+</td>
</tr>
<tr>
<td>North-East Region</td>
<td>NER</td>
<td>Binary variable 1 for property in CR and 0 otherwise.</td>
<td>–</td>
</tr>
<tr>
<td>East Region</td>
<td>ER</td>
<td>Binary variable 1 for property in ER and 0 otherwise.</td>
<td>–</td>
</tr>
<tr>
<td>West Region</td>
<td>WR</td>
<td>Binary variable 1 for property in WR and 0 otherwise.</td>
<td>–</td>
</tr>
<tr>
<td><strong>Neighborhood Attributes</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Distance to shopping mall</td>
<td>LNSHOP</td>
<td>Linear distance to shopping mall (km).</td>
<td>–</td>
</tr>
<tr>
<td>Proximity to public housing</td>
<td>PUBHSG</td>
<td>Binary variable 1 for property within 400m radius of public housing and 0 otherwise.</td>
<td>–</td>
</tr>
<tr>
<td>Distance to MRT</td>
<td>LNMRT</td>
<td>Linear distance to MRT (km).</td>
<td>–</td>
</tr>
<tr>
<td>Proximity to expressway</td>
<td>EXPRESS</td>
<td>Binary variable 1 for property within 400m of expressway and 0 otherwise.</td>
<td>+</td>
</tr>
<tr>
<td><strong>Time</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Adjustment for time</td>
<td>T1–T3</td>
<td>Binary variable 1 for property sold in period 1 and 0 otherwise.</td>
<td>To be defined</td>
</tr>
</tbody>
</table>
Variables of Hedonic Models

<table>
<thead>
<tr>
<th>Variable</th>
<th>Code</th>
<th>Description</th>
<th>Expected Sign</th>
</tr>
</thead>
<tbody>
<tr>
<td>Environmental Amenities</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Green Mark Certified</td>
<td>GMC</td>
<td>Binary variable 1 for building with green mark certified rating and 0 otherwise.</td>
<td>+</td>
</tr>
<tr>
<td>Green Mark Gold</td>
<td>GMG</td>
<td>Binary variable 1 for building with green mark gold rating and 0 otherwise.</td>
<td>+</td>
</tr>
<tr>
<td>Green Mark Gold Plus</td>
<td>GMGP</td>
<td>Binary variable 1 for building with green mark gold plus rating and 0 otherwise.</td>
<td>+</td>
</tr>
<tr>
<td>Green Mark Platinum</td>
<td>GMPL</td>
<td>Binary variable 1 for building with green mark platinum rating and 0 otherwise.</td>
<td>+</td>
</tr>
</tbody>
</table>

Notes: A positive sign is indicative of an expectation of a premium while a negative sign portends reduction in value. Quality is a function of the facilities that a condominium has. NER, ER, and WR constitute outside CR (OCR) in relevant models.

by property market researchers in Singapore. Repeat sales data are used as they more reflect market forces than new sales data in Singapore which are predominantly fixed by developers. Furthermore data for proximity to the nearest MRT (train station in the West), shopping mall, school and public house were obtained from the Singapore Street Directory Online Portal.

The 68 condominium/apartment developments house approximately 21,000 strata-titled units, that is, individual apartments/flats. The eco-labeled 34 developments account for approximately 11,400 strata-titled units while the remaining 9,600 strata-titled units come from the 34 non-certified developments. The BCA certification applies to whole developments of condominiums/apartments. Thus, certification of a development means that all the individual apartment units/flats in it are certified green. Furthermore, the 34 eco-labeled developments used for the study is the exact number of private condominium/apartment developments in Singapore that had received the BCA certification at the time of the study. To ensure comparability, both certified and non-certified developments for each region were chosen from the same neighborhood. Difference in quality is depicted by the types of amenities (e.g., swimming pool, barbeque pit, gym, tennis court, etc.) that a condominium project has.

The sales data that are used for the study, 13,899, relate to sales of individual strata-titled units, which are predominantly bought by private individuals. The sales data span the period from July 2005 to June 2009. Of the 13,899 sales data, about 66.25% (9,208) relate to private high-rise residential properties (condominiums/apartments) in the Central Region (CR) of Singapore while the remaining 33.75% (4,691) are from outside the CR (OCR) comprising North-East, East, and West Regions; the North Region is not included as there were no eco-labeled private apartment there at the time of the study. This is reflective of the
fact that 27 of the 34 BCA certified condominiums/apartments in Singapore are found in the CR. Furthermore, 65.9% (9,161) of the sales data relate to BCA certified buildings. The remaining 34.1% (4,738) are not eco-labeled. Of the 9,161 sales data relating to eco-labeled condominiums/apartment (henceforth referred to as private apartments), GMC buildings account for 18.8% (1,722), GMG buildings account for 59% (5,408), GMGP buildings account for 17% (1,565) and GMPL buildings account for the remaining 5.2% (479).

It is worth noting that of the 1,722 sales data relating to GMC buildings, only 227 (13.18%) are from the CR; the remaining 86.82% come from the OCR. Furthermore, all the GMGP and GMPL buildings, and 80% of the GMG buildings, are located in the CR. In view of the concentration of the eco-labeled buildings in the CR, the analyses will be carried out at the aggregate (i.e., both CR and OCR together) and disaggregate (i.e., separate analyses for CR and OCR) levels.

The above data are complemented with data from a face-to-face random survey of 300 Singaporeans, which was conducted in October 2009 to ascertain the respondents’ appreciation of the BCA certification and the premium that they are willing to pay for eco-labeled private properties in Singapore. The survey was done both during the day and in the night to ensure a fairly good representation of the population. Similarly, the survey was conducted at Woodlands MRT (North), Boon Lay MRT (WEST), Tampines MRT (East), and Raffles Place MRT (Central) in an attempt to ensure that people from different parts of Singapore are fairly well represented in the sample.

The survey was done with the aid of a structured questionnaire, which consisted of four sections, A–D (Appendix 1). Section A was aimed at ascertaining the respondents’ understanding of the phrase “green building,” while section B further probed the respondents’ perception of and attitude towards green buildings, as well as their awareness of BCA’s Green Mark ratings and willingness to pay a premium for green residential property. Section C solicited information on factors that would significantly impact their decision to purchase a condominium unit. This was meant to find out whether green features would be an important factor in their choice of condominium unit to buy. The final section, section D, solicited the respondents’ demographic data.

**Empirical Model**

The data in Exhibit 3 are analyzed via the hedonic model in equation (1):

\[
\ln(\text{price}) = \alpha + \beta_i X_i + \delta_i T_i + \varphi_i N_i + \rho_i Z_i + \gamma_i E_i + \varepsilon, \tag{1}
\]

where the dependent variable is the logarithm of the selling price of sampled properties, and \(\alpha\) and \(\varepsilon\) are the constant and error term, respectively. \(X_i\) is the vector of structural and facility attributes of property \(i\), \(N_i\) is the vector of
neighborhood characteristics, $Z_i$ is the vector of location, and $E_i$ is the vector of certification. The added time effect, $T_i$ (with July 2005 to June 2006 as the base), is to control for macro-economic attributes (Exhibit 3). $\beta_1, \delta_1, \varphi_1, \rho_1$, and $\gamma_1$ are the estimated coefficients, with $\gamma_1$, measuring the GM premium, which is the coefficient of interest.

Twelve models of equation (1) are used for the analyses:

**Model 1**: This is an aggregate model using the entire sample of 13,899 sales data to assess the average overall premium (if any) attributable to GM certification.

**Model 2**: This also is an aggregate model utilizing the full sample sales data to ascertain the differential premium for each tier of GM certification. This will give insight into whether the market understands the certification. A commensurate/incommensurate premium allocation to the tiers will imply that the market does/does not understand the certification.

**Model 3**: This is the first of the disaggregated models to provide further insight into the GM premium. Model 3 analyses data for only CR. This is interesting as the CR is the home for the most prestigious and expensive private apartments in Singapore. The private apartments in the OCR are of a different (relatively inferior) class. Thus, the results of Models 3 and 4 will show whether the GM premium is solely attributable to eco-labeling. If so, there should be no difference in the premium paid for the same tier certification, otherwise the GM premium may not be “pure.”

**Model 4**: This model specifically analyzes sales data from the OCR to verify the “purity” of the GM premium as explained above.

**Model 5**: Investigates the premia for different GM tiered-buildings in the CR. This will be compared to Model 6 to further verify the “purity” of the GM premium.

**Model 6**: Analyzes the premia for different GM tiered-buildings in the OCR.

**Models 7 & 8**: Deal with GM premium by tenure (freehold/leasehold) for the CR. This is another elaboration on the “purity” of the GM premium.

**Models 9 & 10**: Provide evidence on the premia for GM tiered-buildings in the CR by tenure.

**Model 11 & 12**: Provide evidence on the premia for GM tiered-buildings in the OCR by tenure.

### Results of Hedonic Models

The summary of all the results for the 12 hedonic models are presented in Exhibit 4. The detailed results are in the Appendix 2. The results in Exhibit 4 and Appendix 2 show that GM certified private apartments in Singapore command a premium. All the premia are statistically different from zero at the 0.01 level of significance. On the whole, all GM certified private apartments in Singapore command a premium of 11.69% of the sales price (Model 1). Models 3 and 4 (Exhibit 4) show that there is no appreciable difference between the premia for GM certified buildings in the CR (6.59%) and in the OCR (6.64%). However,
### Exhibit 4 | Summary of Hedonic Model Results

<table>
<thead>
<tr>
<th>Variable</th>
<th>Model 1</th>
<th>Model 2</th>
<th>Model 3</th>
<th>Model 4</th>
<th>Model 5</th>
<th>Model 6</th>
</tr>
</thead>
<tbody>
<tr>
<td>GMC</td>
<td>0.1169</td>
<td>0.0000</td>
<td>0.1297</td>
<td>0.0000</td>
<td>0.0659</td>
<td>0.0000</td>
</tr>
<tr>
<td>GMG</td>
<td>0.0964</td>
<td>0.0000</td>
<td>0.0659</td>
<td>0.0000</td>
<td>0.0000</td>
<td>0.0000</td>
</tr>
<tr>
<td>GMGP</td>
<td>0.0961</td>
<td>0.0000</td>
<td>0.0151</td>
<td>0.3221</td>
<td>0.0151</td>
<td>0.3221</td>
</tr>
<tr>
<td>GMPL</td>
<td>0.2774</td>
<td>0.0000</td>
<td>0.0821</td>
<td>0.0001</td>
<td>0.0821</td>
<td>0.0001</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Variable</th>
<th>Model 7</th>
<th>Model 8</th>
<th>Model 9</th>
<th>Model 10</th>
<th>Model 11</th>
<th>Model 12</th>
</tr>
</thead>
<tbody>
<tr>
<td>GMC</td>
<td>0.0919</td>
<td>0.0000</td>
<td>0.1676</td>
<td>0.0000</td>
<td>0.0788</td>
<td>0.0000</td>
</tr>
<tr>
<td>GMG</td>
<td>0.0992</td>
<td>0.0000</td>
<td>0.3336</td>
<td>0.0000</td>
<td>0.0000</td>
<td>0.0000</td>
</tr>
<tr>
<td>GMGP</td>
<td>0.0238</td>
<td>0.2573</td>
<td>0.2110</td>
<td>0.0000</td>
<td>0.0000</td>
<td>0.0000</td>
</tr>
<tr>
<td>GMPL</td>
<td>0.3239</td>
<td>0.0000</td>
<td>0.2426</td>
<td>0.0000</td>
<td>0.0000</td>
<td>0.0000</td>
</tr>
</tbody>
</table>

**Notes:** The values are coefficients. Model 1 deals with the average premium commanded by eco-labeled apartments while Model 2 relates to the premia associated with different ratings (i.e., tiers) of eco-labeled apartments in Singapore. Models 3 and 4 relate to eco-labeled premium for apartments in the Central and Outside Central regions, respectively. Models 5 and 6 deal with the premia associated with different ratings of eco-labeled apartments in the Central and Outside Central regions, respectively. Models 7 and 8 relate to eco-labeled premia for Freehold (Fee Simple) and Leasehold (Leased Fee), respectively (i.e., by tenure/property right), for apartments in the Central Region. A noticeable observation is the market’s illogical allocation of premia to the different GM ratings. Models 9 and 10 deal with the premia associated with different ratings of eco-labeled Freehold (Fee Simple) and Leasehold (Leased Fee) apartments, respectively, in the Central Region; Models 11 and 12 deal with their counterparts Outside Central Region.
apart from Models 6, 7, 8, and 11, all the other models provide evidence that the
market is somewhat confused about the GM certification, as attested by the
illogical allocation of premia to the various tiers. If Models 1, 7, 8, and 11, which
deal with a single tier each, are discounted from the analyses, the results of all
the remaining models virtually imply that the market is, to some extent, confused
by the GM certification.

For example, Model 2 shows that GMC commands a higher premium (12.96%)
than GMG (9.64%) and GMGP (9.61%) while GMG commands a higher premium
than GMGP. This is symptomatic of confusion as an enlightened market would
allocate higher premia to the higher-tiered certified buildings. Overall, only GMPL
in Model 2 shows a logical allocation of premium. The results for Models 5, 9,
10, and 12 attest to a confused market, as evidenced by the illogical allocation
of premia to the tiers. In Model 5, GMC commands a negative premium of 28.60%,
which is considerably lower than the premia for the higher tiers. However, this
negative premium is contrary to expectation as it implies that the GMC rating
reduces the value of private apartments in the CR. This is the only model that
returns a baffling negative premium; further research is required on this.

Furthermore, the results for Models 7 and 8 (Exhibit 4) cast doubts on the “purity”
of the GM premia. Note that GMC (overall) for freehold buildings command a
lower premium (9.19%) than for leasehold buildings (16.76%) in the CR. This
illogical differential premium by tenure for properties in the same area is
somewhat worrying. This is compounded by the fact that the same tier commands
markedly different premium for both freehold and leasehold properties in the CR
(Model 9 and 10). For example, while GMC (freehold properties in CR)
command a premium of 7.88% (Model 9), GMC (leasehold properties in CR)
commands a premium of 12.25% (Model 10). GMG commands a premium of
9.92% (Model 9) while it commands a premium of 33.36% in Model 10. The
results of Models 9 and 10, and 11 and 12 in particular, appear to point to a
market in confusion—a market that does not understand the tiering of the GM
certification. The results of the hedonic models virtually make the “purity” of the
GM premia questionable although the models control for other factors. More
research is required to examine the purity of the GM premia.

Post Model Evaluation

The assumptions of the Classical Linear Regression Model are tested for
heteroscedasticity, multicollinearity, and independence of residuals to verify the
robustness of the models. Three tests: the White Test for heteroscedasticity,
Pearson’s Bivariate Correlation Test, and Multi-collinearity Test (via the variance
inflation factor—VIF) are used for the purpose. As a rule of thumb, a VIF value
of 10 and above is indicative of multicollinearity (Kutner, 2004).
The adjusted $R^2$ for each of the 12 models is relatively high (the lowest being 0.8385), which implies that each model is a good fit (Appendix 2). Furthermore, the results of the Pearson Bivariate Correlation test (Exhibit 5) reveal that the correlation between each pair of explanatory variables is relatively low. The only two explanatory variables with a correlation above 0.50 are Tennis and BBQ with a correlation of 0.615. Moreover, all the VIFs for all the models (Appendix 2) are reasonably well below the benchmark value of 10. This implies that multicollinearity is not much of a problem. However, the White Test revealed the presence of heteroscedasticity in every model. Thus all the figures for each model reported in the Appendix 2 have been adjusted for heteroscedasticity. The results are therefore robust.

**Survey Results**

The profile of the respondents is shown in Exhibit 6. Most of the respondents belong to age groups 40–49 (37.67%) and 50–59 (30.67%). Furthermore, 59.33% of the respondents think that green buildings are environmentally friendly while 20.67% think otherwise; the remaining 20% are not sure whether or not green buildings are environmentally friendly (Exhibit 7). In addition, 62.67% of the respondents accept that green buildings reduce water and electricity bills, 17% think otherwise while the remaining 30.33% are not sure (Exhibit 8).

As far as sustainability is concerned, only 44.67% of the respondents think that green buildings promote sustainability, 20.67% think otherwise while the remaining 34.67% are not sure (Exhibit 9). In contrast, 60% of the respondents will purchase green buildings as a result of increasing environmental concerns (Exhibit 10). Of those who would buy green buildings, 80% are willing to pay a premium for green features (Exhibit 11). Paradoxically, the results in Exhibit 12 show that green features, with a mean rating score of 2.49, have very little impact on the respondents’ choice of private apartment to buy. This may be the rationale for the relatively low premium of 5.47% to 6.82% (Exhibit 11) that the respondents are willing to pay for green features. Moreover, the three most important factors that affect the respondents’ choice of the private apartment to buy are: price (mean rating score of 4.86), accessibility (mean rating score of 4.53), and location (mean rating score of 4.25). In addition, 48.67% of the respondents think that green buildings cost more than conventional buildings, 18.67% think otherwise while the remaining 32.66% are not sure. These results may explain why real estate developers in Singapore do not use green features for marketing.

Astonishingly, only 33.67% of the respondents had heard of the Green Mark rating system at the time of the survey (Exhibit 13) although the system has been in existence since January 2005. Of this proportion, 83.2% are not aware of the differences among the four ratings. This may be attributable to the fact that the ratings (Exhibit 1) are couched in technical language that makes the system unintelligible to the general public. Furthermore, this lack of awareness may explain the apparent confusion in the market as evidenced by the illogical allocation of premium to the four different ratings (tiers).
176

兩

Variables

LnAREA

BBQ

TENNIS

GYM

WFEATURES CLUBHSE LEVEL

PTYTYPE TENURE LnAGE

0.211

⫺0.006

0.660

0.140

0.075

⫺0.027

1.000

0.615

0.479

0.112 ⫺0.078

0.382

⫺0.051 ⫺0.192

0.113

⫺0.073

TENNIS

⫺0.047

0.615

1.000

0.334

0.160 ⫺0.064

0.468

⫺0.032 ⫺0.294

0.207

0.002

GYM

0.012

⫺0.135

LnPRICE

BBQ

LnAREA

1.000 ⫺0.027 ⫺0.047 ⫺0.104

SWIM

CR

0.070 ⫺0.045

T1

T2

T3

0.080 ⫺0.007 ⫺0.087

LnMRT

LnSHOP EXPRESS PUBHSG GMC

GMGP

GMPL

0.098

⫺0.152

0.003

0.004

0.240

0.019 ⫺0.040 ⫺0.110

0.164 ⫺0.159

0.165

0.104 ⫺0.121

0.048

0.056

0.113 ⫺0.327 ⫺0.071 ⫺0.014 ⫺0.020 ⫺0.177

0.071 ⫺0.110

0.214

0.160 ⫺0.032

0.114 ⫺0.265

0.029 ⫺0.210 ⫺0.025

0.305

0.272

⫺0.052

GMG

⫺0.104

0.479

0.334

1.000

0.442

0.038

0.483

0.111 ⫺0.084

0.053

⫺0.080

⫺0.064 ⫺0.114

0.070 ⫺0.013 ⫺0.020 ⫺0.170 ⫺0.079

SWIM

0.012

0.112

0.160

0.442

1.000

0.082

0.213

0.038

0.052

0.130

⫺0.104

⫺0.133 ⫺0.052

0.028 ⫺0.045 ⫺0.006

WFEATURES

0.211 ⫺0.078 ⫺0.064

0.038

0.082

1.000

0.185

0.033

0.198

0.031

⫺0.183

⫺0.332 ⫺0.037

0.096 ⫺0.018

0.006 ⫺0.101

0.426
0.170

0.070

0.012

0.002 ⫺0.359 ⫺0.338

0.013

⫺0.072

0.077

⫺0.370

⫺0.282

0.262 ⫺0.054

0.061

0.008

0.041

0.058

0.049 ⫺0.076

0.059

0.039 ⫺0.066

⫺0.034

0.028

0.058

0.026

0.014

0.184

0.111

0.259 ⫺0.116

0.169

0.122

0.115

0.027

0.065

⫺0.099

0.234

0.057 ⫺0.073

0.169

0.028

0.321

0.201 ⫺0.241 ⫺0.120

0.052

0.216

0.031

CLUBHSE

⫺0.006

0.468

0.483

0.213

0.186

1.000

0.103 ⫺0.079

0.168

⫺0.146

⫺0.160 ⫺0.182

0.096 ⫺0.112 ⫺0.021 ⫺0.068

LEVEL

⫺0.135 ⫺0.051 ⫺0.032

0.111

0.038

0.033

0.103

1.000

0.206 ⫺0.307

⫺0.132

⫺0.224

0.339

0.037 ⫺0.015

LnPRICE

0.660 ⫺0.192 ⫺0.294 ⫺0.084

0.052

0.198

⫺0.079

0.206

1.000 ⫺0.155

0.205

⫺0.151

0.498

0.041

0.199 ⫺0.069

0.186 ⫺0.090

PTYTYPE

0.140

0.130

0.031

0.168

0.240 ⫺0.199 ⫺0.029

0.032 ⫺0.055

0.178

0.004

0.019

0.205 ⫺0.091

0.225

⫺0.001

0.025 ⫺0.052

0.046 ⫺0.114

0.038

0.041

0.061 ⫺0.059 ⫺0.171 ⫺0.318 ⫺0.090

⫺0.125

⫺0.417

0.070

0.136

0.135

⫺0.049

⫺0.028

0.110 ⫺0.061

0.080

0.382

0.113

0.207

0.053

⫺0.307 ⫺0.155

1.000

TENURE

0.075 ⫺0.073

0.002 ⫺0.080 ⫺0.104 ⫺0.183

⫺0.146

⫺0.132

LnAGE

0.070

0.113 ⫺0.064 ⫺0.133 ⫺0.332

⫺0.160

⫺0.224 ⫺0.151

⫺0.045 ⫺0.210 ⫺0.327 ⫺0.114 ⫺0.052 ⫺0.037

⫺0.182

0.339

0.498 ⫺0.199

0.235

0.096

0.037

0.041 ⫺0.029

⫺0.076

⫺0.112

⫺0.015

CR
T1

0.029

0.080 ⫺0.025 ⫺0.071

0.070

0.028

T2

⫺0.007

T3

⫺0.087 ⫺0.040 ⫺0.010 ⫺0.020 ⫺0.006

0.096

0.019 ⫺0.014 ⫺0.013 ⫺0.045 ⫺0.018

LnMRT

0.305 ⫺0.110 ⫺0.177 ⫺0.170

LnSHOP

0.272

EXPRESS

0.098 ⫺0.159 ⫺0.110

0.164

0.071 ⫺0.079

0.006

⫺0.021

0.005 ⫺0.101

⫺0.068

0.039

0.426

0.170

0.041 ⫺0.066

0.216

0.070

0.205 ⫺0.091

⫺0.091
1.000
⫺0.054

0.032

0.004

0.002 ⫺0.069 ⫺0.055

0.019

⫺0.359

0.199

0.240

⫺0.054

0.235 ⫺0.076

1.000 ⫺0.090 ⫺0.084
⫺0.090

1.000 ⫺0.044

⫺0.084 ⫺0.044
0.025

0.061 ⫺0.449

1.000 ⫺0.192

⫺0.052 ⫺0.059 ⫺0.354 ⫺0.192

0.186

0.178

0.205

0.046 ⫺0.171

⫺0.338 ⫺0.090

0.162

⫺0.091

⫺0.114 ⫺0.318

0.077 ⫺0.054

0.225

0.038 ⫺0.090

0.013

1.000 ⫺0.449 ⫺0.364 ⫺0.005

0.033

0.019

⫺0.259 ⫺0.204

0.388 ⫺0.013

⫺0.093 ⫺0.352 ⫺0.233 ⫺0.124

0.021

0.028 ⫺0.045

0.020

⫺0.050 ⫺0.027

1.000 ⫺0.066

0.064 ⫺0.010

0.100

0.092 ⫺0.093

⫺0.192

0.045

0.021 ⫺0.066

1.000

0.277

0.201 ⫺0.440

0.166

0.276

0.033

0.064

0.277

1.000

0.003

0.261

0.212 ⫺0.170

0.224

0.019 ⫺0.045 ⫺0.020

0.201

0.003

1.000

⫺0.071

0.050 ⫺0.057

0.133 ⫺0.116
0.141 ⫺0.204

0.266

PUBHSG

⫺0.152

0.165

0.214

0.058 ⫺0.034

0.184

0.012

⫺0.072 ⫺0.370

0.061

⫺0.001

0.020

0.100 ⫺0.440

0.261 ⫺0.071

1.000

0.197 ⫺0.016

GMC

⫺0.052

0.104

0.160

0.049

0.028

0.111

0.122

⫺0.099 ⫺0.282

0.201

⫺0.259

⫺0.093 ⫺0.417 ⫺0.028 ⫺0.050

0.092 ⫺0.192

0.212

0.050

0.192

1.000 ⫺0.295 ⫺0.134 ⫺0.071

GMG

0.003 ⫺0.121 ⫺0.032 ⫺0.076

0.058

0.259

0.115

0.234

0.169 ⫺0.241

⫺0.204

⫺0.352

0.070

0.110 ⫺0.027 ⫺0.093 ⫺0.080 ⫺0.170 ⫺0.057

⫺0.016

GMGP

0.004

0.048

0.114

0.059

0.025 ⫺0.116

0.027

0.057

0.028 ⫺0.120

0.388

⫺0.233

0.136 ⫺0.061

0.005

0.076

0.166

0.224

0.133

0.141

GMPL

0.240

0.056 ⫺0.255

0.031

0.014

0.065

⫺0.078

⫺0.013

⫺0.124

0.135

0.045 ⫺0.049

0.276

0.265 ⫺0.116

⫺0.204

0.169

0.321

0.052

0.041 ⫺0.125 ⫺0.049

0.028

⫺0.060

0.005

0.076 ⫺0.049

0.080

Notes: The exhibit reports the bivariate correlations to provide preliminary evidence for the existence of collinearity between pairs of variables used in the hedonic models.

⫺0.295

1.000 ⫺0.284 ⫺0.151

⫺0.134 ⫺0.284

1.000 ⫺0.067

⫺0.071 ⫺0.151 ⫺0.067

1.000

Addae-Dapaah and Su Jen Chieh

E x h i b i t 5 兩 Pearson Bivariate Correlation Results


The premia that the respondents are willing to pay for green features are presented in Exhibit 11. These are substantially lower than the implicit premia revealed through the hedonic models. The results exemplify a tale of the “haves” and “have-nots” in Singapore. The survey was conducted on the general public, most of whom live in public housing. These are the “have-nots” as their household income is at most S$8,000 per month. The premia extracted from the hedonic model represent the “haves.” Furthermore the relatively low premium that respondents to the survey are willing to pay for green features is reflective of the relative low impact that green features have on the respondents’ choice of private apartment to buy (Exhibit 12).

It is evident from Exhibit 14 that notwithstanding the relatively low premia that the respondents are willing to pay, it is still profitable for developers and investors to obtain GM certification (i.e., go green) as depicted by the PCR. GMC is the most profitable as measured by the PCR (Exhibit 14). Thus, as far as profitability is concerned, it is in the interest of property developers and investors to aim at the basic green mark certification—GMC—though that may not be the best route for sustainability.

Exhibit 14 shows that there is an economic incentive (profit) for developers and investors to think positively of green residential property development and investment. However, the story could be different from the vast majority of Singaporeans who purchase condominiums for occupation. From the owner-
Exhibit 7 | Green Building is Environmentally Friendly

- Yes: 59.33%
- No: 20.00%
- Not Sure: 20.67%

Exhibit 8 | Green Building Reduces Water and Electricity Bills

- Yes: 62.67%
- No: 17.00%
- Not Sure: 20.33%
Exhibit 9 | Green Building Promotes Sustainability

- Yes: 44.67%
- No: 20.67%
- Not Sure: 34.67%

Exhibit 10 | Will Increasing Environmental Concerns Prompt You to Purchase Green Building?

- Yes: 60.00%
- No: 28.00%
- Not Sure: 12.00%
### Exhibit 11 | Regression versus Survey Premia (Weighted Mean Bracketed)

<table>
<thead>
<tr>
<th>Rating</th>
<th>Regression Results</th>
<th>Survey Findings</th>
</tr>
</thead>
<tbody>
<tr>
<td>Platinum</td>
<td>27.74%</td>
<td>5.1%–10% (6.82%)</td>
</tr>
<tr>
<td>Gold Plus</td>
<td>9.61%</td>
<td>1%–6% (5.60%)</td>
</tr>
<tr>
<td>Gold</td>
<td>9.64%</td>
<td>5.1%–10% (5.58%)</td>
</tr>
<tr>
<td>Certified</td>
<td>12.97%</td>
<td>5.1%–10% (5.47%)</td>
</tr>
</tbody>
</table>

Notes: This exhibit presents the premia allocation among the different Green Mark ratings resulting from the hedonic model and the survey. Values in parentheses are weighted average premia that respondents who are aware of GM rating system are willing to pay.

### Exhibit 12 | Factors Affecting Respondents’ Decision to Purchase Condominiums

<table>
<thead>
<tr>
<th>Factors</th>
<th>Likert Scale (1–5)</th>
<th>Average Score</th>
<th>Ranking</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1  2  3  4  5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Price</td>
<td>0  2  4  28  266</td>
<td>4.86</td>
<td>1</td>
</tr>
<tr>
<td>Accessibility</td>
<td>1  2  33  65  199</td>
<td>4.53</td>
<td>2</td>
</tr>
<tr>
<td>Location</td>
<td>1  3  6  201  89</td>
<td>4.25</td>
<td>3</td>
</tr>
<tr>
<td>Amenities</td>
<td>1  3  35  223  38</td>
<td>3.98</td>
<td>4</td>
</tr>
<tr>
<td>Facilities</td>
<td>2  11  198  65  24</td>
<td>3.33</td>
<td>5</td>
</tr>
<tr>
<td>Green features</td>
<td>34  157  53  41  15</td>
<td>2.49</td>
<td>6</td>
</tr>
<tr>
<td>Promotion</td>
<td>26  178  45  31  20</td>
<td>2.47</td>
<td>7</td>
</tr>
<tr>
<td>Developer</td>
<td>201  72  24  2  1</td>
<td>1.43</td>
<td>8</td>
</tr>
</tbody>
</table>

Notes: This exhibit reports the relative importance of factors that affect the respondents’ decision to buy private apartment. Respondents were asked to state the impact of each factor by choosing a rating score from a Likert scale of 1–5, with 1 representing minimum impact and 5 representing maximum impact. The average score is the weighted average of the respondents score. The numbers under each Likert scale depict how many respondents chose that score for the corresponding factor. There were 300 respondents.

From the occupier’s point of view, what may be of paramount importance is the relationship between the savings attributable to energy efficiency and the incremental cost of green building as economics, particularly price (Exhibit 12), is of paramount importance in the respondents’ choice of private apartment to buy. Let us assume the cost of a condominium to be S$800,000 (this is lower than the average in Singapore). Assume that going green adds 3% to the cost. Note that GMPL can add 2% to 8% to the cost. Thus, the 3% assumption is conservative. This will add S$24,000 the cost which, if amortized over 30 years at a relatively low mortgage rate of 4.5% per annum monthly compounding, will add S$121.60 to the person’s monthly bill. This is likely to be the minimum incremental cost as it
Exhibit 13 | Have You Heard of BCA Green Mark Ratings?

Exhibit 14 | Premium Cost Ratio

<table>
<thead>
<tr>
<th>Rating</th>
<th>Premium / sq. ft.*</th>
<th>Hedonic</th>
<th>Survey</th>
<th>Cost / sq. ft.**</th>
<th>Hedonic</th>
<th>Survey</th>
</tr>
</thead>
<tbody>
<tr>
<td>GMPL</td>
<td>554.80</td>
<td>136.40</td>
<td>56.00</td>
<td>9.91</td>
<td>2.44</td>
<td></td>
</tr>
<tr>
<td>GMGP</td>
<td>192.20</td>
<td>112.00</td>
<td>21.00</td>
<td>9.15</td>
<td>5.33</td>
<td></td>
</tr>
<tr>
<td>GMG</td>
<td>192.80</td>
<td>111.60</td>
<td>14.00</td>
<td>13.77</td>
<td>7.97</td>
<td></td>
</tr>
<tr>
<td>GMC</td>
<td>259.40</td>
<td>109.40</td>
<td>7.00</td>
<td>37.06</td>
<td>15.63</td>
<td></td>
</tr>
<tr>
<td>Overall</td>
<td>233.80</td>
<td>117.35</td>
<td>24.50</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Notes: We report in this table the premium cost ratio (i.e., (average premium / sq. ft.)/(average cost / sq. ft.)) for the different GM Ratings vis-à-vis hedonic model and survey results.

*Based on a modest average price of S$2000 / sq. ft.

**Based on highest construction cost for luxury condominium (S$700 / sq. ft. including professional fees & finance cost) calculated from figures in RLB Research & Development Report, and BCA maximum cost premium: 8% (GMPL), 3% (GMGP), 2% (GMG), and 1% (GMC).
is overly optimistic to think that one can get a mortgage over 30 years at a fixed or average mortgage rate of 4.5% per annum. This implies that if the incremental cost proves to be higher than the total maximum cost savings from green building, one will be hard put to justify investment on purely economic grounds for owner-occupiers unless one argues on the basis of hypothetical, yet-to-be-proven benefits.

The average monthly household electricity, gas, and water consumption in Singapore as shown on monthly utilities bills from February to August 2011 are about 659 kWh, 86 kWh, and 17.3 Cu M respectively. On the basis a unit cost of S$0.2728 per kWh, S$0.1961 per kWh, and S$1.17 per Cu M, respectively, for electricity, gas, and water, a waterborne fee of S$0.2803 per Cu M of water consumed, water conservation tax of 30%, and goods and services tax of 7%, the average household utility bill is about S$243 per month. Assuming energy efficiency of 30%, which is the maximum attributable to GMPL rating, we arrive at a saving in utilities cost of S$73.12 per month. A saving of S$73.12 resulting from a cost of S$121.60 per month, a benefit-cost ratio of 0.6, may be a disincentive more than an incentive for prospective owner-occupied private apartment purchasers to commit to a green condominium on purely an economic basis.

The foregoing analysis does not account for a possible capital gain from the sale of the property at a future date. However, it must be noted that potential future capital gain is, until realized, a pie in the sky. Furthermore, the owner-occupier must be able to keep ownership of the apartment through servicing the mortgage loan until the future date when a sale, which can also result in a loss, takes place. This implies that the net impact of going “green” on the cash flow position of owner-occupiers could be critical in their decision go “green.”

Conclusion

The study set out to determine the premium (if any) commanded by eco-labeling of private apartments in Singapore and above all, to find out if the market understands the different GM ratings. Furthermore, it is aimed to ascertain the relative profitability of the GM ratings. All these are motivated by a desire to provide evidence on eco-labeling vis-à-vis residential properties in an Asian setting (which has never been done) to fill the gap in the extant literature. The objectives were operationalized through the analyses of secondary data of 13,899 private apartment sales data via hedonic model, and primary data from a random survey of 300 people in Singapore.

The results clearly show that eco-labeling in Singapore commands a premium. The premium ranges from an average of 9.61% for GMGP to 27.74% for GMPL (hedonic model) and 5.47% for GMC to 6.82% for GMPL (survey). These results are in harmony with the extant literature on commercial office properties in the U.S. However, the illogical allocation of premium to different GM ratings [e.g., GMC commanding a higher average premium (12.96%) than GMG (9.64%) and GMGP (9.64%)] hints of a market that is confused by the different GM ratings. This confusion is not surprising given that out of the 33.67% of the respondents
who had heard of the GM rating system, 83.2% were not aware of the differences among the four GM ratings, albeit the system have been operational for more than five years.

Furthermore, the fact that the same GM rating commands different premium by tenure and by location within a tiny city-state like Singapore (after controlling for other factors) casts doubt on the “purity” of the GM premia. On the whole, freehold/leasehold private apartments with eco-labeling command an average premium of 9.19%/16.76%, respectively. This phenomenon is difficult to explain and thus, calls for more research. Finally, it is more profitable, on the basis of PCR, for investors and developers to aim for the basic GMC rating. This will not, however, be in the best interest of sustainability as the highest tier rating (GMPL) is supposed to be the most energy efficient. Thus, mass education of the public on the Green Mark ratings, coupled with simplifying descriptions of the rating system to make it intelligible to the public, is required to enlighten the market for it to make logical allocation of premia to the tiers. This could make the higher tiers more profitable than the lower ones on the basis of PCR to encourage developers and investors to aim for GMPL rating to promote sustainability in private apartment development.

However, it is not economically beneficial for owner-occupiers, given an incremental benefit-cost ratio of 0.6, to commit to a green private apartment. There is therefore a dire need for a reduction in the incremental cost of green private apartments to make them appealing to owner-occupiers.

Appendix 1

Questionnaire for Survey

Please tick only where appropriate.

Section A. In your opinion, what is Green Building?

1.0 It is an environmentally-friendly building.
   Yes ☐   No ☐   Not Sure ☐

1.1 It can reduce water and electricity usage and bills.
   Yes ☐   No ☐   Not Sure ☐

1.2 It reduces potential undesirable environmental impact (e.g., global warming).
   Yes ☐   No ☐   Not Sure ☐

1.3 It is designed and constructed to promote sustainability.
   Yes ☐   No ☐   Not Sure ☐

1.4 It emphasizes the efficiency of resource use such as energy, water and materials.
   Yes ☐   No ☐   Not Sure ☐

1.5 It provides cleaner and fresher air for the occupants.
   Yes ☐   No ☐   Not Sure ☐
1.6 It has innovative features (e.g., lighting system to automatically switch lights off when not in use).
   Yes ☐ No ☐ Not Sure ☐

Section B.

1.7 Are you aware that green buildings are built to meet the needs of homebuyers while at the same time minimizing environmental impact?
   Yes ☐ No ☐ Not Sure ☐

1.8 Will the increasing environmental concern prompt you to purchase a green building?
   Yes ☐ No ☐ Not Sure ☐

1.9 Do you think that green building is more costly than non-green building?
   Yes ☐ No ☐ Not Sure ☐

2.0 Are you willing to pay a premium to purchase a unit in a green residential building?
   Yes ☐ No ☐

2.1 Have you heard of the Building and Construction Authority’s (BCA) Green Mark ratings in Singapore?
   Yes ☐ (Continue with question 2.2 to 2.9) No ☐ (Skip question 2.2 to 2.9)

2.2 Do you know that there are four different Green Mark ratings: Green Mark Platinum, Green Mark Gold Plus, Green Mark Gold, and Green Mark Certified?
   Yes ☐ No ☐

2.3 Are you aware of the differences among the above mentioned four Green Mark ratings?
   Yes ☐ No ☐

2.4 A Platinum Mark Rating:
   a. Fulfills the mandatory requirements.
      Yes ☐ No ☐ Not Sure ☐

   b. Has a building envelope design with residential envelope thermal transmittance value (RETV) of 22 W/m² or lower.
      Yes ☐ No ☐ Not Sure ☐

   c. Has a building envelope design with residential envelope thermal transmittance value (RETV) of 20 W/m² or lower.
      Yes ☐ No ☐ Not Sure ☐

   d. Uses ventilation simulation software for wind tunnel testing to identify the most effective building design and layout and has implemented the recommendations derived to ensure good natural ventilation.
      Yes ☐ No ☐ Not Sure ☐

2.5 A Gold Plus Mark Rating
   a. It fulfills the mandatory requirements.
      Yes ☐ No ☐ Not Sure ☐
b. Has a building envelope design with residential envelope thermal transmittance value (RETV) of 22 W/m² or lower.
   Yes ☐  No ☐  Not Sure ☐

c. Has a building envelope design with residential envelope thermal transmittance value (RETV) of 20 W/m² or lower.
   Yes ☐  No ☐  Not Sure ☐

d. Uses ventilation simulation software for wind tunnel testing to identify the most effective building design and layout and has implemented the recommendations derived to ensure good natural ventilation.
   Yes ☐  No ☐  Not Sure ☐

2.6 A Gold Mark Rating

a. Fulfills the mandatory requirements.
   Yes ☐  No ☐  Not Sure ☐

b. Has a building envelope design with residential envelope thermal transmittance value (RETV) of 22 W/m² or lower.
   Yes ☐  No ☐  Not Sure ☐

c. Has a building envelope design with residential envelope thermal transmittance value (RETV) of 20 W/m² or lower.
   Yes ☐  No ☐  Not Sure ☐

d. Uses ventilation simulation software for wind tunnel testing to identify the most effective building design and layout and has implemented the recommendations derived to ensure good natural ventilation.
   Yes ☐  No ☐  Not Sure ☐

2.7 A Certified Mark Rating

a. Fulfills the mandatory requirements.
   Yes ☐  No ☐  Not Sure ☐

b. Has a building envelope design with residential envelope thermal transmittance value (RETV) of 22 W/m² or lower.
   Yes ☐  No ☐  Not Sure ☐

c. Has a building envelope design with residential envelope thermal transmittance value (RETV) of 20 W/m² or lower.
   Yes ☐  No ☐  Not Sure ☐

d. Uses ventilation simulation software for wind tunnel testing to identify the most effective building design and layout and has implemented the recommendations derived to ensure good natural ventilation.
   Yes ☐  No ☐  Not Sure ☐

2.8 How much premium are you willing to pay for residential property with the following BCA Green Mark ratings?

Platinum Green Mark:
0% ☐  1%–5% ☐  5.1%–10% ☐  10.1%–15% ☐  More than 15% ☐
Gold Plus Green Mark:
0% □ 1%–5% □ 5.1%–10% □ 10.1%–15% □ More than 15% □
Gold Green Mark:
0% □ 1%–5% □ 5.1%–10% □ 10.1%–15% □ More than 15% □
Certified Green Mark:
0% □ 1%–5% □ 5.1%–10% □ 10.1%–15% □ More than 15% □

2.9 Do you wish to know more about The BCA Green Mark Scheme?
Yes □ No □

Section C.
What are the factors that would have impact on your decision-making to purchase a condominium unit? Based on a scale of 1–5 (1 is Minimum Impact’ and 5 is Maximum Impact).

<table>
<thead>
<tr>
<th>Min. Impact</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5 Max. Impact</th>
</tr>
</thead>
<tbody>
<tr>
<td>3.0 Location</td>
<td>□</td>
<td>□</td>
<td>□</td>
<td>□</td>
</tr>
<tr>
<td>3.1 Price</td>
<td>□</td>
<td>□</td>
<td>□</td>
<td>□</td>
</tr>
<tr>
<td>3.2 Promotion</td>
<td>□</td>
<td>□</td>
<td>□</td>
<td>□</td>
</tr>
<tr>
<td>3.3 Green features</td>
<td>□</td>
<td>□</td>
<td>□</td>
<td>□</td>
</tr>
<tr>
<td>3.4 Accessibility</td>
<td>□</td>
<td>□</td>
<td>□</td>
<td>□</td>
</tr>
<tr>
<td>3.5 Developer</td>
<td>□</td>
<td>□</td>
<td>□</td>
<td>□</td>
</tr>
<tr>
<td>3.6 Amenities</td>
<td>□</td>
<td>□</td>
<td>□</td>
<td>□</td>
</tr>
<tr>
<td>3.7 Facilities</td>
<td>□</td>
<td>□</td>
<td>□</td>
<td>□</td>
</tr>
</tbody>
</table>

Section D.

3.8 Gender
Male Female

3.9 Age
20–29 30–39 40–49 50–59

4.0 Highest qualification
Primary Secondary Polytechnic Junior College University Others:______________

4.1 Occupation
Administrative Unemployed
Real Estate Housewife
Sales & Marketing Student
Engineering Education
Retired Manufacturing
Government Others, please specify______________

4.2 Monthly income
$1,001–$2,000 $5,001–$6,000
$2,001–$3,000 6,001–$7,000
$3,001–$4,000 $7,001–$8,000
$4,001–$5,000 >$8,000
## Appendix 2

### Results of Hedonic Models

<table>
<thead>
<tr>
<th>Variable</th>
<th>Model 1</th>
<th></th>
<th>Model 2</th>
<th></th>
<th>Model 3</th>
<th></th>
<th>Model 4</th>
<th></th>
<th>Model 5</th>
<th></th>
<th>Model 6</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$\beta$</td>
<td>Prob</td>
<td>$\beta$</td>
<td>Prob.</td>
<td>$\beta$</td>
<td>Prob.</td>
<td>$\beta$</td>
<td>Prob.</td>
<td>$\beta$</td>
<td>Prob.</td>
<td>$\beta$</td>
<td>Prob.</td>
</tr>
<tr>
<td>Constant</td>
<td>7.2221</td>
<td>0.0000</td>
<td>7.2535</td>
<td>0.0000</td>
<td>8.0059</td>
<td>0.0000</td>
<td>9.7953</td>
<td>0.0000</td>
<td>8.0393</td>
<td>0.0000</td>
<td>9.7540</td>
<td>0.0000</td>
</tr>
<tr>
<td>LNAREA</td>
<td>1.1576</td>
<td>0.0000</td>
<td>1.1520</td>
<td>0.0000</td>
<td>1.1497</td>
<td>0.0000</td>
<td>0.7943</td>
<td>0.0000</td>
<td>1.1397</td>
<td>0.0000</td>
<td>0.8012</td>
<td>0.0000</td>
</tr>
<tr>
<td>LEVEL</td>
<td>0.0025</td>
<td>0.0000</td>
<td>0.0027</td>
<td>0.0000</td>
<td>0.0018</td>
<td>0.0000</td>
<td>0.0068</td>
<td>0.0000</td>
<td>0.0014</td>
<td>0.0000</td>
<td>0.0055</td>
<td>0.0000</td>
</tr>
<tr>
<td>PTYTYPE</td>
<td>-0.1444</td>
<td>0.0000</td>
<td>-0.1530</td>
<td>0.0000</td>
<td>-0.1441</td>
<td>0.0000</td>
<td>-0.2186</td>
<td>0.0000</td>
<td>-0.1326</td>
<td>0.0000</td>
<td>-0.2123</td>
<td>0.0000</td>
</tr>
<tr>
<td>LNAGE</td>
<td>-0.0110</td>
<td>0.0028</td>
<td>-0.0159</td>
<td>0.0000</td>
<td>-0.0566</td>
<td>0.0000</td>
<td>-0.0716</td>
<td>0.0000</td>
<td>-0.0644</td>
<td>0.0000</td>
<td>-0.0723</td>
<td>0.0000</td>
</tr>
<tr>
<td>CR</td>
<td>0.6125</td>
<td>0.0000</td>
<td>0.6095</td>
<td>0.0000</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>BBQ</td>
<td>0.0796</td>
<td>0.0000</td>
<td>0.0468</td>
<td>0.0099</td>
<td>0.0931</td>
<td>0.0000</td>
<td>0.0849</td>
<td>0.0000</td>
<td>0.0947</td>
<td>0.0000</td>
<td>0.1278</td>
<td>0.0000</td>
</tr>
<tr>
<td>CLUBHSE</td>
<td>0.0706</td>
<td>0.0000</td>
<td>0.0619</td>
<td>0.0000</td>
<td>0.0456</td>
<td>0.1105</td>
<td>-0.0449</td>
<td>0.0000</td>
<td>0.0172</td>
<td>0.1277</td>
<td>-0.0784</td>
<td>0.0000</td>
</tr>
<tr>
<td>GYM</td>
<td>-0.0507</td>
<td>0.0105</td>
<td>-0.0736</td>
<td>0.0007</td>
<td>-0.0349</td>
<td>0.0000</td>
<td>-0.0076</td>
<td>0.0000</td>
<td>-0.0393</td>
<td>0.0000</td>
<td>-0.0396</td>
<td>0.0000</td>
</tr>
<tr>
<td>SWIM</td>
<td>0.6424</td>
<td>0.0000</td>
<td>0.6685</td>
<td>0.0000</td>
<td>0.481</td>
<td>0.3310</td>
<td>0.4980</td>
<td>0.0000</td>
<td>0.0936</td>
<td>0.0000</td>
<td>0.3226</td>
<td>0.0000</td>
</tr>
<tr>
<td>TENNIS</td>
<td>-0.0971</td>
<td>0.0000</td>
<td>-0.0564</td>
<td>0.0000</td>
<td>-0.0087</td>
<td>0.0000</td>
<td>0.0168</td>
<td>0.1244</td>
<td>0.3226</td>
<td>0.0000</td>
<td></td>
<td></td>
</tr>
<tr>
<td>WFEATURES</td>
<td>0.1828</td>
<td>0.0000</td>
<td>0.1772</td>
<td>0.0000</td>
<td>0.3051</td>
<td>0.0000</td>
<td>-0.1299</td>
<td>0.0000</td>
<td>0.2736</td>
<td>0.0000</td>
<td>0.2412</td>
<td>0.5841</td>
</tr>
<tr>
<td>T1</td>
<td>0.2258</td>
<td>0.0000</td>
<td>0.2247</td>
<td>0.0000</td>
<td>0.2400</td>
<td>0.0000</td>
<td>0.0899</td>
<td>0.0000</td>
<td>0.2218</td>
<td>0.0000</td>
<td>-0.0037</td>
<td>0.0000</td>
</tr>
<tr>
<td>T2</td>
<td>0.5172</td>
<td>0.0000</td>
<td>0.5146</td>
<td>0.0000</td>
<td>0.5637</td>
<td>0.0000</td>
<td>0.3200</td>
<td>0.0000</td>
<td>0.5419</td>
<td>0.0000</td>
<td>0.0855</td>
<td>0.0000</td>
</tr>
<tr>
<td>T3</td>
<td>0.3173</td>
<td>0.0000</td>
<td>0.3153</td>
<td>0.0000</td>
<td>0.3093</td>
<td>0.0000</td>
<td>0.2355</td>
<td>0.0000</td>
<td>0.3200</td>
<td>0.0000</td>
<td>-0.0547</td>
<td>0.0000</td>
</tr>
<tr>
<td>LNSHOP</td>
<td>-0.1587</td>
<td>0.0000</td>
<td>-0.1689</td>
<td>0.0000</td>
<td>-0.1674</td>
<td>0.0000</td>
<td>-0.063</td>
<td>0.0000</td>
<td>-0.1388</td>
<td>0.0000</td>
<td>0.0986</td>
<td>0.0000</td>
</tr>
<tr>
<td>LNMRT</td>
<td>0.0593</td>
<td>0.0000</td>
<td>0.0600</td>
<td>0.0000</td>
<td>0.1139</td>
<td>0.0003</td>
<td>0.0238</td>
<td>0.0000</td>
<td>0.1024</td>
<td>0.0000</td>
<td>0.1073</td>
<td>0.0000</td>
</tr>
<tr>
<td>EXPRESS</td>
<td>0.0044</td>
<td>0.3883</td>
<td>0.0159</td>
<td>0.0049</td>
<td>0.0247</td>
<td>0.0000</td>
<td>0.0544</td>
<td>0.0000</td>
<td>0.0984</td>
<td>0.0000</td>
<td>0.1278</td>
<td>0.0000</td>
</tr>
</tbody>
</table>
## Appendix 2 (continued)

### Results of Hedonic Models

<table>
<thead>
<tr>
<th>Variable</th>
<th>Model 1</th>
<th>Model 2</th>
<th>Model 3</th>
<th>Model 4</th>
<th>Model 5</th>
<th>Model 6</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$\beta$</td>
<td>Prob.</td>
<td>$\beta$</td>
<td>Prob.</td>
<td>$\beta$</td>
<td>Prob.</td>
</tr>
<tr>
<td>PUBHSG</td>
<td>-0.2167</td>
<td>0.0000</td>
<td>-0.2010</td>
<td>0.0000</td>
<td>-0.288</td>
<td>0.0000</td>
</tr>
<tr>
<td>GMC</td>
<td>0.1169</td>
<td>0.0000</td>
<td>0.1297</td>
<td>0.0000</td>
<td>0.0659</td>
<td>0.0000</td>
</tr>
<tr>
<td>GMG</td>
<td></td>
<td></td>
<td>0.0964</td>
<td>0.0000</td>
<td></td>
<td></td>
</tr>
<tr>
<td>GMGP</td>
<td></td>
<td></td>
<td>0.0961</td>
<td>0.0000</td>
<td></td>
<td></td>
</tr>
<tr>
<td>GMPL</td>
<td></td>
<td></td>
<td>0.2774</td>
<td>0.0000</td>
<td></td>
<td></td>
</tr>
<tr>
<td>$R^2$</td>
<td>0.8801</td>
<td></td>
<td>0.8819</td>
<td></td>
<td>0.8894</td>
<td></td>
</tr>
<tr>
<td>Adj. $R^2$</td>
<td>0.8800</td>
<td>0.0000</td>
<td>0.8817</td>
<td>0.0000</td>
<td>0.8891</td>
<td>0.0000</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
### Results of Hedonic Models

<table>
<thead>
<tr>
<th>Variable</th>
<th>Model 7</th>
<th></th>
<th>Model 8</th>
<th></th>
<th>Model 9</th>
<th></th>
<th>Model 10</th>
<th></th>
<th>Model 11</th>
<th></th>
<th>Model 12</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Constant</td>
<td>8.7033</td>
<td>0.0000</td>
<td>8.5668</td>
<td>0.0000</td>
<td>8.7888</td>
<td>0.0000</td>
<td>8.2223</td>
<td>0.0000</td>
<td>9.7699</td>
<td>0.0000</td>
<td>9.4499</td>
<td>0.0000</td>
</tr>
<tr>
<td>LNAREA</td>
<td>1.1334</td>
<td>0.0000</td>
<td>1.1098</td>
<td>0.0000</td>
<td>1.1040</td>
<td>0.0000</td>
<td>1.1583</td>
<td>0.0000</td>
<td>0.7749</td>
<td>0.0000</td>
<td>0.8081</td>
<td>0.0000</td>
</tr>
<tr>
<td>LEVEL</td>
<td>0.0053</td>
<td>0.0000</td>
<td>0.0033</td>
<td>0.0000</td>
<td>0.0083</td>
<td>0.0000</td>
<td>0.0017</td>
<td>0.0000</td>
<td>0.0077</td>
<td>0.0000</td>
<td>0.0047</td>
<td>0.0000</td>
</tr>
<tr>
<td>PTYPE</td>
<td>-0.0563</td>
<td>0.0000</td>
<td>-0.3935</td>
<td>0.0000</td>
<td>-0.0739</td>
<td>0.0000</td>
<td>0.0198</td>
<td>0.0544</td>
<td>0.0000</td>
<td>-0.1694</td>
<td>0.0000</td>
<td></td>
</tr>
<tr>
<td>LNAGE</td>
<td>-0.1304</td>
<td>0.0028</td>
<td>0.1385</td>
<td>0.0000</td>
<td>-0.1079</td>
<td>0.0000</td>
<td>-0.0027</td>
<td>0.7442</td>
<td>-0.1043</td>
<td>0.0000</td>
<td>-0.0778</td>
<td>0.0000</td>
</tr>
<tr>
<td>WFEATURES</td>
<td>0.3112</td>
<td>0.0000</td>
<td>0.4769</td>
<td>0.0000</td>
<td>0.2504</td>
<td>0.0000</td>
<td>0.0000</td>
<td>0.1603</td>
<td>0.0000</td>
<td>0.0000</td>
<td>0.0000</td>
<td>0.0000</td>
</tr>
<tr>
<td>T1</td>
<td>0.1849</td>
<td>0.0000</td>
<td>0.3072</td>
<td>0.0000</td>
<td>0.1804</td>
<td>0.0000</td>
<td>0.3284</td>
<td>0.0000</td>
<td>0.1370</td>
<td>0.0000</td>
<td>0.0867</td>
<td>0.0000</td>
</tr>
<tr>
<td>T2</td>
<td>0.4846</td>
<td>0.0000</td>
<td>0.6005</td>
<td>0.0000</td>
<td>0.4582</td>
<td>0.0000</td>
<td>0.6205</td>
<td>0.0000</td>
<td>0.3202</td>
<td>0.0000</td>
<td>0.3150</td>
<td>0.0000</td>
</tr>
<tr>
<td>T3</td>
<td>0.1982</td>
<td>0.0000</td>
<td>0.4128</td>
<td>0.0000</td>
<td>0.2019</td>
<td>0.0000</td>
<td>0.3834</td>
<td>0.0000</td>
<td>0.2537</td>
<td>0.0000</td>
<td>0.2109</td>
<td>0.0000</td>
</tr>
<tr>
<td>LNSHOP</td>
<td>-0.1763</td>
<td>0.0000</td>
<td>-0.1822</td>
<td>0.0000</td>
<td>-0.1093</td>
<td>0.0000</td>
<td>-0.0924</td>
<td>0.0000</td>
<td>0.0803</td>
<td>0.0000</td>
<td>0.0000</td>
<td>0.0000</td>
</tr>
<tr>
<td>LNMRT</td>
<td>0.0409</td>
<td>0.0000</td>
<td>0.1861</td>
<td>0.0000</td>
<td>-0.0925</td>
<td>0.0000</td>
<td>0.0803</td>
<td>0.0000</td>
<td>0.0000</td>
<td>0.0000</td>
<td>0.0000</td>
<td>0.0000</td>
</tr>
<tr>
<td>EXPRESS</td>
<td>0.0323</td>
<td>0.3883</td>
<td>-0.0328</td>
<td>0.0049</td>
<td>0.0000</td>
<td>0.0000</td>
<td>-0.0521</td>
<td>0.0000</td>
<td>0.0000</td>
<td>0.0000</td>
<td>0.0000</td>
<td>0.0000</td>
</tr>
<tr>
<td>PUBHSG</td>
<td>-0.4122</td>
<td>0.0000</td>
<td>-0.1331</td>
<td>0.0000</td>
<td>-0.4050</td>
<td>0.0000</td>
<td>-0.2401</td>
<td>0.0000</td>
<td>0.0701</td>
<td>0.0000</td>
<td>0.0000</td>
<td>0.0000</td>
</tr>
<tr>
<td>GMC</td>
<td>0.0919</td>
<td>0.0000</td>
<td>0.1676</td>
<td>0.0000</td>
<td>0.0788</td>
<td>0.0825</td>
<td>0.1225</td>
<td>0.0000</td>
<td>0.0000</td>
<td>0.0000</td>
<td>0.0000</td>
<td>0.0000</td>
</tr>
<tr>
<td>GMG</td>
<td>0.0000</td>
<td>0.0000</td>
<td>0.0992</td>
<td>0.0000</td>
<td>0.3336</td>
<td>0.0000</td>
<td>0.1504</td>
<td>0.0000</td>
<td>0.0628</td>
<td>0.0000</td>
<td>0.0000</td>
<td>0.0000</td>
</tr>
<tr>
<td>GMGP</td>
<td>0.0000</td>
<td>0.0000</td>
<td>0.0239</td>
<td>0.2573</td>
<td>0.2110</td>
<td>0.0000</td>
<td>0.0000</td>
<td>0.0000</td>
<td>0.0000</td>
<td>0.0000</td>
<td>0.0000</td>
<td>0.0000</td>
</tr>
<tr>
<td>GMPL</td>
<td>0.0000</td>
<td>0.0000</td>
<td>0.3239</td>
<td>0.0000</td>
<td>0.2426</td>
<td>0.0000</td>
<td>0.0000</td>
<td>0.0000</td>
<td>0.0000</td>
<td>0.0000</td>
<td>0.0000</td>
<td>0.0000</td>
</tr>
<tr>
<td>R²</td>
<td>0.90255</td>
<td>0.0000</td>
<td>0.90641</td>
<td>0.0000</td>
<td>0.9109</td>
<td>0.0810</td>
<td>0.8807</td>
<td>0.0000</td>
<td>0.8709</td>
<td>0.0000</td>
<td>0.8000</td>
<td>0.0000</td>
</tr>
<tr>
<td>Adj. R²</td>
<td>0.90222</td>
<td>0.0000</td>
<td>0.90618</td>
<td>0.0000</td>
<td>0.9106</td>
<td>0.0807</td>
<td>0.8807</td>
<td>0.0000</td>
<td>0.8695</td>
<td>0.0000</td>
<td>0.7995</td>
<td>0.0000</td>
</tr>
</tbody>
</table>
References


---

Kwame Addae-Dapaah, National University of Singapore, Singapore 117566 or rstka@nus.edu.sg.
Su Jen Chieh, National University of Singapore, Singapore 117566 or anniesu999@gmail.com.
Building codes are typically used to influence components of the construction process. Recently their use has expanded to include the current operation of structures, focusing mainly on energy efficiency and the remodeling process. In January 2011, the City of Boulder, Colorado adopted SmartRegs. SmartRegs refers to three separate ordinances that update the city’s housing code, rental licensing code, and provide baseline energy efficiency requirements for existing rental housing (City of Boulder, 2010a). SmartRegs requires the owners of rental property to upgrade their housing stock in order to receive the required rental license. This requirement is precedent setting since efficiency upgrades are typically only required, if at all, at times of sale or construction. This study documents the process used by the City of Boulder to adopt the SmartRegs ordinances. Understanding this process is important for individuals involved in real estate and construction because it reveals several key steps and potential missteps in the adoption of precedent-setting code impacting residential energy efficiency.

The adoption of SmartRegs by Boulder is a leading example of the progressive movement underway throughout the United States to use building codes to establish requirements for the natural environment and conservation of resources and total emissions (USGBC, 2010). This increasing focus on environmental requirements is the result of two key developments: a greater awareness by the industry of the need to decrease the negative environmental impact of buildings, and widespread practical experience with built projects that have been raising the
standards of building design and construction (USGBC, 2010). The goals of energy codes include a decrease in greenhouse gas emissions and pollution, save consumers and businesses money, lessen peak energy demand, increase utility system reliability, and improve indoor air quality throughout the lifecycle of the building, which is typically 50 years (The Building Codes Assistance Project, 2010). SmartRegs focuses on bringing new and existing buildings to a more efficient level of operating performance.

The regulation of energy efficiency in rental housing is one of the means that the City of Boulder is using to meet their 2012 Climate Action Plan goals to reduce greenhouse emissions by 23% from 1990 levels. Rental units in Boulder account for approximately 57% of the housing stock. The residential sector CO₂ target reduction is 94k metric tons by 2012 (City of Boulder, 2011a). Several special interest groups were involved in the adoption process including groups representing homeowner’s/property managers, renters, non-profits, builders, architects, designers, local utility companies, environmental, and community members. As the level of interest increases, so does the complexity of the process. A complex process with several participants typically results in negotiation and significant compromise to attain the desired policy outcome. In Boulder, SmartRegs was adopted without significant change to its contents, but with significant change to the time-line of adoption.

New building codes and standards are developed by organizations such as the International Energy Conservation Code (IECC) and the American Society of Heating, Refrigeration, and Air-Conditioning Engineers (ASHRAE). These model codes are then typically adopted by states or local entities, and updated every three years on the basis of stakeholder deliberation and technical analysis to validate the recommended improvements (EPA, 2006). Each new revision of the codes incorporates the latest in technology, materials, and outcome goals of the promulgating agency. The goal of the 2012 IECC updates is an approximate 30% increase in residential energy-efficiency gains compared to the 2006 edition (Dept. of Energy, 2010).

Local adoption of energy codes can occur directly through state legislation or through regulatory action by local agencies that are authorized by the state legislative body to oversee the development and adoption of those codes (Dept. of Energy, 2010). When adoption is done through the regulatory process, states and local governments often appoint an advisory panel comprised of representatives of various industries related to construction (i.e., design, construction, and enforcement) to work with the public officials in all impacted departments. Such an advisory panel then recommends revisions to existing codes, new codes or code sections that should be considered for local adoption (Dept. of Energy, 2010). In Boulder, many stakeholders directly or indirectly participated in the code adoption including city staff, a working group with two subcommittees, and several other interested parties. The identification and analysis of the groups that participated in the policy adoption process is important research because it allows us to understand the key attributes that facilitated the adoption, as well as any barriers to the adoption process. The specific goal of this study is to test the hypothesis that the effective adoption of a successful energy efficiency
code is facilitated by a high degree of interdepartmental collaboration (Washington State Department of Transportation, 2010).

**Literature Review**

A limited number of articles document the actual process of adopting an energy efficiency code, and fewer highlight the factors of success or the barriers to adoption. Such research is important to the real estate practitioner or investor because researchers are typically commissioned by regulatory agencies to study issues and make policy decision recommendations. The following literature review and case study involving the adoption of SmartRegs by the City of Boulder reveals a recent trend to favor the adoption of a well-articulated policy mix in adopting energy efficiency measures involving both regulatory and voluntary instruments.

Laquatra (1987) identifies the institutional barriers to energy efficiency code adoption in the rental housing sector as: building metering strategies, length of time as a rental unit, existence (or non-existence) of subsidies and rent control ordinances, and availability of favorable financing or other incentive programs. Mandated standards or codes, combined with financial incentives and technical assistance to owners, could be undertaken to successfully overcome these resulting barriers. Similarly, Choi (2010) identifies five major categories of potential market barriers that may impact the implementation of green building practices: knowledge gaps in green development qualifications, communication shortfall, ownership structure and operating cost responsibility, funding issues, and risk and process issues.

Some of the principles for removing market barriers to green development include: integrated design, maintenance and operation expenses when comparing costs (lifecycle cost), design incentives to motivate or change behavior, adoption and alignment of codes to meet environmental goals, and changes to the bidding process to require green features (Choi, 2010).

Lee and Yik (2004) support the adoption of a mix of regulatory and voluntary instruments in adopting energy efficiency measures. Besides setting a minimum standard for all buildings, regulatory controls can also augment existing voluntary instruments. In addition, the use of phase-in periods for regulation and awareness campaigns may also lead to greater acceptance of early conversion or conversion by other market segments to meet the intent of the new regulations. The SmartRegs ordinances use an eight-year phase in period. In addition, the compliance expenditures in the first three years may be offset by federal, state, and local funding (City of Boulder, 2011b). The market recognizes the importance of making a building energy efficient; however, in some situations (e.g., rental housing), the market may recognize that the investment will not be supported with higher return on investment (ROI) due to market limitations (Lee and Yik, 2004). It is in these instances where the use of regulation and financial incentives may be necessary. Choi (2010) examined the effect of municipal policies on commercial green buildings. This research finds that municipal regulatory policy
has been a strong tool in promoting green building. However, the use of incentive-based programs has not been as effective in promoting green building.

As state and local policies and rating systems that promote residential energy conservation become more common, as evidenced by California’s “Title 24” and the National Association of Home Builders (NAHB) “National Green Building Standard,” issues surrounding education and implementation also become more critical. In addition to local policies and rating systems, home energy audits are gaining precedent as other countries such as Germany and the United Kingdom implement mandatory home energy audits. Energy Performance Certificates have been required in the U.K. since 2008 on homes that are being sold, rented or built. The majority of these home improvements are relatively low-cost, and the benefits they provide in terms of reduced energy consumption equate to both short- and long-term savings (Adlam, 2011).

Methodology

The methodology for the study to examine the adoption of Residential Energy Codes by the City of Boulder included interviews and content analysis. Interviews are used in research to fill in the blanks and understand events from an individual perspective (Gubrium, 2002). Content analysis “entails a systematic reading of a body of texts, images, and symbolic matter, not necessarily from an author’s or user’s perspective,” (Krippendorff, 2004, p. 3). In general, the goal of content analysis is to identify words or phrases that are frequently used in a written record based on a set of coding choices: level of analysis, irrelevant information, predefined or interactive concept choice, level of generalization, the creation of translation rules, existence or frequency, and the number of concepts (Carley, 1993). The authors elected not to use software programs such as NVivo or Atlas due to the scope of the study. Instead, the authors performed qualitative data analysis from the data collected from public hearing transcripts, board comments to the city council, and survey results gathered from tenants and landlords. A manual content analysis was performed to identify dominant recurring themes. In cases where the researchers had questions or sought clarification, they incorporated these questions into the interview process of the key stakeholders. The authors, therefore, used a synthesis of methods as appropriate to understand the public policy process where meetings were recorded and made available as public record.

The authors performed two initial interviews of public officials to help direct the researchers to the data sources used in this study, and provide further clarification of the code adoption process. Interviewees were with the Local Environmental Action Division (LEAD) and with the Building Construction and Code Enforcement Division. The first interviewee was the supervising building inspector/assistant building official. The second was the residential sustainability coordinator in the Local Environmental Action Division. A series of questions (Appendix) were asked to decipher the process from the perspective of the interviewees. The questions were open-ended and intended to discern why process worked the way it did, what made it successful, and what barriers may have existed to adoption.
Exhibit 1 | Key Words Identified for Use in the Content Analysis

<table>
<thead>
<tr>
<th>Stakeholder</th>
<th>Key Word</th>
<th>Description, Objectives, and Limitations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Landlord</td>
<td>1. Financial hardships/burden</td>
<td>General references to the inclusion of associated fees and property upgrades to meet compliance pathways, prescriptive and performance measures.</td>
</tr>
<tr>
<td></td>
<td>2. Complex/confusing</td>
<td>Association to general state of affairs with bureaucratic entities; confusion and documentation uncertainties.</td>
</tr>
<tr>
<td></td>
<td>3. Invasive government tactics/bureaucratic</td>
<td></td>
</tr>
<tr>
<td>Tenant</td>
<td>1. Fair</td>
<td>General references to income/wealth disparity between owner and tenant.</td>
</tr>
<tr>
<td></td>
<td>2. Lack of incentive</td>
<td>Retribution for past issues of split incentive.</td>
</tr>
<tr>
<td></td>
<td>3. Equitable</td>
<td></td>
</tr>
</tbody>
</table>

Based on these interviews and initial emerging patterns, the authors identified the following key words and phrases to be used in the content analysis (Exhibit 1). The research identified these words or phrases invoked multiple times in the written records as important concepts relating to the adoption process. For example, building owners continually repeated that they could not afford to make the required upgrades to their properties and that such requirements were a financial hardship. In contrast, the renters repeatedly brought up the concept of fairness since they were paying the utility bills, which were high due to energy-inefficient buildings.

City of Boulder Residential Energy Codes Case Study

In Colorado the state agency responsible for supporting local energy efficiency code adoption is the Governor’s Energy Office (GEO). This office was created in 1997 to promote energy conservation in Colorado and their mission “encourages local adoption of the national model energy codes and works in partnership with building departments and local policymakers to provide outreach, information, data, and other resources to support this process,” (The Building Codes Assistance Project, p. 17, 2010). The GEO encourages local adoption of the national model energy codes and works in partnership with building departments and local policy makers to provide outreach, information, data, and other supporting resources.

Boulder is the eighth largest city in Colorado and has a dynamic economy that is supported by computer, aerospace, scientific, and various research firms (Witt et al., Vasatka, 2003). Boulder has a history of progressive city ordinances, which exemplifies its commitment to the environment. In 1996, it became the first municipality in the country to adopt a formal green building code (and beyond-code green points program) for residential construction (City of Boulder, 2011c).

The Boulder Green Points Building Program is a mandatory residential green building program that requires a builder or homeowner to include a variety of
Exhibit 2 | SmartRegs: New Policy Comparison

<table>
<thead>
<tr>
<th>Previous Policy</th>
<th>New Policy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Boulder Housing Code</td>
<td>Ordinance 7724: Adoption of 2009 International Property Maintenance Code</td>
</tr>
<tr>
<td>Rental Licensing</td>
<td>Ordinance 7725: Updated provisions for new and renewal rental licenses</td>
</tr>
<tr>
<td></td>
<td>Ordinance 7726: Created baseline energy efficiency requirements for existing rental housing</td>
</tr>
</tbody>
</table>

Note: The source is the City of Boulder, CO (www.boulderolorado.gov).

sustainable building elements in their structure. In addition to the minimum green points requirements, new construction projects must also show energy efficiency compliance through the home energy rating analysis (HERS) rating, which will vary according to the size of the home (City of Boulder, 2011c). The HERS process includes a review of plans, energy modeling and various tests to ensure the home will meet the ENERGY STAR performance guidelines (RESNet, 2011).

Rental units in the City of Boulder account for about 51% of the residential housing stock (Swallow, 2010). They represent a substantial energy savings potential and greenhouse gas reduction opportunity. The city’s overall goal is to reduce greenhouse gas emissions coming from homes by 94,000 metric tons of CO₂ by 2012, making rental housing units an attractive opportunity. Specifically, the city proposed to achieve these reductions through the adoption of the SmartRegs ordinances. These ordinances are estimated to contribute about 45k metric tons of CO₂ savings to the City’s 94k metric tons goal for all residential units upon total compliance (Urie, 2010).

**SmartRegs**

SmartRegs refers to three separate ordinances that update the city’s housing code, rental licensing code, and provide baseline energy efficiency requirements for existing rental housing. The changes to existing policy are shown in Exhibit 2.

Under SmartRegs, the Boulder housing code was replaced with the 2009 version of the International Property Maintenance Code. The requirement that all rental housing units need to comply with this code, even if they were not coming in for a permit to do maintenance or remodeling work, set a national precedent (Volckhausen, 2010). The rental unit owners have an eight-year window in which to complete the updates per the code, which went into effect on January 3, 2011. As an incentive, the early adopters of the code requirements can apply to federal, state, and local agencies for help with expenditures made in the first three years of the program.

Property owners can comply with energy efficiency requirements by following either a performance or prescriptive path. The performance path requires a Home Energy Rating System (HERS) score of 120 or better. Alternatively, a prescriptive
path is technical in nature and typically involves a designated checklist. SmartRegs was unanimously approved by the Boulder City Council after more than a year of collaboration with various community and technically-based subcommittees, city advisory boards, and residents.

Stakeholders

Numerous groups are impacted by this specific code adoption: Realtors®, bankers, tenants, property management companies, and several others. Realtors may find that rental sales do not appraise to meet the price needed to pay for improvements required by the code. The financial industry may not fully understand the issues with payback and ROI on energy efficiency improvements and the impact on monthly expenses. Finally, property managers need to be aware of the requirements of the code to ensure the units they manage are in compliance.

Public understanding and awareness of green building code adoption is imperative. If the public and those directly impacted by the code are not educated in the issues and benefits, the negative connotations of another regulation may preclude code adoption. With this targeted sector, rental housing, the reliance on cash flow for debt service and primary or secondary income sources may increase resistance to the proposed code and have trickle-down economic impacts on the local economy.

Industry groups represented in the SmartRegs planning process included two opposing sides: the homeowner’s/property managers, and the renters and progressive non-profit groups. External stakeholders represented in the process included local contractors, builders, architects, designers, local utility staff, energy and construction consultants, residents, local business owners, environmental groups, and community groups. The internal stakeholders included the City Council, the three advisory boards including the Planning Board, the Landmarks Board, the Environmental Advisory Board, and staff. There were several supporters of SmartRegs, primarily a group known as New Era Colorado and secondary groups including: the Boulder Area Housing Authority, Boulder Housing Partners, University of Colorado off-campus student groups, HERS raters, energy consulting firms, the Boulder Area Rental Housing Association, apartment owners, Xcel Energy, PLAN-Boulder County, real-estate brokers, licensed rental housing inspectors, and the community at large.

To foster direct collaboration with stakeholders, the SmartRegs staff began holding meetings with a community Working Group (Exhibit 3). The staff included eight members from various departments within the City of Boulder. This group was responsible for transforming the proposed new code into legal ordinance. The community Working Group was divided into two subcommittees: code updates group and the energy efficiency group. The energy efficiency group was comprised of representatives from the Boulder Area Housing Association, University of Colorado Off Campus Student Services, Boulder Housing Partners, and apartment owners. Two relationships in particular appeared to be fluid in nature depending on the issue: one between the city council and the staff and one between the staff and the community groups (Exhibit 3).
The scope of the work performed by the subcommittees included:

- Consideration of the potential adoption of the International Property Maintenance Code as an alternative to amending the existing housing code.
- Consideration of energy efficiency requirements, measures and options that could be added to the housing code and/or national standards to address CAP objectives.
- Review of proposed revisions to the rental licensing provisions of the code to further streamline and clarify its administration.

**Summary of Results**

The process for adopting SmartRegs took a little over a year and had several milestone events. Exhibit 4 provides a summary of the chronology during the adoption and initial implementation of SmartRegs.
### Exhibit 4 | Milestones Identified during Content Analysis of Public Records

<table>
<thead>
<tr>
<th>Date</th>
<th>Event</th>
</tr>
</thead>
<tbody>
<tr>
<td>November 2008</td>
<td>City Council Study Session</td>
</tr>
<tr>
<td>December 2008</td>
<td>Staff formed</td>
</tr>
<tr>
<td>July 2009</td>
<td>Staff meets with Working Group: Proposed Energy Efficiency Ordinance outlined</td>
</tr>
<tr>
<td>October 2009</td>
<td>WIP drafted from staff to Council</td>
</tr>
<tr>
<td>November 2009</td>
<td>Community Open House</td>
</tr>
<tr>
<td>December 2009</td>
<td>Reviewed by Boards</td>
</tr>
<tr>
<td>December–February 2010</td>
<td>Resident Feedback Gathered</td>
</tr>
<tr>
<td>February 2010</td>
<td>Renter’s Stakeholder Meeting</td>
</tr>
<tr>
<td>March 2010</td>
<td>Survey to Owner and Renters</td>
</tr>
<tr>
<td>Spring 2010</td>
<td>Continual Community Working Group</td>
</tr>
<tr>
<td>March 2010</td>
<td>Survey Results In</td>
</tr>
<tr>
<td>March 2010</td>
<td>Case Study Submitted to City</td>
</tr>
<tr>
<td>April 2010</td>
<td>CU Student Renter Survey administered</td>
</tr>
<tr>
<td>April 2010</td>
<td>Memo to Planning Board</td>
</tr>
<tr>
<td>April 2010</td>
<td>Feedback from Working Group</td>
</tr>
<tr>
<td>April 2010</td>
<td>Board Meetings</td>
</tr>
<tr>
<td>April 2010</td>
<td>Economic Memo from EPS</td>
</tr>
<tr>
<td>April 2010</td>
<td>Memo to Planning Board</td>
</tr>
<tr>
<td>May 2010</td>
<td>First Council Reading</td>
</tr>
<tr>
<td>June 2010</td>
<td>Continuation of 1&lt;sup&gt;st&lt;/sup&gt; Reading</td>
</tr>
<tr>
<td>June 2010</td>
<td>Working Group Feedback</td>
</tr>
<tr>
<td>July 2010</td>
<td>Council Working Session</td>
</tr>
<tr>
<td>July 2010</td>
<td>IPMC Open House for Public</td>
</tr>
<tr>
<td>September 2010</td>
<td>Second Reading and Public Hearing</td>
</tr>
<tr>
<td>September 2010</td>
<td>Third Reading, SmartRegs Adopted</td>
</tr>
<tr>
<td>November 2010</td>
<td>Clean up of Ordinance</td>
</tr>
<tr>
<td>January 2011</td>
<td>Goes into effect</td>
</tr>
<tr>
<td>April 2011</td>
<td>Study Session Proposed</td>
</tr>
<tr>
<td>2011–2013</td>
<td>Implementation Period</td>
</tr>
<tr>
<td>January 2019</td>
<td>Compliance Must be Achieved</td>
</tr>
</tbody>
</table>

**Note:** Dates provided to demonstrate chronological order showing the ‘flow’ of process.
Highlights of the interview findings are summarized in Exhibit 5. Noticeably, both interviewees championed the same long-term goal, yet stressed differences in the factors of success, as well as potential downfalls to the adoption process.

The majority of comments reviewed during the content analysis demonstrated that the landlords/owners of properties were in dissent of the proposed regulations. They cited several reasons, but the overwhelming reasons included potential financial burdens, government intervention, and the complexity of the measures proposed. The tenants of the rental surveys primarily demonstrated agreement with the proposed regulations. They cited potential financial savings, fairness, and means to alleviate split-incentive as primary motivation. Lastly, the city staff noted that it was in the best interest of the both people and the environment to further the mission of the Community Action Plan.

A review of the meeting minutes revealed additional support and opposition groups. A group called New Era encouraged the Council to approve SmartRegs. New Era gathered support by walking the streets of Boulder to gather signatures from the student community in support of the proposed ordinances. Another important supporter of the regulation was the University of Colorado (CU) off-campus student group. Because students primarily rent houses rather than own, they had a significant stake in this process and supported the proposed code.

The group Renters with Benefits canvassed areas with student housing collecting signatures in support of regulations. Additionally, a group called PLAN-Boulder County strongly supported the regulation. They stated, “This government intervention is necessary because the split incentive in the rental market ensures that landlords will not perceive a direct financial benefit for making GHG reducing improvements, and consequently improvements will not be made,” (Plan Boulder County, 2010, p. 1). This sentiment supports the notion of “affordability” (Exhibit 6), whereby renters felt that financial equality and equity would be addressed through SmartRegs. All three of these groups were present at the first and second Council meetings and posted comments in support of the regulation on the SmartRegs website. Due to their level of involvement, each group had representation on both subcommittees of the Working Group for the duration of the process. General results are summarized in Exhibit 6.
### Summary of Content Analysis References

<table>
<thead>
<tr>
<th>Key Word</th>
<th>Sample References</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Financial hardships/burden</td>
<td>Landlord:</td>
</tr>
<tr>
<td>2. Complex/confusing</td>
<td>“Program is unaffordable for landlords.” (Online feedback worksheet–186 occurrences)</td>
</tr>
<tr>
<td>3. Invasive government tactics/too bureaucratic</td>
<td>“This is about personal choice and affordability, and local government mandating decisions on their neighbors that they may be remiss in making.” (Property Owner, Energy Efficiency Survey)</td>
</tr>
<tr>
<td></td>
<td>“I think you are getting way beyond your governmental role in instituting such a System that has to be administered and that adds additional complexity into the business of rental ownership.” (Property Owner, Energy Efficiency Survey)</td>
</tr>
<tr>
<td></td>
<td>“This is a complex issue. I think the city is taking the wrong side on this.” (Property Owner, Energy Efficiency Survey)</td>
</tr>
<tr>
<td>1. Fair</td>
<td>Tenant:</td>
</tr>
<tr>
<td>2. Lack of Incentive</td>
<td>“Rental properties in town are awful with energy efficiency. And unless there is a reason to make rentals more energy efficient, no landlords will make the effort.”</td>
</tr>
<tr>
<td>3. Equitable</td>
<td>“There’s little motivation for landlords to make these changes, so under the circumstances I think government intervention is acceptable.” (Rental Survey Energy Efficiency Survey)</td>
</tr>
<tr>
<td></td>
<td>City of Boulder staff/planning boards:</td>
</tr>
<tr>
<td>1. Long term motivations and incentives</td>
<td>Nov. 18, 2008 City Council Study Session on the CAP, council identified strategies needed to reduce greenhouse gas emissions to meet CAP objectives</td>
</tr>
<tr>
<td>2. Accountable to CAP</td>
<td>Addressing energy efficiency in existing rental housing and existing commercial buildings has been the focus of the 2009/2010 work plan</td>
</tr>
<tr>
<td>3. Value in investments</td>
<td></td>
</tr>
</tbody>
</table>

Note: The Source is the City of Boulder, CO (http://www.bouldercolorado.gov/index.php?option=com_content&view=article&id=13005&Itemid=22).

### Findings from the Code Adoption Process

Several key findings emerged to support the hypothesis that effective adoption of a successful energy efficiency code is facilitated by a high degree of interdepartmental collaboration. In addition, it was determined that compromise was necessary to arrive at the final code language that was adopted.

### Opposing Parties

Public input was analyzed from public hearings and the online forum for public questions/concerns. Opposing opinions of the three stakeholder groups were
displayed throughout the process and reflected the self-interest each group had in the process (Exhibit 6). Stakeholders generally maintained their opinions supporting their agenda throughout the various phases of the process. For example, a City Council member, an elected official, has a desire to follow through on election promises to external stakeholders; in this case, several Council members had promised greenhouse gas reductions; therefore, they had an incentive to accomplish the promised goal.

External stakeholders, consisting of taxpayers, may want to see some concrete evidence that the Climate Action Plan (CAP) tax they voted on in 2006 is actually paying dividends. The Council, with direction from the CAP needed to take action to meet the goal of reducing greenhouse gas emissions to 7% below 1990 levels by 2012. Finally, the issue of social inequity (between two external stakeholders) enabled support by various groups for this program from the beginning of the process.

The City of Boulder strove to place the utility savings in the hands of those who typically pay the utility bills, the renters. The rationale for this goal was the belief that renters are at the mercy of landlords that own energy-inefficient rental properties. While this topic is beyond the scope of this paper, the existence of “split incentives” has been well documented for renters (Higa, 2010). In general, for rental properties, those who make the decisions about a building’s level of energy efficiency are generally not the same people who consume energy within that structure. Research has shown that when occupants are not the ones making energy efficiency decisions, the incentive to invest in energy conservation measures is lost ((Laquatra, 1990). The adoption of building efficiency codes for existing structures can be used to resolve this problem, either through prescription or performance measures.

Existing structures, however, are typically not subject to code updates or adoption cycles. Many existing structures will be in use for the foreseeable future and owners can continue to pass along energy cost increases to tenants regardless of the inefficiencies in a building’s thermal envelope or HVAC systems (Laquatra, 1987). More recently, people in the United Kingdom, and elsewhere, have increasingly called to stop this practice. For example, an attempt is underway in the UK to prevent landlords from renting energy-inefficient homes (Guardian, 2011). Other legislation is in place in Germany, the UK, and Canada that requires energy audits at the time of building sale (The Green Energy Act, 2009). These audits, however, are triggered only at the time of sale, and not a change of tenant. As one member of the city’s staff explained, they were looking at rental houses because they do not have the normal economic incentive to lower energy usage (Volckhausen, 2010). In addition, the Green Points Program was already in effect in the City of Boulder to address sustainability in new homes so the next logical step was to address existing homes, specifically rental homes.

The March, 2010 Property Owner Energy Efficiency Proposal Survey further conveyed the disparity in opposing views between the owners and renters. For example, the following question was posed: The SmartRegs project is proposing energy efficiency requirements for licensed rental properties in the City of Boulder:
Do you agree or disagree? The answer was overwhelmingly in opposition to SmartReg’s proposal. Roughly 75% of property owners said they disagree with energy efficiency requirements. In contrast, in the Renters Energy Efficiency Proposal Survey, 82% of respondents surveyed expressed support of this proposal (City of Boulder, 2010b).

Compromise

A 14-month timeline was needed to accommodate public input, additional public hearings, and multiple clarifications from issues demanded by Council (City of Boulder, 2011d). These challenges in the SmartRegs process included industry opposition due to conflicting agendas and difficulties in deciding what performance criteria to use. In the end, the adversarial environment was overcome because of the early involvement of key stakeholders, specifically interdepartmental groups, working in a collaborative manner to form a consensus recommendation as to the code language to the decision-making body. The City of Boulder stakeholder involvement followed patterns similar to those documented in other code adoption processes (Dunn, 2008) in that: (1) stakeholders served as advocates for a strong program from their perspective; (2) a strong collaborative process served to protect the program’s integrity; and (3) an inclusive process built lasting consensus and a broader base of support.

The City of Boulder recognized early in the process that the homeowners, property managers, renters, and non-profit groups would all be impacted by the proposed regulation. The establishment of working groups enabled both parties to be involved in the process from the beginning. The City of Boulder worked hard to ensure these voices were not only heard, but were equally represented in the working group process. The biggest critic, also part of the working groups, was the non-profit Boulder Area Rental Housing Association (BARHA). They were critical of the proposal’s timeline from the beginning. They expressed to Council at the second reading that property managers “want to make SmartRegs work,” and that the proposed rules were generally rational and reasonable. However, they also stated that a lengthy roll-out was essential. They indicated that thousands of Boulder landlords would be affected by SmartRegs and “have a lot on the line with this program.” Furthermore, they expressed that landlords would have to raise the rent to compensate for the increased expenses, making Boulder rentals potentially even more expensive, driving residents elsewhere (Urie, 2010).

The open dialogue between advocates and skeptics educated the various department staffs and ensured that critical concerns were dealt with directly and effectively. For example, BARHA was able to have extensive input and ultimately the City proposed an eight-year roll-out plan giving owners till January 1, 2019 to meet code. The original council plan had only a three-year timeline. This was a key compromise to gain owner support. As a way to convince the owners to be early policy adopters, the staff educated the owners about possible incentives from federal, state, and local agencies available in the first three years of the policy.

Mayor Susan Osborne praised the collaboration between the landlords and the city planners saying “I think this is about as close as we can get to an ordinance that
is workable, we’ve come a long, long way,” (Urie, 2010, p. 2). The process exemplified how early interdepartmental collaboration and engagement of special interest groups was instrumental in the adoption of an energy efficiency code.

**Code Refinement and Support**

The code set a point value needed to meet the criteria for energy efficiency. One of the first tasks of the working group and staff was determining what programs and performance criteria to use or reference in SmartRegs. They chose to include both the performance and prescriptive path options after the first reading to allow flexibility for owners. Being able to use a checklist to get to the 100 required points removed a level of uncertainty in the process. The checklist also rewarded owners for existing conditions present at the property.

The utilization of consultants helped facilitate the code adoption. At the beginning of the process, Economic Planning Systems (EPS) performed an economic assessment to evaluate the economic impact of SmartRegs on residential rental properties. The city did follow-up testing on seven homes and estimated that reaching the 100-point threshold (prescriptive path) would cost $675–$3,243 per home (Urie, 2010). Populas, another consultant, taught its Energy Code Workshop to county staff and officials in various departments to increase their understanding of the technical nature of energy codes. They also provided energy code design services and a residential energy analysis for SmartRegs rental housing prescriptive approach (Populus, 2010).

**Public Outreach**

Two websites were established to communicate the vision and program to the community, SmartEnergy and SmartRegs. Outreach was one of the main factors that contributed to the successful adoption of the code by allowing the special interest groups to work with their contacts in the various departments at the city level and ensured that the interdepartmental collaborations included all perspectives. Collaborating with utilities on efficiency issues is typical, but many other partnerships were necessary. Training was also necessary to ensure that staff had the capability to provide the technical assistance on energy efficiency designs.

A summary of the lessons learned from public outreach include:

- A study session with Council should have been held after working group was first established.
- Make sure the facts are presented and clarified to the public at the beginning so no ambiguity exists.
- Make sure that the proposed policy is well defined and solid from the beginning.

These key lessons learned highlight the need to have a solid policy model from the beginning so the public understands the intent and impact of the proposed code.
Neutrality

SmartRegs was a politically charged initiative and it was important for the city staff to appear neutral during the adoption process. The staff did not act as an advocacy group, take sides, nor did they relay personal opinions while addressing the Council. They simply worked to make recommendations based on the feedback of the working group and the planning, landmarks, and environmental advisory boards. An important lesson learned during this process is the use of multiple study sessions with Council. In this case, one was held prior to the establishment of the working group, but not afterwards so the Council had no firsthand knowledge of the working group’s position on the issue. Such an additional meeting could have streamlined the process, reduced animosity, and helped in negotiations as a compromise was worked out. However, it is not known whether the additional study session would have negated the need for the second “first” reading of the proposal.

The status quo is always hard to change and communication is necessary to ensure there is no miscommunication of the policy intent and purpose. Landlords accustomed to making property improvements at their discretion typically are not amenable to mandates impacting their decision making and financial planning processes. Exhibit 7 presents the primary barriers and success factors.

Conclusions

The process of code development and implementation is complex and consists of multiple steps (Exhibit 8). The City of Boulder staff played the role of a neutral facilitator in a politically charged policy adoption process, identified solid policy to the community to garner support, and performed public outreach to maximize public understanding. The actions of the staff appear to support the hypothesis that a high degree of interdepartmental collaboration in the code adoption process makes the process more efficient. The City identified both supporting and non-supporting constituencies in order to establish community working groups representing all interested parties. Once established, the community working groups were recognized as legitimate representatives of the community because they spoke for a wide range of people impacted by the proposed code. Open
dialogue at public hearings was the mechanism for an iterative dialogue that eventually led to a sound compromise and code language. While this policy was not sought by rental property owners in Boulder, the interdepartmental collaboration, public involvement, and process culminated in code language and a delayed implementation period that will make this policy more successful in the long run. Ultimately, giving people a forum to express their voice, while listening to the concerns and establishing the facts/information at the forefront of the discussion, supported the successful code adoption.

Critical actions in the adoption of SmartRegs by the City of Boulder include:

1. Identify where codes need to be implemented or revised.
2. Prepare a sound code for presentation to the public and impacted constituents.
3. Identify and secure opposing sponsors of the proposed code to participate through the entire process.
4. Maintain open and upfront dialogue with all parties to promote learning and compromise.
5. Provide proper communication and education forums to ensure support and understanding of the proposed code.
6. Provide a forum for the public to express their interest/concerns and provide iterative feedback.
7. Have a review process to ensure the code adoption process is collaborative, fair, and efficient.
There were lessons that were learned during the process. The first lesson is the policy set forth for consideration should be solid and well thought out. Second, more study sessions with council would have shared important information earlier in the process and may have saved time and effort for those involved. Third, the clear and accurate communication of information to the public removes ambiguity. Fourth, the involvement of multiple interest groups in the process ensures that, through compromise, everyone gets some, but not all of what they want. These lessons can be used in other policy adoption processes focused on energy efficiency in existing homes to ensure a smoother process for all those involved. As the use of codes increases as a way to improve the energy efficiency of housing stock, this process is sure to be repeated many times.

According to the chief executive officer of the ICC, “We are now at a place in the evolution of the sustainability movement that requires the specialty, the reliability and enforceability that only a code can bring,” (Sims, 2009, p. 2). With a proactive, constructive partnership with code officials, city staff, and public constituents, mutual interests may prevail.

Future research may include determining the long-term impacts, over five or ten years, of the SmartRegs ordinances. Policy assessment is the final step in determining the overall success of the policy. The analysis of rental rates during and after the phase-in period would provide valuable information for other jurisdictions wanting to adopt such policies. It would also increase peripheral businesses understanding of the impacts this type of policy may have on their business model. Other areas of interest include: will the rental market in Boulder change in terms of the percentage of rental units to total homes, do students continue to make up the majority of renters, were the targeted energy savings achieved, have the number of rental resale’s increased/decreased, what impact has SmartRegs had in the price of rental units for resale, have financial institutions supported loans for this type of upgrade to rental units? Additional information on the success of the incentive program offered during the first three years of the phase-in period will help other jurisdictions determine the public cost associated with this type of code adoption.

Appendix

Interview Questions

These are open-ended questions aimed at gathering information to assist in ascertaining other information that may need to be gathered but unknown at this time.

1. What is the process for adopting building codes in Boulder?
2. In addition to industry groups, are there local organizations that are involved in the process?
3. What are the short-term goals of Boulder’s green building code?
4. What are the long-term goals of Boulder’s green building codes?
5. What type of cost is associated with the process of adopting code here in Boulder?

6. What methods does the community have in which to provide feedback on the adoption of GB codes?

7. What written meeting records are available concerning code adoption hearings?

8. How far back do they go and how can they be accessed?

References


Laura Barrett, Denver, CO 80209 or lmbarret@gmail.com.
Scott Glick, Colorado State University, Fort Collins, CO 80523 or scott.glick@colostate.edu.
Caroline Clevenger, Colorado State University, Fort Collins, CO 80523 or caroline.clevenger@colostate.edu.
Does Sustainability Pay Off for European Listed Real Estate Companies? The Dynamics between Risk and Provision of Responsible Information

Authors
Marcelo Cajias and Sven Bienert

Abstract
We follow the guidelines of the Global Reporting Initiative and the European Public Real Estate Association to investigate the quality of real estate-related sustainability information provided by European listed real estate companies in 13 countries. We find that human resources and stock price volatility play a significant role in the company’s strength with respect to corporate social responsibility (CSR) activities. Business complexity and financial transparency enhance the provision of sustainable information to capital markets, but business experience does not appear to affect the decision “to go CSR.” Furthermore, the benefits of ex ante responsible activities are reflected in lower levels of idiosyncratic risk, but only for firms providing clear signals to investors and markets.

Over the last decade, socially responsible activities and sustainability in a broader sense have been successfully integrated into corporate strategies and are now considered as an essential value-driver for the long-term success of listed or public companies. Corporate responsibility forces firms allocating resources to preserve a balance between environmental, social, and economical objectives, which may affect internal and external stakeholder groups. Companies maintaining this equilibrium require a socially responsible sustainability agenda, along with a description of short- and long-term action items. The purpose of this study is to identify the factors affecting the firm-specific decision to allocate resources into socially responsible activities and whether these corporate actions mitigate the firm’s risk profile. We provide evidence that socially responsible activities are rewarded by investors and capital markets in a reduction of a company’s idiosyncratic risk.

We have organized the paper as follows. The sections of the paper are split into the two research questions: the drivers of a responsible provision of information and the consequences of providing responsible information. The first section situates our research questions and hypotheses within the existing literature concerning sustainability and real estate. The second section describes our data. The third explains the econometrical methodology in order to explain the results.
in the fourth section. At the end we discuss our findings and present our conclusions.

**Literature Review**

Corporate social responsibility (CSR) has become a growing matter over the last ten years and its diffusion has already reached listed enterprises, non-government organizations, and inevitably real estate companies. Many concepts have been also developed to theoretically describe corporate sustainability activities, such as Environmental, Social, and Governance (ESG), CSR, and Socially Responsible Investment (SRI). Despite the conceptual differences across them, they describe the integration of responsible and environmental activities into a firm’s core strategy in order to react to climate changes and globalization issues in general.

As a response to the increasing importance of sustainability, firms provided voluntarily supplementary information regarding their concerns and awareness to global changes. Sustainability principles, in accordance to the Global Reporting Initiative (GRI), are well known standards that enable the international comparison of firms’ responsibility performance. The GRI framework is applicable to all sectors and since its foundation the number of sustainability reports has grown exponentially. In this context, real estate companies are important participants to the international development and implementation of sustainable policies. According to Nelson, Rakau, and Doerrenberg (2010), the construction and real estate industry has an enormous global impact and “accounts for 42% of the EU’s final energy consumption and for about 35% of all greenhouse gas emissions.”

Facing the fact that sustainability plays an important role in the real estate sector, due to the impact to future generations, it is essential to identify the key elements of sustainable activities, along with their economical benefits. The first subsection examines the mechanism that drives firms to allocate resources in sustainability, while the second subsection explores the economical consequences of the effective resource allocation.

**The Drivers of a Responsible Provision of Information**

Solow (1991) defines sustainability simply as “our obligation to future generations.” In general, firms are active players in the implementation of global sustainability policies and mitigation of risks that affect future generations. Porter and Kramer (2006) delineate this approach as “license-to-operate” and explain that firms identify themselves with social and environmental concerns due to future global challenges. Otherwise, firms would be acting outside their “license” and would disappear. Roberts, Rapson, and Shiers (2007) show that the drivers of social responsibility are an internal adaptation to economic change such as customer demand, as well as an external response to poor ethical standards. Additionally, Falkenbach, Lindholm, and Schleich (2010) argue that real estate companies aim to invest in CSR to enhance their image to investors through the publication of sustainability reports. Furthermore, they conclude that external
Does Sustainability Pay Off

Sustainability includes the effective use of resources and an adequate substitution of resources to minimize consumption (Solow, 1991). For the field of real estate, it is essential to understand the benefits of property investments that consider energy-related, social, and environmental features. Fuerst and McAllister (2009, 2011), Eichholtz, Kok, and Quigley (2009a, 2009b), and Bienert et al. (2010) show that sustainable buildings in general pay off. These findings lead real estate companies to allocate sustainable buildings in their portfolios to force the reduction of energy consumption.

Following these results, companies allocate resources to CSR in order to remain competitive. It is also rationale to assume that real estate firms react to customer demand. This paper examines the real estate-specific characteristics that influence the intensity of sustainable and responsible activities.

The Consequences of Providing Responsible Information

Looking at responsibility and sustainability in order to reveal their link to economic performance requires a clear conceptual framework and definition of variables. A large body of meta-analyses examine if sustainability predicts financial performance (e.g., Orlitzky, Schmidt, and Rynes, 2003; Margolis, Elfenbein, and Walsh, 2007). Generally, they find evidence that firms with high levels of social and environmental performance enjoy enhanced financial performance and vice versa. Apart from several measurement effects, sector heterogeneity, and the sample period, these findings motivate firms allocating resources to CSR activities. On a corporate level, Porter and Kramer (2006) explain that socially responsible activities should have a positive impact on corporate value, preconditioned that their integration into the firm’s core operational business is successful. Therefore, a sustainability agenda must not only cover vague strategies and goals, it must reflect a high awareness to social financial incentives and regulatory policies force companies to reevaluate their core strategies.

A growing literature concentrates on the determinants of voluntary disclosure following the GRI guidelines. Among others, a debate arises concerning whether media visibility or media presence predicts the decision “to go CSR.” Rationally speaking, the assumption that sustainability reports have an impact on corporate reputation and are a media instrument that reveals the positive and negative aspects of a firm’s strategies could be right. Albers and Guenther (2010) concentrate on the determinants of disclosing the social reports of 600 European firms and conclude that social reports are likely to be published by high capitalized companies and by those adhering to sustainability indices. They suggest that media presence is not a determinant for firms “going CSR.” Contradictorily, Gamerschlag, Moeller, and Verbeeten (2010) show that for Germany, higher media visibility increases the probability to disclose a CSR report. For the field of real estate, only a few European companies disclose GRI reports and the empirical evidence is small. Instead of examining media visibility, which highly correlates with size, we aim to expand the literature by analyzing if financial transparency determines CSR.

Sustainability includes the effective use of resources and an adequate substitution of resources to minimize consumption (Solow, 1991). For the field of real estate, it is essential to understand the benefits of property investments that consider energy-related, social, and environmental features. Fuerst and McAllister (2009, 2011), Eichholtz, Kok, and Quigley (2009a, 2009b), and Bienert et al. (2010) show that sustainable buildings in general pay off. These findings lead real estate companies to allocate sustainable buildings in their portfolios to force the reduction of energy consumption.

Following these results, companies allocate resources to CSR in order to remain competitive. It is also rationale to assume that real estate firms react to customer demand. This paper examines the real estate-specific characteristics that influence the intensity of sustainable and responsible activities.

The Consequences of Providing Responsible Information

Looking at responsibility and sustainability in order to reveal their link to economic performance requires a clear conceptual framework and definition of variables. A large body of meta-analyses examine if sustainability predicts financial performance (e.g., Orlitzky, Schmidt, and Rynes, 2003; Margolis, Elfenbein, and Walsh, 2007). Generally, they find evidence that firms with high levels of social and environmental performance enjoy enhanced financial performance and vice versa. Apart from several measurement effects, sector heterogeneity, and the sample period, these findings motivate firms allocating resources to CSR activities. On a corporate level, Porter and Kramer (2006) explain that socially responsible activities should have a positive impact on corporate value, preconditioned that their integration into the firm’s core operational business is successful. Therefore, a sustainability agenda must not only cover vague strategies and goals, it must reflect a high awareness to social
and environmental concerns. Following Surroca, Tribó, and Waddock (2010), corporate responsibility positively affects financial performance through the creation of intangible assets (i.e., sustainability not only enhances a firm’s reputation, it can improve financial outcomes). They conclude that the more intensive and effective a firms’ sustainability strategy, the higher will be the economic benefits.

Concerning the risk profile of companies investing in CSR, a growing body of literature provides evidence that sustainability in a broader sense is able to lessen firms’ unexplained stock volatility. Luo and Bhattacharya (2009) found that corporate responsibility is able to generate stakeholder value and mitigate information asymmetry due to the enhanced provision of information. Information regarding the firm-specific sustainability agenda is a clear positive signal to capital markets and investors. Their results suggest that sustainability activities affect negatively the future unexplained stock volatility, decreasing the idiosyncratic risk. Lee and Faff (2009) argue that sustainability portfolios exert significantly lower levels of idiosyncratic risk, hence sustainability creates, beside the above explained effects, financial stability in terms of a better pricing mechanism (i.e., CAPM). Ferreira and Laux (2007) provide strong evidence that a well-developed corporate governance level also lessens the idiosyncratic risk and enhances the information about the distribution of expected cash flows. Following this result, we aim to provide empirical support that sustainable and responsible activities lead to lower idiosyncratic risk and consequently reduce the uncertainty of a firm’s risk profile.

We believe that the existing real estate literature focuses to a major extent on the economic impact of responsible investments on a property-specific level. In this context, other sustainable real estate-specific activities that play an important role and might affect the overall value of the portfolio or company are a barely untouched research field. Therefore, our approach not only strengthens and supports the related literature on idiosyncratic risk, but also confirms the helpful consequences of responsibility at a company level.

**Data**

The data for our study are from SNL, Thomson Reuters Datastream, and annual reports. The sample includes European real estate listed firms for 2007 and 2008 that are incorporated in the Global Property Research Index 250 (GPR 250), excluding real estate funds. Our initial sample included 84 companies, from which four do not provide sufficient financial information in Datastream. The final sample includes 80 European real estate companies. The annual reports were obtained from SNL and the enterprise’s web pages. All data are employed in a yearly frequency, except for the returns. We use daily returns for the closing day, in order to calculate the yearly mean return, along with our proxies for both estimation and idiosyncratic risk. All variables controlled for possible outliers at 5% and 95%.

We are interested in the quantity and quality of socially responsible information for real estate companies. Our variables measure the firm-specific commitment to
social responsibility in accordance with the European Public Real Estate Association (EPRA) and general sustainable reporting guidelines (GRI-G3). In order to derive our proxies for CSR, we use a questionnaire that has 13 questions and 26 points. Several studies have proxied sustainability using questionnaires. For example, Holder-Webb, Cohen, Nath, and Wood (2009) employ content analysis techniques to externally categorize the amount of information that fall into one of the main GRI-sustainability categories, whereas Plumlee, Brown, and Marshall (2008) concentrate on a separated corporate environmental report and apply an index scorecard to calculate the quality of disclosed information. Similar to these studies, we define the following four responsibility areas as: (1) human rights and social responsibility; (2) environmental responsibility; (3) investment/financial responsibility; and (4) additional disclosure quality. Human rights and social responsibility strengths consider not only the extent to which rights are considered in the company organization, but also information about the company’s cultural, diversity, and recruitment policy. The environmental responsibility covers procedures related to training and raising awareness in relation to environmental aspects, as well as information concerning emissions, waste, and materials. This area covers also the investment in sustainable buildings. Investment/financial responsibility asks whether the company is prepared for climate changes in economical terms, whereas the additional disclosure area covers at what level companies apply EPRA-Best Practices Recommendations. The former drives firms to run scenario analysis of the key performance indicators due to energy price fluctuation and is following the GRI a key factor for real estate companies (Exhibit 1).

In order to avoid time-embedded bias, three researchers read the annual reports independently and 14% of the reports were evaluated doubly to ensure the correctness. We assign 2 points when a firm discloses key performance indicators, 1 point for only explanatory information, and 0 for no information. Exhibit 2 presents the results of our sustainability survey. The values are calculated as the sum of the obtained points divided by the maximal achievable points. We breakdown our results by year, real estate sector, and sustainability area. Over 2007 and 2008, we found a constant sustainability agenda with levels under 50%. European real estate investment trusts (REITs) present generally higher scores than non-REITs and present in 2007 high levels in the environmental and financial responsibility area. All firms present a high acceptance of the EPRA-BPR. Following the GRI, firms should model scenario analysis to determine the financial consequences of energy price fluctuations and weather disasters. Our survey shows low levels concerning environmental risks, which are essential in view of climate change and its associated costs. It is remarkable to establish constant sustainability levels in view of the economical cycle in 2007 and 2008. Surroca, Tribó, and Waddock (2010) propose that resource allocation to CSR activities preconditions a stable economical situation. Contradictory to this proposition, we observe a slightly increasing strength for sustainable and responsible activities across European real estate companies, particularly by REITs.

We derive two variables from our survey in order to explain the drivers and consequences of CSR. Therefore, we define our first variable $CSR_{it}^{quality}$ in dependence to the maximum number of score items as follows:
Exhibit 1 | Sustainability Agenda for Listed Real Estate Companies

- Human Rights & General Goals
- Human Capital & Training Programs
- Diversity
- Policy Structure

- Environmental activities and intensity
- (Certified) Building Information

Human Rights & Social Responsibility

Environmental Responsibility

Sustainability for Real Estate Companies

- Investment/Financial Responsibility
- Additional Disclosure Quality

- Social, Environmental & Ethical Activities
- Social, Environmental & Ethical Decision Process
- Financial risks due to climate changes
- Economical impact of energy price fluctuation

- EPRA Best Practices and Recommendations
- EPRA Portfolio Disclosure
- Corporate Governance Mechanism
Exhibit 2 | Results of the Sustainability Survey

<table>
<thead>
<tr>
<th>Sector</th>
<th>2007 Non-REITs</th>
<th>2007 REITs</th>
<th>2008 Non-REITs</th>
<th>2008 REITs</th>
<th>Overall</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of firms</td>
<td>42</td>
<td>38</td>
<td>42</td>
<td>38</td>
<td></td>
</tr>
<tr>
<td>All sectors</td>
<td>46.98% (7.29)</td>
<td>48.26% (6.42)</td>
<td>47.62%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yearly</td>
<td>42.83% (6.27)</td>
<td>51.12% (8.23)</td>
<td>44.99% (5.96)</td>
<td>51.54% (6.90)</td>
<td></td>
</tr>
<tr>
<td>Responsibility Areas</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Human Rights &amp; Social Responsibility</td>
<td>41.07%</td>
<td>43.42%</td>
<td>40.18%</td>
<td>44.41%</td>
<td>42.27%</td>
</tr>
<tr>
<td>Environmental Responsibility</td>
<td>44.05%</td>
<td>61.18%</td>
<td>44.05%</td>
<td>54.61%</td>
<td>50.97%</td>
</tr>
<tr>
<td>Financial Responsibility</td>
<td>27.08%</td>
<td>41.12%</td>
<td>31.85%</td>
<td>29.93%</td>
<td>32.50%</td>
</tr>
<tr>
<td>Disclosure and Transparency</td>
<td>59.13%</td>
<td>58.77%</td>
<td>63.89%</td>
<td>77.19%</td>
<td>64.75%</td>
</tr>
</tbody>
</table>

Notes: Percentage represents the sum of points relative to the maximal points. Standard deviations of points in parentheses.

\[
CSR_{i,t}^{\text{quality}} = \begin{cases} 
2 & \text{if } \sum (\text{Points})_{i,t} > Q_{77} \\
1 & \text{if } Q_{33} \leq \sum (\text{Points})_{i,t} \leq Q_{77} \\
0 & \text{if } \sum (\text{Points})_{i,t} < Q_{33} 
\end{cases}
\] (1)

Companies whose overall score for the key performance indicators is quantitatively high belong to the highest category, \(CSR_{i,t}^{\text{quality}} = 2\). Companies that disclose only general goals and information belong to \(CSR_{i,t}^{\text{quality}} = 1\). The upper (lower) quintile was 18 and 17 (7 and 8) points for 2007 and 2008, respectively. We assign this ordered response category, as described by Davidson and MacKinnon (2004), in order to generate a latent variable. This approach enables us to investigate the independent factors that lead to more detailed and intensive CSR disclosure (i.e., the variables contribute to the highest information category). Because our focus also lies on the effects of CSR on idiosyncratic risk, we employ an exogenous proxy from our survey to explain the consequences of providing responsible information. \(CSR_{i,t}^{\text{high}}\) takes the value of 1 for \(CSR_{i,t}^{\text{quality}} = 2\) and 0 otherwise. \(CSR_{i,t}^{\text{low}}\) takes the value of 1 for \(CSR_{i,t}^{\text{quality}} = 1\) and 0 otherwise. We relax the assumption of information quality and generate a binary variable that contributes to the robustness check of our models. We assign \(CSR_{i,t}^{\text{quantity}}\) to take the value of 1, if the sum of items, independent of the information category, is higher than or equal to the median of all companies, and 0 otherwise:
\[ CSR_{i,t}^{\text{quantity}} = \begin{cases} 1 & \iff \Sigma(\text{Points})_{i,t} \geq Q_{50} \\ 0 & \text{otherwise} \end{cases} \] (2)

\( CSR_{i,t}^{\text{quantity}} \) measures the overall amount of information independent of the disclosure category (i.e., regardless of qualitative and quantitative information). We use this specification to validate and enhance the veracity of our empirical survey. The 50\% quantile was 9.5 and 11 points for 2007 and 2008, respectively.

We estimate the idiosyncratic risk according to the Capital Asset Pricing Model (CAPM). Rather than taking the standard deviation of the daily residuals directly, we use the measures of Ferreira and Laux (2007). Therefore, we estimate asset pricing regressions with daily returns data within a two-year window. For each firm we calculate our measure for idiosyncratic risk \( \Psi_{i,t} \) as:

\[ \Psi_{i,t} = \log \left( \frac{1 - R^2_i}{R^2_i} \right) = \log \left( \frac{SSR}{ESS} \right), \] (3)

where \( R^2_i \) is the coefficient of determination of each asset pricing equation. We estimate information risk using the accruals quality model of Francis, Lafond, Olsson, and Schipper (2005) with regional adjustment. Information risk arises from the unexplained matching between working capital accruals and operational cash flow. There is strong evidence of the accuracy of this variable as a proxy for information risk (e.g., Aboody, Hughes, and Liu, 2005; Francis, Khurana, and Pereira, 2005; and Ecker et al., 2006). High values of information risk communicate the poor quality of accruals (i.e., low-quality information to investors, thus low financial transparency). Our proxy for estimation risk is calculated as the logarithm of the standard deviation of the daily stock price for the last two years, divided by the mean of its price. Market value is calculated as the share price multiplied by the number of ordinary shares in issue. The number of employees, audit fee, and ROA are obtained either from Datastream or from the annual reports.

Exhibit 3 presents the descriptive statistics. The market value of our real estate companies is on average approximately \( e^{13.156} = 517'104.366 \) Mio \( \) € and is constant over 2007 and 2008. In order to prevent some heteroscedasticity problems, we use the natural logarithm and assume 1 € auditing fees. Concerning the age of European real estate companies, we observe firms that have been listed in the respective market since 1965, which means a maximum of 44.08 years at the end of September 2010. Information risk and estimation risk (Volat) are standard deviations that significantly positively correlate. The ROA is not constant over our observation period, because of the market-based response of the “financially poor” years, 2007 and 2008.

The sample contains only real estate companies (REITs and non-REITs) measuring financial performance with Funds from Operation (FFO), rather than...
**Exhibit 3** | Descriptive Statistics

<table>
<thead>
<tr>
<th>Unit</th>
<th>Size</th>
<th>Audit Fee</th>
<th>Info Risk</th>
<th>Age</th>
<th>Employees</th>
<th>Volat</th>
<th>ROA</th>
<th>Idiosyncratic Risk</th>
<th>FFO</th>
<th>CSR Quantity</th>
<th>CSR Quality</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Log</td>
<td>Tsd. [€]</td>
<td>Std. Dev.</td>
<td>Log</td>
<td>Number</td>
<td>Std. Dev.</td>
<td>%/100</td>
<td>Log</td>
<td>Tsd. [€]</td>
<td>Bivariate</td>
<td>Latent</td>
</tr>
<tr>
<td>Mean</td>
<td>13.156</td>
<td>951.1</td>
<td>0.042</td>
<td>5.286</td>
<td>257.656</td>
<td>0.119</td>
<td>0.016</td>
<td>1.058</td>
<td>105,148.7</td>
<td>0.519</td>
<td>0.875</td>
</tr>
<tr>
<td>Max.</td>
<td>16.321</td>
<td>7,300.0</td>
<td>0.138</td>
<td>6.271</td>
<td>3,550.0</td>
<td>0.321</td>
<td>0.285</td>
<td>2.158</td>
<td>641,145.0</td>
<td>1.000</td>
<td>2.000</td>
</tr>
<tr>
<td>Min.</td>
<td>9.902</td>
<td>0</td>
<td>0.004</td>
<td>4.025</td>
<td>0</td>
<td>0.014</td>
<td>-0.325</td>
<td>0.045</td>
<td>-27,015.10</td>
<td>0.000</td>
<td>0.000</td>
</tr>
<tr>
<td>Std. Dev.</td>
<td>1.258</td>
<td>1,416.9</td>
<td>0.024</td>
<td>0.583</td>
<td>501.899</td>
<td>0.057</td>
<td>0.090</td>
<td>0.628</td>
<td>179,303.7</td>
<td>0.501</td>
<td>0.896</td>
</tr>
</tbody>
</table>
### Exhibit 4 | Correlation Matrix

<table>
<thead>
<tr>
<th></th>
<th>Size</th>
<th>Audit Fee</th>
<th>Info Risk</th>
<th>Age</th>
<th>Employee</th>
<th>Volat</th>
<th>ROA</th>
<th>Idiosyncratic Risk</th>
<th>FFO</th>
<th>CSR Quantity</th>
<th>CSR Quality</th>
</tr>
</thead>
<tbody>
<tr>
<td>Size</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Audit Fee</td>
<td>0.44*</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Info Risk</td>
<td>0.02</td>
<td>0.07</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Age</td>
<td>0.15</td>
<td>0.16</td>
<td>0.07</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Employee</td>
<td>0.48*</td>
<td>0.42*</td>
<td>0.25*</td>
<td>0.30*</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Volat</td>
<td>-0.17*</td>
<td>0.06</td>
<td>0.18*</td>
<td>0.14</td>
<td>0.22*</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ROA</td>
<td>0.18*</td>
<td>-0.12</td>
<td>-0.18*</td>
<td>-0.07</td>
<td>-0.09</td>
<td>-0.35*</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Idiosyncratic Risk</td>
<td>-0.58*</td>
<td>-0.28*</td>
<td>0.16*</td>
<td>0.03</td>
<td>-0.32*</td>
<td>-0.03</td>
<td>-0.04</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>FFO</td>
<td>0.43*</td>
<td>0.09</td>
<td>0.06</td>
<td>0.03</td>
<td>0.38*</td>
<td>-0.03</td>
<td>0.07</td>
<td>-0.43*</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CSR Quantity</td>
<td>0.40*</td>
<td>0.40*</td>
<td>0.02</td>
<td>0.16*</td>
<td>0.52*</td>
<td>0.25*</td>
<td>-0.13</td>
<td>-0.43*</td>
<td>0.31*</td>
<td></td>
<td></td>
</tr>
<tr>
<td>CSR Quality</td>
<td>0.44*</td>
<td>0.38*</td>
<td>-0.05</td>
<td>0.18*</td>
<td>0.57*</td>
<td>0.18*</td>
<td>-0.10</td>
<td>-0.44*</td>
<td>0.32*</td>
<td>0.85*</td>
<td></td>
</tr>
</tbody>
</table>

*Pearson correlation coefficient significant at 10%.
with net income, because of its accuracy in estimating the performance of real estate companies (e.g., Tsang, 2006). By analyzing the linear relationship of our second explanatory variable (Idiosyncratic Risk), we observe that this correlates negatively with size and FFO. This implies that real estate-specific financial performance is associated with lower levels of idiosyncratic risk and vice versa. The description of variables is shown in Exhibit 8.

**Methodology**

**Drivers of a Responsible Provision of Information**

Because \(CSR_{\text{quality}}\) is an ordered categorical variable, we estimate the following latent regression via maximum likelihood as an ordered probit model with three categories, two threshold parameters, and without a constant:

\[
CSR_{\text{quality}} = \beta_1 \log(Mval)_{i,t} + \beta_2 \text{AuditFee}_{i,t} + \beta_3 \log(Emplo)_{i,t} + \beta_4 \text{InfoRisk}_{i,t} + \beta_5 \log(Age)_{i,t} + \beta_6 \log(Volat)_{i,t-1} + \beta_7 \text{ROA}_{i,t} + \beta_8 Region_i + \beta_9 Year_i + u_{i,t}. \tag{4}
\]

We expect the CSR intensity to increase for market value \(\hat{\beta}_1\), our proxy for business complexity AuditFee \(\hat{\beta}_2\), and human resources \(\log(Emplo)\) \(\hat{\beta}_3\). Information risk is expected to be negative, \(\hat{\beta}_4\), because it represents “the likelihood that firm-specific information that it is pertinent to investors pricing decisions is of poor quality,” (Francis, Lafond, Olsson, and Schipper, 2005). We expect \(\hat{\beta}_4\) to be statistically insignificant because experienced companies invest in CSR, just as unskilled companies. Therefore, business knowledge does not influence either the decision “to go CSR” or its intensity. Elevated levels of stock price volatility, the estimation risk, of the past period should enhance a firm’s CSR strength in the next period and therefore \(\hat{\beta}_5 > 0\). Financial performance should contribute to sustainable activities and their intensity, \(\hat{\beta}_7 > 0\). Region and Year control for regional heterogeneity and time-varying effects. Our robustness check relaxes the assumption concerning the quality levels of CSR information by taking only the amount of information as dependent variable.

\[
CSR_{\text{quantity}} = \gamma_1 \log(Mval)_{i,t} + \gamma_2 \text{AuditFee}_{i,t} + \gamma_3 \log(Emplo)_{i,t} + \gamma_4 \text{InfoRisk}_{i,t} + \gamma_5 \log(Age)_{i,t} + \gamma_6 \log(Volat)_{i,t-1} + \gamma_7 \text{ROA}_{i,t} + \gamma_8 Region_i + \gamma_9 Year_i + \pi_{i,t}. \tag{5}
\]

We estimate the model as a binary probit regression, taking into account that the transformation leads to a loss of information. Nevertheless, we expect the same effects as with equation 4.
**Consequences of Providing Responsible Information**

We study the consequences of enhanced responsible information provision on a firm’s idiosyncratic risk $\Psi_{i,t+1}$. Idiosyncratic risk is defined as the error term between the estimated and predicted stock returns, estimated by the market model and scaled by the firm’s total risk. We expect that, as the quality of CSR activities $CSR_{i,t}^{quality}$ increases, financial markets compensate for this strength through a reduction of the idiosyncratic risk.

\[
\Psi_{i,t+1} = \theta_0 + \theta_1 \log(MVal)_{i,t} + Return_{i,t} + \theta_3 FFO_{i,t} + \theta_4 Sector_i + \theta_5 CSR_{i,t}^{high} + \theta_6 CSR_{i,t}^{low} + \nu_{i,t}.
\] (6)

Consequently, we regress $\Psi_{i,t+1}$ on market value as a control for size, one year mean return, financial performance measured as FFO and control for real estate-specific sector variations. Concerning the error term, we estimate the regression assuming random effects for the iid error term $\nu_{i,t}$ in order to control for firms’ unobserved heterogeneity. We expect $\hat{\theta}_1$ to be negatively related to idiosyncratic risk, because the size effect captures this variation observed by Fama and French (1992). According to Lee and Faff (2009), the higher the return, the higher the idiosyncratic risk $\hat{\theta} > 0$. We control for FFO in order to proxy for the investors’ perception of firm-specific real estate financial performance. Considering our CSR-variables, we expect a significant negative effect on the firm’s idiosyncratic risk and $\hat{\theta}_7$ to be negative, significant, and lower than $|\hat{\theta}_5|$. The latter is the case, because $\hat{\theta}_5$ refers to a higher intensity of responsibility than $\hat{\theta}_6$, indicating that the greater the strength of responsible activities, the greater the reduction in $\Psi_{i,t+1}$. We run a robustness check by relaxing the assumption of information quality and regress future idiosyncratic risk on both our control variables and $CSR_{i,t}^{quantity}$:

\[
\Psi_{i,t+1} = \theta_0 + \theta_1 \log(MVal)_{i,t} + \theta_2 Return_{i,t} + \theta_3 FFO_{i,t} + \theta_4 Sector_i + \theta_5 CSR_{i,t}^{quantity} + \nu_{i,t}.
\] (7)

In order to provide additional support to the hypothesis that a sustainability agenda in general does pay off, all else equal, we expect $\hat{\theta}_7$ to be negative, significant, and lower than $|\hat{\theta}_5|$.

**Empirical Results**

**Drivers of a Responsible Provision of Information**

Exhibit 5 presents the regression results of the factors that lead to an enhanced disclosure quality of socially responsible activities. The variance inflation factors
### Exhibit 5: Drivers of a Responsible Provision of Information

<table>
<thead>
<tr>
<th>Variable / Coefficient</th>
<th>Model 1</th>
<th>Model 2</th>
<th>Model 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Log(MValue)</td>
<td>$\beta_1$</td>
<td>0.363</td>
<td>3.096***</td>
</tr>
<tr>
<td>Audit Fee</td>
<td>$\beta_2$</td>
<td>0.172</td>
<td>2.091**</td>
</tr>
<tr>
<td>Log(Employees)</td>
<td>$\beta_3$</td>
<td>0.366</td>
<td>3.725***</td>
</tr>
<tr>
<td>Information Risk</td>
<td>$\beta_4$</td>
<td>-12.640</td>
<td>-2.800***</td>
</tr>
<tr>
<td>Log(Age)</td>
<td>$\beta_5$</td>
<td>-0.076</td>
<td>-0.355</td>
</tr>
<tr>
<td>Log(Volatility)</td>
<td>$\beta_6$</td>
<td>0.705</td>
<td>3.397***</td>
</tr>
<tr>
<td>ROA</td>
<td>$\beta_7$</td>
<td>-1.946</td>
<td>-1.710*</td>
</tr>
<tr>
<td>West Europe</td>
<td>$\beta_8$</td>
<td>1.235</td>
<td>2.952***</td>
</tr>
<tr>
<td>Scandinavia</td>
<td>$\beta_9$</td>
<td>1.592</td>
<td>3.579***</td>
</tr>
<tr>
<td>Year Dummy</td>
<td>$\beta_{10}$</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>$\mu^1$</td>
<td>5.000</td>
<td>3.134***</td>
<td>5.780</td>
</tr>
<tr>
<td>$\mu^2$</td>
<td>5.800</td>
<td>3.612***</td>
<td>6.510</td>
</tr>
<tr>
<td>n*T</td>
<td>160</td>
<td></td>
<td>160</td>
</tr>
<tr>
<td>Pseudo R²</td>
<td>31.91</td>
<td></td>
<td>26.62</td>
</tr>
<tr>
<td>LogL</td>
<td>-112.884</td>
<td></td>
<td>-121.655</td>
</tr>
<tr>
<td>F-stat</td>
<td>0.0000</td>
<td></td>
<td>0.0000</td>
</tr>
<tr>
<td>CSR_{0} = 0</td>
<td></td>
<td>75</td>
<td></td>
</tr>
<tr>
<td>CSR_{0} = 1</td>
<td></td>
<td>30</td>
<td></td>
</tr>
<tr>
<td>CSR_{0} = 2</td>
<td></td>
<td>55</td>
<td></td>
</tr>
</tbody>
</table>

**Notes:** The table uses a latent ordered probit regression approach. The dependent variable is $\text{CSR}_{0}^{\text{real}}$, which is a latent variable with three categories. Companies whose provision of responsible information is quantitatively high belong to the highest category. Companies disclosing only general information about their sustainable activities belong to the next category.

* Significant at the 10% level.
** Significant at the 5% level.
*** Significant at the 1% level.

lie below 2.5 and signal no collinearity within the regressors. Model one indicates that as CSR information increases, the market value of the company increases as well. This result corresponds with previous research (Albers and Guenther, 2010; Gamerschlag, Moeller, and Verbeeten, 2010) and is significant at $\alpha = 1\%$. We are able to confirm that the intensity of socially responsible activities increases, ceteris paribus, whenever the number of employees increases, $\hat{\beta}_3$. Furthermore, the estimated coefficient for information risk $\hat{\beta}_4$ is negative: the greater the information risk, the lower the financial transparency and therefore the lower the CSR intensity. This result implies that, over 2007 and 2008, real estate companies
intensified their CSR activities, which enhanced financial transparency. Therefore, it is important to establish this relationship and to consider financial transparency as a positive contributor to sustainable and responsible activities.

Our latent regression shows that the business experience $\hat{\beta}_5$, proxied by $\log(\text{age})$, does not enhance the probability to intensify CSR activities. Therefore, CSR is an innovative field that does not require extensive business knowledge. However, the estimated coefficient for stock price volatility $\hat{\beta}_6$ shows that enhanced estimation risk in the past year increases the probability of investing intensively in CSR activities in the present period. We do not predict a sign for business complexity $\hat{\beta}_2$. As Exhibit 5 shows, the more complex an enterprise’s business model, the greater their efforts to invest in sustainability. This is important because it is logical to believe that complexity suppresses responsibility. We are able to show at $\alpha = 1\%$ that this is not in fact the case and that real estate companies invest in CSR, perhaps precisely because of the implied posterior benefits. The estimated coefficient of ROA $\hat{\beta}_7$ must be interpreted with caution. The Z-statistic of the predicted regression coefficient is low and insignificant in model two. This could be due to a negative impact of ROA on CSR, but the explanatory power of ROA is low. This result is confusing, because, as described theoretically, financial performance should enhance CSR. We regard this negative coefficient as a market-based response of the “financially poor” years of 2007 and 2008. Nevertheless, our latent regression in model one has an explanatory power of 31.91\%, with 68 degrees of freedom.

Finally, we consider the regional differences by adding two dummy variables: West Europe and Scandinavia. West Europe takes a value of 1 for west Europe including the UK and Scandinavia. It is clear that the probability of achieving a more intensive level of sustainable activities is higher for Scandinavian real estate companies, than for all other countries $\hat{\beta}_9$. This result is in accordance with the survey of KPMG (2009), which indicates the advanced legal and reporting level these countries have concerning general sustainable reporting and GRI guidelines application.

The robustness check for our latent regression employs a probit estimation approach. Exhibit 6 shows that the estimated probit model is able to confirm increased business complexity $\hat{\gamma}_2$ and number of employees $\hat{\gamma}_3$ raises the probability of providing more general information concerning sustainable activities. It also shows that the regional differences are present and that enhanced stock price volatility influences CSR activities positively.

The coefficient of determination indicates an explanatory power of about 39.5\%. However, business transparency and financial performance are at $\alpha = 10\%$ and $\alpha = 5\%$, which are both statistically insignificant. This indicates that the explanatory power of financial transparency influences the quality of information ($CSR_{i,t}^{\text{quality}}$) rather than the amount of information ($CSR_{i,t}^{\text{quantity}}$).

**Consequences of Providing Responsible Information**

Our second research question concentrates on the effect of present enhanced information on sustainable activities, as well as its effect on future idiosyncratic
**Exhibit 6 | Drivers of a Responsible Provision of Information**

<table>
<thead>
<tr>
<th>Variable / Coefficient</th>
<th>Model 1</th>
<th>Model 2</th>
<th>Model 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Log(MValue)</td>
<td>$\gamma_1$</td>
<td>0.403</td>
<td>2.842***</td>
</tr>
<tr>
<td>Audit Fee</td>
<td>$\gamma_2$</td>
<td>0.460</td>
<td>3.102***</td>
</tr>
<tr>
<td>Log(Employee)</td>
<td>$\gamma_3$</td>
<td>0.308</td>
<td>2.787***</td>
</tr>
<tr>
<td>Information Risk</td>
<td>$\gamma_4$</td>
<td>-8.788</td>
<td>-1.583</td>
</tr>
<tr>
<td>Log(Age)</td>
<td>$\gamma_5$</td>
<td>-0.080</td>
<td>-0.317</td>
</tr>
<tr>
<td>Log(Volatility)</td>
<td>$\gamma_6$</td>
<td>0.914</td>
<td>3.367***</td>
</tr>
<tr>
<td>ROA</td>
<td>$\gamma_7$</td>
<td>-1.576</td>
<td>-0.981</td>
</tr>
<tr>
<td>West Europe</td>
<td>$\gamma_8$</td>
<td>0.969</td>
<td>2.051**</td>
</tr>
<tr>
<td>Scandinavia</td>
<td>$\gamma_9$</td>
<td>1.469</td>
<td>2.801***</td>
</tr>
<tr>
<td>Year Dummy</td>
<td>$\gamma_{10}$</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>n*T</td>
<td>160</td>
<td>160</td>
<td>160</td>
</tr>
<tr>
<td>McFadden R²</td>
<td>42.46</td>
<td>38.26</td>
<td>37.77</td>
</tr>
<tr>
<td>LogL</td>
<td>-63.748</td>
<td>-68.405</td>
<td>-68.941</td>
</tr>
<tr>
<td>F-stat</td>
<td>0.0000</td>
<td>0.0000</td>
<td>0.0000</td>
</tr>
<tr>
<td>CSR$^{\text{quantity}} = 1$</td>
<td>83</td>
<td></td>
<td></td>
</tr>
<tr>
<td>CSR$^{\text{quantity}} = 0$</td>
<td>77</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Notes: The table uses a bivariate probit regression approach. The dependent variable is $\text{CSR}^{\text{quantity}}$, which measures the overall amount of information, with respect to the median, independent of the disclosure quality.

* Significant at the 10% level.

** Significant at the 5% level.

*** Significant at the 1% level.

risk for European real estate companies. We regress future idiosyncratic risk on the present CSR variables and control for size, one-year mean return, sectors, and real estate-specific financial performance. Exhibit 7 shows our estimation. Model 1 uses two dummy variables to measure for CSR, while model two employs only one and serves as our robustness check.

Our results indicate that higher returns positively influence idiosyncratic risk, although affects market value negatively. Higher FFOs lead to lower idiosyncratic risk. The estimated coefficient sign indicates that enhanced present financial profitability can reduce the variation between estimated and predicted return for real estate companies $\hat{\theta}_S$. By interpreting our coefficients for corporate social responsibility $\hat{\theta}_S$ and $\hat{\theta}_e$, we find statistically significant evidence that disclosure leads in the future to a decrease in idiosyncratic volatility for the ensuing years. This result holds only for firms that disclose profound key performance indicators,
### Exhibit 7 | Consequences of Providing Responsible Information

<table>
<thead>
<tr>
<th>Variable / Coefficients</th>
<th>Model 1</th>
<th></th>
<th>Model 2</th>
<th></th>
<th>Model 3</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Coeff.</td>
<td>t-Stat</td>
<td>Coeff.</td>
<td>t-Stat</td>
<td>Coeff.</td>
<td>t-Stat</td>
</tr>
<tr>
<td>Constant</td>
<td>$\theta_0$</td>
<td>3.891</td>
<td>8.873***</td>
<td>3.847</td>
<td>8.810***</td>
<td>3.946</td>
</tr>
<tr>
<td>Log(MValue)</td>
<td>$\theta_1$</td>
<td>-0.196</td>
<td>-5.783***</td>
<td>-0.189</td>
<td>-5.647***</td>
<td>-0.197</td>
</tr>
<tr>
<td>Return</td>
<td>$\theta_2$</td>
<td>0.307</td>
<td>4.560***</td>
<td>0.303</td>
<td>4.501***</td>
<td>0.313</td>
</tr>
<tr>
<td>FFO</td>
<td>$\theta_3$</td>
<td>-0.009</td>
<td>-3.175***</td>
<td>-0.008</td>
<td>-2.819***</td>
<td>-0.008</td>
</tr>
<tr>
<td>REITs</td>
<td>$\theta_4$</td>
<td>-0.236</td>
<td>-2.168**</td>
<td>-0.229</td>
<td>-2.134**</td>
<td>-0.233</td>
</tr>
<tr>
<td>CSR High Quality</td>
<td>$\theta_5$</td>
<td>0.236</td>
<td>2.168**</td>
<td>0.229</td>
<td>2.134**</td>
<td>0.233</td>
</tr>
<tr>
<td>CSR Low Quality</td>
<td>$\theta_6$</td>
<td>0.061</td>
<td>-0.823</td>
<td>0.061</td>
<td>-0.823</td>
<td>0.061</td>
</tr>
<tr>
<td>CSR Quantity</td>
<td>$\theta_7$</td>
<td>0.153</td>
<td>2.436**</td>
<td>0.061</td>
<td>-0.823</td>
<td>0.061</td>
</tr>
<tr>
<td>Hausman Test (p-V)</td>
<td>$\chi^2 = 4.544$ (0.208)</td>
<td>$\chi^2 = 4.762$ (0.446)</td>
<td>$\chi^2 = 5.975$ (0.201)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>n*T</td>
<td>160</td>
<td></td>
<td>160</td>
<td></td>
<td>160</td>
<td></td>
</tr>
<tr>
<td>Adj. R²</td>
<td>27.11</td>
<td></td>
<td>29.26</td>
<td></td>
<td>28.51</td>
<td></td>
</tr>
<tr>
<td>F-stat</td>
<td>0.000</td>
<td></td>
<td>0.000</td>
<td></td>
<td>0.000</td>
<td></td>
</tr>
</tbody>
</table>

Notes: The table is an OLS Regression with White diagonal standard errors. The dependent variable is $\text{Idio}_t \text{Risk} (t + 1)$, which measures the idiosyncratic risk for each asset derived from the market model following Ferreira and Laux (2007). It is calculated as the logarithm of the sum of square residuals divided by the explained sum of squares.

*Significant at the 10% level.
**Significant at the 5% level.
***Significant at the 1% level.

goals achieved, and quantitative information, so that the firms are viewed as highly sustainable (i.e., high strength in terms of human rights, and social, environmental, and financial activities). Firms disclosing information on general activities and actions are not able to enjoy benefits in the next period. By analyzing our second model as our robustness check, we provide evidence that the overall strength $\hat{\theta}_7$, without taking the quality of the information into account, decreases the unexplained stock volatility, but the estimated coefficient of $\text{CSR}_{i,t}^{\text{quantity}}$ is lower than $\hat{\theta}_5$, which means that for the idiosyncratic risk mechanism, the quality of information plays a more important role than the quantity. Both quality and amount have a negative effect on idiosyncratic risk, but the latter has a weaker impact. Furthermore, the coefficient of determination explains approximately 28% of the system variation.

Consequently, these results indicate that firms disclosing CSR information are recompensed by the market, but these benefits are only exploited intensively by firms disclosing comprehensive CSR information, such as like the key indicators of CO₂ emissions and energy consumption levels.
### Exhibit 8 | Variable Description

<table>
<thead>
<tr>
<th>Name</th>
<th>Abbreviation</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Market Value</td>
<td>MVal</td>
<td>Market value measured as the share price multiplied by the number of ordinary shares in issue [MV].</td>
</tr>
<tr>
<td>Audit Fee</td>
<td>Audit Fee</td>
<td>Expenditures for external auditing fees in € [WC01801].</td>
</tr>
<tr>
<td>Age</td>
<td>Age</td>
<td>Number of months since inclusion to the stock market.</td>
</tr>
<tr>
<td>Number of Employees</td>
<td>Emplo</td>
<td>Number of employees [WC07011].</td>
</tr>
<tr>
<td>Stock Price Volatility</td>
<td>Volat</td>
<td>Stock price volatility divided by the mean stock price in a two-year estimation window [P]: $\log(\text{Volat}<em>{i,t}) = \sigma(\text{Stock price}</em>{i,t}) / \text{Stock price}_{i,t}$.</td>
</tr>
<tr>
<td>Return on Assets</td>
<td>RoA</td>
<td>Return on Assets in € [WC08326].</td>
</tr>
<tr>
<td>Idiosyncratic Risk</td>
<td>IdioRisk</td>
<td>Measured as logarithm of the sum of squared residuals divided by the explained sum of squares from the one-factor market model,</td>
</tr>
<tr>
<td></td>
<td></td>
<td>using the one-month Euribor as risk-free rate and the individual market return: $\Psi_{i,t} = \log(1 - R^2_i / R^2_t) = \log(\text{SSR} / \text{ESS})$. We normalize the idiosyncratic volatility to</td>
</tr>
<tr>
<td></td>
<td></td>
<td>the total volatility for each asset, rather than by industry, because of the regional heterogeneity of our sample.</td>
</tr>
<tr>
<td>Funds from Operations</td>
<td>FFO</td>
<td>Firm-specific Funds from Operation in € [WC04201].</td>
</tr>
<tr>
<td>CSR-Quality</td>
<td>CSR_quality</td>
<td>Latent variable taking the value of 2 if the provided CSR-information is of high quantitative information; the value of 1 for</td>
</tr>
<tr>
<td></td>
<td></td>
<td>qualitative information and 0 for no information.</td>
</tr>
<tr>
<td>CSR-Quantity</td>
<td>CSR_quantity</td>
<td>Binary variable taking the value of 1 if the amount of provided information is greater than the median, independently of the</td>
</tr>
<tr>
<td></td>
<td></td>
<td>quality of CSR information.</td>
</tr>
<tr>
<td>CSR-High-Quality</td>
<td>CSR_High</td>
<td>Binary variable taking the value of 1 for $\text{CSR}_\text{quality} = 2$ and 0 otherwise</td>
</tr>
<tr>
<td>CSR-Low-Quality</td>
<td>CSR_Low</td>
<td>Binary variable taking the value of 1 for $\text{CSR}_\text{quality} = 1$ and 0 otherwise</td>
</tr>
<tr>
<td>West Europe dummy</td>
<td>West Europe</td>
<td>Binary variable taking the value of 1 for Belgium, France, Germany, Netherland, United Kingdom, and Austria.</td>
</tr>
<tr>
<td>Scandinavia dummy</td>
<td>Scandinavia</td>
<td>Binary variable taking the value of 1 for Finland, Norway and Sweden. The reference category is Greece, Turkey, Italy, and</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Switzerland.</td>
</tr>
<tr>
<td>Information Risk</td>
<td>InfoRisk</td>
<td>Standard deviation of the past four residuals of cross-sectionally regressions: $\sigma(\hat{e}_{i,t})$, $t \in {t - 4, \ldots , t}$. The higher the standard deviation, the higher the information risks. Model following</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Francis et al. (2005) controlled for country heterogeneity: $\text{TCA}<em>{i,t} / \text{TA}</em>{i,t-1} = \alpha_1 + \alpha_2 \text{CFO}<em>{i,t-1} / \text{TA}</em>{i,t-1} + \alpha_3 \text{CFO}<em>{i,t} / \text{TA}</em>{i,t-1} + \alpha_4 \text{CFO}<em>{i,t-1} / \text{TA}</em>{i,t-1} + \alpha_5 \Delta \text{REV}<em>{i,t} / \text{TA}</em>{i,t-1} + \alpha_6 \text{PPE}<em>{i,t} / \text{TA}</em>{i,t-1} + \alpha_7 \text{Region}<em>{i,t} + \epsilon</em>{i,t}$. Because our sample contains only real estate firms, we add two dummy variables that control for regions, rather than regressing for each industry sector.</td>
</tr>
<tr>
<td>Total Current Accruals</td>
<td>TCA</td>
<td>Total current accruals calculated as $\Delta \text{CA} - \Delta \text{CL} + \text{StDebt} + \text{Depr.} (\Delta \text{from } t - 1 \text{ to } t)$.</td>
</tr>
</tbody>
</table>
### Exhibit 8 | (continued)

<table>
<thead>
<tr>
<th>Name</th>
<th>Abbreviation</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Accruals</td>
<td>TAC</td>
<td>Total accruals calculated as TCA − Depr.</td>
</tr>
<tr>
<td>Total Assets</td>
<td>TA</td>
<td>Total current assets [WC02999].</td>
</tr>
<tr>
<td>Cashflow from Operations</td>
<td>CFO</td>
<td>Cashflow from operations calculated as NIBE − TAC.</td>
</tr>
<tr>
<td>Revenues</td>
<td>REV</td>
<td>Revenues [WC01001].</td>
</tr>
<tr>
<td>Property, Plant and Equipment</td>
<td>PPE</td>
<td>Property, Plant and Equipment [WC02301].</td>
</tr>
<tr>
<td>Current Assets</td>
<td>CA</td>
<td>Current Assets, calculated as [WC02651] − [WC02051] (Other Assets — Receivables).</td>
</tr>
<tr>
<td>Current Liabilities</td>
<td>CL</td>
<td>Current Liabilities calculated as [WC03351] − [WC02051] (Total Liabilities − Current Liabilities).</td>
</tr>
<tr>
<td>Short-term Debt</td>
<td>StDebt</td>
<td>Short-term Debt [WC03051].</td>
</tr>
<tr>
<td>Depreciation</td>
<td>Depr</td>
<td>Depreciation, Depletion, and Amortization [WC01151].</td>
</tr>
<tr>
<td>Net Income before Extraordinary</td>
<td>NIBE</td>
<td>Net Income before Extraordinary [WC01551].</td>
</tr>
</tbody>
</table>

Note: Codes in brackets represent the respective Worldscope Datastream Code.

### Conclusion

After developing a survey in accordance to the guidelines from the GRI and EPRA, we measure the extent and intensity of sustainable activities of listed European real estate companies over 13 countries.

Our first research question reveals an increasing strength in CSR activities among European real estate companies, particularly among REITs. We conclude that CSR activities are influenced positively by market value, the number of employees, and auditing fees. Higher levels of financial transparency enhance the intensity and quality of socially responsible activities, whereas the probability of “going CSR” increases significantly for companies whose past stock price volatility is high.

Our second research question shows that ex ante CSR activities are rewarded by a reduction in unexplained stock variance (i.e., the idiosyncratic risk). Therefore, in order to exploit additional benefits, real estate companies should structure their CSR activities in such a way that clear signals are sent to capital markets. Furthermore, the greater the intensity and quality of ex ante CSR information, the lower the idiosyncratic risk. The analysis provides evidence that the overall strength in CSR activities is proportionally related to its benefits.

Our study is limited by the size of the sample. Nevertheless, we expect to expand our methodology by applying non-parametric models to identify possible non-
linear effects and see the importance of this statistical field because of the lack of empirical results for real estate and sustainability. We believe that further investigations in this field should concentrate on the (possible) non-linear mechanism of CSR activities and financial performance. Furthermore, we are the first study, to our knowledge, a latent ordered probit regression model to investigate the drivers for a high provision of responsible information to capital markets.

Endnotes

2 Leaving this implication behind, we found similar results, so that this assumption does not lead to incorrect inferences.
3 Funds from Operations (FFO) are defined by Tsang (2006) as “an alternative (measure) to net income.” Specifically, FFO is calculated “by adding back the net income the amount of depreciation and amortization related to real estate properties, gains and losses on the sale of real estate assets, and certain other unusual and infrequent specific accrual items.”
4 Estimation procedure excludes a constant, because the system would otherwise not be identifiable.
5 We also estimate equations 4 and 5 with FFO as a proxy for real estate financial performance and achieve the same results.

References


——. EPRA Sustainability Reporting Committee. GRI CRESS Response and Proposal for EPRA BPR. 2010.


*We thank Nora Rothacher, Marina Bauer, Peter Geiger, Thomas Braun, and Anita Krajinovic-Bilos.*

Marcelo Cajias, University of Regensburg, D-93953 Regensburg, Germany or marcelo.cajias@irebs.de.
Sven Bienert, University of Regensburg, D-93953 Regensburg, Germany or sven.bienert@irebs.de.
Facility Sustainment and Firm Value: A Case Study Based on Target Corporation

Author Robert Beach

Abstract This paper argues that increasing the level of facility sustainment (maintenance and repair) funding can increase firm value. Higher levels of facility sustainment funding reduce the list of maintenance and repair projects and maintain the liquidation value of the firm’s facilities. A condition is derived that establishes the minimum probability of financial distress required for firm value to increase as sustainment funding increases. This condition is tested with a case study based on the annual reports of a major retailer, Target Corporation. The results support the hypothesis. This holds even though adverse externalities that might occur from underfunding sustainment have not been considered.

Most firms are responsible for the operation of a number of buildings and other facilities. In managing these facilities, they must make decisions that can have a profound impact on human health and the natural environment. For example, consider Leadership in Energy and Environmental Design (LEED) standards for operation and maintenance of existing buildings. These standards apply to a number of operation and maintenance activities including occupant comfort, air quality, and waste management (U.S. Green Building Council, 2008). It is widely accepted that the decision to adopt LEED standards can reduce the harmful health and environmental effects from the operation of these facilities.

This paper looks at another important facility management decision: how much to fund facility sustainment. This decision can also significantly impact health and the environment yet receives little attention in the sustainability and corporate finance literature. As it is used here, facility sustainment refers to the yearly cost of maintaining a facility in good working order over its expected lifespan. Funding facility sustainment at 100% maximizes the value and usefulness of the facility. Underfunding facility sustainment not only leads to a growing backlog of maintenance and repair projects but can also result in catastrophic failures that lead to severe health and environmental consequences. For example, the 2005 explosion at the British Petroleum refinery in Texas City, Texas resulted in the death of fifteen people and pollution of the surrounding neighborhood. This incident was largely attributed to the inadequate maintenance of production facilities (Lyall, 2010). As another example, sources of Legionnaires’ disease, a very serious pulmonary illness, include large central air-conditioning systems that have been inadequately maintained. Despite its potential health and environmental consequences, many firms and organizations routinely underfund facility


sustainment since the costs of doing so will be deferred to an unknown point in the future. A recent assessment of the facility sustainment backlog at a major U.S. university was $620 million (Carlson, 2008). Many experts would agree that this is probably the typical case rather than the exception.

The hypothesis of this paper is that under certain conditions increasing sustainment funding can increase firm value. In many cases, the liquidation value of facilities that have been adequately maintained will be higher than otherwise and outweigh the additional expense of higher sustainment funding. The model developed here is based on a tradeoff theory of capital structure that takes into account the probability of financial distress and incorporates the facility degradation process that occurs when sustainment is underfunded. It represents the initial effort in the literature to model the impact of the level of sustainment funding on firm value. It contributes both to the literature on the tradeoff model of capital structure along the lines proposed by Damodaran (2006) and to the literature on sustainment funding and facility condition as discussed in Choi, Jondrow, Taylor, and Weis (1994) and Ottoman, Nixon, and Lofgren (1999a, 1999b).

Using a case study based on the financial reports of a major retailer, Target Corporation, it is shown that this hypothesis holds in two different versions of the model. The first is referred to as the finite valuation period model and is based on an expected value model of financial distress similar to that described in Damodaran (2006). A condition is derived for the probability of financial distress that must be met for firm value to increase as sustainment funding is increased. It is shown that for the parameters of the case study, this condition is met. Within the framework of this model, firm value is also calculated at Target’s historical level of sustainment, 51.7%, and at the recommended level of sustainment, 100%. The results support the hypothesis that firm value can increase as sustainment funding increases. The second model is a Monte Carlo simulation. Again Target’s historical funding level of 51.7% and the recommended funding level at 100% are considered. The Monte Carlo simulation also supports the hypothesis that firm value can increase as sustainment funding is increased.

A Model of Facility Sustainment and Firm Value

A version of the backlog projection model is used to model facility sustainment in this paper. The backlog projection model predicts the future backlog of maintenance and repair given expected funding. It requires estimates of sustainment cost factors, a method of measuring facility condition, a model of the facility degradation process, and estimates of degradation rates for different types of facilities.

Sustainment cost factors for facilities found on a typical military installation have been developed by Neely and Neathammer (1991) of the Army’s Civil Engineering Research Laboratory. These cost factors are updated annually and are also available from commercial sources such as the R.S. Means Company or Whitestone Research, both of which publish an annual update of facility
sustainment cost factors for commercial and residential facilities. The sustainment cost factors for retail stores used in the case study below come from government sources.

A facility condition index (FCI) measures the condition of a given facility and whether it meets the standard for the primary use of that facility. Ottoman, Nixon, and Lofgren (1999a, 1999b) summarize the various approaches to facility condition measures used by academic, government, and commercial planners.


Backlog projection models also require a degradation rate. The degradation rate for the retail stores considered in the case study come from studies conducted by the author and others (Beach, Carson, and Keating, 1998; and Beach, 2004).

**Backlog Projection Model**

The backlog projection model discussed above defines the relationship between funding and facility condition. It can be expressed as:

\[
C_t = (1 + \rho)C_{t-1} + S_t - F_t,
\]

where \( C_t \) is the cost of facility deficiencies (the backlog of maintenance and repair projects) at the end of year \( t \), \( \rho \) is the degradation rate, \( S_t \) is the required yearly sustainment to maintain the facility in good operating condition, and \( F_t \) is the level of sustainment funding for year \( t \). (The year subscripts are retained for \( S_t \) and \( F_t \), even though in the case study discussed below both are taken as constant.)

This equation can also be expressed as:

\[
C_t = (1 + \rho)C_{t-1} + (1 - \alpha)S_t,
\]

where \( \alpha \) is the percentage of sustainment funded. That is: \( F_t = \alpha S_t \).

The firm’s sustainment requirement, \( S_r \), for a given type of facility is computed using the following equation:

\[
S_r = TSF_r \cdot SCF_r.
\]
where \( S_t \) is the firm’s sustainment requirements for year \( t \), \( TSF_t \) is the total square footage of that type of facility in year \( t \), and \( SCF \) is the sustainment cost factor based on the industry standard for a given type of facility.

**Finite Valuation Period Model**

The finite valuation period model estimates the expected firm value over a finite number of future years. The estimate of firm value is similar to the approach described in Damodaran (2006). This approach assumes there is a positive probability of financial distress and that expected firm value over the valuation period is made up of a going concern component and a financial distress component. This is expressed in the following equation:

\[
V_F = V_{GC} + V_{FD},
\]

where \( V_F \), \( V_{GC} \), and \( V_{FD} \) represent the expected value of the firm, the expected value of the going concern component, and the expected value of the financial distress component, respectively.

The going concern value is based on the present value of the free cash flow of the firm over the valuation period. Free cash flow is estimated using the following equation:

\[
FCF = \text{ebit}(1 - t_c) + \text{dep} - (\text{capex} + \Delta\text{nwc}),
\]

where \( FCF \) is free cash flow, \( \text{ebit} \) is earnings before interest and taxes, \( t_c \) is the corporate tax rate, \( \text{capex} \) is the yearly capital expenditures, \( \text{dep} \) is the current year depreciation, and \( \Delta\text{nwc} \) is the yearly change in net working capital.

The expected going concern value of the firm is estimated by calculating the present value of the free cash flow of the firm over the valuation period times the annual probability that the firm will not experience financial distress. That is:

\[
V_{GC} = (1 - \pi) \sum_{h=1}^{H} \frac{FCF}{(1 + WACC)^h},
\]

where \( FCF \) is the yearly free cash flow of the firm as defined in Equation 5, \( H \) is the valuation period, \( \pi \) is the annual probability of financial distress, and \( WACC \) is the weighted average cost of capital based on the weighted average of the firm’s cost of debt and cost of equity.
By separating out sustainment cost expenses, the going concern value can be expressed in a more convenient form as:

\[ V_{GC} = (1 - \pi) \sum_{h=1}^{H} \frac{FCF_{adj} - \alpha S_t(1 - t_c)}{(1 + WACC)^h}, \]  

(7)

where \( FCF_{adj} \) is the free cash flow before subtracting out sustainment expenses.

The financial distress value is estimated as the expected liquidation value of the firm’s facilities.\(^1\) For liquidation value, we use the plant replacement value (PRV) of the facility adjusted for expected degradation based on the level of sustainment funding. PRV represents the cost of building a similar facility on the current site. It does not include site preparation or the value of the land. In the absence of fire sale effects, the adjusted PRV value represents a conservative estimate of the liquidation value since the market value could easily be much higher.\(^2\) The financial distress value can be expressed as:

\[ V_{FD} = \pi \sum_{h=1}^{H} \frac{PRV - \sum_{j=1}^{h} (1 + \rho)^{j-1}S_t(1 - \alpha)}{(1 + WACC)^h}, \]  

(8)

where all variables are as defined above.

Given Equations 3–8, the model of firm value can be expressed as:

\[ V_F = (1 - \pi) \sum_{h=1}^{H} \frac{FCF_{adj} - \alpha S_t(1 - t_c)}{(1 + WACC)^h} \]

\[ + \pi \sum_{h=1}^{H} \frac{PRV - \sum_{j=1}^{h} (1 + \rho)^{j-1}S_t(1 - \alpha)}{(1 + WACC)^h}, \]  

(9)

where \( V_F \) represents the expected value of the firm given sustainment funding at \( \alpha \)\(^{\%} \) and with an annual probability of financial distress of \( \pi \). Equation 9 states that expected firm value is the discounted sum of the expected cash flows for each year in the valuation period.

**The Critical Value of Financial Distress**

Taking the first derivative of Equation 9 with respect to the percent of sustainment funded, \( \alpha \), the following expression is derived:
It follows for this to be positive the following must hold:

$$\sum_{h=1}^{H} \frac{(1 + \rho)^{j-1}}{(1 + WACC)^{h}} > (1 - \pi)(1 - t_c) \sum_{h=1}^{H} \frac{1}{(1 + WACC)^{h}}. \quad (11)$$

Solving Equation 11 for $\pi$, the annual probability of financial distress, the following condition is derived.

**Condition 1.** Firm value increases as sustainment funding increases if the annual probability of financial distress is greater than the critical value, $\pi_c$, described by:

$$\pi_c = \left[ (1 - t_c) \sum_{h=1}^{H} \frac{1}{(1 + WACC)^{h}} \right] + \left[ \frac{H}{\sum_{h=1}^{H} \frac{(1 + \rho)^{j-1}}{(1 + WACC)^{h}} + (1 - t_c) \sum_{h=1}^{H} \frac{1}{(1 + WACC)^{h}}} \right]. \quad (12)$$

The critical value of the probability of financial distress, $\pi_c$, can be interpreted as a measure of the likelihood that an increase in sustainment funding, $\alpha$, will increase firm value. That is, as $\pi_c$ decreases, the likelihood that an increase in $\alpha$ will increase firm value will go up for any given valuation period.

The critical value of the probability of financial distress depends on the weighted average cost of capital, $WACC$, the degradation rate, $\rho$, and the valuation period, $H$. The three propositions below determine the response of the critical value of $\pi$ to changes in these three parameters.

**Proposition 1.** For a valuation period, $H > 1$, the response of the critical value of $\pi$ to a change in the degradation rate, $\rho$, is negative.

**Proposition 2.** For a valuation period, $H > 1$, the response of the critical value of $\pi$ to a change in the weighted average cost of capital, $WACC$, is positive.
Proposition 3. As the valuation period, $H$, becomes longer, the critical value of $\pi$ decreases.

The proofs of the three propositions can be found in Appendix A. Propositions 1 and 2 are consistent with the intuition that anything that reduces the liquidation value of the firm’s facilities will increase the critical value of $\pi$; and anything that increases the liquidation value of the firm’s facilities will decrease the critical value of $\pi$.

In the case of the degradation rate, the greater the degradation rate, the faster facilities degrade and the greater the potential gain if sustainment funding is increased. Hence the critical value of $\pi$ goes down as the degradation rate goes up.

In the case of the weighted average cost of capital, the greater the weighted average cost of capital, the more free cash flow and the liquidation value of the firm’s facility are discounted. At first glance, the impact of increasing the weighted average cost of capital is ambiguous. However, the liquidation value occurs when the firm experiences financial distress at the end of the valuation period and hence gets discounted the most. Proposition 2 confirms that this effect dominates and the critical value of $\pi$ goes up as the weighted average cost of capital increases.

Proposition 3 shows that it must be the case that as the valuation period becomes longer, the cumulative effect of the degradation process becomes greater and the critical value of $\pi$ decreases.

Case Study

The case study estimates the parameters of the finite valuation period model for a specific example: a major retail firm, Target Corporation. This firm was chosen because of the major retailers considered it was the only one that specifically stated its maintenance and repair costs in its annual reports. Data from the firm’s annual reports from 1993 through 2007, available on its website, is the basis for the analysis. Since the primary focus here is the firm’s facility sustainment funding, the analysis is simplified by assuming the firm’s property, plant, and equipment is represented by its retail stores. The loss of generality is minimized in this case since retail stores represent 95% of the firm’s facilities and 85% of the firm’s property, plant, and equipment.

This data is used to estimate the following parameters of the model:

- $TSF$ = Total square footage of the retail floor space;
- $\pi$ = Annual probability of financial distress;
- $\alpha$ = Historic level of sustainment funding of the firm as a percentage of requirements;
- $FCF$ = Free cash flow of the firm;
- $R_D$ = Cost of debt for the firm;
- $R_E$ = Cost of equity for the firm;
- $WACC$ = The firm’s weighted average cost of capital; and
- $t_c$ = The firm’s corporate tax rate.
Exhibit 1 | Case Study Parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Variable</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Square Feet (1,000 SF)</td>
<td>TSF</td>
<td>207,945</td>
</tr>
<tr>
<td>Probability of Financial Distress (%)</td>
<td>( \pi )</td>
<td>4.00</td>
</tr>
<tr>
<td>Sustainment Funding %</td>
<td>( \alpha )</td>
<td>51.70</td>
</tr>
<tr>
<td>Free Cash Flow ($million)</td>
<td>( FCF )</td>
<td>1,162.70</td>
</tr>
<tr>
<td>Cost of Debt (%)</td>
<td>( R_D )</td>
<td>5.55</td>
</tr>
<tr>
<td>Cost of Equity (%)</td>
<td>( R_E )</td>
<td>9.39</td>
</tr>
<tr>
<td>Weighted Average Cost of Capital (%)</td>
<td>( WACC )</td>
<td>7.64</td>
</tr>
<tr>
<td>Corporate Tax Rate (%)</td>
<td>( t_c )</td>
<td>37.80</td>
</tr>
</tbody>
</table>

Note: Parameters based on annual report data of Target Corporation for 1993–2007.

Exhibit 2 | Cost Factors and the Degradation Rate

<table>
<thead>
<tr>
<th>Cost Factor</th>
<th>Variable</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sustainment Cost Factor</td>
<td>( SCF )</td>
<td>$3.34/SF</td>
</tr>
<tr>
<td>New Construction</td>
<td>( NCF )</td>
<td>$92.21/SF</td>
</tr>
<tr>
<td>Degradation Rate</td>
<td>( \rho )</td>
<td>8.57%</td>
</tr>
</tbody>
</table>

Note: Cost factors and the degradation rate apply to retail stores for 2007, based on industry and DOD sources.

In addition to these parameters, standard cost factors and a degradation rate for retail stores are required. The cost factors for retail stores used here come from commercial and government sources. The degradation rate for retail stores comes from studies conducted by myself and others as cited above. For retail stores the following cost factors are required:

\[ SCF = \text{Sustainment cost factor per square foot}; \]
\[ NCF = \text{New construction cost factor per square foot}; \]
\[ \rho = \text{Degradation rate expressed as a percent}. \]

Estimating the annual probability of financial distress is central to the analysis and is explained in the following section. The procedure for estimating the other parameters is discussed in Appendix B.

The parameter values for the case study are summarized in Exhibit 1. The cost factors and degradation rate values are listed in Exhibit 2.
**Estimating the Probability of Financial Distress**

Assuming a constant probability of financial distress over time, the market price of the firm’s bonds can be used to estimate the probability of financial distress, \( \pi \). That is, by adjusting the coupon and principal payments by the annual probability of financial distress, the bond price can be expressed in terms of certainty equivalent cash flows and discounted with the risk-free interest rate. Given bond prices for the firm’s outstanding debt, this means the probability of financial distress can be estimated using the following equation:

\[
Bond \ Price = \sum_{t=1}^{N} \frac{coupon \cdot (1 - \pi)^t}{(1 - r_f)^t} + \frac{facevalue \cdot (1 - \pi)^N}{(1 + r_f)^N}, \quad (13)
\]

where \( \pi \) represents the probability of financial distress and \( r_f \) is an appropriate risk-free interest rate.

Using the firm’s 10-year-to-maturity bonds, the above equation was solved for each bond issue and a weighted average computed for the value of the probability of financial distress. This method yields an estimated value for \( \pi \) of 4.0%.

---

**Firm Value in the Finite Valuation Period Model**

**Testing Condition One**

Using the values of \( \pi \), \( \rho \), and WACC estimated for the case study, Condition 1 is tested. Critical values of \( \pi \) are calculated for 5-, 10-, 15-, 20-, 25-, and 30-year valuation periods. Consistent with Proposition 3, the longer the valuation period, the smaller the critical value required for an increase in sustainment funding to increase firm value. It is clear from Exhibit 3 that between years 20 and 25, the firm’s probability of financial distress of 4% will exceed the critical value and firm value will increase as sustainment funding increases.

Exhibit 3 also displays the critical values when the weighted average cost of capital is increased by 25% over the base case. Given Proposition 2, we would expect the critical value of \( \pi \) to go up relative to the case study. The last column displays the critical value when the degradation rate is increased by 25% over the case study. Given Proposition 1, we would expect the critical value of \( \pi \) to go down relative to the case study.

**Comparing Firm Value: Historical Funding and 100% Funding**

Using the model expressed in Equation 9, firm value is calculated for valuation periods of 5, 10, 15, 20, 25, and 30 years for the case where sustainment is funded at 51.7% (the firm’s historical rate) and 100%. The percentage change in firm value is calculated in the last column. These results are displayed in Exhibit 4.
Facility Sustainment and Firm Value

**Exhibit 3** | Comparison of the Critical Values of $\pi$ for Various Valuation Periods

<table>
<thead>
<tr>
<th>Valuation Period</th>
<th>Critical $\pi$ (Base Case)</th>
<th>Critical $\pi$ (WACC = 9.55%)</th>
<th>Critical $\pi$ ($\rho = 10.71%$)</th>
</tr>
</thead>
<tbody>
<tr>
<td>5 Years</td>
<td>16.3%</td>
<td>16.5%</td>
<td>16.0%</td>
</tr>
<tr>
<td>10 Years</td>
<td>8.9%</td>
<td>9.2%</td>
<td>8.5%</td>
</tr>
<tr>
<td>15 Years</td>
<td>5.9%</td>
<td>6.2%</td>
<td>5.4%</td>
</tr>
<tr>
<td>20 Years</td>
<td>4.2%</td>
<td>4.6%</td>
<td>3.8%</td>
</tr>
<tr>
<td>25 Years</td>
<td>3.2%</td>
<td>3.6%</td>
<td>2.8%</td>
</tr>
<tr>
<td>30 Years</td>
<td>2.5%</td>
<td>3.0%</td>
<td>2.1%</td>
</tr>
</tbody>
</table>

Notes: The table compares the critical values of $\pi$ for valuation periods of 5, 10, 15, 20, 25, and 30 years to the base case: probability of financial distress ($\pi$) = 4.0%; weighted average cost of capital (WACC) = 7.64%; and degradation rate ($\rho$) = 8.57%.

**Exhibit 4** | Firm Value based on the Case Study Parameters and Cost Factors with a 4% Annual Probability of Financial Distress

<table>
<thead>
<tr>
<th>Valuation Period</th>
<th>Critical $\pi$ (%)</th>
<th>Firm Value at 51.7%</th>
<th>Firm Value at 100%</th>
<th>% Change</th>
</tr>
</thead>
<tbody>
<tr>
<td>5 Years</td>
<td>16.3%</td>
<td>7,418.660</td>
<td>6,783.498</td>
<td>-8.57%</td>
</tr>
<tr>
<td>10 Years</td>
<td>8.9%</td>
<td>12,269.947</td>
<td>11,477.954</td>
<td>-6.45%</td>
</tr>
<tr>
<td>15 Years</td>
<td>5.9%</td>
<td>15,332.082</td>
<td>14,726.708</td>
<td>-3.95%</td>
</tr>
<tr>
<td>20 Years</td>
<td>4.2%</td>
<td>17,143.079</td>
<td>16,974.978</td>
<td>-0.98%</td>
</tr>
<tr>
<td>25 Years</td>
<td>3.2%</td>
<td>18,074.694</td>
<td>18,530.871</td>
<td>2.52%</td>
</tr>
<tr>
<td>30 Years</td>
<td>2.5%</td>
<td>18,383.604</td>
<td>19,607.613</td>
<td>6.66%</td>
</tr>
</tbody>
</table>

Notes: Firm value based on the case study parameters and cost factors with the annual probability of financial distress, $\pi$, equal to 4.0%. The results are for 5-, 10-, 15-, 20-, 25-, and 30-year valuation periods. Firm value is in millions of dollars.

In Exhibit 5, the parameters are the same as in the case study except the probability of financial distress is assumed to be 5% instead of 4%. This exhibit illustrates that for a higher probability of financial distress, it takes a shorter valuation period before an increase in sustainment funding will increase firm value.

**Monte Carlo Simulation**

As an alternative approach, a Monte Carlo simulation is developed to calculate the impact of a change in sustainment funding on firm value. The simulation is


**Exhibit 5 | Firm Value based on the Case Study Parameters and Cost Factors with a 5% Annual Probability of Financial Distress**

<table>
<thead>
<tr>
<th>Valuation Period</th>
<th>Critical $\pi$</th>
<th>Firm Value at 51.7%</th>
<th>Firm Value at 100%</th>
<th>% Change</th>
</tr>
</thead>
<tbody>
<tr>
<td>5 Years</td>
<td>16.3%</td>
<td>8,101.648</td>
<td>7,517.964</td>
<td>-7.20%</td>
</tr>
<tr>
<td>10 Years</td>
<td>8.9%</td>
<td>13,354.909</td>
<td>12,720.699</td>
<td>-4.75%</td>
</tr>
<tr>
<td>15 Years</td>
<td>5.9%</td>
<td>16,621.439</td>
<td>16,321.203</td>
<td>-1.81%</td>
</tr>
<tr>
<td>20 Years</td>
<td>4.2%</td>
<td>18,496.853</td>
<td>18,812.898</td>
<td>1.71%</td>
</tr>
<tr>
<td>25 Years</td>
<td>3.2%</td>
<td>19,392.631</td>
<td>20,537.252</td>
<td>5.90%</td>
</tr>
<tr>
<td>30 Years</td>
<td>2.5%</td>
<td>19,592.788</td>
<td>21,730.575</td>
<td>10.91%</td>
</tr>
</tbody>
</table>

Notes: Firm value based on the case study parameters and cost factors with the annual probability of financial distress, $\pi$, equal to 5.0%. The results are for 5-, 10-, 15-, 20-, 25-, and 30-year valuation periods. Firm value is in millions of dollars.

Based on the probability of financial distress. Random numbers are generated based on this probability and used to determine a given realization. Using the Monte Carlo simulation, realizations in which the financial distress occurs in the first year can be considered with realizations in which financial distress occurs in a distant future year. The average of firm value for all of the realizations can then be used to estimate firm value.

Using the parameters estimated above for the case study, the Monte Carlo simulation is run for the following: (1) sustainment funded at the firm’s historical rate of 51.7% of requirements; and (2) sustainment funded at 100% of requirements.

The Monte Carlo simulations yield the following results. At 51.7% sustainment, firm value is calculated as $14,348.517 million. At 100% sustainment, firm value is calculated as $14,460.825 million. Firm value increases by 0.78% if sustainment is funded at 100%, which supports the hypothesis that fully funding sustainment can increase firm value.

**Sensitivity Analysis**

To test the robustness of this result, sensitivity analysis is performed by changing the values of the annual probability of financial distress, $\pi$; the firm’s weighted average cost of capital, WACC; and the degradation rate, $\rho$.

The results of the sensitivity analysis are displayed in Exhibit 6. Changes in the parameters WACC, $\pi$, and $\rho$ are calculated. Each parameter is increased by 25% and then decreased by 25%. The sensitivity analysis indicates that firm value goes up for an increase in $\pi$ or $\rho$, and for a decrease in WACC. Firm value decreases for a decrease in $\pi$ or $\rho$, and for an increase in WACC.
Exhibit 6 | Monte Carlo Simulation Sensitivity

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Parameter Value</th>
<th>Firm Value at 51.7%</th>
<th>Firm Value at 100%</th>
<th>% Change</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\pi^+$</td>
<td>5.00%</td>
<td>$14,412,740</td>
<td>$14,765,400</td>
<td>2.44%</td>
</tr>
<tr>
<td>$\pi^-$</td>
<td>3.00%</td>
<td>$14,351,300</td>
<td>$14,104,720</td>
<td>-1.72%</td>
</tr>
<tr>
<td>$\rho^+$</td>
<td>10.71%</td>
<td>$14,183,760</td>
<td>$14,460,825</td>
<td>1.95%</td>
</tr>
<tr>
<td>$\rho^-$</td>
<td>6.43%</td>
<td>$14,525,876</td>
<td>$14,457,311</td>
<td>-0.48%</td>
</tr>
<tr>
<td>WACC$^+$</td>
<td>9.55%</td>
<td>$12,548,714</td>
<td>$12,418,367</td>
<td>-1.04%</td>
</tr>
<tr>
<td>WACC$^-$</td>
<td>5.73%</td>
<td>$16,762,781</td>
<td>$17,294,136</td>
<td>3.17%</td>
</tr>
</tbody>
</table>

Notes: Sensitivity of the Monte Carlo simulation to changes in the probability of financial distress ($\pi$), the degradation rate ($\rho$), and weighted average cost of capital (WACC). Increasing $\pi$ and $\rho$, or decreasing WACC results in an increase in firm value. Decreasing $\pi$ and $\rho$, or increasing WACC results in a decrease in firm value. Firm value is in millions of dollars.

These results are consistent with Propositions 1 and 2 above. Recall that Proposition 1 states that as the degradation rate increases, the critical value of $\pi$ decreases. This means for any given probability of financial distress, it is more likely that an increase in sustainment funding will result in an increase in firm value. Proposition 2 says that as the weighted average cost of capital increases, the critical value of $\pi$ increases. For any given probability of financial distress, it is less likely that an increase in sustainment funding will result in an increase in firm value.

Conclusion

This paper represents the initial effort to relate the literature on sustainment funding and facility degradation to firm value. It argues that the level of facility sustainment can be a significant factor in determining firm value for the major retailer considered in the case study. Higher levels of sustainment funding reduce the list of maintenance and repair projects and maintain the value of the firm’s facilities. Through the degradation process and the effect of the degradation rate, funding at lower levels of sustainment increases the rate of deterioration and accelerates the decrease in the liquidation value of its assets.

The analysis supports the conclusion that, at least for some firms, an increase in sustainment funding can result in an increase in firm value. In the finite valuation period model and the Monte Carlo simulation this is shown to be the true for the major retailer in the case study. Based on the Monte Carlo simulation, gain in firm value from fully funding sustainment in the case study is modest at 0.78%. This is due primarily to the low probability of financial distress of 4%. However, the Monte Carlo sensitivity analysis shows that at a slightly higher probability of
financial distress of 5%, the gain is more substantial at 2.44%. For firms facing more serious financial problems, the probability of financial distress could be much higher. Using the same method represented by Equation 13, Damodaran (2006) estimated that shortly before its bankruptcy proceedings, Global Crossing’s probability of financial distress was 13.53%.

Whether these results hold for another firm depends on the firm’s weighted average cost of capital, the firm’s annual probability of financial distress, and the degradation rates required for the firm’s facilities. If other major retailers have the same capital structure as the firm in the case study, it is quite likely that the results of this paper also apply.

The increase in firm value here is due to the increase in the liquidation value of the firm’s retail stores. The additional maintenance and repair expense of funding sustainment at 100% has been taken into account, but other factors that could have a positive impact on free cash flow and the going-concern value of the firm have not. For example, better maintained stores could have a positive impact on employee morale and productivity, as well as customer satisfaction. Both of these factors would increase firm value even more when sustainment is funded at 100%.

It is interesting to consider these results from the perspective of the firm’s stakeholders. The increase in firm value comes about from preserving the liquidation value of the firm’s assets. Because of the additional maintenance and repair expenses incurred, the cost of this is a reduction in the ongoing operations value of the firm since its free cash flow is reduced. For this reason, CEOs and shareholders may find fully funding sustainment is undesirable. Indeed, Graham, Harvey, and Rajgopal’s (2005) survey found that 78% of CEOs would sacrifice long-term value for short-term earnings gains. However, since it preserves the liquidation value of the firm’s assets, debt holders could find fully funding sustainment to be in their best interest. Since typically it is upper management and shareholders that have the final say as to the level of sustainment funding, this suggests that it is in the interest of the firm’s debt holders to include covenants regarding the level of sustainment funding when the corporation issues debt.

These results occur despite the fact that issues of pollution, health threats, and other adverse externalities that might occur from underfunding facility sustainment have not been taken into consideration.

Within the context of facility sustainment, this paper illustrates a potentially fruitful approach to considering issues related to green facilities and sustainability. By looking beyond free cash flow, it is clear that many firm decisions that have environmental or social consequences also impact the financial value of the firm. When these effects can be quantified, a clearer financial picture emerges as to their true benefits and costs.

Appendix A
Proofs of Propositions

Proposition 1. For a valuation period, \( H > 1 \), the response of the critical value of \( \pi \) to a change in the degradation rate, \( \rho \), is negative. That is:
\[ \frac{\partial \pi_c}{\partial \rho} = \left\{ \begin{array}{l} - \left[ (1 - t_c) \sum_{h=1}^{H} \frac{1}{(1 + \text{WACC})^h} \right] \\
(1 - t_c) \sum_{h=1}^{H} \frac{(j - 1)(1 + \rho)^{j-2}}{(1 + \text{WACC})^h} \end{array} \right\} \\
\div \left\{ \sum_{j=1}^{H} (1 + \rho)^{j-1} \left( \frac{1}{(1 + \text{WACC})^h} + (1 - t_c) \frac{1}{(1 + \text{WACC})^h} \right) \right\}^2 < 0. \] 

(A1)

**Proof**

From Equation 12:

\[ \frac{\partial \pi_c}{\partial \rho} = \left\{ \begin{array}{l} - \left[ (1 - t_c) \sum_{h=1}^{H} \frac{1}{(1 + \text{WACC})^h} \right] \\
(1 - t_c) \sum_{h=1}^{H} \frac{(j - 1)(1 + \rho)^{j-2}}{(1 + \text{WACC})^h} \end{array} \right\} \\
\div \left\{ \sum_{j=1}^{H} (1 + \rho)^{j-1} \left( \frac{1}{(1 + \text{WACC})^h} + (1 - t_c) \frac{1}{(1 + \text{WACC})^h} \right) \right\}^2. \] (A2)

First, note that since there are no negative terms in the denominator, it must be positive. By inspection, if \( H = 1 \), the numerator equals zero. For \( H > 1 \), both of the numerator terms in brackets are positive, and, since these are multiplied by \(-1\), the numerator must be negative.

**Proposition 2.** For a valuation period, \( H > 1 \), the response of the critical value of \( \pi \) to a change in the weighted average cost of capital, \( \text{WACC} \), is positive. That is:
\[
\frac{\partial \pi_c}{\partial \text{WACC}} = \left\{ \left[ \sum_{h=1}^{H} \frac{1}{(1 + \text{WACC})^h} \right] \right. \\
\left. + (1 - t_c) \sum_{j=1}^{h} \frac{(-h)}{(1 + \text{WACC})^{h+1}} \right\} \\
\div \left\{ \sum_{h=1}^{H} \frac{1}{(1 + \text{WACC})^h} + (1 - t_c) \sum_{h=1}^{H} \frac{1}{(1 + \text{WACC})^h} \right\}^2 > 0. \quad \text{(A3)}
\]

**Proof**

From Equation 12, and simplifying:

\[
\frac{\partial \pi_c}{\partial \text{WACC}} = \left\{ \left[ \sum_{h=1}^{H} \frac{1}{(1 + \text{WACC})^h} \right] \right. \\
\left. + (1 - t_c) \sum_{h=1}^{H} \frac{1}{(1 + \text{WACC})^h} \right\} \\
\div \left\{ \sum_{h=1}^{H} \frac{1}{(1 + \text{WACC})^h} + (1 - t_c) \sum_{h=1}^{H} \frac{1}{(1 + \text{WACC})^h} \right\}^2 \cdot \frac{1}{(1 - t_c)} \right\}. \quad \text{(A4)}
\]
To simplify the notation let:

$$Z_h = \sum_{j=1}^{h} (1 + \rho)^{j-1}. \quad (A5)$$

Equation A5 has the property that if $k > h$, then $Z_k > Z_h$.

First, note that since there are no negative terms in the denominator, it must be positive. Thus, if the numerator is positive, then Proposition 2 must hold. That is, if:

$$- \left[ \sum_{h=1}^{H} \frac{Z_h}{(1 + \text{WACC})^h} \right] \left[ \sum_{h=1}^{H} \frac{h}{(1 + \text{WACC})^h} \right] + \left[ \sum_{h=1}^{H} \frac{hZ_h}{(1 + \text{WACC})^{h+1}} \right] \left[ \sum_{h=1}^{H} \frac{1}{(1 + \text{WACC})^h} \right] > 0. \quad (A6)$$

The proof is by induction. Letting $H = 2$ in Equation A6, we get the following terms:

$$- \left[ \frac{Z_1}{(1 + \text{WACC})^3} + \frac{Z_2}{(1 + \text{WACC})^4} + \frac{2Z_1}{(1 + \text{WACC})^4} \right. + \left. \frac{2Z_2}{(1 + \text{WACC})^5} \right]$$

$$+ \left[ \frac{Z_1}{(1 + \text{WACC})^3} + \frac{2Z_2}{(1 + \text{WACC})^4} + \frac{Z_1}{(1 + \text{WACC})^4} \right. + \left. \frac{2Z_2}{(1 + \text{WACC})^5} \right] = - \frac{Z_2 + 2Z_1}{(1 + \text{WACC})^4} + \frac{2Z_2 + Z_1}{(1 + \text{WACC})^5}. \quad (A7)$$

Since $Z_2 > Z_1$; Equation A6 must hold for $H = 2$.

Assume true for $H = N$ and prove that the additional terms generated for $H = N + 1$ are zero or positive.

Expanding Equation A6 for the additional terms generated for $H = N + 1$: 
The denominators for the terms in Equation A8 have exponents from $N + 3$ to $2N + 3$. That is,

$$
\frac{1}{(1 + WACC)^{N+j}}, \quad (A9)
$$

where $3 \leq j \leq N + 3$.

Numerator for the negative terms can be shown to be of the form:

$$(j - 2)Z_{N+1} + (N + 1)Z_{j-2}. \quad (A10)$$

Numerator for the positive terms can be shown to be of the form:

$$(j - 2)Z_{j-2} + (N + 1)Z_{N+1}. \quad (A11)$$

Since for $k > h$, $Z_k > Z_h$, it can be shown that for each $j$:

$$(j - 2)Z_{j-2} + (N + 1)Z_{N+1} > (j - 2)Z_{N+1} + (N + 1)Z_{j-2}. \quad (A12)$$

This means that for each term the positive numerators are greater than the negative numerators. The exceptions is when $j = N + 3$, in which case the positive numerator equals the negative numerator. Hence, the inequality in Equation A6 holds and the proposition is true.

**Proposition 3.** As the valuation period, $H$, becomes longer, the critical value of $\pi$ decreases. That is:
\[ \frac{\Delta \pi_c}{\Delta H} = \left\{ (1 - t_c) \sum_{h=1}^{N+1} \frac{1}{(1 + WACC)^h} \right\} \]
\[ \quad \div \left\{ \sum_{h=1}^{N+1} \frac{Z_h}{(1 + WACC)^h} + (1 - t_c) \sum_{h=1}^{N+1} \frac{1}{(1 + WACC)^h} \right\} \]
\[ \quad - \left\{ (1 - t_c) \sum_{h=1}^{N} \frac{1}{(1 + WACC)^h} \right\} \]
\[ \quad \div \left\{ \sum_{h=1}^{N} \frac{Z_h}{(1 + WACC)^h} + (1 - t_c) \sum_{h=1}^{N} \frac{1}{(1 + WACC)^h} \right\} \leq 0. \] (A13)

**Proof**

It is assumed that \( H \) is a discrete variable. It is shown that the critical value of \( \pi \) for \( H = N + 1 \) is less than the critical value for \( H = N \). From Equation 12:

\[ \frac{\Delta \pi_c}{\Delta H} = \left\{ (1 - t_c) \sum_{h=1}^{N+1} \frac{1}{(1 + WACC)^h} \right\} \]
\[ \quad \div \left\{ \sum_{h=1}^{N+1} \frac{Z_h}{(1 + WACC)^h} + (1 - t_c) \sum_{h=1}^{N+1} \frac{1}{(1 + WACC)^h} \right\} \]
\[ \quad - \left\{ (1 - t_c) \sum_{h=1}^{N} \frac{1}{(1 + WACC)^h} \right\} \]
\[ \quad \div \left\{ \sum_{h=1}^{N} \frac{Z_h}{(1 + WACC)^h} + (1 - t_c) \sum_{h=1}^{N} \frac{1}{(1 + WACC)^h} \right\}. \] (A14)

To simplify notation, let \( D_{N+1} \) represent the divisor of the first term in brackets and let \( D_N \) represent the divisor of the second term in brackets. Also, as above, let:

\[ Z_h = \sum_{j=1}^{h} (1 + \rho)^{j-1}, \] (A15)
and note that $Z_{h+1} > Z_{h}$.

Given this notation and finding a common denominator, the following expression is derived.

$$\frac{\Delta \pi_c}{\Delta H} = \left\{ \left[ (1 - t_c) \sum_{h=1}^{N+1} \frac{1}{(1 + WACC)^h} \right] \left[ \sum_{h=1}^{N} \frac{Z_h}{(1 + WACC)^h} + (1 - t_c) \sum_{h=1}^{N} \frac{1}{(1 + WACC)^h} \right] - \left[ (1 - t_c) \sum_{h=1}^{N} \frac{1}{(1 + WACC)^h} \right] \left[ \sum_{h=1}^{N+1} \frac{Z_h}{(1 + WACC)^h} + (1 - t_c) \sum_{h=1}^{N+1} \frac{1}{(1 + WACC)^h} \right] \right\} \div \{D_{N+1}, D_N\}.$$  \hspace{1cm} (A16)

This simplifies to:

$$\frac{\Delta \pi_c}{\Delta H} = \left\{ \left[ (1 - t_c) \sum_{h=1}^{N-1} \frac{1}{(1 + WACC)^h} \right] \left[ \sum_{h=1}^{N} \frac{Z_h}{(1 + WACC)^h} \right] - \left[ (1 - t_c) \sum_{h=1}^{N} \frac{1}{(1 + WACC)^h} \right] \left[ \sum_{h=1}^{N+1} \frac{Z_h}{(1 + WACC)^h} \right] \right\} \div \{D_{N+1}, D_N\}. \hspace{1cm} (A17)$$

This can also be expressed as:

$$\frac{\Delta \pi_c}{\Delta H} = \left\{ \left[ (1 - t_c) \sum_{h=1}^{N} \frac{1}{(1 + WACC)^h} + (1 - t_c) \frac{1}{(1 + WACC)^{N+1}} \right] \left[ \sum_{h=1}^{N} \frac{Z_h}{(1 + WACC)^h} \right] - \left[ (1 - t_c) \sum_{h=1}^{N} \frac{1}{(1 + WACC)^h} \right] \left[ \sum_{h=1}^{N+1} \frac{Z_h}{(1 + WACC)^h} \right] \right\} \div \{D_{N+1}, D_N\}. \hspace{1cm} (A18)$$

This further simplifies to:
Facility Sustainment and Firm Value

\[
\frac{\Delta \pi_c}{\Delta H} = \left\{ \frac{1}{(1 + WACC)^t} \left[ \sum_{h=1}^{N} \frac{Z_h}{(1 + WACC)^h} \right] \right\} \\
- \left\{ \frac{1}{(1 + WACC)^{N+1}} \left[ \sum_{h=1}^{N} \frac{Z_{N+1}}{(1 + WACC)^h} \right] \right\} \\
\div \{ D_{N+1} \cdot D_N \} < 0. 
\] (A19)

Since \( Z_{N+1} \) is greater than any \( Z_h \), Proposition 3 must hold.

Appendix B

Parameter Estimates

Total Square Footage: The total square footage of the firm’s retail stores is based on the total square footage reported in the 2007 annual report. In 2007, total square footage (in thousands of square feet) was 207,945.

Sustainment Requirement: The sustainment requirement represents the amount that should be funded, based on industry standards, to maintain facilities in good working condition. It is the product of total square footage and the sustainment cost factor. That is:

\[
S_t = 207,495 \text{ SF} \cdot \$3.25/\text{SF} = $675.821 \text{ million}, \quad (B1)
\]

where SF is in thousands of square feet.

Sustainment Funding: Sustainment funding is based on the firm’s expenditures for maintenance and repair of property, plant, and equipment. This type of information is not necessarily reported in a firm’s annual report. However, for the firm in the case study, maintenance and repair expenditures were reported for 2003–2007. Since 85% of property, plant, and equipment is retail stores, 85% of the maintenance and repair expenditure was applied to the retail stores. The average historical funding percentage was calculated based on the sustainment requirements for each of these years. The calculated historical funding is 51.7%.

Free Cash Flow: Free cash flow is estimated using the following equation:

\[
FCF = ebit \cdot (1 - t_c) + dep - (capex + \Delta nwc), \quad (B2)
\]

where \( ebit \) is earnings before interest and taxes, \( t_c \) is the corporate tax rate, \( capex \) is the yearly capital expenditures, \( dep \) is the current year depreciation, and \( \Delta nwc \) is the yearly change in net working capital.
Free cash flow was computed by averaging the above variables from the annual returns for 2003–2006. This was calculated as:

\[
\begin{align*}
FCF &= 4560 \cdot (1.0 - 0.378) + 1,519 \\
&\quad - (3,702 - 509) = 1,162,
\end{align*}
\]

where all dollar amounts are in millions.

**Weighted Average Cost of Capital (WACC):** $WACC$ is based on the weighted average of the cost of debt and the cost of equity. For the cost of debt, $R_D$, the average yield to maturity of the firm’s 10-year bonds is used. This is calculated as $R_D = 5.55\%$. For the cost of equity, $R_E$, the CAPM model is used. Using the interest for the 10-year Treasury bond, $r_f = 4.02\%$; beta = 0.70 (as reported on the Internet for 2007); $E(R_m) = 11.69\%$ (based on the S&P 500 returns for 1928–2007). This is calculated as $R_E = 9.39\%$. Debt and equity weights are in millions of dollars. Debt is based on the firm’s 2007 annual report and equity is based on the 2007 market capitalization. $WACC$ is calculated as:

\[
\begin{align*}
WACC &= \frac{17,090}{58,027} (5.55\%)(1 - .378) \\
&\quad + \frac{40,937}{58,027} (9.39\%) = 7.64\%,
\end{align*}
\]

where all dollar amounts are in millions.

**Endnotes**

1. I abstract from other costs of financial distress to focus on the impact of sustainment funding. The assumption here is these costs are the same for any given level of sustainment funding.

2. The argument against fire sales is along two lines: (1) they mostly occur when an industry or the overall economy is experiencing a downturn, or (2) when the assets are specialized and industry specific. Acharya, Bharath, and Srinivasan (2007) support the first argument and find no correlation in the second.


**References**


The author expresses gratitude to Richard Gregory, William Trainor, and the faculty of the Economics and Finance Department at East Tennessee State University, Johnson City, Tennessee, for seminar discussions that gave shape and direction to this research.

Robert Beach, East Tennessee State University, Johnson City, TN 37614 or beachr@etsu.edu.
The Cost of LEED—An Analysis of the Construction Costs of LEED and Non-LEED Banks

Authors
Chad Mapp, MaryEllen C. Nobe, and Brian Dunbar

Abstract
This study is an analysis of the initial building costs for two Leadership in Energy and Environmental Design (LEED) banks and eight non-LEED banks with similar building types and sizes located in western Colorado. The purpose of this study was to compare the costs of these banks, and to assess costs directly associated with LEED certification. The analysis examines total building costs, square footage costs, soft costs, and hard costs per MasterFormat Division. The study finds that the building costs of the LEED banks are similar to and within the same ranges as non-LEED banks. Additionally, the direct cost associated with seeking LEED certification is estimated to be below 2% of the total project cost.

Many in the building industry perceive green and/or Leadership in Energy and Environmental Design (LEED) certified buildings to be much more expensive than conventional buildings (Building Design & Construction [BD&C], 2003; McGraw-Hill Construction, 2005; Turner Construction, 2005). This perception has been the single largest obstacle to greater mainstream acceptance of green building design (Kats, 2003), as evidenced in studies citing cost as the number one barrier facing green building (BD&C, 2003; McGraw-Hill Construction, 2005; Turner Construction, 2005; Galuppo and Tu, 2010).

For example, the readers of BD&C revealed their perceptions in a 2003 survey: 44% said sustainable design was viewed as adding significantly to first costs, while 42% felt the market was not interested or not willing to pay a premium for sustainability. Thirty-five percent felt sustainable design was hard to justify, even on the basis of long-term savings.

According to Turner Construction’s 2005 Green Building “Market Barometer” survey, 75% of executives at organizations involved with green buildings felt green construction costs were higher than for traditional buildings (Turner Construction, 2005, p. 16). Further, those same executives estimated green construction costs to be 13% higher than traditional construction costs, while executives without green building experience estimated the costs to be 18% higher (Turner Construction, 2005, p. 16). Additionally, the survey respondents of McGraw-Hill Construction’s 2006 Green Building SmartMarket Report indicated “higher first costs” as the most serious obstacle to green building (McGraw-Hill Construction, 2005).

In a similar study conducted by Galuppo and Tu (2010) of NAIOP and PREA members, the vast majority of survey respondents believed the cost of energy-
efficient building to be higher than a traditional building with comparable features. A number of respondents (21%) estimated additional costs to be more than 10%. This study also found that over 90% of lenders, equity investors, and developers believed energy-efficient buildings cost more. Forty percent of the lenders believed that energy-efficient buildings cost in excess of 10% more than conventional construction.

According to these surveys, significantly higher construction costs are a common perception associated with green buildings and LEED certification and one that has persisted over time. Evidence from previous studies and reports, however, identifying the actual costs associated with LEED certification demonstrate that construction costs for LEED buildings are far below the perceptions reported by many in the industry.

Previous Studies

The U.S. General Services Administration (GSA) was the first to address the cost of LEED certification and commissioned a study to identify the costs associated with the pilot phase of LEED v1.0. The 2002 study concluded that a 2.5% to 7% construction cost premium was necessary for federal buildings to achieve the various levels of certification if the standard GSA design guidelines were met (BD&C, 2003, p. 29). More specifically, the study found that: (1) a LEED v1.0 certification would add “little or no increase in project costs”; (2) a federal building in Oklahoma City would require a 2% premium to reach LEED v1.0 Silver; (3) a LEED v1.0 Gold certification for a federal courthouse in Denver would have added 7% to the construction costs; and (4) other typical federal projects could reach LEED v1.0 Silver with about a 2.5% premium.

Later, in response to updated LEED requirements, the GSA (2004) commissioned another study to estimate costs to develop LEED certified federal facilities in compliance with the more stringent LEED version 2.1. For the construction of a 262,000-square-foot new federal courthouse, the GSA LEED Cost Study estimated that achieving a LEED Certified/Silver rating decreased cost by 0.4%–4.4%, a savings of $0.75 to $10 per square foot (GSA, 2004). A Gold rating for a new courthouse was estimated to add 1.4%–8.1% to the construction costs or $3–$18 per square foot (GSA, 2004). The study found that the overall cost premium was surprisingly limited when GSA projects made use of “no cost” or “low cost” credit opportunities. Under some cost scenarios, project costs actually decreased (GSA, 2004). The conclusion of the report was that LEED certification could be achieved within a standard GSA project budget without a green building allowance (GSA, 2004).

The most definitive LEED construction cost analysis to be conducted early in the application of LEED design and construction standards was conducted by Kats et al. (2003). In order to determine the cost of building green compared to conventional design, the costs of 33 green buildings from across the United States were compared to conventional designs for those same buildings. The analysis reported an average premium for green buildings of about 2%, or $3 to $5 per
square foot (Kats et al., 2003, p. 15). The study found to achieve the basic level of LEED certification increased costs less than 1% while achieving Silver certification resulted in a premium of just over 2%. To achieve the highest certification level of Platinum resulted in a premium of 6% (Kats et al., 2003, p. 15). The majority of increased costs were due to increased architectural and engineering design time, modeling costs and time necessary to integrate sustainable building practices into projects (Kats, 2003).

Matthiessen and Morris (2004) examined the cost of LEED from multiple perspectives in a study funded by Davis Langdon, a global construction consulting company. First, the study assessed the cost of incorporating individual sustainable elements. Second, the study compared the total construction costs of 138 buildings: 45 LEED seeking and 93 non-LEED buildings. Third, the final cost of LEED buildings were compared to their original budgets. Consistent with the previous studies, this report found that most projects achieved LEED certification for 0 to 3% over the initial budget (Matthiessen and Morris, 2004). Over half the projects had original budgets set without regard to sustainable design and received no additional funding to achieve their sustainable goals and LEED certification. Of those that did receive additional funding, the range was 0–3% of the initial budget and usually only for specific enhancements, such as photovoltaic systems (Matthiessen and Morris, 2004).

In addition, the data suggested that the cost per square foot for buildings seeking LEED certification was within the range of costs for similar non-LEED seeking buildings without sustainable features (Matthiessen and Morris, 2004). No statistically significant difference was found between the costs of LEED certified buildings compared to non-LEED certified buildings. Matthiessen and Morris (2004) concluded that many construction projects can achieve sustainable design and LEED certification within their budget or with very little additional funding.

More recently, Davis Langdon (2007) expanded upon this study as to provide a wider look at the cost of green by examining a larger sample of projects and additional building types. The authors state that the more recent study reveals essentially the same results as the 2004 study. “There is no significant difference in average costs for green buildings as compared to non-green buildings,” (Davis Langdon, 2007, p. 3). They concluded that many projects achieve LEED certification within their budgets and in the same cost range as non-LEED projects.

Contrary to current perceptions related to costs premium (Galuppo and Tu, 2010), these studies demonstrated that many new construction projects are achieving LEED certification within the same cost range as non-LEED buildings or with only slightly higher costs. What is missing from these studies is the inclusion of bank building. The GSA study focused on building types typically owned by the government and the two studies funded by Davis Langdon focused on academic buildings, laboratories, community centers, and ambulatory care facilities. It is interesting that lenders tend to have the most pessimistic view of green construction costs, while at the same time the buildings they work in have not been included in studies addressing the issue of cost associated with increased energy efficiency and/or LEED certification. Some evidence does suggest that the
results from the studies reviewed here do apply to banks. Gary Saulson, Director of Corporate Real Estate for PNC Financial Services Group, says that “each new 3,650-square-foot LEED certified branch costs from $1.3 to $1.4 million—$150,000 less than the competition is building non-green banks for while using 40%–50% less energy than a typical branch” (McGraw-Hill Construction, 2005, p. 38). While this is significant, more evidence of both the costs associated with green banks and the benefits are needed.

**Research Questions**

Due to the discrepancy between the premium perception associated with green buildings held by many in the building and lending community and the results of previous research on costs of LEED certified buildings, a need exists to further analyze the costs associated with LEED certification. The research question guiding this study is “Can LEED banks be designed and constructed for costs comparable to non-LEED banks?”

The following sub-questions will guide the data analysis:

1. How do total building costs (TBC) of LEED banks compare to costs of non-LEED banks?
2. How do the square foot costs of LEED banks compare to costs of non-LEED banks?
3. How do the soft costs of LEED banks compare to costs of non-LEED banks?
4. How much are the direct costs associated with LEED certification?

**Methodology**

A collective case study design was implemented to address the research questions to see if previously published findings on the costs associated with LEED certification hold true for banks. Collective case study research attempts to address an issue in question while adding to the literature that helps us better conceptualize a theory involves the selection and use of several instrumental cases (Hancock and Algozzine, 2006). To this end, Stake (1995) points out that case study research is not sampling research and that selection of a case study should be guided by both the goal to maximize what can be learned and an ability to access needed information.

**Identification of Cases**

Cases included in this study were chosen from the historical cost data of Alpine Banks, who owns and operates 37 banks in the Western Slope area of Colorado. Two of the 37 banks have been designed and construction to meet LEED for New Construction (LEED NC) requirements. As an owner/developer of their own projects, it was important for Alpine Banks to better understand the costs associated with LEED certification as they move forward with the design and
construction of future projects. Because of their interests in the costs associated with LEED certification, they were willing to provide unhindered access to design and construction costs from past projects. Further, all of the cases selected are located in similar geographical locations, resulting in similar code/design requirements, eliminating many of the regional differences (e.g., wind and snow load requirements) in the designs.

After identifying the pool of possible cases for inclusion in this study, the next step was to identify those cases which would be included in the final analysis. This decision was based on the time of construction and whether a project was LEED certified or not. It was found that two of the 37 projects had been LEED certified. Projects built prior to 1997 were determined ineligible due to the lack of reliable cost data for these projects. The result was a group of ten bank locations for inclusion.

All ten cases in this study were constructed between 1997 and 2008 (Exhibit 1). Of these, one is LEED certified and another is certified as LEED Silver. The remaining eight did not seek LEED certification. The difference between the two groups is simply that two of the LEED certified banks were designed and constructed to achieve LEED certification, while LEED certification was not a goal for the eight other banks. Non-LEED buildings often qualify for 10–20 LEED points by nature of their design, location, and other factors (Matthiessen and Morris, 2004). All the cases included in the study have many similar features, regardless of whether or not LEED certification was sought. Since they are all owned by the same institution and were built over a relatively short timeframe, they were all designed according to the same fundamental design criteria of Alpine Banks. These features include high performance HVAC systems, durable high-end materials and finishes, industry-specific banking equipment, security system features, as well as drive-thru facilities with canopies and systems to convey documents. The ten banks are all relatively similar building types with sizes ranging from 2,730 to 5,122 gross square feet (Exhibit 2). The projects are broken into three categories based on size: small, medium, and large. Five projects are small, ranging from 2,730 SF to 3,078 SF, four projects are medium size, ranging from 4,240 SF to 4,455 SF, and one falls into the large category at 5,122 SF.

Data Collection Form

A data collection form was developed using Microsoft Excel software. The Excel workbook was used to organize the construction cost data associated with the cases. The first tab sheet was the Project Summary sheet, which categorized basic information about the bank facility and the associated project costs. The Project Summary sheet included both soft costs and hard costs for the 16 CSI Divisions for each bank. Cost data was tracked using the Construction Specification Institute’s (CSI) MasterFormat 1995 Divisions. A summary of the costs for all 16 CSI Divisions for each project is provided in the Appendix.

Following the Project Summary sheet, the workbook had a sheet dedicated to the soft costs (e.g., design, engineering, and consulting fees) for each project. Another
### Exhibit 1 | Impact of LEED Certification on Bank Construction Costs

<table>
<thead>
<tr>
<th>Location</th>
<th>Year</th>
<th>Building SF</th>
<th>Size Category</th>
<th>Total Project Cost&lt;sup&gt;a&lt;/sup&gt;</th>
<th>Total Building Cost&lt;sup&gt;b&lt;/sup&gt;</th>
<th>Soft Costs&lt;sup&gt;c&lt;/sup&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td>Breckenridge</td>
<td>2003</td>
<td>5,122</td>
<td>Large</td>
<td>$3,429,973</td>
<td>$3,197,193</td>
<td>$382,950</td>
</tr>
<tr>
<td>Clifton</td>
<td>2001</td>
<td>3,078</td>
<td>Small</td>
<td>$2,249,713</td>
<td>$2,032,186</td>
<td>$89,084</td>
</tr>
<tr>
<td>Delta</td>
<td>2008</td>
<td>4,240</td>
<td>Medium</td>
<td>$2,883,841</td>
<td>$2,537,911</td>
<td>$172,637</td>
</tr>
<tr>
<td>Frisco</td>
<td>2007</td>
<td>4,320</td>
<td>Medium</td>
<td>$2,865,928</td>
<td>$2,563,407</td>
<td>$139,184</td>
</tr>
<tr>
<td>Fruita</td>
<td>2007</td>
<td>4,320</td>
<td>Medium</td>
<td>$2,633,904</td>
<td>$2,432,851</td>
<td>$169,548</td>
</tr>
<tr>
<td>Horizon Drive</td>
<td>1997</td>
<td>2,809</td>
<td>Small</td>
<td>$2,086,952</td>
<td>$1,938,620</td>
<td>$161,082</td>
</tr>
<tr>
<td>Mesa Mall</td>
<td>1999</td>
<td>2,916</td>
<td>Small</td>
<td>$2,078,551</td>
<td>$1,950,518</td>
<td>$159,936</td>
</tr>
<tr>
<td>Montrose</td>
<td>2001</td>
<td>2,907</td>
<td>Small</td>
<td>$2,573,353</td>
<td>$2,336,207</td>
<td>$135,053</td>
</tr>
<tr>
<td>Ridgway (LEED Silver)</td>
<td>2008</td>
<td>4,455</td>
<td>Medium</td>
<td>$2,834,945</td>
<td>$2,568,978</td>
<td>$161,257</td>
</tr>
<tr>
<td>Rifle South (LEED Certified)</td>
<td>2007</td>
<td>2,730</td>
<td>Small</td>
<td>$2,343,577</td>
<td>$1,717,174</td>
<td>$161,657</td>
</tr>
</tbody>
</table>

Notes:

<sup>a</sup> Total project cost is the sum of all 16 CSI Divisions and does not include land costs. Total cost per CSI Division is provided in the Appendix.

<sup>b</sup> Total building cost equals total project cost less CSI Division 2: Site Work.

<sup>c</sup> Soft costs are fees related to the design, engineering and consulting associated with a project.
sheet was dedicated to each of the 16 CSI Divisions. Each tab sheet listed a general description of the work, the date procured, and the amount. The amount per CSI Division was totaled at the bottom of each tab sheet and reflected on the Project Summary page.

**Collection, Triangulation, and Normalizing of Data**

Cost information for the initial design and construction of all projects was collected and triangulated from a variety of sources. These included bank personnel (e.g., accounting representatives, bank presidents, and facilities management) and the projects’ architects and general contractors. Triangulation of the data between these various sources helped to ensure reliability and validity of the data. The accounting representatives generated expense reports for the design and construction for each bank from the bank’s Fixed Asset Software (FAS) system. The FAS reports were triangulated with bank president’s records, as well as invoices and pay applications from contractors, consultants, and material suppliers. All contractors used a form similar to the American Institute of Architects (AIA) G702 and G703 forms for application for payment. The form categorized the descriptions of work and related costs into the 16 CSI MasterFormat Divisions.

Before comparing construction costs for the ten projects, the costs of all projects were normalized for location and time using RSMeans’ Location Factors and Historical Cost Indexes. First, all project costs were normalized based on a national average using RSMeans Location Factors (RSMeans Company, c 1996–). The purpose of a location factor is to compare the cost of construction at a particular location to the national average (RSMeans Company, c 1996–). Location factors take into account the impact of building location on the costs of materials and installation. Next, costs were adjusted to 2011 using RSMeans
Historical Cost Index for 2011 for each location. The purpose of the Historical Cost Index is to convert building costs from the date of construction to the same point in time. The Historical Cost Index is based on nine different building types, 66 commonly-used construction materials, labor hours for six types of construction trades, and equipment rental for six types of equipment typically used in installation of the 66 materials tracked.

Results

After normalizing the data for time and location, costs was evaluated in the following ways:

1. The total building costs of LEED banks were compared to those of non-LEED banks.
2. The square footage costs of LEED banks were compared to those of non-LEED banks.
3. The architectural and engineering fees of LEED banks were compared to those of non-LEED banks.
4. The direct costs associated with LEED certification.

Total Building Cost and Costs/SF

Total building costs (TBC) are costs associated with designing and constructing the building and do not include site work (Division 2). TBC were calculated for all 10 projects by summing costs for all 16 CSI Divisions, less Division 2 (Exhibits 1 and 3). The TBC for the non-LEED bank locations ranged from $1.938 million for Horizon Drive to $3.197 million at Breckenridge. Total building costs for the two LEED projects were $1.717 million for 2,730 SF (or $629/SF) for Rifle South
In the small project group, non-LEED TBC ranged from $1.938 million at Horizon Drive to $2.336 million at Montrose. The TBC for Rifle South, the LEED project in the small group, was $1.717 million, below the range for the non-LEED projects. Within the medium group, TBC ranged from $2.432 million at Fruita to $2.563 million at Frisco. The LEED project in this group was Ridgway, which had TBC of $2.568 million, essentially equal to the top of the range for the medium group.

Square footage costs (Exhibit 4) were calculated by dividing the total building costs by the gross square footage of each bank facility (Exhibit 1). The square footage cost for non-LEED bank locations ranged from $563/SF at the Fruita location to $804/SF at the Montrose location. In comparison, the square footage costs for the two LEED projects were $577/SF for Ridgway (LEED Silver) and $629/SF for Rifle South (LEED Certified). When comparing square footage costs of the LEED projects to the non-LEED projects, they were within the range of square footage costs for all ten projects. The range this cost for the non-LEED small projects ranged from $660/SF at Clifton to $804/SF at Montrose. The square footage costs for Rifle South, the LEED project in the small group, was below the range of the small non-LEED projects at $629/SF. The square footage costs for the non-LEED medium group ranged from $563/SF at Fruita to $599/SF at Delta. Ridgway, the LEED project for this group, was within this range, with costs of $577/SF. The $624/SF cost for Breckenridge, the largest project in this study, falls in between the small and medium projects (Exhibit 5).
Soft Costs

According to previous studies, the majority of increased costs for green buildings are due to increases in soft costs (e.g., design, engineering, and consulting fees) (Kats, 2003). For the LEED projects, soft costs also included costs associated with LEED certification (e.g., registering projects with the U.S. Green Building Council, added project administration and documents, and applying for LEED certification). Soft costs were also analyzed based on total soft cost, soft cost per square foot, and soft cost as a percentage of total building cost (TBC). The total soft costs for non-LEED banks ranged from $89,084 for the Clifton location to $382,950 for the Breckenridge location (Exhibits 1 and 5). In comparison, soft costs for Rifle South were $161,657 and $161,257 for Ridgway, well within the total range for the non-LEED projects.

Total soft costs (TSC) for the small group ranged from $89,084 at Clifton to $161,082 at Horizon Drive for the non-LEED projects. TSC for Rifle South, the LEED project in this group, was slightly above the TSC range for the small projects at $161,657. TSC for the medium group ranged from $139,184 at Frisco to $172,637 at Delta for the non-LEED projects. The LEED project in this group, Ridgway, was within this range, with a TSC of $161,257.

The soft costs associated with square footage for the non-LEED projects in the small group ranged from $29/SF at Clifton to $75/SF at Breckenridge (Exhibit 6). Rifle South’s soft costs were $59/SF, within the upper end of the soft costs for the non-LEED locations. Ridgway’s soft costs of $36/SF were also within the non-LEED range, but were closer to the lower end of the range. Within the small
project group, soft costs ranged from $29/SF at Clifton to $57/SF at Horizon Drive. Soft costs for the LEED project in this group (Rifle South) was $59/SF, slightly higher than the non-LEED range for small projects. Within the medium group, soft costs ranged from $32/SF at Frisco to $41/SF at Delta for the non-LEED projects. Ridgway, the LEED project in this group, had soft costs of $36/SF.

As a percentage of total building costs (TBC), soft costs for the non-LEED banks range from 4.38% to 11.98% (Exhibit 7). The soft costs for Rifle South were 9.41% of the TBC, placing it within the non-LEED soft cost range, but toward the higher end of the range. Ridgway’s soft costs of 6.28% of TBC were well within the range for the non-LEED banks.

For the small group, the percentage of soft costs to TBC ranged from 4.38% at Clifton to 8.31% at Horizon Drive for the non-LEED projects. The percentage for Rifle South was high for the small group at 9.41%. Within the medium group, the percentage of soft costs to TBC ranged from 5.43% at Frisco to 6.97% at Fruita for the non-LEED projects. The percentage for Ridgway was 6.28%, well within the range for the medium group.

**Direct Costs of LEED Certification**

The direct costs associated with LEED certification were estimated to be $37,200 for each project (Exhibit 8). These costs were part of the soft costs tracked under CSI Division 0. It should be noted that the cost of LEED certification does not change based on the level of LEED certification sought. The direct costs for
The Cost of LEED

Exhibit 7 | Soft Costs as a Percentage of TBC Adjusted for Location and Time of Construction (2011 dollars)

Exhibit 8 | Costs Associated with LEED Certification

<table>
<thead>
<tr>
<th>Description of LEED Cost</th>
<th>Amount</th>
</tr>
</thead>
<tbody>
<tr>
<td>LEED Registration</td>
<td>$450</td>
</tr>
<tr>
<td>LEED Certification Review</td>
<td>$1,750</td>
</tr>
<tr>
<td>Modeling to Satisfy LEED Credits</td>
<td>$5,000</td>
</tr>
<tr>
<td>Commissioning for LEED</td>
<td>$10,000</td>
</tr>
<tr>
<td>LEED Management Fees (In-house LEED Project Administrator)</td>
<td>$10,000</td>
</tr>
<tr>
<td>Additional Design Fees Related to LEED</td>
<td>$5,000</td>
</tr>
<tr>
<td>Additional Construction Fees Related to LEED</td>
<td>$5,000</td>
</tr>
<tr>
<td>Total Costs Directly Associated with LEED</td>
<td>$37,200</td>
</tr>
</tbody>
</table>

seeking LEED certification were below 2% of TPC and between 1.5% and just over 2% of TBC (Exhibit 9).

The LEED certification process involved two costs associated with the U.S. Green Building Council (USGBC). The first cost was the fee to register the project for LEED certification, which was $450 for each of the LEED banks. The registration
Exhibit 9 | Costs Associated with LEED Certification as a Percentage of Total Project and Building Costs

<table>
<thead>
<tr>
<th>Bank</th>
<th>LEED Certification Level</th>
<th>LEED Costs as % of TPC</th>
<th>LEED Costs as % of TBC</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ridgway</td>
<td>LEED Silver</td>
<td>$37,200</td>
<td>1.31%</td>
</tr>
<tr>
<td>Rifle South</td>
<td>LEED Certified</td>
<td>$37,200</td>
<td>1.59%</td>
</tr>
</tbody>
</table>

Notes:

a Calculations of LEED costs provided in Exhibit 8.
b Total project costs (TPC) are provided in Exhibit 1.
c Total building costs (TBC) are provided in Exhibit 1. TBC = TPC – CSI Division 2: Site Work.

fee was the same amount charged to USGBC member organizations, regardless of project size and type (USGBC, 2009). The second cost was the fee for certification review, which was $1,750 for each of the LEED banks. The certification review cost was dependent on project size and member status.

Energy modeling is a requirement for LEED certification. The purpose is to demonstrate the percentage improvement in the proposed building’s performance compared to a baseline building’s performance (USGBC, 2009). This involves conducting a whole building project simulation and energy analysis. Modeling costs for the Rifle South and Ridgway bank projects were about $5,000 each.

LEED certification requires Fundamental Building Commissioning as a prerequisite to certification (Kibert, 2005). The intent of building commissioning is “to verify that the project’s energy-related systems are installed, and calibrated to perform according to the owner’s project requirements, basis of design and construction documents,” (USGBC, 2009 p. 29). Although commissioning can be used on non-LEED projects, commissioning costs were treated as added costs required for LEED certification in previous studies reviewed. Therefore, commissioning costs in this study were also considered as added projects costs required for LEED certification. Commissioning costs were $10,000 for each LEED certified bank.

Documentation and management of the LEED certification process for the Rifle South and Ridgway LEED projects were conducted by an in-house LEED Accredited Professional. The hours spent on LEED management were tracked separately from this individual’s other responsibilities within the company. The estimated amount of time spent on LEED administration and documentation was 200 hours per project. In addition, an estimated 20 hours per project was spent on construction monitoring and photographing. The resulting 220 hours for LEED Management were billed at an hourly rate of $45/hour. The direct cost to manage the LEED process in-house was estimated and rounded up to $10,000 per project.

Additional design fees directly related to LEED certification were limited to very small increases in design time for LEED charrettes, product research, and time
necessary to complete submittals requirements for LEED certification. A $5,000 amount has been estimated to cover this additional time.

A $5,000 amount has been estimated to cover minimal additional construction activities determined to be directly related to complying with the requirements of the following LEED credits:

1. Sustainable Sites Prerequisite 1: Construction Activity Pollution Prevention
2. Materials and Resources Credit 2.1–2.2: Construction Waste Management
3. Materials and Resources Credit 4.1–4.2: Recycled Content
4. Indoor Environmental Quality Credit 3.1: Construction IAQ Management Plan

Discussion

Total Building Costs and Square Footage Costs

The TBCs for the non-LEED banks ranged from $1.938 to $3.197 million (Exhibits 1 and 3). With a difference of over $1.2 million, this was much wider than anticipated. However, when considering the TBC range in relation to the range of building sizes of the cases, three sub-groups of banks became apparent and clarify the findings. Five of the banks had gross building sizes of around 3,000 SF or less and the TBC ranges from $1.717 to $2.032 million, a difference of $300,000. Four banks had gross building sizes of between 4,000–4,500 SF, and TBC ranged from $2.432 to $2.568 million, a difference of only $136,000. The last group was comprised of a single property at over 5,000 SF and a TBC of $3.197 million.

Four of the five smallest banks (Horizon Drive, Mesa Mall, Clifton, and Montrose) are non-LEED facilities and share relatively the same building plan and size. Additionally, these banks were designed and built by the same architectural firm and general contractor. Three of these banks are located in the Grand Junction area (Horizon Drive, Mesa Mall, and Clifton) and the fourth is about 60 miles away in Montrose. Of the banks located in and around Grand Junction, the geographic and socioeconomic conditions of these areas are very similar. These similarities are reflected in many of the cost indicators used in this study. For example, the three banks in the Grand Junction area have TBCs ranging from $1.938 million to $2.032 million and square footage costs ranging from $660/SF to $690/SF. Additionally, the hard costs per CSI division are very similar.

Despite these similarities, other costs varied considerably for the non-LEED banks. For instance, the Montrose facility, a non-LEED project, was completed in 2001 for $2.336 million (TBC). The Clifton bank was completed in the same year, using the same building plan and project team, but cost significantly less (Exhibit 3). Additionally, the Montrose facility’s square footage cost was $804/SF, which is the highest of all the locations in the study and notably higher than the similar
banks (Exhibit 4). The higher costs were determined to result from redundant mechanical systems including a gas-fired system and a geothermal system. The redundant systems costs explain why the bank has a higher square footage cost for Division 15—Mechanical of $38/SF.

The fifth bank in the group of smaller locations is the Rifle South location, a LEED certified bank completed in 2007. Despite incorporating many green features into the design, LEED certification was not part of the project’s original scope. The project team decided to pursue LEED certification after construction had started on the project. Fortunately, many LEED prerequisites were already satisfied within the original project scope and design. For example, the site is one acre and required to comply with the State of Colorado’s storm water discharge permit, thus satisfying a LEED Sustainable Site prerequisite. Additionally, the small size of the building allowed the mechanical engineer to serve as the commissioning agent. This avoided additional costs to commission systems that had already been designed and purchased. Rifle South’s TBC was $1.717 million, which is on the lower end of the range for similar sized banks included in this study and on the lower end of the range of square footage costs for the small group.

This Rifle South project also included innovative features that were not included in any other facility. These features included a 6.5 kW photovoltaic (PV) solar electric system and a lighting control system (LCS). The PV system is located on the drive-thru canopy and is estimated to generate almost 20% of the building’s electrical energy usage. The LCS takes advantage of good natural daylighting conditions; when natural light levels are adequate, the electric lighting automatically dims, saving on electricity consumption. Given the small size of the building, both the solar electric and lighting control systems contribute to and in increased square footage costs for Division 16—Electrical.

Ridgway is among the group of larger banks with 4,455 SF (Exhibit 2). The bank had a total building cost of $2.568 million and a square footage cost of $577/SF. Both of these cost indicators were in the range of similar sized locations (Exhibits 3 and 4). The Ridgway facility was actually the third LEED project for Alpine Banks. The other project, which was not been included in this study, was an interior remodel that sought certification under the LEED for Commercial Interior requirements in 2007, prior to the Ridgway project. There was a carryover of individuals who had worked on the LEED CI project to the Ridgway project. This increased experience and knowledge of LEED certification resulted in a more streamlined incorporation of LEED requirements into the overall project delivery, minimizing additional costs.

To summarize the analysis of TBC, it was found that the TBCs for the LEED projects were within the range established by the non-LEED projects. Within the small and medium groups, the TBCs for the LEED projects were within the range of the non-LEED projects, although Ridgway was at the top of the range for the medium projects. With respect to square footage costs, it was found again that the LEED projects were within the range of these costs established by the non-LEED projects both overall and within the small and medium groups.
Soft Costs

Soft costs for both LEED projects included in this study were within the non-LEED bank ranges for total soft costs (TSC). The two LEED projects did not experience any unanticipated additional soft costs related to the LEED certifications. Additional soft costs directly related to LEED certification for both LEED banks were limited to minimal increases in design time for LEED charrettes, product research, and the time necessary to complete submittals for LEED documentation, as well as modeling and LEED management. With respect to TSCs, the LEED projects were within the overall range established by the non-LEED projects. The TSCs for the LEED project in the small group were high for that group. The TSCs for the LEED project in the medium group were well within the range established by the non-LEED projects. When TSCs were compared to TBCs, again the LEED projects were within the over range for the non-LEED projects and the LEED project in the small group was high while the LEED project in the medium group was within the range for that group.

Direct Costs

The in-house LEED management costs for the LEED projects were estimated at $10,000 each. If an in-house LEED project administrator had not been available, an outside consultant would have been necessary to manage the LEED process. In 2007–2008, outside consultants’ LEED management fees for small commercial facilities in Colorado were typically in the $30,000–$40,000 range (J. Plaut, personal communication, June 4, 2009). Other LEED project administrators in Colorado have estimated the time spent on LEED management at 400 to 800 hours (M. Reott, personal communication, June 4, 2009). If it had been necessary for the developer to contract with an outside consultant, the fees could have increased to $30,000. This would have increased LEED direct costs to $57,200 per project. In this situation, LEED direct costs would have been 2%–3% of the total project costs and 3%–4% of the total building cost.

Conclusion

The data and analysis presented in this paper address the question “Can LEED banks be designed and constructed for costs comparable to non-LEED banks?” To answer this question, ten case studies were selected for analysis. Cases were grouped by gross square footage into small, medium, and large groups. Design and construction costs were normalized based on location and time. These results demonstrated that across very similar projects, it was possible to achieve LEED certification for minimal additional costs. The findings of this study demonstrate the costs associated with the LEED projects were always within the overall range of the non-LEED projects. Within sub groups, it was found that for the project team with less experience, soft costs for the LEED project tended to be just above the range of the non-LEED range. For the project team with more documented experience with LEED, costs associated with LEED tended to be at the middle or low end of the range established using similar non-LEED buildings. This was an
unexpected, but interesting result, which demonstrated how the project team’s experience with LEED can impact project costs. The results showed that as the project team gained more experience with LEED requirements and certification, there was a decline in costs associated with LEED certification.

This study found that design and construction costs for the two LEED banks are within the same overall cost ranges as the non-LEED banks. Seeking LEED certification added 2%–3% to total building costs and less than 2% to the total project cost, depending upon whether the company used an in-house LEED project administrator or outside consultant. These results both confirm and extend previous research on the costs associated with LEED certification to include bank facilities, hopefully encouraging more banks to consider incorporation of LEED requirements into their projects, building their experience with and understanding of LEED certified and energy-efficient buildings.

This study did not consider the impact of LEED requirements on either post occupancy satisfaction or the cost of facility operation and maintenance. Future studies addressing these issues are needed to increase adoption of LEED requirements and energy efficiency in buildings.
## Appendix

**Building Cost Data by Construction Specification Institute’s (CSI) MasterFormat 1995 Divisions**

<table>
<thead>
<tr>
<th>Bank</th>
<th>(Year Completed)</th>
<th>Gross SF</th>
<th>Div. 0</th>
<th>Div. 1</th>
<th>Div. 2</th>
<th>Div. 3</th>
<th>Div. 4</th>
<th>Div. 5</th>
<th>Div. 6</th>
<th>Div. 7</th>
<th>Div. 8</th>
</tr>
</thead>
<tbody>
<tr>
<td>Breckenridge (2003)</td>
<td>5,122</td>
<td>$382,950</td>
<td>$780,380</td>
<td>$232,780</td>
<td>$185,036</td>
<td>$42,183</td>
<td>$52,963</td>
<td>$294,954</td>
<td>$82,084</td>
<td>$94,372</td>
<td></td>
</tr>
<tr>
<td>Clifton (2001)</td>
<td>3,078</td>
<td>$89,084</td>
<td>$253,663</td>
<td>$217,527</td>
<td>$193,140</td>
<td>$—</td>
<td>$151,158</td>
<td>$250,802</td>
<td>$160,040</td>
<td>$270,300</td>
<td></td>
</tr>
<tr>
<td>Frisco (2007)</td>
<td>4,320</td>
<td>$139,184</td>
<td>$462,730</td>
<td>$302,521</td>
<td>$105,751</td>
<td>$78,665</td>
<td>$128,406</td>
<td>$419,159</td>
<td>$130,655</td>
<td>$93,910</td>
<td></td>
</tr>
<tr>
<td>Horizon Drive (1997)</td>
<td>2,809</td>
<td>$161,082</td>
<td>$254,730</td>
<td>$148,332</td>
<td>$225,272</td>
<td>$—</td>
<td>$84,477</td>
<td>$167,204</td>
<td>$134,870</td>
<td>$185,149</td>
<td></td>
</tr>
</tbody>
</table>
## Building Cost Data by Construction Specification Institute’s (CSI) MasterFormat 1995 Divisions

<table>
<thead>
<tr>
<th>Bank</th>
<th>Gross SF</th>
<th>Div. 9</th>
<th>Div. 10</th>
<th>Div. 11</th>
<th>Div. 12</th>
<th>Div. 13</th>
<th>Div. 14</th>
<th>Div. 15</th>
<th>Div. 16</th>
</tr>
</thead>
<tbody>
<tr>
<td>Clifton (2001)</td>
<td>3,078</td>
<td>$120,647</td>
<td>$38,177</td>
<td>$158,416</td>
<td>$127,135</td>
<td>$—</td>
<td>$—</td>
<td>$73,926</td>
<td>$145,699</td>
</tr>
<tr>
<td>Fruita (2007)</td>
<td>4,320</td>
<td>$129,406</td>
<td>$117,826</td>
<td>$165,038</td>
<td>$120,882</td>
<td>$—</td>
<td>$—</td>
<td>$102,560</td>
<td>$212,012</td>
</tr>
<tr>
<td>Horizon Drive (1997)</td>
<td>2,809</td>
<td>$126,551</td>
<td>$83,820</td>
<td>$235,670</td>
<td>$77,561</td>
<td>$—</td>
<td>$—</td>
<td>$60,653</td>
<td>$138,582</td>
</tr>
<tr>
<td>Mesa Mall (1999)</td>
<td>2,916</td>
<td>$121,871</td>
<td>$21,468</td>
<td>$234,974</td>
<td>$87,249</td>
<td>$—</td>
<td>$—</td>
<td>$62,899</td>
<td>$136,773</td>
</tr>
</tbody>
</table>
References


Chad Mapp, Sustainable Building Services LLC or chad@sbsleed.com.

MaryEllen C. Nobe, Colorado State University, Fort Collins, CO 80523-1584 or mary.nobe@colostate.edu.

Brian Dunbar, Colorado State University, Fort Collins, CO 80523-1584 or brian.dunbar@colostate.edu.
Creative Construction: The Capacity for Environmental Innovation in Real Estate Development Firms

Author William B. Bradshaw II

Abstract Despite advances in understanding green building performance in property markets, the green development process is poorly understood. Green development adopters change firm structure in three ways to make adoption of environmental innovation easier: they take greater control of the projects, they seek more patient capital (either by identifying a patient investor or by providing more equity), and they create longer term relationships with design and construction talent. Through a web-based survey, and follow-up interviews with two survey respondents, the paper examines three hypotheses: (1) green development adopters and their investors take a longer-term stake in projects; (2) price competition is less important than competition over quality, and (3) the developer takes greater control, especially in the provision of design and construction services.

Two recent studies test how green real estate projects perform in comparison to conventional projects in specific markets (Eicholtz, Kok, and Quigley, 2008; Miller, Spivey, and Florance, 2008). These studies are the first to use large samples of buildings to test how green projects lease, sell, and operate as compared to conventional buildings of the same type in the same location. This breakthrough in understanding is critical. The green development movement was built around case study data that provided possible but incomplete predictions about the performance of green buildings in real estate markets (Bradshaw, 2006). Investors and developers were supposed to change their development practices without having a strong idea about what such a change meant for their bottom lines. These new studies give us the first statistically significant glimpse of what green development may mean for investors and owners, and the story is a good one. While they differ in the magnitude of their results, both studies find that green building developers have created extraordinary value. This increase in value for the space users can be captured in part by the building owner through increased lease rates, increased selling prices, and decreased vacancy. This is the first good statistical evidence of what green building advocates have believed for over a decade: that green buildings outperform conventional buildings in the market place, especially in the commercial and industrial realm (Wilson, et al. 1998; Kats, et al. 2003). A wide body of research has shown that retail customers spend more in buildings with daylight and fresh air (Wilson, et al. 1998; Kats, et al. 2003; Kats, 2007), that employees experience fewer sick days and have higher productivity in buildings with good indoor air quality (Lucuik, Trusty, Larsson, ...
and Charette, 2005; Kats, 2007), and that employee retention is stronger when workers feel like their employer reflects their values (Senge and Carstedt, 2001; Kats 2007). But prior to the availability of the data used in this research, no one had tested the performance of large numbers of green buildings (which are more likely to have these particular characteristics) versus large numbers of conventional ones in specific markets.

While it is wonderful to see these advances in knowledge, it is not clear that the results will speed up the diffusion of green building among other development firms, because these studies do not focus on the process by which development decisions are made. This study starts to fill that gap, focusing exclusively on the development process. In building a hypothesis, the study looks at three things: (1) the conventional relationship between the owner, design professional, and contractor; (2) the social optimum of green development; and (3) whether larger firms are better positioned to adopt green development approaches. The hypothesis is tested through a survey of green development adopters (Appendix A), and a follow-up discussion with two respondents.

**The OPC Model**

The conventional and most common organizational model for development teams, the “OPC model,” addresses the complexity of the development process, the need for efficient contracting, and the capacity concerns of small firms that are embarking on complex projects. The OPC model focuses on the most critical relationships in any development team, those between the owner, the design professional, and the contractor. The traditional method for organizing this relationship is shown in Exhibit 1 (Poage, 1990).
There are several critical components to this OPC structure. First, the owner has a direct relationship with the design professional and the contractor, but the design professional administers the owners’ agreement with the contractor. In addition, many of the other professionals needed to carry out a project are sub-consultants to the design professional or the contractor. The design professional manages all engineering, landscape architecture, etc. In turn the contractor is responsible for all relationships with materials, materialmen/suppliers, and subcontractors. In this conception of the development process, the owner is responsible for the maintenance of the relationship with the design professional, and all other parties who are directly involved with the creation of plans for the building or the construction of the building are managed as an outgrowth of the agreement with the design professional. This is an excellent model for a small firm with limited capacity taking on a complex task. It puts significant emphasis on the skills and capacity of the design professional and to a lesser extent the contractor. It also makes the assembly and disassembly of a team fairly straightforward. The owner needs to contract with a design professional and a contractor, and the majority of the other critical relationships are taken care of by those two members of the team. This convenience does not come without a price. The owner is giving up significant control, but he is also adding expertise, capacity, and networks to the resources already available to his firm.

Another interesting implication of the conventional OPC structure is the suggestion of linearity in the development of a project. In this structure, the design professional fully designs the building, and then the owner and design professional competitively bid the project in order to retain the services of a contractor. This framework works best when the building can be fully conceived through the design process, and there is no time constraint pushing the developer to overlap the design process and the construction process (Gordon, 1994).

The conventional OPC structure also has some significant drawbacks. First, the process puts enormous emphasis on the knowledge of the design professional (Gordon, 1994). Not only must the design professional be a skilled designer, but the individual must also be knowledgeable about building materials, construction cost, constructability, and the availability of certain types of labor. Such expertise is unlikely to be held in a single person or single firm, particularly as projects become larger and more complex. Second, this process provides little flexibility for future changes. This lack of downstream flexibility puts a premium on understanding all future contingencies, something that is hard for any development project (due to its complexity) but particularly hard for innovative ones. Once the design documents are complete, construction bids are received, and a construction contract is awarded, it is generally expensive to make even small changes in the plans. However, other forms of this OPC relationship provide for more flexibility later in the process. Third, the conventional OPC relationship creates an adversarial quality in the relationship between the design professional and contractor (Gordon, 1994; Schlosser, 2010). The design professional in effect becomes the policeman of the contractor, working on behalf of the owner to ensure that no corners are cut, that quality is high, and that delivery of the building matches the intentions as laid out in the plans and specifications. While such
oversight is critical in a successful project, this structure can also mean that the contractor has little to no incentive to protect the interests of the owner or otherwise improve the project. These agency issues become particularly important in innovative efforts when the long-term impact of decisions may not be well understood ex ante, and an owner will want as much expertise from all team members as possible and for those people to protect the owner’s interests in ways that cannot be easily contracted.

Because of these limitations, the author believes that green developers will steer away from conventional OPC relationships, seeking out alternative contracting models (design-build, integrated design team, construction management, etc.) instead. These alternative models will place more importance on relationships, particularly the owner, design professional, and contractor relationships that are central to the development process. It’s not clear whether these relationships will follow a model where the same people are used on multiple projects but not formally contracted between projects or a more formal or truly vertically integrated approach. Eccles (1981) argues that based on the structure of development firms, inter-project relationships are hard and may actually be poor strategy except in certain circumstances. However, the requirements of green development create circumstances that would push towards greater vertical integration, as a way of minimizing risk related to new products, materials, or methods. As a result, it is also likely that green developers will take more control of their projects, in order to manage the increased complexity directly.

The Social Optimum of Green Development

As an organizing principle for the understanding of green development, the idea of the social optimum gets right to the heart of the issue in the adoption of green development, namely that there are externalities that our markets do not price in the real estate development process. This approach claims some measure of market failure (i.e., the market is not delivering the real estate solution we would collectively prefer). Buildings create pollution, the pieces and parts of buildings generate toxins that are released into the world when they are manufactured, shipped, installed, and used in buildings. Building location impacts air quality, public health, access to open space, and the ecology of a particular place. But these issues and many more are not part of the standard decision process in development, in fact thinking about them is often seen as extraneous to the central mission of a developer—to get the project built. Environmental innovation in development provides a framework for measuring the scale of these issues, but it also runs headlong into a debate, represented by the opinions of the people interviewed in this study. Andy Schlosser describes the inability to pay a penny more for anything that is not a public or private requirement. Ann Goggin says that tenants will not pay a penny more for green. David Zucker constantly works with his design, construction, and marketing teams to determine what part of green they can sell and for how much (Zucker, 2010). And Jim Lutz argues that Liberty Property Trust’s buildings are more valuable and their tenants pay more because of their overall project quality, of which greening is a component (Lutz, 2010).
This idea of the social optimum allows us to make sense of these competing comments, and to put them in a researchable framework. On the Liberty and Zocalo side of the ledger, they have learned how to extract some of the social value of green building through their projects, and to earn a premium for it. With Goggin and Schlosser, a building is a commodity product, and the drivers for space have little to do with a building’s impact on ecology. They are defining a market optimum. The real power in this framework is if we can start to define what the market is willing to absorb, and what is optimal for all forms of life, then we can also begin to define a gap between the market and social optima. This gap also points at the need to identify new types of financial resources in order to get greener projects development. These resources can come in the form of a regulatory imperative (i.e., we force everyone to meet certain green targets), or they can come in the form of more patient capital that sees opportunity in having a better building for the long term. Either way, some changed form of investment is likely to be part of greener buildings that get developed.

**Does Size Matter for Green Development?**

On one hand, development firms have historically been small, and there are significant productivity and operational advantages to small size as predicted by the inside contracting models of Williamson (1976) and Eccles (1981). On the other hand, large firms, particularly firms with access to public capital markets like REITs, have significant operational advantages related to their ability to scale and smooth out the lumpy nature of development cash flows. Beyond this, there is also a significant trend towards the increasing complexity of development projects and development technology, and large firms are better able to retain expertise and manage such complexity. But decades of development industry history, reflected in what the author has called the first principle of organizational structure for real estate development firms [i.e., development firms are small, on average (Bradshaw, 2010)], points in exactly the opposite direction, and there is significant evidence in other research that small firms have more aggressively adopted green building practices because they are nimble enough to do so. This conflict begs the question of which result is dominant, particularly if you accept the premise that the real estate development industry is in a state of flux, and it will ultimately settle into a new equilibrium. Will that equilibrium look like what Phil Thompson observed in Germany, with a number of small, nimble firms who are leading edge practitioners in green development (Thompson, 2010), or will it be a world where large developers with a national reach will dominate the marketplace?

Large developers have significant financial advantages that allow them to take on projects in multiple markets. This ability can also help diversify across geography, which may further enhance the financial advantages that large firms enjoy over smaller firms. However, relationships and reputation, which are the lifeblood of successful developers, are localized phenomena. One cannot translate reputation from one location to another easily, and this may be even harder with relationships. Both relationships and reputation come from a long history of delivering
successful projects on the ground in certain locations. Ultimately, size will dominate in this field, with large developers having an advantage over their smaller counterparts. However, smaller developers that do adopt green practices will frequently have some patient source of capital that allows them to meet the early cash demands of a green project.

**Three Hypotheses for Green Development**

These discussions lead to three related hypotheses for the green development process:

1. Large developers with easier access to capital are likely to have pushed further than small, local developers in the adoption of environmental innovation. The small firms who have been leading adopters are likely to utilize alternative financing arrangements with at least some investors that give the developer or the investor a longer-term stake in the project.

2. Early adopters of environmental innovation have moved away from price competition in the selection of development team members, in favor of long-term relationships, inter-project learning, and negotiated bid arrangements where, especially the providers of design and construction services, are familiar with the requirements and the past projects of the developer.

3. The developer exerts greater control throughout the entire development process, especially in the provision of design and construction services.

These three hypotheses will be tested through this study.

**A Survey of Green Developers**

A large survey of develop firms was conducted to test these hypotheses. The survey results provide a broad-based understanding of how frequently firms engaged in green development also engaged in these practices.

**Respondents**

A list of 1,085 firms involved in the real estate development industry was created largely using two websites: (1) 536 firms came from the U.S. Green Building Council’s (USGBC) member list for groups classified as real estate service providers (they have no category for developers) and (2) 493 firms came from the participants in the Builder’s Challenge program of the U.S. Department of Energy (DOE). The additional 56 firms were organizations involved in real estate development. In addition, friends and family (12 people) of the author involved in the industry filled out the survey during a pilot phase, which helped him to revise the survey instrument. The responses are included in the results. This sample of survey respondents is not representative of developers as a whole, but rather green developers. This limits the sample in some critical ways (i.e., as to
why firms chose not to develop green buildings), but also creates an interesting perspective for interpretation, especially as it relates to the hypotheses.

Every potential respondent firm was sent a personal email beginning on February 14, 2010 asking for their participation in the survey. This email had a read receipt from his Massachusetts Institute of Technology (MIT) webmail account, and confirmed that 290 of these emails were read by the intended recipient, and 47 survey responses were received from this group. Another 63 email requests were deleted without ever having been opened; 732 emails generated no read receipt response. Of these, 43 firms filled out the survey, so some significant portion of these emails got through to their intended recipient, but there is no way to know how many. At least ten days after receiving the initial request to complete the survey, a follow-up email was sent reminding people of the survey and asking again for their participation. This message also came from his MIT webmail account, and included instructions for checking his identity to ensure the author was an MIT student. The author closed the survey on March 20. All results were compiled on SurveyMonkey, where the survey was designed and disseminated.

There were significant data problems with this list of potential respondents. First, neither lists consists purely of real estate developers. The USGBC list includes attorneys, real estate brokerage firms, material suppliers, consultants, and other professionals, though it is predominantly developers. The DOE website includes policymakers, building science consultants, and contractors who do not traditionally act in an owner-developer role. Second, the USGBC list includes many foreign firms, which needed to be excluded from the study. Third, the real estate industry has struggled during the financial downturn, and 59 firms no longer had working email addresses. In addition, some of the firms where a no read receipt response was elicited may have gone out of business or terminated the position of the contact. Fourth, these lists are heavily slanted towards firms who are interested in green building and energy efficiency. These shortcomings were addressed in the following ways:

1. Groups who were not development firms were removed from the list by looking at the company name, and by clearly stating in the survey invitation and instrument that it was intended for people who were active real estate developers. In 102 unique responses, there was not a single respondent who does not seem to undertake some development activity.
2. Firms were removed from the list if they had an international phone number. No responses were from firms who did all of their work overseas, though several respondent firms were international with a US headquarters, and were kept in the list.
3. Firms were removed if the email was undeliverable. In two cases, respondents had started new firms under a different name than what was in the list but retained the same email address. Those responses are included in the results.
4. There was a non-adopter of green building practices in the follow-up interviews, as well as a firm who had a negative experience with green development.
Once the survey criteria were met, there were 955 potential respondent firms. There were 102 unique responses from this group, 90 not including the pilot responses, for a total response rate of around 10% (9.4% not including pilot, 10.6% including pilot). Exhibit 2 shows the geographic distribution of the respondent firms.

### Characteristics of the Respondent Firms

The median respondent firm was a small, privately-held, male-led firm, where the principal had a graduate degree and was based in the South. Almost every respondent firm had developed at least one project they self-labeled as green, and they were equally likely to be involved in single-family residential, office, multi-family residential, and mixed-use development with significant though somewhat smaller representation from retail and industrial development firms. Many firms did not specialize in one of these areas, but developed several types of projects.

The top executives in the respondent firms were overwhelmingly male (82%) and between the ages of 40 and 60 with some significant representation from people under 40. Exhibit 3 shows that regardless of the metric, the respondent firms tended to be small. Even more intriguing is the fact that there are relatively few medium-sized respondents. In the case of annual revenue, commercial and industrial square footage developed annually, number of employees, and firm capitalization, the overwhelming majority of respondents were in the first two categories combined, and the third highest concentration of respondents was in the last category, which is meant to capture the biggest firms. This result may imply a story about the advantages of scale in development firms, which has been predicted in the work of Egan (1998) and Pauly (2005).

Exhibit 4 shows that nearly half of the top level executives in the respondent firms had a graduate degree or had pursued some graduate school. Over 80% had an executive with at least a bachelor’s degree. This implies that people engaged in green development activities are a very well educated group.

Exhibit 5 shows that experience in the green development industry was fairly evenly spread between people with less than five years of experience and those with over 30. Most executives had between 10 and 30 years of experience, but it
### Exhibit 3 | Size of Respondent Firms

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Size</th>
<th>Total Respondents</th>
</tr>
</thead>
<tbody>
<tr>
<td>Annual Revenue</td>
<td>&lt; $1 million</td>
<td>$1 to $5 million</td>
</tr>
<tr>
<td></td>
<td>39%</td>
<td>31%</td>
</tr>
<tr>
<td>Residential Units Annually</td>
<td>Under 100 units</td>
<td>100–250 units</td>
</tr>
<tr>
<td></td>
<td>77%</td>
<td>14%</td>
</tr>
<tr>
<td>Commercial/Industrial SF annually</td>
<td>Less than 100k sf</td>
<td>100k–250k sf</td>
</tr>
<tr>
<td></td>
<td>71%</td>
<td>14%</td>
</tr>
<tr>
<td>Number of Employees</td>
<td>&lt; 10</td>
<td>10 to 25</td>
</tr>
<tr>
<td></td>
<td>57%</td>
<td>19%</td>
</tr>
<tr>
<td>Firm Capitalization</td>
<td>&lt; $5M</td>
<td>$5–$10M</td>
</tr>
<tr>
<td>Your Firm</td>
<td>71%</td>
<td>5%</td>
</tr>
</tbody>
</table>
Exhibit 4 | Education Level of Top Five Executives

<table>
<thead>
<tr>
<th>Individual</th>
<th>High School Diploma</th>
<th>Some College</th>
<th>Associates Degree</th>
<th>Bachelors Degree</th>
<th>Some Graduate School</th>
<th>Graduate Degree</th>
<th>Total Respondents</th>
</tr>
</thead>
<tbody>
<tr>
<td>Person 1</td>
<td>5%</td>
<td>8%</td>
<td>5%</td>
<td>34%</td>
<td>7%</td>
<td>40%</td>
<td>99</td>
</tr>
<tr>
<td>Person 2</td>
<td>4%</td>
<td>2%</td>
<td>4%</td>
<td>32%</td>
<td>6%</td>
<td>51%</td>
<td>47</td>
</tr>
<tr>
<td>Person 3</td>
<td>6%</td>
<td>6%</td>
<td>3%</td>
<td>48%</td>
<td>3%</td>
<td>32%</td>
<td>31</td>
</tr>
<tr>
<td>Person 4</td>
<td>0%</td>
<td>7%</td>
<td>0%</td>
<td>43%</td>
<td>14%</td>
<td>36%</td>
<td>14</td>
</tr>
<tr>
<td>Person 5</td>
<td>0%</td>
<td>22%</td>
<td>0%</td>
<td>44%</td>
<td>22%</td>
<td>11%</td>
<td>9</td>
</tr>
</tbody>
</table>

Exhibit 5 | Development Experience of Executives

<table>
<thead>
<tr>
<th>Individual</th>
<th>Less than 5</th>
<th>5–10</th>
<th>10–20</th>
<th>20–30</th>
<th>Over 30</th>
<th>Total Respondents</th>
</tr>
</thead>
<tbody>
<tr>
<td>Person 1</td>
<td>13%</td>
<td>18%</td>
<td>23%</td>
<td>25%</td>
<td>22%</td>
<td>97</td>
</tr>
<tr>
<td>Person 2</td>
<td>15%</td>
<td>9%</td>
<td>37%</td>
<td>33%</td>
<td>7%</td>
<td>46</td>
</tr>
<tr>
<td>Person 3</td>
<td>17%</td>
<td>17%</td>
<td>27%</td>
<td>27%</td>
<td>13%</td>
<td>30</td>
</tr>
<tr>
<td>Person 4</td>
<td>14%</td>
<td>29%</td>
<td>36%</td>
<td>21%</td>
<td>0%</td>
<td>14</td>
</tr>
<tr>
<td>Person 5</td>
<td>0%</td>
<td>10%</td>
<td>40%</td>
<td>20%</td>
<td>30%</td>
<td>10</td>
</tr>
</tbody>
</table>

was more likely that an executive had less than 10 years of experience than it was that they had more than 30.

The most prevalent background for executives was in construction, followed by finance and design (Exhibit 6). Interestingly enough, the lead executive was most likely to have a construction background, where every other executive was slightly more likely to have a background in finance. In addition, many people had experience not included in the listing of options, as indicated by the high number of people marking other in response to this question. There was significant previous experience in real estate sales, brokerage, and property management (9 write-in comments), engineering of some type (8 write-ins), and law (5 write-ins).

Respondent firms tended to do more than develop projects, offering a broad range of additional services including project management/construction management, property management, construction/general contracting, design, and real estate sales and leasing. In the overwhelming majority of cases (83%), the respondent firms were privately held with five or fewer people having control. The next most prevalent ownership structure was as a non-profit (nearly 10%), then private with
more than five people having control (5%), and finally firms that are publicly traded (4%).

Respondent firms also had a very high level of interest in green building and significant experience in that area. This is to be expected based on the source of respondent firms. Over 70% of respondents had completed a green project, nearly 90% had a green project in construction, and over 94% planned to have one in construction in the next two years, leaving just under 6% of the study sample with no experience in developing green and no plans to start a green development. As noted previously, respondents could self-label as green, so no determination has been made to determine how green a given project was.

**Testing the Hypotheses**

This analysis provides an interesting window into the mindset of firms who adopt green practices, and their motivations and challenges in doing this. In addition, it builds some basic knowledge about the makeup and constitution of real estate development firms who have decided to carry out a green project: who runs them, what they do, how big they are, where they are located, and what types of projects they take on. This information is very helpful in building a general picture of the green real estate development industry. But the purpose of this study is to take that information one step further. The three hypotheses imply that real estate development firms are poorly organized for the adoption of green development practices, and that leading edge adopters of green development will adjust those standard practices in predictable ways. The survey responses show mixed results, but generally support the hypotheses.

**Finding Investors for the Long-term**

Looking at the whole survey sample shows that the two most common sources of project financing for survey respondents were conventional debt and developer equity. This is not a surprising result, and it is not clear that this rate would be any more or less for developers of conventional projects. Beyond this, there were

<table>
<thead>
<tr>
<th>Individual</th>
<th>Construction</th>
<th>Design</th>
<th>Finance</th>
<th>Non-profit</th>
<th>Public Sector</th>
<th>Other</th>
<th>Total Respondents</th>
</tr>
</thead>
<tbody>
<tr>
<td>Person 1</td>
<td>39%</td>
<td>9%</td>
<td>17%</td>
<td>7%</td>
<td>3%</td>
<td>26%</td>
<td>90</td>
</tr>
<tr>
<td>Person 2</td>
<td>26%</td>
<td>7%</td>
<td>31%</td>
<td>0%</td>
<td>5%</td>
<td>31%</td>
<td>42</td>
</tr>
<tr>
<td>Person 3</td>
<td>22%</td>
<td>7%</td>
<td>33%</td>
<td>4%</td>
<td>4%</td>
<td>30%</td>
<td>27</td>
</tr>
<tr>
<td>Person 4</td>
<td>27%</td>
<td>9%</td>
<td>36%</td>
<td>18%</td>
<td>0%</td>
<td>9%</td>
<td>11</td>
</tr>
<tr>
<td>Person 5</td>
<td>13%</td>
<td>13%</td>
<td>63%</td>
<td>0%</td>
<td>13%</td>
<td>0%</td>
<td>8</td>
</tr>
</tbody>
</table>


Exhibit 6 | Professional Background of Executives
fairly low rates of participation by non-traditional sources of equity that are likely to be very patient sources of capital such as direct public investment, program-related investments from foundations, and the use of specialized financing tools like the New Markets Tax Credit or Low-Income Housing Tax Credit. In addition, only two of 94 firms that responded to another question said they had created their own equity or financing practice, independent of their development work.

Even more instructive than the tabulation of responses to this question were the comments that people made in response to it. Sixteen firms made comments in their answer to this question, and fifteen of which referred to patient investments that made the project in question possible. These comments ranged from people saying that the project had been built for cash or all equity provided by the developer or ultimate owner, to comments about public investments or guarantees that made the difference in the deal. Of these comments, eight referred to private investments of developers, ultimate owners distinct from the developer, or outside investors. Six referred to public investments of some type that pushed the project forward, and one referred to small grants and donations provided to the project. This level of response indicates that there may be more investment of this type going in to projects than the initial survey captured. More research is needed on this point.

These responses become even more interesting when cross-tabulated by ownership structure, including private closely held (control rests with less than five people), private widely held (control rests with more than five people), public, and non-profit/community development corporations. For private firms, both closely held and widely held, conventional debt (74%) is by far the most frequent source of capital for projects, with developer equity (45%) and investor equity (27%) as a distant second and third. Other sources are rarely present (13% or less of the time) in the capital stacks of these projects. These are all fairly conventional investment sources, and especially with conventional debt and investor equity as there are likely to be time pressures around performance that will be placed on a project, notwithstanding its green approach. However, the projects carried out by publicly traded companies were built entirely with developer equity or with the backing of the company balance sheet. No external time pressure would be applied to these projects, except any discipline which would come from the public capital markets. This is a significant advantage for publicly-traded companies wanting to do green projects. The other interesting finding was the frequency that public and philanthropic financing drives the work of non-profit developers, coupled with conventional debt. Even though the use of PRI, public financing, tax credit equity, and other sources that help groups make more patient investments in projects was low in the general sample, these sources were the dominant source of financing for non-profit projects, followed closely by conventional debt. This implies that non-profit organizations may also be well positioned (at least with respect to access to patient capital) to adopt environmental innovations.

In summary, patient sources of capital are not frequently used when looking at the full sample, but when that sample is parsed into various types of owners, more interesting results are observable. The survey bears out the hypothesis that publicly-traded firms have more flexibility around greening because they finance
development with their balance sheet and their own liquidity. This gives them opportunities to try things that privately-held developers might not be able to do because of requirements of their conventional debt and equity investment sources. Non-profit developers do utilize patient equity sources that are outside the firm in large percentages, including tax credit equity (43%), public financing (86%), program-related investments (14%), and philanthropic grants (14%). This indicates that they are another group that has some financing advantages around greening.5 In addition, only a small number of firms have developed a robust financing or equity arm that might invest in projects developed by another firm. Follow-up interviews with participating firms provide some insight into how their financing is structured. This investigation lends support to the idea that publicly-traded firms have significant financial flexibility due to their access to public capital markets, and privately-held firms struggle with access to capital, often seeing it as their most significant obstacle to scale.

Reduced Price Competition in Design and Construction

There is significant evidence that vertical integration of design and/or construction services is happening at the firm level with groups adopting green development. The work of Poage (1990), Gordon (1994), and Geltner and Miller (2001) suggests that the most common way of organizing a development team is through a conventional OPC relationship. The findings of the current work support this observation. However, of the 94 firms, predominantly firms engaged in green development, who answered questions about their services, 47 included construction, 52 included project management and construction management, and 42 included design and design/build. Twenty-five firms engaged in two of these services, and 20 engaged in all three, meaning that 76 of the 94 respondents to this question had vertically integrated design or construction services on some level. Only one in four firms who have not completed a green project provide construction/general contracting in-house, one in four provide design/design-build, and two in four provide construction management. In addition, one company performs construction/general contracting, construction management, and design/design-build, meaning that three out of the four firms provide no design or construction services in house, and two of the four provide no construction management/project management services either. Even though this sample of non-adopters is very small and non-representative, it agrees with the earlier result that green developers are more interested in longer-term relationships with design and construction expertise, often going so far that they have internalized those services into their shop.

At the project level, there is also significant evidence that owner/developers are utilizing alternative forms of project delivery that create a more team-based approach between the architect and the contractor (Exhibit 7). Of the 65 respondents to a question about the contract form used for project delivery, 28 said they used a conventional contract (think conventional OPC or the GMP-FP from Gordon), the single largest number. However, 18 owners self-performed construction work, twelve used multiple primes, another eleven used a design-build process, and two used a construction manager. All of these forms endeavor
to create less adversarial relationships between the development team members, especially design-build and the use of a construction manager. In addition, they all imply a more involved owner than would be conventional for a development project. Self-performed construction and the use of a multiple-primes contract generally indicates an owner who has vertically integrated around the delivery of some construction and/or design services. Taken together, 28 owners say they used a conventional contract form while 43 used a form that gives the owner more control over the process and engenders a less adversarial approach to the OPC relationship than is conventional.

Twenty-two of the thirty comments in this section indicated long-term relationships among the OPC partners, relationships that would not be utilized under a conventional OPC structure. In many cases, respondents said that they used traditional contract forms but the designer or the builder worked for or was wholly owned by the developer. In others, the respondent described the increased level of control that the developer/owner exerted in every phase of design and construction. There were also some comments about the owner, designer, and contractor having worked as a team before, or at least starting to work as a team on each project very early in the conceptual design phase.

In summary, there was much evidence that price competition around procuring design and construction services was reduced in favor of quality competition and instilling inter-project learning among team members. In the extreme cases, this resulted in actual vertical integration, which occurred in a surprisingly high number of cases, in fact it seemed to be the dominant form of organization among
respondents. The in-depth interviews further support this story, including an analysis of a firm, Zocalo, who self-performs construction services and has a captive design partner, as well as other firms who are examining how to choose partners based on the quality of service and not just the price.

**Increased Developer Control of the Process**

Most of the evidence for developer control comes out in the in-depth case studies of two firms. However, there are some findings from the web-based survey that provide some support for this hypothesis. First, there are the results from the previous section about the amount of vertical integration that is taking place in design and construction. If developers are finding that they need to aggressively incorporate design and construction services into their own shop, and/or enter into inter-project arrangements with design professionals and contractors, this is a strong indicator that they are taking more control of the process, and they are demanding certain outcomes from their development teams.

The survey results show that commissioning an energy model (75%), using an integrated design process (59%), and a post-occupancy evaluation of the building (51%) were done fairly frequently by survey respondents. These are changes that would imply greater developer involvement in the design process than typical in a conventional OPC structure. In the case of an energy model or post-occupancy evaluation, the fact that these studies are done show significant developer interest (they are willing to pay someone to do this) in the performance of the building before, during, and after its development. And the use of an integrated design process implies that a developer will also need to be more involved in steering the work of the team, since there will be more people.

The final sections of this study will investigate the survey findings in more detail through the analysis of two development firms who have been leading adopters of green practices. These firms are intended to highlight specific areas of interest for further investigation.

**Liberty Property Trust**

**Liberty’s First Green Project**

Liberty Property Trust is the largest industrial real estate investment trust (REIT) in the United States and possibly the largest owner of LEED-certified real estate development projects in the world. They own seven million square feet of LEED-certified buildings representing $1.3 billion in investment. They became interested in green building in 2001, based on the interest of two of the firm’s leaders, Jim Lutz and John Gatusso.

Liberty’s first green project, the PP&L building, cost $58 million, roughly $230 per square foot. It was a 252,000-square foot, eight-story building, and it was almost all build to suit for PP&L. There was a small amount of retail space on the ground floor and one speculative floor. Liberty retained ownership of the entire
building for a number of years (Lutz could not recall the exact transfer date), and because they are a REIT, they were able to finance the project in house and place corporate debt on it when it was advantageous. The project was leased to PP&L and mostly used as offices.

In addition to being the first private, LEED-Gold certified building in Pennsylvania, it was also named an AIA top 10 green building of the year in 2003, it received a ULI Award of Excellence, and they had the building ENERGY STAR certified in 2005.

Finding the Right Partners

One of the main changes Liberty makes with contracts is to lessen the control of the architect. As Lutz says, “the standard AIA forms make the architect god. We are much too concerned with being long-term owners to be comfortable with that arrangement.” They make final decisions on design, pricing, change orders, etc. in consultation with the architect. In the actual contract, they replace “the architect decides” with “the owner decides in consultation with the architect.” Lutz says that this is not meant to be arrogant, but rather to signal that they are willing to spend more money on some things and want to keep that control. This also directly reflects the idea that green building adopters will take more control of the design process, and work to create a less adversarial relationship between the design professional and the contractor.

They also like having long-term relationships with design and construction partners, and have developed relationships with architects and contractors that they use over and over again. Lutz says that these long-term partners understand their requirements. “When I sit down with a contractor for the first time, I say, ‘I want to explain to you what I’m looking for in a general contractor.’ I’m completely okay if you say that it’s not for you. But, I don’t want a contractor who is bidding plans and specs. Don’t ever come to me in the middle of a job and say these doors don’t have any hinges in the plans and specs. If you are a quality contractor you know that doors need hinges. So don’t put errors in your price. I want a builder who knows how to build buildings of this type. I don’t want to hear later on that you had no foundations because page S1 was missing from your bid set. If you know page S1 is missing ask for it ahead of time and put the foundation in your price.” This discussion continues to underscore the idea that Liberty wants design and construction partners to compete on quality, not just price, and they need team members that will protect Liberty’s interests throughout a project. In addition, both points together underscore something about their approach to development that predated their interest in green building, but likely made them more open to that approach: their interest in being a long-term owner of a building.

We see this patient investment strategy with the PP&L project in Allentown, and it is reflected in the way they approach their relationships with their contractors and design professionals. They want people doing the best work possible for them, and are willing to pay for that quality in order to have a better building over the long term.

“I’m asking you to take more responsibility. I’m also allowing you to come in and say the architect asked you to put this in and I don’t think you need it. I want
you to be part of a team. If you do this well, I’m more likely to use you again. I want you to protect me in all sorts of ways that I could never contract. You found things that are missing or unnecessary. I’m asking you for more, but because of that you also get more in terms of future jobs. But I need someone who likes doing that, someone who likes being part of a team. When I find people like that I’m more likely to use them over and over again. We have general contractors we have worked with for 30 years. There are going to be times where I’m going to do negotiated work because we have a deal that is moving too fast for a standard bid process. So I go to the guys I know we can trust, guys that we have worked with before. I tell them, if we win, you win. I don’t have to worry, because the builder knew this new job was kind of like the building he made for me before. He knows what it takes to build that building. He can give me a price on very sketchy plans and knows that I’ll work with him. If he comes to me and says, they are killing me on the design, we will work together on the design.”

Lutz believes that the people who work with them over the long term like that challenge. They like adding value to the project, and they generally do add value. There are also other contractors who argue about what is and is not in the plans. As far as Lutz is concerned, “It’s not on the plans” is not a good excuse for anything. He wants people to be more thorough. “Don’t get lazy, and you can get the benefit of working with us. We pay on time. We are not going to go out of business. You will get a check at the end of the day. If we work well together you can do work for us for decades.”

“Our contracts haven’t changed significantly over time other than we will reference requirements in the contract to do what is necessary to meet LEED requirements. So they know what is expected with documentation and with the way that they do certain things, like recycle construction and demolition waste on the job site. There are certain things that need to be taken into account. They have to be aware that this will be a LEED building, and that they need to be cooperative and responsive to do what is necessary to get points,” Lutz said.

**Liberty and the Green Building Hypotheses**

The Liberty Property Trust story provides strong support for the three hypotheses presented earlier. On the investment side, Liberty has a natural advantage over most developers through their structure as a REIT. Because of their access to the public capital markets, they can be their own long-term investor, and this attitude was reflected over and over again through the comments of Lutz. In addition, this approach of making long-term investments in green building reinforced the sort of long-term investments in better buildings that Liberty was already used to making. They made decisions on the basis of 5-, 10-, and 15-year holding patterns in particular markets with their buildings, and they are always working to enhance and protect their ability to get high value leases for their space. They see better energy performance, air quality, more access to light, better storm water maintenance, and other green building attributes as critical to protecting the long-term value in their assets.

With respect to design and construction firms, the Liberty story reinforces the idea that firms engaged in green development actively work to create long-term
relationships with designers and contractors, and that they structure the team to lessen the adversarial relationship between the two in order to get more of the expertise of both design professionals and contractors involved in the process. Liberty’s approach to doing this is somewhat different, but they have the construction and design expertise in house to manage it. In addition, Lutz clearly prioritizes quality over price in selecting team members. He wants people to be able and willing to protect his interests, and in exchange for doing that, he will give them work over a period of decades.

Liberty takes much more control of their projects than would be typical under standard contractual forms. Lutz mentioned specifically that they change their AIA contracts so that every place that it says “the architect decides” they write “the owner decides in consultation with the architect.” In addition, they have both the contractor and the architect report directly to Liberty, and final decisions about how to design and construct the building rest with the owner and (where possible) the tenant.

Zocalo Community Development

Zocalo’s First Green Project

Zocalo Community Development is a Denver-based developer of mixed-income, mixed-use communities. They have their own construction company and an exclusive relationship with an architect who is technically a third party. In addition, Zocalo also manages the properties that they develop. Their principal, David Zucker, founded Zocalo with a commitment to social equity. In 2005, they began to explore sustainability and green building due to a confluence of factors relating to both “people and process,” (Zucker 2010). Some of their team had some tangential experience with issues of sustainability, and they felt that it was not only a growing interest, but it fit with their principles of community-based development and mixed-income projects.

This first green project was a 62-unit condominium, of which two condos were commercial. It was a total of 160,000-square feet inclusive of the parking structure within the building. They had 1.2 parking spaces per unit, for a total of 74. Their average residential condo was about 1,150-square feet, and they had a $17.8 million total development cost. The building took 14 months to build.

They wanted to meet the LEED-New Construction guidelines, and they focused on energy conservation. At first, Zucker did not think they’d be able to achieve their 30% energy reduction target, but in the end they exceeded it. They got their LEED certification, and they “didn’t go broke doing it.”

Finding the Right Partners

For Zocalo, design, construction, and development are all in-house. The architect is legally a third party, but he does all his work for Zocalo, and they never use anyone else. The three partners (designer, contractor, and developer) work together
at a design-build firm. This gives them comfort with a development process where they are their own general contractor and architect. However, the way this design-build firm did business is a bit too loose for Zucker’s taste. They make things work in the design-build arrangement by being a little bit loose with the numbers. If they are able to save on one thing, they can shift it to another item that is running over budget. Their drawings don’t need to be tight. They don’t make money on drawings, but on the construction side. And the Zocalo team, Chris (licensed architect and general contractor), John Ganyon (architect of record), and Zucker feel that the design-build process cannot be an apology or an excuse to provide less detail in the plans.

Ganyon went to work for another firm, but he feels like an in-house partner, except for about one week on every project when they negotiate contracts. “We execute an A111 or a GC-form we use occasionally, and everything else is a handshake,” Zucker said. “This is not a relationship that is heavy-handed or that involves finger-pointing.”

This structure directly supports the hypothesis about the likelihood that green developers will vertically integrate around design and construction. Zocalo is a perfect illustration of this approach, and they have had a great deal of success working in that arrangement. In addition, there is a similarity to Liberty, in the sense that this multi-headed team pre-dated their interest in green. So they were already working in a way that made adoption of green building easier prior to adoption.

According to Zucker the best part of this team is the institutional memory that comes with it. The design process becomes “a type of Vulcan mind merge.” This iterative learning means that every project is smarter in its design than the last. There are also checks that make sure “we don’t blow it again and don’t put the vent too low for the vent off the dryer.” Zucker recognizes that if you do not have the same team that things can easily be lost, and because of these relationships they are able to learn faster and better than their competition.

There is also a happy confluence of skill sets and expertise that support the “meritorious tinkering” of creating a LEED-certified project. The design process ends up not just being about design, but the construction guys incorporate information on what is buildable while the property management team says what is marketable. It is a “virtuous network of connections” that help them adopt something like LEED, which is so focused on process. These connections help them determine, within the context of meeting LEED goals, when there are diminishing returns for energy efficiency, indoor air quality, etc., and also where there is a balance between what they can sell and the marketing of sustainability. Zucker also notes that this relationship between their marketing, development, construction, and design functions pre-dates their decision to go green. They had already become a “four-headed mammal,” according to Zucker, and “that four-headed mammal has been quite useful in the transition to greener projects.”

They decided to venture out of this structure to respond to a request for proposals that the Housing Authority issued. The project did not go well and it was their
fault. This reinforced Zucker’s commitment to working with John Ganyon on all their projects, even if they have more design work than Ganyon can do on his own. “It just makes a lot of sense, if his knowledge base is in the deal,” Zucker says. “If there are more projects that we’re building than he can design and bring to 100% construction drawings himself, he could be the governor making sure that the new temporal relationship with a new architect conforms to how we design, develop, and construct properties.”

This sense of carrying lessons from project to project is critical to the hypotheses presented in this study about green building. By doing that, they blur the lines between development teams and development firms in ways that benefit the ability of any given team to deliver a better building. Zucker continues, “It’s an iterative process of trying to figure out what’s viable, what level of score is viable within that category, and how are we going to achieve it. These are things we never needed help with in a standard project. But everything about the LEED process is opened up for meritorious tinkering, and we design a better project as a result.”

**Specialized Financing**

Zucker says they did not receive any specialized financing as a result of greening, but greening was a nice benefit that some of their investors included in their consideration of the project. For example, they had subordinate debt from the non-profit lender, Seedco. The green goals were a motivating factor for them to take a position, but not the motivating factor. Green was an additional check box that most projects could not really check. Zocalo paid off the Seedco investment as scheduled.

In addition, they had about 50 kilowatts of photovoltaic panels on the roof. Ten kilowatts powered the common areas. Each of the 36 owners received 1,260 watts. Zocalo worked to figure out how to make solar work as an operating cost neutral expense. They knew the federal tax credit, estimated savings, etc. and in the end Zucker convinced Countrywide to reduce the interest rate on the mortgage they were charging the condo buyers by 1/8 of a point. He doubts he could get Bank of America to do this today.

One of the largest obstacles Zucker has to expanding on the Zocalo model and their successful track record to date is access to equity financing, particularly access to patient investment partners. Unlike Liberty, he has to raise all the investment dollars he needs in private markets.

**Zocalo and the Green Development Hypotheses**

Zocalo provides strong support for the three hypotheses presented earlier. Zucker’s central frustration around his ability to scale is their lack of access to patient capital. He is currently seeking pre-development dollars that former investors (people he has paid back as agreed) are unwilling to provide. He is seeking other equity backers that are scared away from commercial real estate investment despite his track record of success. So for Zocalo, his inability to find patient capital is the instructive point. Despite a track record of significant success over a number
of years, the private market is currently unwilling to invest in Zucker’s company, and public capital markets are not available to him as they are to Liberty.

Zocalo has, for all practical purposes, vertically integrated design, construction, development, and property management services. For them, this process is about iterative learning, and they are self-conscious about driving beyond the targets they have already hit in each of their projects. This relationship pre-dates their commitment to green building, and, like Liberty, makes them more capable of successfully adopting green innovation. Their success to date with green building certainly supports that argument.

Zocalo has taken much greater control of their projects than would be typical. First, they are vertically integrated with construction and property management, and work with a captive design professional. By itself, this level of integration points toward greater involvement. In addition, Zucker is clearly quite involved in the design and construction processes, which is atypical.

**Analyzing the Cases**

Exhibit 8 shows that there is strong support for the three hypotheses. This reinforces the results from the web-based survey presented earlier. There are three themes that shed light on the questions about whether development firms are structured in a way that hampers environmental innovation: (1) green as a better business; (integrating for green); and green as a mission.

**Green as Better Business**

Koebel, Papadakis, Hudson, and Cavell (2003) suggest that development firms who adopt environmental innovations do not do so because they believe it will improve short-term profits or cut short-term costs. They do so because they believe that innovation adoption will make them more competitive in the long run and change their reputation with their clients. This idea is consistent with the web-based survey results.

These two ideas point at a critical conflict in the world of green development; the system may have at least two optimal points. One might be thought of as the *market* optimum. This optimum would be sought by those who are trying to figure out what their customers will pay for, and how much they will pay. Their decision-
making is motivated by an attempt to maximize profits. The other may be thought of as the social optimum. This optimum would be concerned with what the best outcome is for the natural context in which a project is placed, and decision-making would be based on an attempt to maximize community welfare in the broadest sense. It is not a stretch to say that this second optimum would involve more green development than what the market currently provides, and it would necessitate some mechanism for calculating the positive externalities of green development so we might better understand the social and environmental value of things like reducing the heat island effect or producing solar power.

In this market optimum versus social optimum framework, early adopters of green innovation in development are straddling the two optima. Groups like Zocalo and Liberty Property Trust invest in a different way of doing business because they believe it will pay off for them in the long run. They are willing to develop properties in a way that pushes them closer to the social optimum because they believe they have a way of capturing some of the social value that their projects create.

In the Liberty case, they are a long-term building owner and operator of commercial and industrial space, and they believe that worker productivity is higher in better buildings. They can extract a premium in comparison to conventional space, because their tenants stay longer and are more successful in their buildings. They also believe that this trend will continue, so by investing in better buildings today, they will have buildings that are more competitive and give them greater value tomorrow. Also, Liberty has a critical advantage over the other developers interviewed in this study; they have access to the public capital markets. This means that they do not have the problems of lumpy returns that most developers face, and this access to capital gives them an opportunity to smooth out any hiccups in their cash flow that might result from spending a little more on building quality.

In the Zocalo case, they are a long-term building operator7 in a particular geographic area. This geographic focus means that they can develop a reputation of quality that will generate greater interest in Zocalo projects versus their competitors. In addition, since they have a captive team that runs the whole project from start to finish, they are able to directly incorporate learning from one project into the next. This iterative learning process makes them increasingly efficient, and means that they are constantly achieving better green development results at lower costs when viewed on an inter-project basis. But the most telling piece of the Zocalo “green as better business story” is that they do not have access to the equity they need to make their deals happen. This lack of access to capital is the most difficult obstacle for Zocalo to overcome, and it underscores the hypotheses about what green developers will do to make their work easier. Zucker has vertically integrated around design and construction. He has taken greater control of his projects to create greener results, yet he still struggles to get the equity to fund his projects.

Several key lessons can be distilled from these cases: (1) Easy access to patient capital is a critical component of success for developers who adopt environmental
innovation; (2) Long-term behavioral trends and buyer preferences will have a significant impact on whether or not the long-term investments that these companies have made in green development will pay significant dividends; and (3) reputational issues are paramount and can be a driver of long-term value and access to projects or customers over the long term. These two firms believe that green is better business, and they have organized themselves in ways that allow them to seamlessly transition to a greener practice.

**Integrating for Green**

All three hypotheses about how green developers would organize themselves to better adopt environmental innovations are central to the idea of integrating for green. The reasons why such vertical integration would happen, namely so that the developer could retain additional control over critical stages in the development process where their green building goals may not align with other team members, do seem to have influenced behavior among adopter firms.

Both case study firms said that they took on an expanded role in the process as developer, especially with respect to design and construction. In addition, they both support the idea of multi-project relationships with particular designers and contractors to instill learning around the green development process, ensuring that there was a clear understanding about the working relationships between developer, contractor, and architect.

In the case of Zocalo, vertical integration is critical for their success. Zucker talks specifically about their ability to move all the lessons from one project to the next through their team approach, and how important it is that everyone shares in the success and failures of the team. It’s not just about how something got designed and making sure we don’t blow it again and give enough room in the laundry closet to fit the laundry in. But, we can figure out, in this virtuous network of connections, which (aspects of LEED) are reasonable to attempt to achieve, where there are diminishing returns, and also where there is a balance between the buyer and renter and the marketing of sustainability.” Zucker believes that through that long-term partnership, they can find the places where the market optimum, which allows them to out-compete other development firms, can be pushed towards the social optimum of green building activity in Denver.

In the Liberty case, their focus on long-term relationships with suppliers, design firms, and contractors, as well as their integration with equity, has predates their interest in green. This raises an interesting question about whether these stories around vertical integration of various components of the development team have to do with green development exclusively or if they are more indicative of a certain developer ethic focused on quality and value generated through long-term ownership. For Jim Lutz, it is clear that a green building equates to a better building: it is easier and cheaper to operate, it is more desirable to tenants, and it functions better in the space where it is located than a traditional building would. They also have had several competitive advantages: (1) they are REIT with access to public capital markets, which allows them to expand in ways that most developers cannot; (2) they are long-term owners of quality products, and they
engage in differentiating partners by quality, not just price; (3) they have two executives who are knowledgeable in green building; and (4) they had a client who wanted to do a major green project at a time where most institutional investors and large-scale developers thought green was just a color.

These interviews indicate that some level of vertical integration is desirable for development firms taking on green projects. It is not clear whether this occurs through integrating their operations with contractors and designers, or through using the same contractor or designer repeatedly, but not formally integrating. In addition, there is some movement towards vertically integrating with equity, though the only group of those interviewed to do that successfully has been Liberty Property Trust. In the case of Zocalo, greater access to patient equity and closer integration with those sources would greatly expand their ability to deliver on projects.

Green as Mission

Critics of green development often claim that people undertake green development projects because they are motivated by something other than profit (Wendall, 2008). This sense of mission is characteristic of many firms involved in green development, and is reflected in the results of the survey and would be predicted by the work of Koebel, Papadakis Hudson, and Cavell (2003). The predominant reason that respondent firms had taken on green projects was that they believed it was the right thing to do. Of the two case firms, Zocalo Community Development can be described as mission driven. Their story highlights a number of important characteristics of the mission-driven company involved in for-profit green development. While Zocalo has motivating factors beyond profit, management must organize the firm to compete with other companies, both green and conventional. Stated simply, they decided ex ante that they would be green and had to figure out how to make money doing double or triple-bottom line projects. Taken together, their stories indicate that there are two critical factors that define success for the mission-driven green developer: (1) integrate design, construction, and investment in a way that creates cooperation between team members; (2) participate actively in design, engineering, construction, finance, and marketing discussions and ensure that insights from each of these areas impact the decision making in others.

Zucker’s story reflects a profound interest in team structure, particularly in finding team members with the right knowledge and skills, and incentivizing them in an appropriate way to make the project successful. Zocalo is reliant on the development team to meet its goals, and there is a huge emphasis on getting everyone to transition the same way at the same time.

Conclusion

The three hypotheses are supported by both the survey responses and the follow-up case studies. They suggest that the conventional development process creates problems for the adoption of green development, and leading edge adopters of
green practices will adjust their operating structure in predictable ways. Namely, they will take greater control of their projects, they will seek out more patient capital (either by identifying a patient investor or by providing more equity), and they will create longer-term relationships with design and construction talent. Understanding these changes to the development process is just as important as understanding how changes in the development product will impact the market for real estate in a given place and product type. However, this study only begins to analyze the development process.

There are many ways in which the available data are incomplete, and additional research is needed to more fully understand these behaviors and phenomena. In particular, it would be helpful if the US Green Building Council, the National Association of Homebuilders, the National Association of Office and Industrial Properties, and/or the Urban Land Institute would support future research in this area. They all declined to participate directly in this study, and access to their data and membership records would dramatically improve the conclusions that could be drawn here. Such an addition would help to strengthen the largely anecdotal arguments made in this work.
Appendix A
Survey Instrument

Green Development Adoption

1. Company and Top Executives

CONSENT TO PARTICIPATE IN SURVEY

The capacity for environmental innovation in real estate development

You have been asked to participate in a research study conducted by Will Bradshaw from the Department of Urban
Studies and Planning at the Massachusetts Institute of Technology (M.I.T.). The purpose of the study is to understand
more about the capacity for environmental innovation in the real estate development industry. The results of this study will
be included in Will Bradshaw’s dissertation. You were selected as a possible participant in this study because of your
involvement in the development industry. You should read the information below, and ask questions about anything you
do not understand, before deciding whether or not to participate.

- This survey is voluntary. You have the right not to answer any question, and to stop the survey at any time or for any
  reason. We expect that the survey will take about 30 minutes.

- You will not be compensated for this survey.

This project will be completed by summer 2010.

I understand the procedures described above. By continuing with this survey, I agree to participate in this study.

Please contact Will Bradshaw at willyb@mit.edu or 504-715-1129 with any questions or concerns or to get a copy of the
results, which we will be happy to share in a fashion that does not identify any respondents.

If you feel you have been treated unfairly, or you have questions regarding your rights as a research subject, you may
contact the Chairman of the Committee on the Use of Humans as Experimental Subjects, M.I.T., Room E25-143b, 77
Massachusetts Ave, Cambridge, MA 02139, phone 1-617-253-6787.

Each respondent to the survey will receive a number, based on their order of responses. That number will be used to
identify the participants’ answers to questions, and their identifying information will not appear with the data.

Paper records related to survey responses will be kept in a locked filing cabinet in the principal investigator’s office.
Electronic records will be kept on the PI’s personal computer and on-line at survey monkey in a password protected
account. Records without identifying information will be stored in a regular filing cabinet. When the study is complete,
survey data will be stored in a locked filing cabinet and ultimately destroyed.

* 1. Please tell us the name of your firm and its principal location (an answer is required
   for this question).

  Company:

  City/Town:

  State:

  ZIP:

  Country:

* 2. Please list the city and state of company offices other than the principal office. If you
   have no other offices, please write none (an answer is required for this question).

  [Blank Line]

  [Blank Line]
Green Development Adoption

3. Provide the names and titles of the five most senior executives in your firm (an answer is required for this question, but you do not need to list 5 senior executives, if you do not have that many. Listing 1 is sufficient).

Person 1 (Name and Title):
Person 2 (Name and Title):
Person 3 (Name and Title):
Person 4 (Name and Title):
Person 5 (Name and Title):

4. Tell us more about these executives by filling out the chart below.

<table>
<thead>
<tr>
<th>Person</th>
<th>Age</th>
<th>Gender</th>
<th>Education Level (Check highest level obtained)</th>
<th>Years of Development Experience</th>
<th>Background (if multiple, write in all that apply in comment field below)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Person 1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Person 2</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Person 3</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Person 4</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Person 5</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Write other background in here


Green Development Adoption

2. Company Demographics

This page collects information about the size and focus of the company.

1. How big is your firm, on any or all of the following metrics

<table>
<thead>
<tr>
<th>Annual Revenue</th>
<th>Residential Development Annually</th>
<th>Commercial/Industrial Development Annually</th>
<th>Number of Employees</th>
<th>Firm Capitalization</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Please provide any clarifying comments:

2. Describe the geographic focus of your company

- Single City (please name in comment section below)
- Single State (please name in comment section below)
- Regional (please describe in comment section below)
- Nationwide
- International
- Other (please describe in comment section below)

Comment:

3. Tell us more about the type of projects you take on (please check all that apply)

- Single-Family
- Multi-Family
- Commercial/Office
- Industrial
- Retail
- Mixed-Use
- Other (please describe)

Comment:
Green Development Adoption

4. Tell us more about the services you offer (please check all that apply)

- [ ] Own/Develop
- [ ] Property Management
- [ ] Project Management/Construction Management
- [ ] Real Estate Sales/Leasing
- [ ] Construction/General Contracting
- [ ] Design/Design Build
- [ ] Other (please describe)

5. What is your ownership structure?

- [ ] Private—Closely Held (control rests with less than 5 people)
- [ ] Private (More than five people have majority control)
- [ ] Publicly Traded
- [ ] Community Development Corporation/other non-profit
- [ ] Other (describe below)

[ ]
Green Development Adoption

3. Green Building Projects

This page will ask you for information about how your firm decided to undertake green projects and the systems you have used to measure your success.

1. On any green project that your firm has undertaken, have you used a green building guideline or standard? If so, which ones (please mark all that apply)?

- [ ] LEED-Homes
- [ ] LEED-Core and Shell
- [ ] Energy Star
- [ ] LEED-Neighborhood Development
- [ ] LEED-Operations and Maintenance
- [ ] DOE Builder’s Challenge
- [ ] LEED-Commercial/Major Renovation
- [ ] NAHB Green Building Guideline
- [ ] Enterprise Green Communities
- [ ] LEED-interiors
- [ ] NAHB Green Building Standard (After ANSI adoption in 2008)
- [ ] Other (please specify)

2. If you have developed green projects, what were some obstacles you faced in those projects (check all that apply)?

- [ ] Lender ignorance/unwillingness related to green building approach
- [ ] Increased cost
- [ ] Builder ignorance/unwillingness related to green building approach
- [ ] Lack of material availability
- [ ] My firm has not developed green projects
- [ ] Uncertainty and/or limited data about the performance of the project or particular components
- [ ] It is harder to get a permit or necessary zoning approvals because of green approach
- [ ] Our customers are unwilling to pay a premium for a green approach
- [ ] Green approach increases construction time
- [ ] Other (please specify)
Green Development Adoption

3. What is the single largest obstacle you have faced to developing green projects?
   - My firm has not developed green projects
   - Increased cost
   - Lack of material availability
   - Long-term uncertainty about the performance of the project or particular components
   - Increased entitlement risk as a result of green approach
   - Our customers won’t pay a premium for a green approach
   - A green approach increases construction time
   - Other (please specify)

4. If you have undertaken green projects, why have you done this? Please check all that apply.
   - My firm has not developed green projects
   - An investment partner wanted to develop green projects
   - A green approach was required by a public agency
   - Other (please specify)
   - One of our principals wanted to develop green projects
   - We believe green projects are more profitable
   - Green building is part of our commitment to high quality spaces
   - Our customers demand green projects
   - We believe green projects are the right thing to do
Green Development Adoption

5. What is the single largest reason you have undertaken green projects? Please select one from the list below.

- My firm has not developed green projects
- An investment partner wanted to develop green projects
- A green approach was required by a public agency
- One of our principals wanted to develop green projects
- We believe green projects are more profitable
- Green building is part of our commitment to high quality spaces
- Our customers demand green projects
- We believe green projects are the right thing to do
- Other (please specify)
4. Specific Green Projects

This page will ask you specifically about a green project (for you to select) that your firm has completed.

1. Has your firm developed a green project? (There is currently much debate about what constitutes a green project, and much research is focused on distinguishing between something that is "truly green" and "green washing". This is not our purpose here. If you believe that you developed a project that was green, then for the purpose of this survey you did. We are going to ask you about the characteristics of that project and how you organized your development team to manage it.)
   - We have completed at least one green project.
   - We have a green project under development, but have not completed it.
   - We are planning a green project in the next 2 years.
   - We have not developed a green project.

2. What percent of your projects are green?

<table>
<thead>
<tr>
<th>Percentage</th>
<th>0%</th>
<th>25-50%</th>
<th>50-75%</th>
<th>75-100%</th>
<th>Zero</th>
</tr>
</thead>
<tbody>
<tr>
<td>Currently</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>Expected</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
</tr>
</tbody>
</table>

3. Please tell us about a green building project your firm completed.

- Project Name: 
- Year completed:
- Size (# of units or square feet of space):
- Green Building Rating:
- System Used:
- Level Achieved in Rating:
- Other major goals for project:
- Biggest challenges:
- Additional comments about the project:

4. What specifically did you do to make this a green project? For example, you might have followed a green building rating system (please state the system and level of performance achieved), focused on energy efficiency, indoor air quality, the use of recycled materials, etc (please provide some examples about materials and systems used).
5. Would you describe this project as a success? Why or why not?

6. After this project, did your firm decide to take on additional green projects? Why or why not?

7. Did you do any of the following on this project (please mark all that apply).
   - Hire builder or construction manager before the design was complete so they could participate in design decision-making
   - Commission an energy model on the existing building or proposed design
   - A post-occupancy evaluation of the building
   - Obtain performance guarantees from your general/subs that extend beyond the statutory minimums (please describe below in comments section)
   - Obtain performance guarantees from someone else on the development team (please describe below in comments section)
   - Contract with any development team members for multiple projects rather than just this one
   - Contracts with development team members that indicate clearly delineated expectations about building performance

   Comments

8. What contract form did you use for project delivery (please check all that apply)?

   - This project
   - Conventional (owner hires architect and builder, architect administers construction process and certifies completion)
   - Multiple primes (owner contracts with various subs for specialized construction)
   - Owner-contractor (where owner acts as the general contractor)
   - Design-build (where architect acts as the contractor)
   - Construction manager (where third-party construction manager delivers the project)

   Comments
Green Development Adoption

9. Indicate the type of financing you used in this development project (please check all that apply).

<table>
<thead>
<tr>
<th>Financing Type</th>
<th>This project</th>
</tr>
</thead>
<tbody>
<tr>
<td>Conventional Debt</td>
<td></td>
</tr>
<tr>
<td>Developer equity - company funds or funds from principals</td>
<td></td>
</tr>
<tr>
<td>Investor equity</td>
<td></td>
</tr>
<tr>
<td>Tax Credit Equity (NMTC, LIHTC, HTC, solar credits, etc)</td>
<td></td>
</tr>
<tr>
<td>Other public financing (CDBG, HOME, etc)</td>
<td></td>
</tr>
<tr>
<td>Philanthropic grants</td>
<td></td>
</tr>
<tr>
<td>Program Related Investments (PRI) - a debt or equity investment made by a philanthropic entity out of its endowment and not funds used for grant-making</td>
<td></td>
</tr>
<tr>
<td>Other (please describe below in comments section)</td>
<td></td>
</tr>
</tbody>
</table>

Comments

10. Indicate the project delivery approach you used on this real estate project (please check all that apply).

<table>
<thead>
<tr>
<th>Delivery Approach</th>
<th>This project</th>
</tr>
</thead>
<tbody>
<tr>
<td>Site-built</td>
<td></td>
</tr>
<tr>
<td>Modular</td>
<td></td>
</tr>
<tr>
<td>Panelized (including structural insulated panels)</td>
<td></td>
</tr>
<tr>
<td>Computer assisted design/computer assisted manufacturing</td>
<td></td>
</tr>
<tr>
<td>Other (please describe below in comments section)</td>
<td></td>
</tr>
</tbody>
</table>

Comments
Appendix B

Emails to Potential Respondents

I, Will Bradshaw, am a PhD candidate in Urban Economics and Sustainable Community Development at MIT, and I am doing a study on the capacity for real estate development firms to adopt environmental innovation, looking particularly at the structure of the development process and whether it leads to slower adoption of environmentally-related improvements in buildings. One of the participants in the study is my own firm, Green Coast Enterprises, a triple-bottom line developer based in New Orleans. The attached link connects to a survey targeted at real estate developers designed to understand more about their interest in green development, and their efforts to carry out green projects. It should take about 15 minutes to complete, and I would be pleased to have you fill out the survey. I will be happy to share tabulated results with anyone that asks, with identifying information removed of course. The study is scheduled to be complete in summer 2010.

You can access the survey at http://www.surveymonkey.com/s/XFZ28KX. Thank you for your time and consideration.

Sincerely,
Will

Recently, I sent you an email requesting that you participate in a survey related to my dissertation research on the capacity for real estate development firms to adopt environmental innovations. I do not believe you have yet responded to the survey, and I wanted to send this follow-up asking again for your participation. I know from a few of the responses I received that there was some question about my identity and whether or not this research is real, especially since the survey asks for some sensitive information. To address that issue, I wanted to send the following:

If you go to the MIT homepage at web.mit.edu, you will see a people search at the top right of the screen. You can search for my full name, William Bradshaw, and it will show you that I am a graduate student in the Department of Urban Studies and Planning and provide my home address in New Orleans. The survey itself also has contact information for MIT’s Institutional Review Board (called the Committee on the Use of Humans as Experimental Subjects) which sets standards for research ethics and the treatment of sensitive information. They have approved this research based on protocols that I am following to keep your information private, and you can contact them directly if you have concerns about my activities.

I would greatly appreciate your participation in this survey, which I plan to close on March 19 at midnight CST. Thank you very much for your time and consideration. I could not complete this study without you. The link to the survey is http://www.surveymonkey.com/s/XFZ28KX.

Sincerely,
Will
Endnotes

1 The text of the letter is available in Appendix B.
2 The text of the second letter is available in Appendix B.
3 I received several responses to the first email doubting his purpose and student status.
4 This result is not representative of the development industry and it indicates that his survey respondents were generally green developers rather than a cross-section of the development industry. Efforts were made to counter this problem, but ultimately the Urban Land Institute, the National Association of Homebuilders, and the National Association of Industrial and Office Properties declined to support this research by sharing access to their membership or their own demographics in a way that could be cited, and the Economic Survey data provides no baseline for a real estate development firm.
5 Despite a significant interest in this finding, the balance of this study will not test it further. It is an interesting opportunity for further research.
6 This question did not preclude firms from selecting multiple answers. In fact, almost everyone who selected other did so to clarify the particular nature of the relationship that the owner had to the rest of the team members.
7 As distinct from a long-term owner since they sell condo units in most of their projects, but then manage the property for the condo association.

References

Bradshaw, W.B. Buying Green. Department of Urban Studies and Planning and the Center for Real Estate. Cambridge, MA Massachusetts Institute of Technology. MSRED and MCP, 2006.


The author is grateful for support from the Tulane School of Architecture’s Dean’s Fund for Excellence, the National Science Foundation Graduate Research Fellowship, and the Massachusetts Institute of Technology.

William B. Bradshaw II, Green Coast Enterprises, LLC and Tulane University, New Orleans, LA 70119 or will@greencoastenterprises.com.
Sustainability and Graduate Business Education: An Analysis of the Need, Best Efforts to Date, and Curriculum Recommendations

Author Marnie L. Abramson

Abstract This paper examines the current state of green education by identifying the top graduate business programs that offer high quality education, relevant coursework, and sustainable campus-wide operations. The paper brings to light a strong need for more comprehensive and integrated coursework within the core curriculum of our nation’s top programs. The paper provides the opportunity for enhanced thought leadership by introducing a series of four classes that represent a cross-section of the most important concepts of sustainability.

Business, Education, and Sustainability

This paper is an examination of graduate business schools and the institutions that house them as a means of opening a conversation on what an integrated, systems-based, sustainable business education should look like. In order to provide a framework for discussion, three well-established, public sources were selected to examine the following: (1) business schools that were pre-determined to offer students a top quality education; (2) business schools that offer access to coursework and faculty producing research on sustainability; and (3) universities that rank highly in terms of sustainable campus-wide operations, as a means of providing proof of concept and an experiential, hands-on opportunity to compliment the theory of traditional coursework. These sources were combined using a weighted average (equal distribution) to produce a list of 14 programs that are at least attempting to take a systems-wide approach to sustainability, and have the market credibility to promote these practices.

Sources of Information

The first source is the 2009 Bloomberg Businessweek’s Business School Rankings and Profiles. This well-respected and often-cited source uses 12 criteria to determine the final ranking of the top MBA programs on an annual basis. Detailed responses to each of these criteria, as well as the Top 30 business schools, and a partial list of second-tier schools, can be found in Exhibit 1.

The second source is the Global 100: Preparing MBAs for Social and Environmental Stewardship published by the Aspen Institute, which examines the
### Exhibit 1 | 2009 Businessweek Rankings of Top MBA Programs

<table>
<thead>
<tr>
<th>Rank</th>
<th>School</th>
<th>Grad Poll</th>
<th>Corp Poll</th>
<th>Intel Cap</th>
<th>Tuition &amp; Fees</th>
<th>Pre-MBA $ (000)</th>
<th>Post-MBA $ (000)</th>
<th>Selectivity</th>
<th>Job Offers</th>
<th>Gen Mgmt</th>
<th>Analysis</th>
<th>Teaching</th>
<th>Careers</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Chicago (Booth)</td>
<td>1</td>
<td>2</td>
<td>6</td>
<td>97,165</td>
<td>78.0</td>
<td>105.0</td>
<td>22</td>
<td>94.8</td>
<td>A+</td>
<td>A+</td>
<td>A+</td>
<td>A+</td>
</tr>
<tr>
<td>2</td>
<td>Harvard</td>
<td>4</td>
<td>4</td>
<td>9</td>
<td>101,660</td>
<td>77.0</td>
<td>121.0</td>
<td>12</td>
<td>100.0</td>
<td>A+</td>
<td>A+</td>
<td>A</td>
<td>A+</td>
</tr>
<tr>
<td>3</td>
<td>Northwestern (Kellogg)</td>
<td>6</td>
<td>1</td>
<td>25</td>
<td>93,918</td>
<td>75.0</td>
<td>110.0</td>
<td>20</td>
<td>97.0</td>
<td>A+</td>
<td>A+</td>
<td>B</td>
<td>A+</td>
</tr>
<tr>
<td>4</td>
<td>Pennsylvania (Wharton)</td>
<td>3</td>
<td>5</td>
<td>11</td>
<td>100,860</td>
<td>80.0</td>
<td>120.0</td>
<td>18</td>
<td>95.6</td>
<td>A+</td>
<td>A+</td>
<td>B</td>
<td>A+</td>
</tr>
<tr>
<td>5</td>
<td>Michigan (Ross)</td>
<td>10</td>
<td>3</td>
<td>12</td>
<td>90,879</td>
<td>63.5</td>
<td>105.0</td>
<td>20</td>
<td>95.9</td>
<td>A+</td>
<td>A</td>
<td>B</td>
<td>A</td>
</tr>
<tr>
<td>6</td>
<td>Stanford</td>
<td>2</td>
<td>9</td>
<td>2</td>
<td>97,842</td>
<td>75.0</td>
<td>125.0</td>
<td>8</td>
<td>96.7</td>
<td>A+</td>
<td>A+</td>
<td>B</td>
<td>A+</td>
</tr>
<tr>
<td>7</td>
<td>Columbia</td>
<td>7</td>
<td>6</td>
<td>8</td>
<td>94,104</td>
<td>75.0</td>
<td>110.0</td>
<td>15</td>
<td>94.2</td>
<td>A</td>
<td>A+</td>
<td>A</td>
<td>A+</td>
</tr>
<tr>
<td>8</td>
<td>Duke (Fuqua)</td>
<td>13</td>
<td>7</td>
<td>1</td>
<td>95,000</td>
<td>65.0</td>
<td>100.0</td>
<td>30</td>
<td>94.9</td>
<td>A+</td>
<td>A</td>
<td>A</td>
<td>A</td>
</tr>
<tr>
<td>9</td>
<td>MIT (Sloan)</td>
<td>5</td>
<td>8</td>
<td>14</td>
<td>93,568</td>
<td>70.0</td>
<td>116.0</td>
<td>15</td>
<td>96.2</td>
<td>B</td>
<td>A+</td>
<td>B</td>
<td>A</td>
</tr>
<tr>
<td>10</td>
<td>UC–Berkeley (Haas)</td>
<td>8</td>
<td>11</td>
<td>5</td>
<td>84,055</td>
<td>78.0</td>
<td>110.0</td>
<td>12</td>
<td>94.4</td>
<td>A+</td>
<td>A+</td>
<td>B</td>
<td>A</td>
</tr>
<tr>
<td>11</td>
<td>Cornell (Johnson)</td>
<td>15</td>
<td>10</td>
<td>13</td>
<td>93,000</td>
<td>68.0</td>
<td>96.5</td>
<td>19</td>
<td>95.0</td>
<td>A</td>
<td>A</td>
<td>A+</td>
<td>A+</td>
</tr>
<tr>
<td>12</td>
<td>Dartmouth (Tuck)</td>
<td>11</td>
<td>16</td>
<td>7</td>
<td>91,905</td>
<td>65.0</td>
<td>115.0</td>
<td>16</td>
<td>95.0</td>
<td>A</td>
<td>B</td>
<td>A+</td>
<td>A+</td>
</tr>
<tr>
<td>13</td>
<td>NYU (Stern)</td>
<td>12</td>
<td>13</td>
<td>17</td>
<td>89,184</td>
<td>65.0</td>
<td>95.0</td>
<td>15</td>
<td>94.4</td>
<td>B</td>
<td>A</td>
<td>B</td>
<td>A</td>
</tr>
<tr>
<td>14</td>
<td>UCLA (Anderson)</td>
<td>18</td>
<td>18</td>
<td>4</td>
<td>77,126</td>
<td>65.0</td>
<td>100.0</td>
<td>20</td>
<td>91.8</td>
<td>A</td>
<td>A</td>
<td>B</td>
<td>B</td>
</tr>
<tr>
<td>15</td>
<td>Indiana (Kelley)</td>
<td>9</td>
<td>19</td>
<td>27</td>
<td>76,440</td>
<td>44.0</td>
<td>92.0</td>
<td>34</td>
<td>96.2</td>
<td>B</td>
<td>A+</td>
<td>A+</td>
<td>A</td>
</tr>
<tr>
<td>16</td>
<td>Virginia (Darden)</td>
<td>14</td>
<td>12</td>
<td>38</td>
<td>94,000</td>
<td>63.0</td>
<td>100.0</td>
<td>25</td>
<td>94.4</td>
<td>A+</td>
<td>A</td>
<td>A+</td>
<td>A</td>
</tr>
<tr>
<td>17</td>
<td>UNC (Kenan-Flagler)</td>
<td>17</td>
<td>14</td>
<td>19</td>
<td>81,401</td>
<td>60.0</td>
<td>95.0</td>
<td>34</td>
<td>96.0</td>
<td>A</td>
<td>B</td>
<td>A+</td>
<td>B</td>
</tr>
<tr>
<td>18</td>
<td>SMU (Cox)</td>
<td>21</td>
<td>17</td>
<td>37</td>
<td>81,384</td>
<td>50.0</td>
<td>90.0</td>
<td>36</td>
<td>83.7</td>
<td>B</td>
<td>B</td>
<td>A+</td>
<td>A</td>
</tr>
</tbody>
</table>
### Exhibit 1 (continued)

2009 Businessweek Rankings of Top MBA Programs

<table>
<thead>
<tr>
<th>Rank</th>
<th>School</th>
<th>Grad Poll</th>
<th>Corp Poll</th>
<th>Intel Cap</th>
<th>Tuition &amp; Fees</th>
<th>Pre-MBA $ (000)</th>
<th>Post-MBA $ (000)</th>
<th>Selectivity</th>
<th>Job Offers</th>
<th>Gen Mgmt</th>
<th>Analysis</th>
<th>Teaching</th>
<th>Careers</th>
</tr>
</thead>
<tbody>
<tr>
<td>19</td>
<td>Carnegie Mellon (Tepper)</td>
<td>20</td>
<td>21</td>
<td>23</td>
<td>93,844</td>
<td>58.0</td>
<td>102.0</td>
<td>27</td>
<td>96.5</td>
<td>A</td>
<td>A+</td>
<td>B</td>
<td>A</td>
</tr>
<tr>
<td>20</td>
<td>Notre Dame (Mendoza)</td>
<td>23</td>
<td>20</td>
<td>24</td>
<td>77,340</td>
<td>49.0</td>
<td>93.5</td>
<td>34</td>
<td>89.9</td>
<td>B</td>
<td>C</td>
<td>A+</td>
<td>A</td>
</tr>
<tr>
<td>21</td>
<td>Texas–Austin (McCombs)</td>
<td>22</td>
<td>22</td>
<td>15</td>
<td>81,400</td>
<td>65.0</td>
<td>95.0</td>
<td>27</td>
<td>92.9</td>
<td>A</td>
<td>A</td>
<td>B</td>
<td>A</td>
</tr>
<tr>
<td>22</td>
<td>Brigham Young (Marriott)</td>
<td>27</td>
<td>15</td>
<td>41</td>
<td>37,010</td>
<td>50.0</td>
<td>90.0</td>
<td>56</td>
<td>93.9</td>
<td>A</td>
<td>A</td>
<td>A</td>
<td>B</td>
</tr>
<tr>
<td>23</td>
<td>Emory (Goizueta)</td>
<td>16</td>
<td>30</td>
<td>28</td>
<td>82,856</td>
<td>57.0</td>
<td>95.0</td>
<td>29</td>
<td>85.8</td>
<td>A</td>
<td>B</td>
<td>A</td>
<td>B</td>
</tr>
<tr>
<td>24</td>
<td>Yale</td>
<td>19</td>
<td>33</td>
<td>10</td>
<td>93,098</td>
<td>55.0</td>
<td>97.0</td>
<td>14</td>
<td>94.1</td>
<td>C</td>
<td>C</td>
<td>A+</td>
<td>B</td>
</tr>
<tr>
<td>25</td>
<td>USC (Marshall)</td>
<td>25</td>
<td>25</td>
<td>31</td>
<td>88,800</td>
<td>60.0</td>
<td>95.0</td>
<td>23</td>
<td>79.1</td>
<td>A</td>
<td>A</td>
<td>C</td>
<td>B</td>
</tr>
<tr>
<td>26</td>
<td>Maryland (Smith)</td>
<td>28</td>
<td>42</td>
<td>3</td>
<td>82,435</td>
<td>53.0</td>
<td>91.0</td>
<td>28</td>
<td>92.0</td>
<td>C</td>
<td>C</td>
<td>B</td>
<td>B</td>
</tr>
<tr>
<td>27</td>
<td>U. of Washington (Foster)</td>
<td>30</td>
<td>26</td>
<td>29</td>
<td>64,902</td>
<td>50.0</td>
<td>85.0</td>
<td>30</td>
<td>83.0</td>
<td>B</td>
<td>B</td>
<td>B</td>
<td>B</td>
</tr>
<tr>
<td>28</td>
<td>Washington University (Olin)</td>
<td>24</td>
<td>41</td>
<td>16</td>
<td>82,672</td>
<td>50.0</td>
<td>90.0</td>
<td>34</td>
<td>95.7</td>
<td>C</td>
<td>C</td>
<td>A</td>
<td>B</td>
</tr>
<tr>
<td>29</td>
<td>Georgia Tech</td>
<td>31</td>
<td>28</td>
<td>26</td>
<td>64,152</td>
<td>55.0</td>
<td>95.0</td>
<td>29</td>
<td>100.0</td>
<td>B</td>
<td>A</td>
<td>B</td>
<td>B</td>
</tr>
<tr>
<td>30</td>
<td>Vanderbilt (Owen)</td>
<td>29</td>
<td>27</td>
<td>39</td>
<td>81,076</td>
<td>57.0</td>
<td>91.0</td>
<td>36</td>
<td>85.7</td>
<td>B</td>
<td>B</td>
<td>A</td>
<td>B</td>
</tr>
<tr>
<td>2nd Tier</td>
<td>Arizona State (Carey)</td>
<td>35</td>
<td>40</td>
<td>34</td>
<td>59,208</td>
<td>45.0</td>
<td>83.0</td>
<td>24</td>
<td>81.6</td>
<td>A</td>
<td>B</td>
<td>B</td>
<td>B</td>
</tr>
<tr>
<td>2nd Tier</td>
<td>Boston U.</td>
<td>36</td>
<td>43</td>
<td>40</td>
<td>73,996</td>
<td>50.0</td>
<td>90.0</td>
<td>28</td>
<td>83.9</td>
<td>B</td>
<td>B</td>
<td>A</td>
<td>C</td>
</tr>
<tr>
<td>2nd Tier</td>
<td>George Washington</td>
<td>43</td>
<td>31</td>
<td>44</td>
<td>65,550</td>
<td>47.5</td>
<td>80.0</td>
<td>39</td>
<td>85.4</td>
<td>C</td>
<td>C</td>
<td>C</td>
<td>C</td>
</tr>
<tr>
<td>2nd Tier</td>
<td>Georgetown (McDonough)</td>
<td>26</td>
<td>38</td>
<td>42</td>
<td>83,868</td>
<td>55.0</td>
<td>95.0</td>
<td>30</td>
<td>93.3</td>
<td>C</td>
<td>C</td>
<td>C</td>
<td>B</td>
</tr>
<tr>
<td>2nd Tier</td>
<td>Thunderbird</td>
<td>38</td>
<td>23</td>
<td>45</td>
<td>78,255</td>
<td>45.0</td>
<td>85.0</td>
<td>75</td>
<td>71.7</td>
<td>A</td>
<td>B</td>
<td>C</td>
<td>C</td>
</tr>
</tbody>
</table>
extent to which MBA programs incorporate social and environmental issues in their curriculum. The report then published rankings based on four criteria: (1) availability of relevant coursework; (2) student exposure (the extent to which students are actually taking the referenced courses); (3) relevant courses on for-profit impact (roll of business in improving environmental conditions; and (4) faculty research. The list and rank of U.S. schools who qualified for this study can be found in the Exhibit 2. A complete list of all 100 schools can be found at www.beyondgreypinstripes.org/rankings.

The third source is the College Sustainability Report Card. This report is published annually by the Sustainable Endowments Institute, and covers the colleges and universities with the 300 largest endowments in the U.S. and Canada, as well as 32 other schools that applied for inclusion. As a contrast to the other two ranking systems, the Report Card does not focus on academic or research programs related to sustainability, it examines the behavior of the university through the lens of sustainability. A partial list of these schools and their rankings can be found in Exhibit 3. Details on their methodology and individual school rankings can be found at: www.greenreportcard.org/report-card-2010/methodology.

Culling the Performance Data

Each source was given an equal weight of 33.3%. This determination was based on the desire to recognize excellence among programs that may not currently be top ranked by the business community, but are making aggressive moves in within their programs and universities to elevate their status and ranking. Therefore graduate business programs ranked in the second tier as determined by Businessweek, but show excellence in programming, research, and operations have the opportunity to showcase those efforts by scoring highly in those categories, and elevating their rankings for this list.

In order to be considered, programs met all of the following criteria: (1) Received a ranking by all three institutions (meaning schools are either a first or second tier graduate business program, and they offer meaningful coursework on sustainability, and the campus provides a living laboratory to experience some of these socially responsible actions); (2) Received a combined average of score of 100 or less (meaning the program averages in the top third in each category); and (3) Received a grade of B or higher as their average GPA on the College Sustainability Report Card (meaning they are slightly above the national average in implementing campus wide sustainable operations.)

After inputting that criteria, there were 14 business schools that remained: Stanford University, University of Michigan (Ross), Yale University, University of North Carolina–Charlotte (Kenan-Flagler), Columbia University, Duke University (Fuqua), University of California–Berkeley (Haas), New York University (Stern), Cornell University (Johnson), University of Notre Dame (Mendoza), Dartmouth College (Tuck), George Washington University, Carnegie Mellon University(Tepper), and Massachusetts Institute of Technology (Sloan).
### Exhibit 2 | Aspen Institute’s List of Global 100 Sustainable MBA Programs

<table>
<thead>
<tr>
<th>Rank</th>
<th>School</th>
<th>Relevant Courses</th>
<th>Student Exposure</th>
<th>For-Profit Impact</th>
<th>Faculty Research</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>U. of Michigan (Ross)</td>
<td>8</td>
<td>23</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>2</td>
<td>Yale School of Management</td>
<td>3</td>
<td>4</td>
<td>4</td>
<td>16</td>
</tr>
<tr>
<td>3</td>
<td>Stanford</td>
<td>2</td>
<td>14</td>
<td>2</td>
<td>18</td>
</tr>
<tr>
<td>4</td>
<td>Notre Dame (Mendoza)</td>
<td>4</td>
<td>5</td>
<td>14</td>
<td>3</td>
</tr>
<tr>
<td>6</td>
<td>UC Berkeley (Haas)</td>
<td>7</td>
<td>31</td>
<td>5</td>
<td>4</td>
</tr>
<tr>
<td>7</td>
<td>NYU (Stern)</td>
<td>5</td>
<td>10</td>
<td>14</td>
<td>29</td>
</tr>
<tr>
<td>8</td>
<td>Columbia Business School</td>
<td>11</td>
<td>59</td>
<td>7</td>
<td>13</td>
</tr>
<tr>
<td>9</td>
<td>U. of Virginia (Darden)</td>
<td>31</td>
<td>61</td>
<td>7</td>
<td>5</td>
</tr>
<tr>
<td>10</td>
<td>Cornell (Johnson)</td>
<td>13</td>
<td>36</td>
<td>7</td>
<td>23</td>
</tr>
<tr>
<td>11</td>
<td>GWU School of Business</td>
<td>5</td>
<td>42</td>
<td>23</td>
<td>26</td>
</tr>
<tr>
<td>12</td>
<td>UNC (Kenan-Flagler)</td>
<td>16</td>
<td>44</td>
<td>2</td>
<td>55</td>
</tr>
<tr>
<td>13</td>
<td>Simmons</td>
<td>33</td>
<td>2</td>
<td>32</td>
<td>24</td>
</tr>
<tr>
<td>14</td>
<td>Duke (Fuqua)</td>
<td>14</td>
<td>49</td>
<td>14</td>
<td>20</td>
</tr>
<tr>
<td>15</td>
<td>Wisconsin-Madison</td>
<td>14</td>
<td>8</td>
<td>10</td>
<td>68</td>
</tr>
<tr>
<td>16</td>
<td>Duquesne (Donahue)</td>
<td>10</td>
<td>54</td>
<td>14</td>
<td>42</td>
</tr>
<tr>
<td>17</td>
<td>U. of New Mexico</td>
<td>45</td>
<td>27</td>
<td>14</td>
<td>20</td>
</tr>
<tr>
<td>18</td>
<td>U. of Denver (Daniels)</td>
<td>27</td>
<td>13</td>
<td>23</td>
<td>49</td>
</tr>
<tr>
<td>19</td>
<td>U. of San Diego</td>
<td>37</td>
<td>22</td>
<td>6</td>
<td>68</td>
</tr>
<tr>
<td>20</td>
<td>Loyola</td>
<td>16</td>
<td>50</td>
<td>42</td>
<td>24</td>
</tr>
<tr>
<td>21</td>
<td>Ohio State (Fisher)</td>
<td>23</td>
<td>43</td>
<td>32</td>
<td>34</td>
</tr>
<tr>
<td>22</td>
<td>Portland State</td>
<td>52</td>
<td>33</td>
<td>10</td>
<td>42</td>
</tr>
<tr>
<td>23</td>
<td>Babson (Olin)</td>
<td>29</td>
<td>28</td>
<td>32</td>
<td>41</td>
</tr>
<tr>
<td>24</td>
<td>San Francisco State</td>
<td>33</td>
<td>34</td>
<td>23</td>
<td>55</td>
</tr>
<tr>
<td>25</td>
<td>UC Davis</td>
<td>26</td>
<td>32</td>
<td>14</td>
<td>102</td>
</tr>
<tr>
<td>26</td>
<td>Georgetown (McDonough)</td>
<td>36</td>
<td>58</td>
<td>42</td>
<td>34</td>
</tr>
<tr>
<td>35</td>
<td>Dartmouth (Tuck)</td>
<td>23</td>
<td>75</td>
<td>23</td>
<td>96</td>
</tr>
<tr>
<td>38</td>
<td>Carnegie Mellon (Tepper)</td>
<td>45</td>
<td>9</td>
<td>71</td>
<td>85</td>
</tr>
<tr>
<td>39</td>
<td>Boston U. School of Management</td>
<td>69</td>
<td>102</td>
<td>14</td>
<td>42</td>
</tr>
<tr>
<td>40</td>
<td>Northwestern (Kellogg)</td>
<td>39</td>
<td>98</td>
<td>32</td>
<td>59</td>
</tr>
<tr>
<td>57</td>
<td>Arizona State (W.P. Carey)</td>
<td>72</td>
<td>46</td>
<td>103</td>
<td>12</td>
</tr>
<tr>
<td>43</td>
<td>Thunderbird School of Global Management</td>
<td>37</td>
<td>87</td>
<td>51</td>
<td>59</td>
</tr>
<tr>
<td>46</td>
<td>U. of Southern California (Marshall)</td>
<td>52</td>
<td>109</td>
<td>51</td>
<td>38</td>
</tr>
<tr>
<td>56</td>
<td>Vanderbilt</td>
<td>45</td>
<td>101</td>
<td>71</td>
<td>55</td>
</tr>
<tr>
<td>60</td>
<td>Massachusetts Institute of Tech. (Sloan)</td>
<td>33</td>
<td>77</td>
<td>32</td>
<td>134</td>
</tr>
<tr>
<td>67</td>
<td>U. of Maryland (Smith)</td>
<td>58</td>
<td>84</td>
<td>71</td>
<td>115</td>
</tr>
</tbody>
</table>
### Exhibit 3  | College Sustainability Report Card Grades by University

<table>
<thead>
<tr>
<th>Overall Grade</th>
<th>Climate Change &amp; Energy</th>
<th>Food &amp; Recycling</th>
<th>Green Building</th>
<th>Student Involvement</th>
<th>Transportation</th>
<th>Endowment Transparency</th>
<th>Investment Priorities</th>
<th>Shareholder Engagement</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Univ. of Chicago</strong></td>
<td>C</td>
<td>C</td>
<td>C</td>
<td>B</td>
<td>D</td>
<td>C</td>
<td>A</td>
<td>F</td>
</tr>
<tr>
<td><strong>Harvard University</strong></td>
<td>A-</td>
<td>A</td>
<td>A</td>
<td>A</td>
<td>B</td>
<td>B</td>
<td>A</td>
<td>C</td>
</tr>
<tr>
<td><strong>Northwestern</strong></td>
<td>B-</td>
<td>C</td>
<td>C</td>
<td>A</td>
<td>A</td>
<td>B</td>
<td>B</td>
<td>D</td>
</tr>
<tr>
<td><strong>Univ. of Pennsylvania</strong></td>
<td>A-</td>
<td>B</td>
<td>A</td>
<td>A</td>
<td>B</td>
<td>A</td>
<td>A</td>
<td>C</td>
</tr>
<tr>
<td><strong>Univ. of Michigan</strong></td>
<td>B+</td>
<td>B</td>
<td>B</td>
<td>A</td>
<td>B</td>
<td>B</td>
<td>A</td>
<td>A</td>
</tr>
<tr>
<td><strong>Stanford University</strong></td>
<td>A-</td>
<td>A</td>
<td>B</td>
<td>A</td>
<td>A</td>
<td>A</td>
<td>A</td>
<td>F</td>
</tr>
<tr>
<td><strong>Columbia University</strong></td>
<td>B</td>
<td>B</td>
<td>C</td>
<td>B</td>
<td>B</td>
<td>B</td>
<td>B</td>
<td>A</td>
</tr>
<tr>
<td><strong>Duke University</strong></td>
<td>B+</td>
<td>A</td>
<td>A</td>
<td>A</td>
<td>A</td>
<td>A</td>
<td>A</td>
<td>F</td>
</tr>
<tr>
<td><strong>MIT</strong></td>
<td>B+</td>
<td>B</td>
<td>B</td>
<td>A</td>
<td>A</td>
<td>A</td>
<td>A</td>
<td>F</td>
</tr>
<tr>
<td><strong>UC Berkeley</strong></td>
<td>B</td>
<td>A</td>
<td>A</td>
<td>A</td>
<td>B</td>
<td>A</td>
<td>B</td>
<td>C</td>
</tr>
<tr>
<td><strong>Cornell University</strong></td>
<td>B</td>
<td>A</td>
<td>B</td>
<td>B</td>
<td>C</td>
<td>B</td>
<td>B</td>
<td>A</td>
</tr>
<tr>
<td><strong>Dartmouth College</strong></td>
<td>B+</td>
<td>B</td>
<td>A</td>
<td>A</td>
<td>B</td>
<td>A</td>
<td>B</td>
<td>B</td>
</tr>
<tr>
<td><strong>New York University</strong></td>
<td>B</td>
<td>A</td>
<td>A</td>
<td>A</td>
<td>B</td>
<td>A</td>
<td>A</td>
<td>D</td>
</tr>
<tr>
<td><strong>UC Los Angeles</strong></td>
<td>B</td>
<td>A</td>
<td>B</td>
<td>A</td>
<td>B</td>
<td>A</td>
<td>A</td>
<td>B</td>
</tr>
<tr>
<td><strong>Indiana University</strong></td>
<td>B-</td>
<td>B</td>
<td>B</td>
<td>B</td>
<td>C</td>
<td>A</td>
<td>C</td>
<td>C</td>
</tr>
<tr>
<td><strong>Univ. of Virginia</strong></td>
<td>B-</td>
<td>A</td>
<td>B</td>
<td>A</td>
<td>B</td>
<td>A</td>
<td>A</td>
<td>F</td>
</tr>
<tr>
<td><strong>UNC Chapel Hill</strong></td>
<td>A-</td>
<td>A</td>
<td>A</td>
<td>A</td>
<td>A</td>
<td>A</td>
<td>A</td>
<td>D</td>
</tr>
<tr>
<td><strong>Southern Methodist</strong></td>
<td>C+</td>
<td>C</td>
<td>C</td>
<td>B</td>
<td>B</td>
<td>B</td>
<td>A</td>
<td>F</td>
</tr>
</tbody>
</table>
### Exhibit 3 (continued)

College Sustainability Report Card Grades by University

<table>
<thead>
<tr>
<th>Overall Grade</th>
<th>Admin</th>
<th>Climate Change &amp; Energy</th>
<th>Food &amp; Recycling</th>
<th>Green Building</th>
<th>Student Involvement</th>
<th>Transportation</th>
<th>Endowment Transparency</th>
<th>Investment Priorities</th>
<th>Shareholder Engagement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Carnegie Mellon</td>
<td>B</td>
<td>C</td>
<td>A</td>
<td>A</td>
<td>A</td>
<td>A</td>
<td>D</td>
<td>A</td>
<td>D</td>
</tr>
<tr>
<td>Univ. of Notre Dame</td>
<td>B</td>
<td>A</td>
<td>B</td>
<td>B</td>
<td>A</td>
<td>B</td>
<td>D</td>
<td>A</td>
<td>C</td>
</tr>
<tr>
<td>Univ. of Texas, Austin</td>
<td>B−</td>
<td>B</td>
<td>A</td>
<td>B</td>
<td>B</td>
<td>A</td>
<td>A</td>
<td>A</td>
<td>C</td>
</tr>
<tr>
<td>Brigham Young</td>
<td>D−</td>
<td>F</td>
<td>F</td>
<td>D</td>
<td>F</td>
<td>F</td>
<td>F</td>
<td>C</td>
<td>F</td>
</tr>
<tr>
<td>Emory</td>
<td>B</td>
<td>A</td>
<td>C</td>
<td>A</td>
<td>A</td>
<td>A</td>
<td>C</td>
<td>A</td>
<td>F</td>
</tr>
<tr>
<td>Yale</td>
<td>A−</td>
<td>A</td>
<td>A</td>
<td>A</td>
<td>A</td>
<td>A</td>
<td>D</td>
<td>A</td>
<td>A</td>
</tr>
<tr>
<td>Univ. of So. Cal</td>
<td>C+</td>
<td>B</td>
<td>D</td>
<td>B</td>
<td>D</td>
<td>B</td>
<td>A</td>
<td>F</td>
<td>A</td>
</tr>
<tr>
<td>Maryland</td>
<td>B+</td>
<td>A</td>
<td>B</td>
<td>A</td>
<td>A</td>
<td>A</td>
<td>A</td>
<td>F</td>
<td>F</td>
</tr>
<tr>
<td>Vanderbilt</td>
<td>C+</td>
<td>B</td>
<td>C</td>
<td>B</td>
<td>B</td>
<td>A</td>
<td>B</td>
<td>F</td>
<td>A</td>
</tr>
<tr>
<td>Arizona State</td>
<td>A−</td>
<td>A</td>
<td>A</td>
<td>A</td>
<td>A</td>
<td>A</td>
<td>B</td>
<td>C</td>
<td>F</td>
</tr>
<tr>
<td>Boston University</td>
<td>B</td>
<td>B</td>
<td>D</td>
<td>A</td>
<td>B</td>
<td>A</td>
<td>A</td>
<td>C</td>
<td>A</td>
</tr>
<tr>
<td>Georgetown</td>
<td>B</td>
<td>B</td>
<td>A</td>
<td>B</td>
<td>B</td>
<td>C</td>
<td>D</td>
<td>A</td>
<td>A</td>
</tr>
<tr>
<td>George Washington</td>
<td>B</td>
<td>A</td>
<td>B</td>
<td>A</td>
<td>A</td>
<td>F</td>
<td>A</td>
<td>F</td>
<td>F</td>
</tr>
<tr>
<td>Thunderbird</td>
<td>n/a</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Beyond the Rankings: Key Program Highlights

Although the list of 14 business schools represents an unscientific ranking of the top programs in the U.S., it does provide a manageable framework within which to examine (despite their high performance across a multitude of independent sources and rankings) whether these schools are actually meeting the needs of today’s young leaders and preparing them for the kind of comprehensive, integrated, and dynamic challenges they will face in a global business environment over the next few decades where sustainability will become (if it is not already) a key driver of operations and value. This next section provides an overview of what sets these 14 programs apart and lays another level of foundation for the discussion on whether educational institutions are integrating sustainability into core curriculum coursework effectively, ultimately positioning their graduates for success.

Stanford University Graduate School of Business

Stanford University is considered the number six business school in the country by *Businessweek*. The Aspen Institute ranked them the number two business school in the world in terms of relevant coursework in sustainability, as well as the application of those courses in a for-profit environment. Stanford earned an A– from the Sustainable Endowment Institute, recognizing them as an Overall College Sustainability Leader. They received marks of excellence for Green Buildings and Investment Priorities, among others.

In 2007, Stanford radically re-worked their MBA curriculum in four key ways: 1) eliminating course requirements, using placement exams and faculty advisors to create an individual study plan for each student; sometimes in classes with as few as ten students; (2) using an integrated systems-approach to learning, courses do not focus on a single discipline but encourage analysis of an issue that transcends any single function of management, such as alleviating global poverty; (3) exposure to cultural diversity by completing either an international internship, an overseas learning trip, or a student exchange program; and (4) capstone project examining a student's strengths and weaknesses within the business environment, honing their communication skills through self-evaluation.

In January of 2010, Stanford Business School launched the “Social-M Challenge,” a social-movement business plan competition designed to inspire sustainability-themed behavior change within a local or global environment.

Within the Business School, the Center for Social Innovation offers an MBA/Public Management Program designed to build knowledge in sustainable business practices and social entrepreneurship (among other areas), as well as the role of these sectors in creating social and environmental value. They also offer a joint MBA/MS degree in environmental sciences.

Stanford Business School has a $350 million campus under construction that is expected to deliver in 2011, and designed to earn a LEED Platinum certification from the U.S. Green Building Council.
One interesting elective course from their curriculum that focuses on sustainability and the for-profit world within the context of marketing is (MKTG 551) Initiating, Sustaining, & Monetizing Green Marketing, offered through the Department of Environmental Management. Their website Sustainable Stanford offers a report card on how Stanford is performing in twelve categories of environmental stewardship.

University of Michigan, Stephen M. Ross School of Business

The Ross School of Business is ranked as the number five business school in the country by Businessweek, and number one on the Global 100 list of sustainable MBA programs. In terms of their for-profit impact, integrating sustainability into traditional business settings, they are also number one out of 590 globally ranked programs. They received a grade of B+ on their campus-wide sustainability initiatives with excellence in their investment priorities, and a B in terms of green buildings.

Their partnership with the School of Natural Resources offers a three-year dual MBA/MS degree focused on Global Sustainable Enterprise. Ross Business School has also been named Net Impact Chapter of the Year in 2007, 2008, and 2009. Ross graduate students won for their initiative to make all food scraps, utensils, cups, plates, and bowls purchased at the Ross Cafeteria 100% compostable—diverting up to 50% of the waste that would have otherwise gone to a landfill, as well as for instituting green building standards for the university to reduce the environmental footprint of all new building construction and major renovations on campus.

One notable elective program from their dual degree program is STRAT 564/SNRE 513: Competitive Environmental Strategy. “This course deals with environmental issues from a strategic perspective, focusing on how environmental pressures (e.g., sustainable development) and environmental problems (e.g., global warming, air pollution, waste disposal) impact corporate mission, competitive strategy, technology choices, product development decisions, and production process.”

Yale University, School of Management

Yale School of Management (SOM) is ranked number 24 by Businessweek, and second in the Global 100 list. The School of Management ranked third globally for the number of relevant courses on sustainability, and fourth for the number of students who take those programs, and for those course's for-profit impact. Their overall GPA of A— on the Sustainable Report Card also makes them an Overall College Sustainability Leader. Yale received straight A’s in eight out of nine total categories on the Report Card, making their campus initiatives the most comprehensive of any schools examined in this study.

SOM integrates social and environmental considerations into the majority of their curriculum, studying programs such as GE’s Ecomagination Initiative, as well as creating their own multi-media case studies such as “Giving Voice to Values,”
a curriculum initiative created for the Aspen Institute’s Center for Business Education Business Leadership Case Study Competition.\textsuperscript{13}

Yale SOM’s Net Impact Chapter was Chapter of the Year in 2005, and an award winner in 2007 for their (now) annual fundraising initiative to buy Renewable Energy Credits (RECs) to offset the schools carbon footprint. In 2008, the school won Philadelphia’s Green Economy Case Competition with their concept to create green jobs by initiating a “Philly Fund” credit card that would direct 1% of the net transactions to a business incubator that would provide start-up money to promising local start ups that are focused on “People, Planet, Profit.”\textsuperscript{14}

One interesting course from their elective curriculum is called Energy, Economics, and the Environment.

University of North Carolina, Chapel Hill, Kenan-Flagler Business School

Kenan-Flagler Business School is ranked number 17 by \textit{Businessweek}, and number 12 on the list of Global 100 graduate business schools. Their course work is ranked second in terms of its for-profit impact, and 16\textsuperscript{th} in terms of the number of courses that are available to students. They received an overall grade of A– on the Sustainability Report Card, making them an Overall College Sustainability Leader. They received seven A’s for their on-campus initiatives.

Innovative programs at Kenan-Flagler include the National Sustainable Investment Competition, launched in 2003 by their Net Impact Club. This annual competition gives students from top business schools real-world venture capital experience as well as an awareness of double or triple bottom line valuation techniques.\textsuperscript{15} The Business Accelerator for Sustainable Entrepreneurship (BASE) business incubator is designed to help speed the growth of companies addressing financial profitability, social equity, and environmental sustainability.\textsuperscript{16} Since 1998, they have also hosted an annual Sustainable Business Career Fair, which focuses on recruitment by organizations specifically looking to fill positions or internships at socially responsible organizations.\textsuperscript{17}

Columbia University, Columbia Business School

Columbia Business School is ranked number seven by \textit{Businessweek}, and number eight on the Global 100 list. Their faculty research on issues related to sustainability is ranked fifth globally, and their for-profit impact is ranked seventh. Their overall sustainability grade related to campus initiatives is a B, and though they received a grade of C on their climate and energy initiatives, all other scores were a B or above.

The Individual, Business and Society (IBS) curriculum attempts to focus students on the competing demands of businesses, individuals, and society. Some specific non-curriculum activities include the Global Social Venture Competition, which is a partnership between Columbia Business School, Hass School of Business, the London Business School, and the Indian School of Business, which promotes ventures that measure both social and financial returns.\textsuperscript{18}
Columbia has a Social Enterprise program that initiates summer internships with for-profit and not-for-profit organizations with a focus on sustainability. The Eugene Lang Entrepreneurship Center has funded socially conscious business ventures from graduates such as the Mamatini, a bottled organic, herbal infused drink to help nursing mothers increase their energy and breast milk supply. The Chazen Institute of International Business supports study trips with students and faculty members that have a corporate social responsibility and international development focus, and the Paul Milstein Center for Real Estate has supported winning business plans that address urban renewal and community development issues.

**Duke University, Fuqua School of Business**

The Fuqua School of Business is ranked number eight by *Businessweek* and number 14 on the list of Global 100 sustainable MBA programs. They rank 14th globally for both the number of relevant courses on sustainability, as well as the for-profit impact of those courses. They rank 49th in terms of the number of students actually taking those programs, and 55th in terms of faculty research. Duke received an overall grade of B+ from the College Sustainability Report Card. They received seven A grades, but their F in Endowment Transparency and B in Shareholder Engagement brought their overall average down below the level needed to be a Sustainability Leader.

One of the more interesting initiatives at Fuqua is the Big Think program, which is an online forum where people can share their thoughts and ideas in any type of media. The site includes interviews with subject experts and thought leaders, as well as student initiatives from the Net Impact club and other groups. Big Think then connects to various social networks like YouTube, Facebook, and Twitter, sharing these ideas to the global online community.

Fuqua launched a Corporate Sustainability Initiative (CSI) in 2007. The goal of this program is twofold: develop the theory and practice of corporate sustainability, and educate business professionals on how to implement them. Additionally, the business school participates in the university-wide Nicholas Institute for Environmental Policy Solutions, which engages with public, private, and social sector decision-makers to develop innovative proposals that address critical environmental challenges. Finally, the Center for Energy, Development, and the Global Environment (EDGE) within Duke’s Fuqua School of Business examines issues such as how to meet the global demand for energy, identifying pathways toward sustainable energy systems and economic systems that accelerate market transformations.

One interesting elective course offered through the Department of Corporate Responsibility/Business Ethics is Corporate Social Impact Management.

**University of California at Berkeley, Haas Business School**

The Haas Business School is ranked as the 10th best graduate business program in the country by *Businessweek*, and sixth overall on the list of Global 100
sustainable MBA programs. They are listed fourth in terms of faculty research, fifth in for-profit impact, and seventh in terms of the number of relevant courses offered. However, the number of students actually taking those courses is ranked 31st on the list. In terms of the Sustainability Report Card, Haas received an overall grade of B. Low marks came from the following: a B in both Green Buildings and Transportation, a C in Investment Priorities and Endowment Transparency, and an F in Shareholder Engagement. Still high marks in Climate & Energy, Food & Recycling, and Student Involvement help keep their GPA high enough to make the final list.

In 2010, The Financial Times ranked Haas Business School the number two program globally for Corporate Social Responsibility26 (preceded by Notre Dame’s Mendoza Business School, who also appears on this list.) In 2003, Haas launched the Center for Responsible Business, and this program has seen considerable success in just seven years. According to the Center for Responsible Business’s Biennial Report,27 through 2008 they have launched cutting-edge programs such as Sustainable Products & Solutions. This collaboration from the Haas Business School and the College of Chemistry is possible through a 5-year, $10 million endowment from the Dow Chemical Company. This program has resulted in the development of environmentally safe hand sanitizer, sustainable packaging standards, and arsenic remediation in the drinking water in Bangladesh. It has also led to the development of student fellowships, speaker series’, and teaching seminars.

Other experiential learning programs offered through the Center for Responsible Business include a year-long LifeScan Community Relations Graduate Fellow Program, and a semester long program, McDonald’s CRS Research Fellows, where students develop and help integrate corporate social responsibility initiatives into these organizations. They also have a student-run Socially Responsible Investment Fund. Since its inception this program has published 37 Working Papers on Sustainability.28

The Lawrence Berkeley National Laboratory is an internationally renowned institution that led in early research on Green Buildings, including the landmark 2003 study by Greg Katz, “The Costs and Financial Benefits of Green Buildings,” also works with student teams from the Haas Business School to develop strategies that commercialize their discoveries.

Haas Business School also joined forces with the College of Natural Resources to create the Berkeley Energy Resources Collaborative to work on problems and solutions of energy independence. The new Center for Energy & Environmental Innovation offers interdisciplinary curricula also designed to develop sustainable energy solutions.29

One interesting course from their diverse curricula is Energy and Environmental Markets. Topics include the development and effect of organized spot, futures, and derivative markets in energy; the political economy of deregulation; climate change, environmental impacts, and policies related to energy production and use; privatization of publicly-owned energy assets; market power and antitrust; and the transportation and storage of energy commodities.
New York University, Stern School of Business

Stern School of Business is ranked number 13 by Businessweek for graduate business programs. The Global 100 list of sustainable MBA programs ranks them number seven. Stern is fifth out of 590 international graduate business programs in terms of the number of courses that they offer, and 10th in terms of the number of students that take those courses. Their for-profit impact is 14th on the list, and faculty research is 29th. The College Sustainability Report Card gives New York University an overall grade of B. While they received A’s in six of nine categories, their B in Green Buildings, D in Endowment Transparency, and F in Shareholder Engagement brought down their overall grade point average. However, their A in Investment Priorities indicates a move towards greater on-campus sustainability.

Stern has implemented a Campus Greening Initiative, which led to an A grade in terms of their current and future investment priorities in the Sustainability Report Card.

MBA students have the opportunity to create a concentration in Social Innovation and Impact, which focuses on intersecting corporate wealth creation and corporate social impact, providing social, environmental, and economic perspectives to enhance competition and have a positive impact on the community and environment.

In 2003, Stern launched the Markets, Ethics, and Law Program. A hallmark of the program is the appointment of a distinguished fellow, whom students then interact with frequently throughout the year. One such example is Fred Krupp, President of the Environmental Defense Fund. Additionally, Stern, like many other top business schools, has a student-run Socially Responsible Investment Fund.

In 2009, NYU began offering a Graduate Certificate Program in Sustainable Design, Construction, and Development. Two required courses of this program include Principles of Environmentally Sustainable Design and Managing Sustainable Building Projects. These courses cover issues such as lifecycle costing, rating systems, financial incentives, design, and construction techniques, as well as evaluating and selecting products, construction waste management, and more. One innovative elective course offered at the Stern is Leading Sustainable Enterprises.

Cornell University, Samuel Curtis Johnson Graduate School of Management

The Johnson Graduate School of Management is ranked 11th on Businessweek’s list of top graduate business schools. They are ranked 10th on the list of Global 100 MBA programs, ranking 13th with the number of courses they offer, and 7th in their for-profit impact, but they are 36th in terms of the number of students that are actively engaged in those classes. Faculty research gets a rank of 26 out of 590 schools surveyed. Their overall grade on the College Sustainability Report Card is a B. This is surprising as Cornell’s sustainable programming extends well beyond their business school. Their School of Forestry is considered world-class, and they have an extensive organic garden that provides seasonal produce to the
on-campus dining facilities. Their grades across the board were mostly B’s, with A’s in Administration and Investment Priorities, which offsets their C’s in Green Buildings and Shareholder Engagement.

The School of Management frames the issue of sustainability as an unmet market need that can be addressed through innovation leading to a competitive advantage. This is somewhat of a departure from some other programs that tend to frame the issue more in terms of ethics or corporate social responsibility. Their Center for Sustainable Global Enterprise (SGE) focuses on a systems-based approach to education leveraging all degree programs at the university, in an effort to create a program designed to address complex issues of sustainability using interrelated skills that lead to practical business solutions.31 Their SGE Immersion Program is an optional part of the core MBA program, where, in addition to their core coursework, students engage in field projects to address real problems currently being faced by sponsoring companies.

Additionally the school has partnered with eleven countries to create an expertise in low-income market development and sustainable innovation that addresses the needs of the world’s poorest countries in ways that are both culturally appropriate and environmentally responsible, including working with the US Army and Marine Corps on ways to help rebuild infrastructure in places like Iraq, Afghanistan, Philippines, and more.

University of Notre Dame, Mendoza College of Business

The Mendoza College of Business is ranked 20th on Businessweek’s list of top MBA programs, and fourth on the Global 100 list of sustainable MBA programs. This gap is the second largest between the two program rankings. Mendoza is ranked third globally for their faculty research, fourth for the number of relevant courses related to sustainability, and fifth in terms of the number of students at the business school who register for those courses. The for-profit impact of those courses received a rank of 14 out of 590. Their overall grade for the College Sustainability Report Card was a B, with the school receiving three A’s for Administration, Student Involvement and Investment Priorities, four B’s for Climate Change & Energy, Food & Recycling, Green Buildings, and Transportation, one C in Shareholder Engagement, and a D in Endowment Transparency.

In 2005, the College of Business introduced a new curriculum focused on problem-solving in the context of three issues: individual ethics, organizational effectiveness, and social responsibility. This program includes 14 required courses, and offers 93 electives, each designed to integrate all three of the issues outlined above. Some of these more interesting classes include: The UN Global Compact & the Future of the Economy, and Deep Dive, where students examine issues related to sustainability at leading organizations such as recycling, product development, and reducing the carbon footprint of Coca-Cola32 and Ten Years Hence, a one-credit speaker series program that explores ideas, issues, and trends likely to affect business and society over the next decade.33
The College of Business is a founding member of Principles for Responsible Management Education (PRME), which is a consortium of 225 global business schools that are committed to incorporating the values of the UN Global Compact into their business school curricula and research. Their chapter of Net Impact recently won the 2009 Sustainability Case Competition, focused on renewable energy systems.

The UN Global Compact & the Future of the Economy is an example of one course designed to connect students with the business, environmental, and ethical issues facing the world economy.

**Dartmouth College, Tuck School of Business**

The Tuck School of Business is ranked number 12 on the *Businessweek* list of top US graduate business programs. The Global 100 list of sustainable MBA programs ranks Tuck at number 35. Their high scores were in the number of relevant courses and the for-profit impact of those courses, where Tuck ranked 23rd out of 590 global programs. The number of students actually taking those courses, showed up 75th on the list of programs, and their faulty research was ranked 96th out of 590. Their overall grade on the College Sustainability Report Card was a B+, with no single category receiving lower than a B, which is unusual. Highest marks came from Climate & Energy, Food & Recycling, Student Involvement, and Shareholder Engagement; where Administration, Green Buildings, Transportation, Endowment Transparency, and Investment Priorities all received a grade of B.

Sustainability initiatives were not as easy to identify at Tuck compared to the other business schools examined. They offer just one degree through the business school (MBA) and have a total of only 212 students. However, the Net Impact chapter is one of the largest student organizations within the graduate business program, with 170 members. The school’s Allwin Initiative for Corporate Citizenship is a program designed to be the nexus of business and society. Students who participate enter into case competitions through the Aspen Institute, and have served as delegates to the UN conference in Copenhagen that outlined a plan for leading global business programs to teach the UN Global Compact. The Allwin Student Roundtable gives students an administrative voice in helping set and directs the long-term goals for the School of Business. They offer significant access to conferences that deal with issues of sustainability, including the recent Building a New Model—Resource Constraints on the Path to Prosperity.

The School’s Net Impact website noted that because of the small size of their business school, there is typically only one or two classes offered on sustainability per semester. However, additional classes are offered through the other Dartmouth schools and Tuck students are able to apply those courses towards their MBA. One interesting course is offered through the Engineering School, Department of Environmental Management, called Industrial Ecology, where students study the flow of materials and energy through industrial systems.
George Washington University, School of Business

The George Washington School of Business is among the list of second-tier graduate business schools on the Businessweek list. As mentioned previously, there were 15 schools that were listed as second tier after the top 30 programs were ranked. All second-tier programs received a ranking of 45 for purposes of this analysis. It was George Washington’s rank of 11 in the Global 100 list that enabled them to be the only second-tier graduate business program that made the final list of schools for this study. The School of Business ranked fifth out of 590 schools in terms of the number of courses that they offer on sustainability. They were 23rd in terms of the for-profit impact of those courses and 42nd for the number of students that are actually enrolled in those courses. Their sustainable research ranked 26th out of the 590 global programs surveyed. Their overall GPA as listed on the College Sustainability Report Card was a B. The School of Business received A’s in five categories including: Administration, Food & Recycling, Student Involvement, Transportation, and Investment Priorities. They received B’s in Climate Change & Energy as well as Green Buildings. The university received an F in both Endowment Transparency and Shareholder Engagement.

The location of the School of Business is ideal for leveraging government, non-profit, and trade organizations that are involved with sustainability and the creation of public policy. The business school offers two concentrations with a sustainable focus: Environmental Policy & Management and Strategic Management & Public Policy. They also offer a global MBA program known as Global Leadership of Business Enterprise (GLOBE) that is a two-year full-time MBA program where the first year is dedicated to developing business skills within the context of a global economy.38

Carnegie Mellon University, Tepper School of Business

Carnegie Mellon is ranked number 19 on the Businessweek list of top MBA programs, and number 38 on the Global 100 list of top sustainable MBA programs. They were ranked 9th globally in terms of their student exposure to courses that focus on sustainable issues, although they were 45th in terms of the number of programs that they offer, and 71st in terms of their for-profit impact. Faculty research at Tepper was ranked 85th out of 590 global programs. Carnegie Mellon’s overall GPA on the College Sustainability Report Card was a B. Although they received A’s in six of nine categories, including: Climate Change & Energy,
Food & Recycling, Green Buildings, Student Involvement, Transportation and Investment Priorities. They received a C in Administration and a D in both Endowment Transparency and Shareholder Engagement.

All students who attend Tepper must attend a 12-hour introductory course on ethics during their orientation, which has a substantial focus on sustainability. Student groups include Net Impact, as well as the Tepper Energy Club. Every year they host a Meginnis Venture Competition, and in 2007 they added a Sustainable Technology Award for a business that has created a product or use that is original, profitable, and sustainable in terms of climate change mitigation, energy efficiency, or materials and water use.39

Massachusetts Institute of Technology, Sloan School of Management

The Sloan School of Management has a combined score of 100. Sloan is ranked number 9 on the Businessweek list of top MBA programs, and number 60 on the Global 100 list of top sustainable MBA programs. This is largely due to their low score in terms of faculty research, where Sloan ranked 134th out of 590 global business programs. The number of courses offered in sustainability was ranked 33rd and the for-profit impact of those courses was 32nd on the list. The number of students enrolled in these classes ranked them 77th out 590. The College Sustainability Report Card gives Sloan a combined GPA of B+. They received A’s in Food & Recycling, Green Buildings, Student Involvement, Transportation, and Investment Priorities, and B’s in Administration, Climate Change & Energy, and Shareholder Engagement. They received an F in Endowment Transparency.

Despite their low scores on the Global 100 list, information on sustainability at Sloan was easy to find. In 2007, they created the MIT Sloan Initiative for Sustainable Business & Society (S-Lab) as a means to change the way businesses use and manage resources.40 Based on collaborations with Fortune 500 companies, start-ups, NGO’s, and non-profits, this program offers students real-world consulting opportunities and case study development. The S-Lab also offers a Sustainable Business Certificate41 consisting of four required classes and one capstone course. This can be pursued while achieving the MBA degree. The S-Lab also offers podcasts that feature topics of sustainability including Will Sustainability Sell? and Sustainability in the Built Environment.42

A new introduction to the MIT Sloan curriculum in the Sloan Innovation Period (SIP) that replaces the traditional 13-week semester with two six-week classes that feature a one-week intensive, hands-on learning experience in the middle. Topics are focused on research initiatives being conducted within the business school.43

Sloan has other interesting projects like the Center for Collaborative Intelligence, Sustainable Food Lab, and the Alliance for Global Strategy, which address issues of sustainability. However, the most creative project is the Greenhouse Gas Emissions simulator, which is an online tutorial and interactive learning experience that teaches about greenhouse gasses, global warming, and to what degree we need to change behavior to effect positive changes to the environment.
One of the interesting courses offered by the Sloan School of Management is Global Climate Change: Economics, Science, and Policy. This course introduces scientific, economic, and ecological issues threatening the global climate, and the institutions engaged in negotiating and international response.

**Ideal Curriculum**

There is a growing trend towards incorporating concepts of sustainability into academic curricula and research. However, many of these courses are still focused on the moral and ethical implications of the topic, viewing sustainable design in terms of corporate or social responsibility, rather than as a part of a core business strategy that can provide financial gain. Additionally, the majority of these courses are offered as electives rather than as an integrated part of a core curriculum. The primary challenge to implementation is likely that regulatory issues, as well as climate change science and resource constraints are relatively new to mainstream economics, and these issues are not well-addressed through traditional neoclassical formats of study.

One of the major components we need to address in the context of business and the economy is how we define sustainability. To an environmentalist sustainability may imply the definition given from the Brundtland Principles, from the UN Report of the World Commission on Environment and Development: “Sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs.” To a business person sustainability could simply be throughput, or output relative to input. In order for a business to sustain itself, it must get out more than it puts in, and the extent to which you are able to put in less and get out more, productivity and profits rise. The business can sustain itself, and ultimately grow. At the most basic level these two definitions are very similar—get more from less, and productivity and profits will rise.

Part of the problem with this over simplification is what we choose to define, or more accurately what we choose to include, in our accounting of inputs and outputs. The industrial revolution forever changed how we source our “inputs” and what we consider an “output.” For generations we have discounted the true cost of production by not accounting for the true cost of the inputs; natural resources themselves (based on cost to extract and regenerate, as well as the ecosystem service they provide and the costs to reproduce those services such as habitat, water filtration, temperature control, etc.) transportation, labor, corruption, etc; and the actual net value of the outputs, which would be the value of the product being sold, less the cost of pollution, toxic waste, the permanent damage to ecosystems, and the loss of natural resources due to comingling products that keeps them from being reused or recycled either in terms of a new product, or through the natural process of biodegrading, among other things.

It would be a major understatement to conclude that changing the industrial process, as well as the entire concept of neoclassical economics by eliminating
free-riders, is unlikely. Because of this, many businesses, governments, and individuals have tried to adapt programs or slogans, like the 3 R’s: Reduce, Reuse, and Recycle. The problem with slogans like this is that we are a society, a global society that likes to consume. When we have money, we like to spend it, and businesses like creating products that entice us to do just that. So, now we are talking about two major impediments to change: severe complexity and lack of desire. That is why, as William McDonough so aptly states in his seminal book *Cradle to Cradle*, “Being less bad is no good.” This phrase is both exciting and inspiring. Rather than castigate, it challenges us to do what we as humans do best: evolve. It represents a revolution and a renaissance all in one. And it begins with possibilities, ones that can best be explored through the combination of technical skill and philosophy that is the hallmark of higher education.

This combination of technical skill and philosophy is a hallmark of systems-based thinking. Sustainability needs to be an integrated component of a comprehensive business philosophy that sees the role as a primary driver of profits and competitive advantage. Integrating this into the existing framework of core classes then opens the door for more complex instruction through specialization and the development of meaningful knowledge for those who choose to concentrate their degree in this area. This concentration can then be much more impactful, specific, and technical in nature because it has evolved from a basic overview to a competitive tool that can be used to perform at a higher level in finance, strategy, marketing, and/or operations.

An illustration of this concept using the course syllabus (Exhibit 4) for Johns Hopkins Carey School of Business, Special Topics in Real Estate: Sustainable Real Estate Development and Finance, Spring 2009 is provided here for discussion. The course overview lists five primary learning objectives, noted as Enduring Understandings. Examples will be given as to how each objective can easily be incorporated into existing coursework included in the Core Program Requirements for the Masters of Real Estate Program. The primary learning objectives are:

1. Understanding the role that real estate plays in the consumption of energy and production of greenhouse gases that has influenced the development of public policy for sustainable development.

2. While sustainable buildings allow for the conservation of energy and other natural resources, these savings can be greatly enhanced through sustainable land use planning practices at the city and regional levels that allow for the better integration of residential, commercial, and open space land uses.

3. Provide an understanding of sustainable building principles and how life cycle cost analysis represents a philosophical departure from traditional first cost analysis.

4. Providing constructive working knowledge of sustainable planning, construction, marketing, and certification process.

5. Provide a framework for objectively analyzing and evaluating sustainability features on the financial performance of a commercial real estate project.
Course Overview
The course is intended to appropriately balance theoretical and practical applications of sustainable development that will provide students a basis for objectively analyzing the potential impact of green or sustainability features on new and existing commercial real estate projects. This class was developed to also explore the broader application of sustainability principles on large scale planning efforts and the potential beneficial broader impacts on quality of life and environmental preservation.

Enduring Understandings
1. Understanding of the role that real estate plays in the consumption of energy and production of greenhouse gases that has influenced the development of public policy for sustainable development. This relates to Program Objectives 3 and 4.
2. While sustainable buildings allow for the conservation of energy and other natural resources, these saving can be greatly enhanced through sustainable land use planning practices at the city and regional levels that allow for the better integration of residential, commercial, and open space land uses. This relates to Program Objective 3.
3. Provide an understanding of sustainable building principles and how life cycle cost analysis represents a philosophical departure from traditional first cost analysis. This relates to Program Objectives 1, 2, and 6.
4. Providing constructive working knowledge of sustainable planning, construction, marketing, and certification process. This relates to Program Objectives 1 and 2.

Provide a framework for objectively analyzing and evaluating sustainability features on the financial performance of a commercial real estate project. This relates to Program Objectives 5 and 6.

Consumption of Energy and Production of Greenhouse Gasses: These topics can easily be integrated into existing coursework on Urban Economics, Site Planning and Building Design, Land Use Regulation, and Ethics and Humanity.

Development of Public Policy: This can be integrated into Land Use Regulation, Legal Issues in Real Estate, Real Estate Development Process, and Business Communication.

Conservation of Energy and Other Natural Resources: This can be taught as a component of Urban Economics, Financial Modeling for Real Estate, Site Planning and Building Design, Construction Project Delivery, and Land Use Regulation.

Land Use Planning: This can be taught as a component of Land Use Regulation, Urban Land Economics, Site Planning and Building Design, and Real Estate Development Process.

Sustainable Building Principles: This can be addressed through courses on Site Planning and Building Design, Real Estate Development Process, Construction Project Delivery, Land Use Regulation, Business Communication, Urban Land Economics, and Ethics and Humanity.

Planning, Construction, Marketing and Certification: Each of these can be addressed individually through the following existing courses; Site
Planning and/or Land Use Regulation, Construction Project Delivery, Business Communication, and Real Estate Development Process and/or Construction Project Delivery.

**Analyzing and Evaluating Financial Performance:** This can be addressed in existing courses on Market Analysis and Financial Modeling for Real Estate.

This simple exercise illustrates how concepts that are reserved for discussions in classes specifically geared towards sustainable practices can easily be integrated into the core curriculum, creating a more systems-level understanding of these concepts, and leaving degree concentrations open to exploring more in-depth topics that can help develop graduates into thought leaders.

---

**Getting to Green: “Sustainable” Sustainability**

A chief sustainability officer at a real estate development company was asked: “What’s the most important thing that people should know if they want to work in the field of sustainability?” He answered, “Their job.” Meaning you have to actually know how to do something. You cannot get a job in sustainability. You must take a practice within a field that you know and reinvent it. But first and foremost, you must know what you do, and why you are doing it. Graduate business programs are designed to create leaders. But in order to lead you must understand what you are doing and why, so that you can begin to identify opportunities to do things better, smarter, faster, and safer because that is what will sustain your enterprise, your planet, and yourself.

A good education combines practical knowledge and theory. Most of the core curriculum within a graduate business program is focused on “how” to do things. These courses tend to comprise the more technical skills used to complete a task, such as how to read a lease, or construction drawings, how to increase throughput, or do a discounted cash flow analysis. This leaves room for deeper skill development and/or creativity within the elective course work, or specialty concentrations.

Based on this study of top business schools in America, most are well suited to provide basic elements of sustainability in their core curriculum. Basic elements are determined according to the dearth of information and material available for use in case studies, including transportation, non-renewable resource constraints, pollution, corporate social responsibility, marketing and communication of value (including recruiting, retention, workforce health), regulatory advantages, and change management, among many others, all under the umbrella of driving operational value and profits.

Four representative courses have been created for this study that represent a concentration in sustainable real estate, with the assumption that all core classes would include elements of sustainability as a component of the course work so that these specialized courses do not need to focus on the most basic elements of
sustainable practices. These courses are based on the key areas of study currently being offered at these top business programs, but represent original thought and content in their presentation. They were selected based on the broad cross-section of interests that affect the greatest number of people: economic framework (difference between a long- and short-term economy and how each has a role to play in sustainability), practical applications of new technologies that are driving value today, workforce health and productivity, and community-based initiatives (in a for-profit environment)

A concentration in sustainable real estate would include these four classes: (1) A New World Order in Sustainable Design: Environmental Economics, Ecology and Best Practices in Sustainability; (2) Energy, the Economy, and Existing Buildings; (3) Sustainable Design as a Core Business Strategy: Productivity and the Workplace; and (4) Reimagining a World City: Sustainable Community Development. Description of the course work for these classes appears below.

**Course Syllabus: A New World Order in Sustainable Design: Environmental Economics, Ecology, and Best Practices in Sustainability**

“No problem can be solved by the same consciousness that created it.” Albert Einstein

“A managers job is to do something right (to be efficient), but an executive’s job is to do the right thing (to be effective).” Peter Drucker

When looking at the role of real estate in the broader concept of the business world and its impact on the global economy, it is easy to see that leadership is not created or sustained simply by meeting the minimum standards for building design. Today’s business and thought leaders must re-imagine the process, and ask how can their product enhance the economic, ecological, and social health of those who construct, work in, and live near the facility. This is the challenge that will be addressed through this course.

**Recommended Textbook**

*Blueprint for a Sustainable Economy.* D. Pearce and E. Barber (2000).

**Additional Reading**

*Mid-Course Correction: Toward a Sustainable Enterprise: The Interface Model.* R. Anderson. Published by Chelsea Green (1999).

**Week 1**

Overview of Traditional Economic Theory: An Overview
Ecological Economics: History and Theory
Tools and Applications: Introduction of transforming theory into practice

**Topics Covered**

- Microeconomics: Supply/Demand, Utility, Opportunity Cost
- Macroeconomics: Public Policy and Growth
- Environmental Economics
- Resource Economics
Ecological Economics: Economy as a subset of the environment, welfare, public policy, and sustainability

Overview of tools and applications for translating theory into practice: life cycle assessments, technological innovation, backcasting, discounting, leading indicators (GDP, ISEW, GPI)

**Readings/Presentations**
This article explores the economy’s relationship to the ecosystem and why limitless economic growth is impossible.

This article questions the efficacy of market-based environmental policy.

**Assignment**
Write a brief memo (no more than 2 pages) on something you learned this week that surprised or interested you, and why. It can be related to your work or of personal interest.

**Week 2**
What Does a Sustainable World Look Like?

**Topics Covered**
- Weak versus Strong Sustainability
- Linking Economic Efficiency and Sustainability

**Readings**

**Assignment**
Write a two-page memo on how the real estate industry can help meet the goals and objectives of the UN Report, Our Common Future.

**Week 3**
Decision Making Frameworks: Valuing Ecosystem Services

**Topics**
- Mitigation (costs and benefits)
- Risk and Uncertainty
- Present Needs versus Future Needs
- Lifecycle Analysis
- Limitations and Alternatives to Monetary Valuations

**Readings**
Assignment
Write a two-page memo on how ecosystem services are accounted for in the design and development of green buildings.

Week 4
Macroeconomic Approaches to Measuring Sustainable Development

Topics
- Understanding and Measuring GNP
- Green GNP: Modifying GNP for Non-market Values
- Review for Mid-Term Exam (take home)

Readings
Chapter 4, Measuring Sustainable Development: Economic Approaches. Pearce & Barbier.
Chapter 5, Measuring Sustainable Development: Ecological Approaches. Pearce & Barbier.

Assignment
Take Home Exam

Week 5
Review of Take Home Exam
Causes of Environmental and Social Degradation

Topics
- Government Policy: Successes and Failures
- Social and Environmental Measurement and Accounting
- Multi Criteria Analysis (MCA)

Readings
Chapter 6, Causes of Environmental and Social Degradation. Pearce & Barbier.

Week 6
Solving Environmental Problems

Topics
- Property Rights
- Market Policy Instruments: Taxation, Cap and Trade, Incentives, Rebates
- Capital Markets and the Global Economy

Readings
Chapter 8, Solving Environmental Problems: Policy Instruments. Pearce & Barbier.
Assignment
Write a two-page memo on one market policy related to green buildings that you think is particularly effective and why.

Week 7
International Comparison of Green Building Rating Tools

Topics
- Overview of International Green Building Certifications
- Living Building Challenge
- SMART Certified
- Cradle-to-Cradle certification

Readings

Assignment
Write a two-page memo comparing and contrasting LEED, BREEAM, and the Living Building Challenge.

Week 8
Presentations of Final Project: A Sustainable Certification Program.

Assignment
Final paper and class presentation integrating the lessons you learned in this course, and through Ray Anderson’s book Mid-Course Correction, and devise a certification program of sustainability that can be immediately implemented within your organization.

Course Syllabus: Energy, the Economy, and Existing Buildings

Businesses are a key part of the environmental picture in terms of global governance and a key part of the climate solution, whose success requires implementation by businesses. However, policies on climate change and energy efficiency are largely limited due to a fragmented, weak, and undeveloped market. This fragmentation leads to a wait-and-see attitude among businesses who do not want to get stuck making financial commitments to policies and/or technologies that will ultimately be replaced with newer, better, or more politically popular concepts. In response to this, many local governments have tried to respond with their own initiatives and guidelines, as well as businesses who have undertaken these projects on their own accord, believing there is either, at best, a financial advantage, and at worst, a brand advantage, to being an early mover in these areas.

The first part of this course will examine some of the above mentioned policies and the challenges to implementation, as well as market leading concepts that are slowly helping us move towards more environmentally responsible energy policies. The second half of the class will focus on methods of implementing energy efficiency in existing buildings.
Recommended Textbook


Week 1
Exploring government-sponsored policies and programs, as well as business organizations involved in determining climate change policy for the U.S. An introduction to green buildings and the importance of retrofits from a GHG perspective, as well as the challenges to implementation of sustainable practices.

Topics
Introduction and overview of the following:
- Clean Air Act
- Kyoto Protocol
- Waxman-Markey bill
- New Energy Plan for America
- Barriers to Retrofitting An Office Building
- Case Study: The Empire State Building Goes Green

Readings

Assignments
Write a two-page memo on your thoughts about environmental regulation. Does it enhance competitiveness or it is an annoying cost? Why. Use facts, logic, and contemporary examples to back up your opinion.

Week 2
Energy Supply and Demand and Unlocking Solutions to Energy Policy in the U.S.

Topics
- Pricing
- Market Power and Scarcity
- Regulated and Unregulated Energy Markets
- Renewable Energy Purchasing
- Cap and Trade
- Carbon Disclosure
- Climate Registry

Energy Efficiency Potential in the U.S. Economy
- NPV Positive Opportunities
- Efficiency by Market Sector (special emphasis on real estate)
- Barriers to Implementation
- Elements of a Holistic Strategy

Readings


Review: Carbon Disclosure Project Website: http://cdproject.net/

Assignments
Write a three-page memo on whether benefits and drawbacks of voluntary versus compulsory carbon reduction programs in the context of what you have learned about the Kyoto Protocol, Waxman-Markey bill, Cap and Trade, and Carbon Disclosure. Which strategic solutions you think would be most successful in terms of rapid implementation and why. Identify challenges to implementation, ways to mitigate them, as well as recommendations to enhance successful strategies.

Week 3
Planning a green office retrofit.

Topics
- Defining a Strategy for Green Retrofit
- Code Standards and Voluntary Certification Programs
- Cost Benefit and Analysis of Green Retrofit Opportunity
- McDonalds Case Study
- 1828 L Street Case Study: Working towards ENERGY STAR

Readings

Assignment
Create a cost-benefit analysis for three green features within your corporate office space, or within a building of your choice. This should include a description of the upgrade (e.g., eliminating incandescent lighting, installing occupancy sensors, adding a building energy management system or changing out chillers), the initial costs to install, annual commodity savings, annual cost savings, and simple payback.

For this exercise you will need to have access to your electrical consumption in terms of total KWh, as well as your cost per kilowatt. If these are not available to you, please use publicly available information regarding averages for this region, and detail where you got your numbers and why they are an accurate representation.

You have two weeks to complete this assignment.

Week 4
Retrofitting office buildings for energy efficiency.

Topics
- Evaluating Site and Climate Conditions
- Landscaping Strategies
- Building Envelope
- Building Mechanical Systems
Sustainable Interiors
Brief Discussion on Historic Preservation and Green Retrofits

Readings
Chapter 3, ULI Textbook, pages 40–83.


Assignment
Complete assignment from Week 4.

Week 5
Managing the green retrofit process.

Topics
- Collaboration between Project Team Members
- Identifying a Strong Green Building Consultant
- Construction Considerations
- Minimizing Legal Risks in Green Design and Construction

Readings
Chapter 4, ULI Textbook. Pages 87–106.

Assignments
For the final project and presentation, identify a building in the Washington DC area and present a case study for a green building retrofit. Include a cost-benefit analysis. Also include a section that deals with marketing to and educating tenants on these new upgrades and how they will benefit from them. Extra credit will be given for identifying possible rebate and incentive programs and how a particular program can change the payback for specific upgrades.

Week 6
The business of green office renovations.

Topics
- Green Building Costs and Paybacks
- Leasing, Rental Rate, and Sales Price Benefits
- Strong Global Demand
- Restricted Supply and Premium Green Rents
- Underwriting Green Office Retrofits and Renovations
- Green Real Estate Finance Vehicles

Readings
Chapter 5, ULI Textbook. Pages 116–123.
Case Study: 545 Madison Avenue, ULI Textbook. Pages 208–218.

Assignment
Work on final project and presentation.
Week 7
Examine green property operations.

Topics

- Property Management Agreements, Leases, and Risk Management
- Green Operating Metrics
- Maintaining Energy-Efficient Operations
- Establishing Green Operating Programs
- Green Property Management Certification Programs

Readings

Chapter 6, ULI Textbook. Pages 140–158.


Assignment

Work on final project and presentation.

Week 8

Toward the future: new directions in green building.

Topics

- Building Information Modeling
- New Building Materials and Systems
- Smart Buildings and Smart Grids
- Buildings as Living Systems

Reading

Chapter 8, ULI Textbook. Pages 187–203.

Assignment

Final presentations and papers due.

Course Syllabus: Sustainable Design as a Core Business Strategy: Productivity and the Workplace

The smoking gun in terms of the benefits of sustainability has always been in the productivity numbers. Although there are measurable reductions in utility costs due to energy and water efficiency, and there are a number of studies that point to increases in rental rates for LEED and/or ENERGY STAR rated buildings, these numbers are relatively low compared to potential gains in employee productivity, as well as the ability of these buildings to reduce turnover and sick time. This is because rent makes up about 8%–10% of businesses operating expenses, while people make up roughly 88%. Therefore, looking to save money on rent could potentially increase overall costs by not looking at how buildings impact the occupants. This course will examine a concept called return on rent, which looks at published studies and attempts to examine the concept of face rents versus effective rents based on a building’s ability to impact workers in terms of productivity, turnover, and sick days.

Ongoing Assignment: Journal of the Built Environment

Throughout history buildings were designed to create not just a sense of place but to instruct your senses on what kind of place you are in (e.g., a cathedral, an office building, hotel,
etc.). Today we seem mostly unaware of how these spaces and their design can impact us and our emotions. Your assignment throughout this course is to keep a journal of the spaces you visit. Notice their function, design, color palette, amount of darkness/light, and how you feel when you are inside. How clean is the space? Do you smell anything? What do you see? What would you change about these spaces if you could? What did you like? What elements would you incorporate into a building if you could? The idea is to reconnect with the built environment. Be creative.

**Final Assignment**
You are one of the top three brokerage firms seeking to win business from a developer known in the market to be the largest developer of green projects in your region. They are looking for a brokerage house that understands their business and focus on sustainability. In order to win their business you must develop a marketing plan for their new LEED Gold 200,000 SF downtown building. It is highly recommended that you use the financial benefits of green buildings to lure tenants into this building. It is also highly recommended that you be creative and think outside of the box, as this developer has long felt that broker understanding of the green market is very shallow. Make recommendations for marketing strategies that may be non-traditional, and very creative. It could include creating marketing boards, a video presentation for a website, sample advertisements, broker gifts, events, etc. Plan to be very aggressive in your presentation. A written marketing plan as well as a 15–20 minute presentation of recommendations is required.

You will be evaluated based on: (1) Overall marketing plan and quality of the write up. Organization, understanding of the problems and issues, comprehensiveness, accuracy, innovation and quality of material; and (2) The presentation organization, understanding of company issues, style, professionalism, creativity, and innovation.

**Week 1**
Introduction to return on rent.

**Topics**
Concept overview including a theoretical tenant
- Understanding Productivity and What Impacts Worker Productivity
- Understanding Costs of Corporate Recruiting and Training When Losing a Knowledge Worker
- Understanding the True Cost of an Employee

**Reading**

**Assignment**
Please come to class with the following information regarding the company you work for:
- Rent per square foot that your company currently pays, as well as how many square feet in the building. If you have a NNN lease, include the average operating expenses. If your company has multiple locations, select one office for purposes of this analysis.
- The number of employees that work within the office space above.
- Average cost per employee for the organization. If you work for a private company and this information is not available, make an informed guess.
- Your company’s factor for health insurance and overhead.
- Average number of sick days per employee.
- Average annual turnover for your organization.

If your company will not make this information available to you, do your own independent research based on average numbers for this market in terms of rent, knowledge worker salaries, sick days, and turnover.

**Week 2**
The factors that affect productivity.

**Topics**
Indoor Air Quality
- Impacts of IAQ During Construction and Operation of a Building
- How to Reduce or Eliminate These from a Work Environment
- The Effects of IAQ on Worker Productivity
- Sample Air Quality Tests

**Readings**


**Reference/Additional Reading**

**Week 3**
The factors that affect productivity.

**Topics**
Light and Lighting
- Qualities of Light and Their Effect on Human Physiology
- Types of Lighting and Their Effect on Productivity (natural, overhead, fluorescent, task)
- The Link between Daylight and Productivity

**Readings**


**Week 4**
The factors that affect productivity.

**Topics**
Thermal Comfort
Reading

Week 5
Corporate values.

Topics
How Corporate Social Responsibility and Shared Values Impact Employee Retention and Turnover

Readings

Week 6

Topics
Costs of Training and Development of Knowledge Workers

Readings

Week 7

Topics
- Building Operations: Expenses and Management Responsiveness to Issues
- Beyond Green Buildings: Can Architecture Impact Worker Health and Productivity

Readings

Week 8

Topics
Final paper and presentations.
Course Syllabus: Reimagining a City: Sustainable Community Development

“Today, more than any time in history, we live in a global economy where quality of place drives the free flow of capital. And the lines between urban, suburban, and rural challenges blur from poverty to housing affordability, strong neighborhoods are increasingly becoming a yardstick with which we measure America’s success.” Shaun Donovan, Secretary of the U.S. Department of Housing and Urban Development.

When Thomas Friedman released his book *The World is Flat* in 2005, he wrote how technology was making developing nations economically competitive, and that outsourcing jobs to other countries will help raise their standard of living and increase their demand for American goods and services; ultimately creating a global country of mutual economic dependency. The book provides an excellent example of the interconnectivity of people and our mutual dependence on each other. Although Friedman was talking primarily about goods and services, understanding the concept of interconnectedness is paramount to understanding the concept of sustainable development and the local community’s effect and ultimate impact on the larger global community.

This course will focus on the core concepts of green community development, examining issues of density and transportation, conservation and preservation, energy and resources, and the health and sustainability of local and global communities.

**Recommended Textbooks**
*Green Community*. Edited by S. Piedmont-Palladino and T. Mennel.


**Final Assignment**
A 10-page term paper on either (1) a pure theory paper about some aspect of the human/nature relationship in the Western intellectual tradition, or (2) a public policy paper on a contemporary environmental issue and a solution to that issue using course materials. The presentation should be ten minutes long. In the presentation you should give a synopsis of your paper. PowerPoint is optional but not required.

**Week 1**
The green community in context.

**Topics**
- Putting Contemporary Problems into A Global Context
- A History of Sustainability and What We Can Learn from Designs of the Eighteenth and Nineteenth Centuries
- How Technology Impacted Design in the Twentieth Century
- Personal, Economic, and Social Benefits of Well-planned/Designed Dense Neighborhoods

**Readings**


Grassroots, Chapter 1. Do American’s Favor Environmental Protection.

Assignments
Write a two-page memo on the following: What aspects of personal space and design are most important to you? What excites you/concerns you about the concept of densely-designed mixed-use neighborhoods? Would you want to live there? Specifically whether you feel there is an inherent conflict between the ideologies of green communities versus people’s desire to actually live there. What are the positive and negative aspects?

Week 2
The aspects of density and transportation.

Readings
Green Communities. Introduction to Connectivity. F. Hansen.
Grassroots. Chapter 2, How Deep is the Public Commitment to the Environment?

Assignment
Write a two-page memo on the following: What aspects of your daily life are currently causing environmental pollution? Think about how you dispose of your garbage. Do you sort your recycling? How do you get to work, to school, or into town to socialize with friends? Do you take a bus? Do you drive a car? And what products do you use to clean your house? To store your groceries? What groceries do you buy? How much impact do you make on the world?

Week 3
The aspects of land conservation and preservation are discussed.

Topics
- Green Communities and the Redefining of Community Wealth
- Managing/Controlling Development to Build Green Communities
- Regulation vs. Incentive
- How Land Conservation Policies Have Changed Through Time and Changing Political Environments

Readings
Grassroots. Chapter 3, Have Environmental Attitudes Changed Over Time?

Assignment
Write a two-page memo on the following: Examine your life as it exists today and tell whether or not there are any modifications you could make that would have a positive impact on the environment. Don’t say “join the Sahara Club” or some other local interest group. Include ways to achieve the exact same life, with less negative impact. Be interesting and realistic.

Week 4
Examine energy and resources.
Topics
- Local Sustainable Energy Sources
- Energy and Communities
- How Attitudes Towards These Issues Change Over Time

Readings
Grassroots, Chapter 5, *Are Environmental Attitudes Inconsistent?*

Assignment
Present an annotated bibliography of at least 10 sources, as well as a term paper topic overview of 150 words stating in clear, concise terminology your intended topic, and outline in general terms your strategy for arguing your point.

Week 5
Discussion of local and global health.

Topics
- Public Health, Climate Change, and the Built Environment
- Is Environmentalism Elitist

Readings
Green Community. *Healthy Communities, Green Communities*. H. Frumkin. Pages 118–120.
Grassroots. Chapter 4, *Is Environmentalism Elitist?*

Week 6
Discussion of local and global health.

Topics
- Food and Community Greening
- Growing Crops for Biofuel

Readings

Week 7
A discussion of the consumer, the marketplace, and environmentalism.
Sustainability and Graduate Business Education

Topics

- Elections and the Environment
- Motivating the Citizen Consumer
- Rethinking the Strategy of Environmental Communication

Readings

Grassroots. Conclusion: Rethinking Environmentalism.

Week 8

Final papers are due. Presentations and course review.

Conclusion

This discussion represents the beginning of a conversation on the present state of graduate business education within the framework of sustainability as a driver of corporate value. It also lays out a foundation for the near future in terms of enhancing our systems-based thinking to produce more dynamic young leaders. Today’s graduate business students must be equipped to face the challenges of profitability in a business environment with new resource constraints, new government regulations, and new methods of accounting for production costs and profits.

Businesses need to evolve beyond basic concepts of corporate social responsibility and identify profit centers focused on new technologies, new manufacturing processes, new building practices, and new financial models. They must be ready to educate, renovate, and reinvent the entire value chain, and send a message to our government and the world that we are prepared to take a leadership role in the next industrial revolution that will be efficient, smart, clean, and green.

Endnotes

1 The rankings are compiled on a yearly basis. www.businessweek.com/bschools/rankings/.
2 Beyond Grey Pinstripes 2009–2010: Preparing MBAs for Social and Environmental Stewardship. Published by the Aspen Institute Center for Business Education.
6 http://www.stanford.edu/group/fusion/cgi-bin/site/social-m-challenge/.
7 http://csi.gsb.stanford.edu/education-programs.


http://mba.yale.edu/news_events/CMS/Articles/6708.shtml.

http://www.kenan-flagler.unc.edu/Programs/MBA/Academics/casestuaccomplish.cfm.


http://www4.gsb.columbia.edu/realestate/research/housingcrisis/resources.


http://nicholas.duke.edu/csi/overview.html.

http://nicholas.duke.edu/institute/about.html.

http://www.fuqua.duke.edu/edge.


http://business.nd.edu/Ask_More/Integrated_Curriculum/More_Courses/#mbacourses, Ten Years Hence.


http://mba.tuck.dartmouth.edu/initiative/.


http://business.gwu.edu/grad/mba_comp_chart.html.


Marnie L. Abramson, NextGen Partners, LLC, Rockville, MD 20852 or marnie@nextgenpartners.net.
2011 AMERICAN REAL ESTATE SOCIETY
JOURNAL MANUSCRIPT PRIZE WINNERS

Journal of Real Estate Research

Winner of the Homer Hoyt Advanced Studies Institute Manuscript Prize ($1,000) for the best research paper published in JRER in 2010.

Listing Contract Length and Time on Market
Bennie D. Waller, Ray Brastow, and Ken H. Johnson
(32:3, 271–88)

Journal of Real Estate Portfolio Management

Winner of the PREA Manuscript Prize ($1,000) for the best research paper published in JREPM in 2010.

Slicing, Dicing, and Scoping the Size of the U.S. Commercial Real Estate Market
Andrew C. Florance, Norm G. Miller, Ruijue Peng, and Jay Spivey
(16:1, 101–18)

Congratulations to all the authors.
The American Real Estate Society proudly announces the following manuscript prize winners for research papers presented at the American Real Estate Society’s 27th Annual Meeting.


Apartments, sponsored by National Multi Housing Council (NMHC): Alan Ziobrowski, Prashant Das, and Alan O. Tidwell for “The Relationship Between Internet Searches and REIT Returns.”


Housing, sponsored by the Lucas Institute for Real Estate Development and Finance at Florida Gulf Coast University: Shuang Zhu and R. Kelley Pace for “The Influence of Foreclosure Delays on Borrower’s Default Behavior.”

Industrial Real Estate, sponsored by the NAIOP Research Foundation: David M. Harrison and Michael J. Seiler for “The Political Economy of Green Industrial Warehouses.”


International Real Estate Investment/Portfolio Management, sponsored by the Education Foundation of the CCIM Institute: Ping Cheng, Zhenguo Lin, and Yingchun Liu for “Performance of Thinly-Traded Assets: A Case in Real Estate.”


Real Estate Brokerage/Agency, sponsored by the National Association of Realtors (NAR): Bennie D. Waller and Scott Wentland for “The Role of Transaction Costs in Impeding Market Exchange in Real Estate.”

Real Estate Cycles, sponsored by the Pyhrr/Born Trust for Real Estate Cycle Research: Don Haurin, Stanley McGreal, Alastair Adair, Louise Brown, and James R. Webb for “List Price and Sales Prices of Residential Properties During Booms and Busts.”


Real Estate Valuation, sponsored by the Appraisal Institute (AI): William H. Dare, Paul R. Goebel, and Carl Issett for “Addressing Appraisal Creep in Property Taxation: Alternatives to Traditional Taxation Methods.”

Retail Real Estate, sponsored by the International Council of Shopping Centers (ICSC): Crocker H. Liu and Peng Liu for “Is What’s Bad for the Goose (Tenant), Bad for the Gander (Landlord): A Retail Real Estate Perspective.”

Sustainable Real Estate, sponsored by the NAIOP Research Foundation: Sofia Dermisi for “Spatial Penetration and Performance of LEED Ratings & Certification Levels Among Office Buildings.”

Seniors Housing, sponsored by the National Investment Center for the Seniors Housing and Care Industry (NIC): No papers submitted or presented in this category in 2011.
SPECIAL ISSUES
JOURNAL OF REAL ESTATE RESEARCH

Real Estate Brokerage (Summer, 1988): Sponsored by the National Association of REALTORS (NAR).

Corporate Real Estate (Fall, 1989): Sponsored by AICAM and HHASI.

Appraisal (Spring, 1990): Sponsored by the Appraisal Institute (AI).

Determinants of Demand (Fall, 1991): Sponsored by NAR.

Environmental Influences on Value (Summer, 1992): Sponsored by AI.

Real Estate Investment (Fall, 1992): Sponsored by the Pension Real Estate Association.

Corporate Real Estate (Fall, 1993): Sponsored by the International Association of Corporate Real Estate Executives (NACORE).


Real Estate Brokerage (Winter, 1995).

REITs (1995: Vol. 10(3/4)): Sponsored by the National Association of Real Estate Investment Trusts (NAREIT) and Equitable Real Estate Investment Management.


International Real Estate Investment (1996: Vol. 11(2)): Sponsored by Jones Lang Wootton USA.


International Real Estate Investment (1997: Vol. 13(3)): Sponsored by Jones Lang Wootton USA.


REITs (1998: Vol. 16(3)): Sponsored by the National Association of Real Estate Investment Trusts.

Corporate Real Estate (1999: Vol. 17(3)): Sponsored by NACORE International.

Cycles in Real Estate (1999: Vol. 18(1)): Sponsored by PricewaterhouseCoopers and SynerMark Investments.


Corporate Real Estate (2001: Vol. 22(1/2)): Sponsored by NACORE International.

Multifamily Housing (2003: Vol. 25(2)): Sponsored by Freddie Mac.

Issues For Inner-City Real Estate Markets: (2003: Vol. 25(4)): Sponsored by the Real Estate Research Center of Morehouse College.

ARES MONOGRAPHS
PAST, PRESENT AND FUTURE

PAST
1996: Megatrends in Retail Real Estate (co-sponsored by ICSC: 378 pages).
1997: Seniors Housing (sponsored by the National Investment Center for the Seniors Housing and Care Industries: 248 pages).
2006/8: Indigenous Peoples and Real Estate Valuation Issues (co-sponsored by the Appraisal Institute Education Trust and the Appraisers Research Foundation).

FORTHCOMING
2012/13: ARES 25 Year Anniversary.

IN PROCESS
2014/15: Property Values and Environmental Factors (needs a sponsor).
2016: Financial Engineering and Innovation in Real Estate (needs a sponsor).
2017: Real Estate Market Microstructure (needs a sponsor).
2018: Behavioral Real Estate (needs a sponsor).
2019: Dangerous Visions: The Future of Real Estate Research (needs a sponsor).
CoStar Group will provide a $1,000 manuscript prize for the best research paper presented at the ARES Annual Meeting that uses CoStar data. CoStar has comprehensive, detailed property level information and up to 15 years of historical data in most major markets throughout the U.S. and U.K. They currently track approximately 1.6 million commercial properties totaling 30 billion square feet and have verified comparable sales data on approximately 1.3 million sales transactions—all property types, including retail, multifamily, hospitality and land. Anyone interested in obtaining CoStar data for research purposes should contact:

Jay Spivey  
Director of Analytics  
CoStar Group, Inc.  
2 Bethesda Metro Center, 10th Floor  
Bethesda, MD 20814  
Phone: 888-576-9223  
Fax: 888-537-9358  
Email: jspivey@costar.com
The Journal of Real Estate Research (JRER) has a new set of best paper awards. As you know, currently there are two best paper awards ($5,000 and $10,000) for papers published in JRER. In April 2007, the awards ($5,000 and $10,000) were given for two papers that were published in 2006.

For April 2011, the top award will be increased to US $25,000. This means that there will be three awards ($5,000, $10,000, and $25,000) for papers published in JRER during 2009 and 2010. However, the Editor (Ko Wang) reserves the right to extend the evaluation period for the three awards from 2009–2010 to 2009–2011. Again, the winners of the awards will be based on the votes of the JRER editorial board.

Please solicit (or send your) very best papers to JRER. Any paper accepted now will be eligible for the three awards, since it will be published in 2009 or later (2008 is full). Your efforts to make JRER a better journal are greatly appreciated.

The top two papers published in JRER for years 2007–2008 as determined by the editorial board of JRER are as follows:

$10,000 Prize
The 1998–2005 Housing Bubble and the Current Correction: What’s Different this Time?
William Wheaton and Gleb Nechayev

$5,000 Prize
The Pricing of Home Mortgage Loans to Minority Borrowers: How Much of the APR Differential Can We Explain?
Marsha Courchane
The American Real Estate Society (ARES) has established three best paper awards for papers published in the Journal of Real Estate Research (JRER) in selected years. The first award is $25,000 (US), the second is $10,000 (US), and the third is $5,000 (US). The three awards will be determined by the votes of the JRER Editorial Board after the papers are published in the Journal. The three awards, ($25,000, $10,000, and $5,000) will be given for the first time either in 2011 (for papers published in 2009 and 2010) or in 2012 (for the papers published in 2009, 2010, and 2011). The exact year (2011 or 2012) will be determined later by the editor of the journal. For details on the selection process of the three awards, please visit, http://cbeweb-1.fullerton.edu Jurnal/awards/default.htm.

In addition to these three awards, ARES also gives one $1,000 (US) best paper award for papers published in each calendar year. This $1,000 best paper award is selected based on the votes by all ARES members.
CALL FOR PAPERS

JOURNAL OF SUSTAINABLE REAL ESTATE

The American Real Estate Society announces a call for papers for a new journal, the Journal of Sustainable Real Estate. The objective of the JOSRE is to serve as an outlet for theoretical and empirical research on a broad range of topics on sustainable real estate-related topics, including but not limited to, green buildings and sustainable development, how standards are established and how they are measured, and how green buildings and sustainable developments are financed.

1. All papers will be subject to anonymous double blind review by practicing professionals and academicians.
2. 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. Early submissions are greatly appreciated.
3. Style guidelines are available in the back of all JOSRE issues.
4. Submissions are preferred in MS Word or PDF format.
5. Manuscripts should be original, unpublished works not under publication consideration anywhere else.

Authors should submit their manuscripts to Norm Miller, the editor.

Norman Miller
University of San Diego
Burnham-Moores Real Estate Center
5998 Alcala Park
San Diego, CA 92110-2492
Email: nmiller@sandiego.edu
Phone: 619-260-7939
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. Electronic submissions are strongly encouraged, either as email attachments, CD-ROM or disk. Preferable word processing format is as a PDF or Microsoft Word file. Paper submissions require four copies of the manuscript. 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. Interested authors should contact or submit manuscripts to:

Ken H. Johnson
Florida International University
11200 SW 8 Street, MARC 234
Miami, FL 33199
Phone: 561-886-7099
jhr@fiu.edu
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.

Interested authors should contact or submit manuscripts to:

William G. Hardin III  
Florida International University  
Dept. of Finance  
11200 8th St., SW  
University Park, RB208  
Miami, FL 33199  
jrepe@fiu.edu
2011 Membership Form
American Real Estate Society

Name________________________________________Title/Department____________________________________

Company/University___________________________________________________________________________

Address____________________________________________________________________________________

City__________________________ State_______ ZIP Code________+____ Country__________________________

Phone ________________________ Fax ______________________________________________________________

Email_____________________________________________________________________________________

2011 Membership Dues

___ Professional Membership (circle one)
Printed Media…………………………………… $300
Electronic Media………………………………… $300
Both (printed and electronic)…………………. $340

___ Academic Membership (circle one)
Printed Media…………………………………… $135
Electronic Media………………………………… $135
Both (printed and electronic)…………………. $175

___ Academic Retired Membership (circle one)
Printed Media…………………………………… $85
Electronic Media………………………………… $85
Both (printed and electronic)…………………. $125

___ Student Membership (circle one)
Printed Media…………………………………… $85
Electronic Media………………………………… $85
Both (printed and electronic)…………………. $125

___ Life Membership
___Printed Media
___Electronic Media

For information on becoming a Life Member, contact Mike Seiler at (757) 683-3505 or mseiler@odu.edu.

___ Corporate Membership (circle one)
Printed Media…………………………………… $600
Electronic Media………………………………… $600
Both (printed and electronic)…………………. $640

___ Fellows Contribution Regular…………. $250
___ Fellows Contribution Distinguished…… $500
___ Fellows Contribution Benefactor……….. $1000
___ Endowed Doctoral Sponsorship …….. $10,000
___ Endowed International Scholar ……… $25,000
___ Sponsor………………………………… $1500
___ Regent…………………………………. $3000
___ President’s Council……………………… $6000

Method of Payment

Total Dues $____________________

___Check (Payable to ARES) Payment by check preferred by ARES

Method of Payment ___VISA ___MasterCard ___Discover

Card # ___________ - ___________ - ___________ - ___________
Expiration ___________

Authorized Signature ________________________________

Date________________________

Return this form with payment to:

Diane Quarles
Clemson University
Department of Finance
Box 341323
Clemson, SC 29634-1323
Phone: 864-656-1373
Fax: 864-656-7519
EDITORIAL POLICY and SUBMISSION GUIDELINES

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. Authors are encouraged to provide data (at a reasonable cost) for replication purpose should such a request arise.

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.

Review and Publication Policies
The Editor reads each submitted manuscript to decide if its topic and content of the paper fit the objectives of JOSRE. Manuscripts that are appropriate are assigned anonymously by the Editor to one member of the Editorial Board and at least one other reviewer. The Editor makes the final decision regarding re-submissions. Upon receiving a re-submission, the Editor determines whether or not the manuscript should re-enter the reviewing process, be accepted or simply be returned.

The Editor determines the publication schedule for accepted manuscripts. As a general rule, the Editor attempts to “balance” the topics covered in any one issue. Consequently, the Editor may choose the articles to be included in a given issue from among those already accepted for publication. This general rule will be set aside should the Board of Directors decide to do so, such as in the case of a special issue devoted to a single topic.

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.

Submission via email is strongly encouraged. Except for the final version, manuscripts can be submitted via email in Word® or PDF® file formats to nmiller@sandiego.edu. Submitted papers will be sent to reviewers via email, whenever feasible. For manuscripts submitted via email, the expected turnaround time is eight weeks. For hard copy submissions, the expected turnaround time is twelve weeks. Upon acceptance, authors will have to submit a PC-compatible disk containing the file of the manuscript, four style-correct hard copies and a signed release form. The Editor does not accept responsibility for damage or loss of submitted papers.
Articles and correspondence can also be directed to:

Norman G. Miller  
University of San Diego  
Burnham-Moores Center for Real Estate  
5998 Alcala Park Drive  
San Diego, CA 92110-2492  
Phone: 619-260-7939  
Email: nmiller@sandiego.edu

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

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.

Summary
Each manuscript should include at the end of the text, a non-technical summary statement of the main conclusions.

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 2 or 3 numbers. All figures need to be sharp, clear and laser-quality. Exhibits in the final version must not be in color.

Mathematical Proofs, Equations
Lengthy mathematical proofs and extensively detailed mathematical tables should be placed in an appendix (or omitted entirely) and every effort should be made to explain the proofs. Equations should be placed on a separate line, centered and numbered consecutively at the right margin.

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.

References
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. For nonmembers, a submission fee of $135 is required (one year’s Academic Membership dues).
THE AMERICAN REAL ESTATE SOCIETY

Officers

President
Robert A. Simons
Cleveland State University

President Elect
Grant Thrall
Business Geography Advisors

Treasurer
Karl L. Guntermann*
Arizona State University

Director of Publications
William G. Hardin, III
Florida International University

Vice President and Program Chair
G. Stacy Sirmons
Florida State University

Secretary
Thomas M. Springer
Clemson University

Executive Director
Stephen Pyhrr*
Kennedy Wilson

Associate Executive Directors
Steven C. Bourassa
University of Louisville
Chris Manning
Loyola Marymount University

Executive Editor, JHR
Leonard Zumpano
University of Alabama

Managing Editor, JHR
H. Shelton Weeks
Florida Gulf Coast University

Editor, JOSRE
Norman G. Miller
University of San Diego

Ass. Editors, JOSRE
Kwame Addae-Dapaah
National University of Singapore
Nico B. Rottke
European Business School

Editor, JREPE
William G. Hardin, III
Florida International University

Newsletter Editor
Stephen Pyhrr
Kennedy Wilson

Historian and Parliamentarian
Joseph D. Albert*
James Madison University

Associate Executive Editors
David M. Harrison
Texas Tech University
Mauricio Rodriguez*
Texas Christian University
Michael J. Seiler
Old Dominion University

Editors, JREL
Paul Gallimore
Georgia State University
William G. Hardin, III
Florida International University
Daniel Winkler
University of North Carolina–Greensboro

Editors, JREPM
Randy Anderson
University of Central Florida
Ping Cheng
Florida Atlantic University
Glenn R. Mueller*
University of Denver & Dividend Capital

Executive Editor, JRER
Ko Wang
Baruch College / CUNY

Editors, JREPE
Paul Gallimore
Georgia State University
William G. Hardin, III
Florida International University
Daniel Winkler
University of North Carolina–Greensboro

Editors, JREPM
Randy Anderson
University of Central Florida
Ping Cheng
Florida Atlantic University
Glenn R. Mueller*
University of Denver & Dividend Capital

Newsletter Editor
Stephen Pyhrr
Kennedy Wilson

Board of Directors

Youguo Liang (2010–14)
Prudential Real Estate

Marc A. Louargand* (2008–13)
Commercial Real Estate Advisers

Margaret McFarland (2009–12)
University of Maryland

Norman G. Miller* (2007–12)
University of San Diego

Mauricio Rodriguez* (2009–14)
Texas Christian University

Douglas Sawyer (2009–14)
CCIM Institute & Sawyer Properties

Sean Salter (2011–2016)
Middle Tennessee State University

James Shilling (2009–14)
DePaul University

Thomas M. Springer (2008–13)
Clemson University

John Williams* (2011–16)
Morehouse College

Richard Wincott (2008–13)
Altus Group

Elaine M. Worzala* (2011–16)
Clemson University

IRES Board Members

Jane Londerville (2010–13)
University of Guelph

Karen Gibler (2011–14)
Georgia State University

Marsha Courchane (2010–15)
Charles River Associates

Sofia Dermisi (2010–15)
Roosevelt University

Terry R. Dunkin (2007–12)
Appraisal Institute & Grubb & Ellis

Andrew C. Florance (2010–15)
CoStar Group

William G. Hardin, III (2008–13)
Florida International University

David Harrison (2007–12)
Texas Tech University

Steven P. Laposa* (2010–15)
Colorado State University

Marc Anikeef (2009–12)
Johns Hopkins University

*Past President

Mauricio Rodriguez* (2010–15)
Texas Christian University

Michael Seiler
Old Dominion University

ARES Webmasters
Mark Sunderman
University of Memphis

Ko Wang
Baruch College / CUNY

Meeting Planner
Arthur L. Schwartz, Jr.*
University of South Florida–Emeritus

Director of International Liaison
Graeme Newell
University of Western Sydney

Director of Finance
Joseph B. Lipscomb*
Texas Christian University

Director of Placement
Margot Weinstein
MW Leadership Consultants, LLC

Industry Liaison
Geoffrey Dohrmann
Institutional Real Estate, Inc.

Ombudsperson
Larry E. Wofford*
University of Tulsa

IRES Board Members

Jane Londerville (2010–13)
University of Guelph

Karen Gibler (2011–14)
Georgia State University

Michael Anikeef (2009–12)
Johns Hopkins University

*Past President
ix Preface

1 Dynamics of Green Rentals over Market Cycles: Evidence from Commercial Office Properties in San Francisco and Washington DC
Prashant Das, Alan Tidwell, and Alan Ziobrowski

23 Residential Land Values and Walkability
Stephanie Yates Rauterkus and Norman G. Miller

44 The Political Economy of Green Industrial Warehouses
David M. Harrison and Michael J. Seiler

68 Greening the Regulatory Landscape: The Spatial and Temporal Diffusion of Green Building Policies in U.S. Cities
Constantine E. Kontokosta

91 Explaining LEED Concentration: Effects of Public Policy and Political Party Eugene Choi and Norman G. Miller

109 Valuing Green Home Designs: A Study of ENERGY STAR® Homes
Bryan Bloom, MaryEllen C. Nobe, and Michael D. Nobe

127 The Demand for Green Housing Amenities
Kimberly R. Goodwin

142 The Role of Dual-pane Windows and Improvement Age in Explaining Residential Property Values
Ramya Rajajagadeesan Aroul and J. Andrew Hansz

162 Green Mark Certification: Does the Market Understand?
Kwame Addae-Dapaah and Su Jen Chieh

192 The Process for Adopting an Energy Efficiency Code in Existing Homes: A Case Study of Boulder, Colorado’s SmartRegs Program
Laura Barrett, Scott Glick, and Caroline Clevenger

211 Does Sustainability Pay Off for European Listed Real Estate Companies? The Dynamics between Risk and Provision of Responsible Information
Marcelo Cajias and Sven Bienert

232 Facility Sustainment and Firm Value: A Case Study Based on Target Corporation
Robert Beach

254 The Cost of LEED—An Analysis of the Construction Costs of LEED and Non-LEED Banks
Chad Mapp, MaryEllen C. Nobe, and Brian Dunbar

274 Creative Construction: The Capacity for Environmental Innovation in Real Estate Development Firms
William B. Bradshaw II

312 Sustainability and Graduate Business Education: An Analysis of the Need, Best Efforts to Date, and Curriculum Recommendations
Marnie L. Abramson