Rating Green Buildings Ratings: Examining the Relationship between Green Building Certification and Property Values under Energy Benchmarking and Disclosure Policies

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INTRODUCTION

The construction and operation of buildings account for 36% of global energy use and 39% of energy-related carbon dioxide emissions.[1] While the importance of sustainable and environmentally-friendly buildings is evident, the exact avenue for how to achieve reductions in building energy consumption and carbon emissions has not always been clear.

Green building certification systems arose in the 1990s and grew rapidly in the 2000s as a private-sector pathway toward building more sustainable buildings. Introduced in 1998, Leadership in Energy and Environmental Design (LEED) experienced slow growth early on but grew rapidly from 2005 and onwards, particularly in the new office and institutional building sectors.[2] While initially private-sector driven, green building certification soon crossed over into the public sector. By the late 2000s, LEED had become the de facto U.S. green building standard both in the private sector and in public policy regulations. In the United States, green building certification and LEED certification became almost synonymous with one another.

Fast forward a decade, however, and LEED certification has slowly but surely lost its luster. While it remains the preeminent green building certification program in the United States, LEED certification adoption rates have been on a steady decline for the last decade. By the mid-2010s, it became clear to many in the industry that the system would never meet market needs in a way that leads to widespread adoption.[3] Furthermore, while LEED continues to have decent recognition among the general public, it is now only embraced by a relatively small and diminishing segment of the real estate development industry.[4]

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[1] World Green Building Council, "Global Status Report 2017."
[2] Yudelson, *Reinventing Green Building*.
[3] Yudelson.
[4] Yudelson.

At the same time, more and more municipalities began incorporating green building ratings and certifications directly into their urban planning policies. Some, such as Chicago, have chosen to eschew LEED certification and instead adopt their own green building metrics. The City of Chicago implemented the Chicago Energy Benchmarking Ordinance in 2013, which mandates buildings over 50,000 square feet to report their energy usage statistics annually. The Chicago Energy Rating system, derived from the ENERGY STAR Score system used by the Environmental Protection Agency (EPA), was introduced in 2019 to supplement the benchmarking ordinance in order to improve the transparency and visibility of energy efficiency information reported under the Chicago Energy Benchmarking Reports. Under the Energy Benchmarking Ordinance, all buildings receive a one- to four-star rating on the Chicago Energy Rating scale and a one to one hundred score on the ENERGY STAR score scale based on their reported energy usage data.[5]

This relatively new development provides a case study for understanding the role of green building certifications in the context of mandatory benchmarking and disclosure policies. As LEED certification rates continue to decline and sustainable building advocates search for an alternative certification system that works for all buildings, the proliferation of mandatory benchmarking and disclosure requirements in major cities provides an opportunity to study whether mandatory energy benchmarking systems can fill the gap and replicate the economic benefits of LEED certification at a fraction of the cost.

This project examines the relationship between the two green building certification standards—Chicago Energy Rating and ENERGY STAR—and residential property values in downtown Chicago, in order to determine whether the newly introduced certification system can successfully bring public recognition to energy-efficient building practices and translate that

[5] City of Chicago, "Chicago Energy Benchmarking Homepage."

recognition into economic value. My findings shed light on the broader question of whether greater visibility and transparency from mandatory reporting can lead to greater willingness to pay for green-certified residential spaces, as well as whether such a system has the potential to replace the more costly LEED certification process.

Ultimately, I argue that there is, at least so far, no evidence of a significant relationship between either Chicago Energy Rating or ENERGY STAR score and residential property values in downtown Chicago. Hence, mandatory energy benchmarking and disclosure policies are currently unable to completely replicate LEED's ability to translate recognition of sustainable building practices into economic premiums. Despite these initial findings, I remain optimistic that a positive correlation between certification status and property value will eventually develop as public awareness of the benchmarking program increases.

I begin with a brief explanation of the different green building certification systems, before conducting a broad review of existing scholarly literature on the economic value of green building certification and mandatory energy benchmarking policies. Then, using annual building-level Chicago Energy Benchmarking Report data and publicly-available property records obtained from the PropertyRadar database,[6] I quantify the relationship between the two certification statuses and residential property purchase prices while holding external factors such as purchase date, number of bedrooms, and square footage constant. After a description of my findings, I contextualize the results of the study and discuss its implications.

[6] "PropertyRadar - Discover."

BACKGROUND & CONTEXT

The two green building certifications that I primarily refer to in this study are ENERGY STAR and Chicago Energy Rating. Although these two programs are linked to one another, they differ in their certification process, implementation, history, scope, and stated goals. It is imperative to understand the fundamental distinctions between the certification methods in order to evaluate each certification's weaknesses and how they can be fixed or replaced, as well as whether steps can be taken to improve green building certification adoption rates as a whole.

ENERGY STAR Score

Established in 1992, ENERGY STAR is a program run by the U.S. Environmental Protection Agency and U.S. Department of Energy that provides energy consumption information about a wide range of products to promote energy efficiency.[7] One component the program measures is building energy performance. ENERGY STAR has since become the most widely-used green building certification in the United States in terms of building space covered due primarily to its ease of use, integration with municipal policies, and low costs relative to other more comprehensive green building certifications such as LEED.[8] However, despite nearly 25% of U.S. commercial building space actively using the ENERGY STAR Portfolio Manager system,[9] it has nonetheless struggled to generate the same public awareness and inroads into popular lexicon as LEED. Questions have also been raised regarding its attractiveness to private-sector developers, particularly in terms of 'brand value'.

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[7] US EPA, "ENERGY STAR."
[8] US EPA, "ENERGY STAR Certification for Buildings."
[9] ENERGY STAR uses a software called ENERGY STAR Portfolio Manager, an energy measurement and tracking tool that allows building managers to benchmark energy use against the energy performance of similar buildings nationwide.

ENERGY STAR is a descriptive measuring system—it describes a given building's standing relative to peer buildings. Unlike certifications that are devised to be used as design tools, ENERGY STAR does not seek to define what measures constitute a 'sustainable building' nor does it seek to prescribe the methods of achieving energy efficiency. Rather, it focuses purely on the actual energy performance of the building.

ENERGY STAR's scoring system is straightforward—buildings receive a score from 1 to 100, with 50 representing the median. A score higher than 50 means that the given building's energy performance is better than the median building of the same building type, while a lower score indicates worse performance. In essence, the ENERGY STAR score is a percentile ranking among similar buildings nationwide, adjusting for primary building use, weather, and climate.[10] In addition to energy use, water use, waste and materials, and greenhouse gas emissions can also be tracked using the Portfolio Manager software; however, these measurements do not have a direct impact on the ENERGY STAR score. Furthermore, buildings can qualify for ENERGY STAR Certification if they achieve a score of at least 75 on the 1 to 100 scale—equivalent to the top 25% of similar buildings.[11] So far, the proportion of total U.S. commercial building space that is eligible to be ENERGY STAR Certified is slightly below 6.25%.[12]

Chicago Energy Rating

The Chicago Energy Rating System, implemented in 2019, provides all buildings in compliance with the Chicago Energy Benchmarking Ordinance with a score from one star to four stars, with one star indicating the lowest performance and four stars indicating the highest energy

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[10] Rather than comparing with buildings in Portfolio Manager, which would obviously create selection bias, peer group data is based on Commercial Building Energy Consumption Survey (CBECS) data, a national survey conducted every 5-7 years by the U.S. Department of Energy's Energy Information Administration.
[11] US EPA, "ENERGY STAR Certification for Buildings."
[12] (calculation) 25%*25% = 6.25%

performance. Property owners are required to post their assigned rating in a conspicuous place at the building entrance and share it when listing the property for sale or lease.[13]

The rating system is directly integrated with the ENERGY STAR Portfolio Manager system and tracks with ENERGY STAR score, but with a few caveats. A Chicago Energy Rating score of 1 star equates to an ENERGY STAR score of 1 to 30; 1.5 stars to 31-40; 2 stars to 41-50; 2.5 stars to 51-60; 3 stars to 61-70; 3.5 stars to 71-80; and 4 stars to 81-100. A building can also gain an additional star if it improves at least 10 points within the past two reporting years.[14] Therefore, Chicago Energy Rating scores not only represent a building's energy performance but also year-to-year energy performance improvements, thereby providing an additional incentive for building managers to strive towards marginal energy efficiency gains.

[13] City of Chicago, "Chicago Energy Benchmarking Homepage."
[14] City of Chicago, "Chicago Energy Rating."

PRIOR SCHOLARSHIP ON THE ECONOMIC VALUE OF CERTIFICATION

Although the main objective of green building certifications is to quantify and assess the environmental performance of a building, the economic benefits of certification are often equal to, if not more important, in determining the adoption rates of green building certifications. Historically, attempts at quantifying the property-level economic benefits of green building certification focus on operating cost savings, rental premiums, and sales premiums. The mixed and/or inconclusive results of these studies suggest that they may have failed to consider broader trends that can affect economic performance metrics. While many studies have focused on property-level effects, fewer studies examine city-level factors such as urban public policies and their confounding effects on the relationship between environmental certification and economic performance. One such example of a public policy is the implementation of mandatory energy benchmarking and disclosure policies, an action that many cities around the country have implemented in recent years. Intuitively, these benchmarking policies should fundamentally change the relationship between certification and economic benefits by virtue of improving transparency and reducing information asymmetry. Yet because these are relatively new developments, they have not been, to this point, well-studied. Using Chicago as a case study, this project seeks to better understand whether mandatory energy benchmarking and disclosure policies have an impact on the property-level economic benefits of green building certifications.

Operating costs

Operating cost savings, particularly in the form of reducing energy costs, is often a major drawing point of green buildings for owners and operators since the long-term operating expense savings can offset the upfront costs of certification. Subsequently, substantial literature has been dedicated to empirically study this relationship. Theoretically, green building-certified properties are designed to be more energy-efficient and thus have lower operating costs. In practice, however, the current evidence on green building certifications' impact on operating costs (and energy efficiency) is inconsistent and often contradictory.

Some studies have pushed back against the assumption that green-certified buildings are cheaper to operate. For example, a 2014 study by Szumilo and Fuerst found that the operating expenses of LEED or ENERGY STAR Certified buildings in the four largest US office markets were actually 11.2% higher than non-certified buildings.[15] Other studies found that while LEED-certified buildings had slightly lower operating costs, ENERGY STAR Certified buildings had slightly higher operating costs than non-certified buildings.[16,17] The conclusion that ENERGY STAR Certified buildings have higher operating costs is particularly surprising considering that the ENERGY STAR Rating scale is entirely based on energy usage, a major operating cost. Potential explanations for this seemingly counterintuitive finding include the energy rebound effect, increased (non-energy related) maintenance costs, and self-selection bias.[18]

Nonetheless, scholars generally agree that tenant willingness to pay for rental premiums is associated with lower operating costs, even if actual performance is inconclusive.[19,20,21] Reichardt separated LEED-certified buildings between those where tenants pay for operating expenses and those where tenants do not pay for operating expenses and found that buildings where tenants were not responsible for their operating costs had no significant rental premiums,

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[15] Szumilo and Fuerst, "The Operating Expense Puzzle of U.S. Green Office Buildings."
[16] Reichardt, "Operating Expenses and the Rent Premium of Energy Star and LEED Certified Buildings in the Central and Eastern U.S."
[17] Devine and Kok, "Green Certification and Building Performance."
[18] Szumilo and Fuerst, "The Operating Expense Puzzle of U.S. Green Office Buildings."
[19] Eichholtz, Kok, and Quigley, "Doing Well by Doing Good?"
[20] Newsham, Veitch, and Hu, "Effect of Green Building Certification on Organizational Productivity Metrics."
[21] Livingstone and Ferm, "Occupier Responses to Sustainable Real Estate."

while buildings where tenants were responsible for their operating costs had an average rent premium of 8.6%.[22] This evidence suggests that the value of certification is at least partially related to operating cost savings.

Price Premiums

The economic rationale for property developers pursuing green building certification often relies on the assumption that the costs of certification can be passed downstream—that prospective owners and tenants are willing to pay a premium for green building certification. As with the case of operating costs, the existing body of research does not present a consensus on whether empirical evidence supports this assumption.

On one hand, some studies have found no statistically significant relationship between green certification status and rental prices.[23,24,25] Potential explanations include tenant ignorance or indifference, energy costs being only a small percentage of total costs, and relatively small sample sizes.[26,27] On the other hand, however, a more recent (2020) review of aggregated peer-reviewed studies concluded that environmental certification has a significant positive effect on rental income.[28] The meta-analysis found that rental incomes from certified buildings were a median of 4.6% higher compared to non-certified buildings. Similarly, a 2009 study conducted

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[22] Reichardt, "Operating Expenses and the Rent Premium of Energy Star and LEED Certified Buildings in the Central and Eastern U.S."
[23] Gabe and Rehm, "Do Tenants Pay Energy Efficiency Rent Premiums?"
[24] Fuerst and McAllister, "The Impact of Energy Performance Certificates on the Rental and Capital Values of Commercial Property Assets."
[25] Veld and Vlasveld, "The Effect of Sustainability on Retail Values, Rents, and Investment Performance."
[26] Gabe and Rehm, "Do Tenants Pay Energy Efficiency Rent Premiums?"
[27] Fuerst and McAllister, "The Impact of Energy Performance Certificates on the Rental and Capital Values of Commercial Property Assets."
[28] Leskinen, Vimpari, and Junnila, "A Review of the Impact of Green Building Certification on the Cash Flows and Values of Commercial Properties."

by Berkeley researchers found that the sales prices of units in certified buildings were on average 16% higher than in non-certified buildings.[29]

Market factors also play an important role in the relationship between green building certification and rental premiums. Specifically, rental premiums vary heavily between market segments and over time, both on the property-level and market-level scale.[30] On the individual property-level scale, a study by Robinson and McAllister found that green building certifications were associated with rental premiums in low and medium-value buildings, but not in high-value buildings.[31] They theorized that because the high-value building market segment was already highly saturated with green-certified buildings, certification was considered the norm and therefore not a differentiating factor. On the city scale, a 2013 study conducted by Eichholtz et al. found that the size of rent premiums was correlated with smaller and/or lower-cost regions, as well as less expensive parts of metropolitan areas.[32] On a global scale, a 2017 study by Costa et al. concluded that rental premiums were higher in developing markets than in more established markets.[33] Certified office buildings in emerging markets yielded larger premiums than peer buildings in developed countries. Since 'high value' buildings are more likely to be in more expensive parts of metropolitan areas and developed markets are more likely to have a higher concentration of 'high value' buildings, Robinson and McAllister, Eichholtz et al., and Costa et al.'s findings corroborate one another.

[29] Mergens and Perrus, "The Legal and Business Case for LEED Certification in the Post-Recession World."
[30] Leskinen, Vimpari, and Junnila, "A Review of the Impact of Green Building Certification on the Cash Flows and Values of Commercial Properties."
[31] Robinson and McAllister, "Heterogeneous Price Premiums in Sustainable Real Estate?"
[32] Eichholtz, Kok, and Quigley, "The Economics of Green Building."
[33] Costa et al., "Are Green Labels More Valuable in Emerging Real Estate Markets?"

Importantly, as the supply of green buildings increased, rent premiums decreased over time.[34,35,36] These studies suggest that as green certifications become more common, the economic benefits of pursuing green certification diminish. The public relations value of LEED certification has also greatly decreased—developers and corporations can no longer promote projects as 'firsts' or as early adopters.[37]

The finding that rent premiums decrease as market saturation increases is particularly important to study in the context of mandatory building performance disclosure implementation since it yields the question: when reporting becomes mandatory, do the premiums associated with green building certification remain?

The Lack of Studies on Residential Buildings

It is important to note that the vast majority of existing research on the economic value of green building certification focuses on commercial office buildings rather than residential buildings. Commercial office buildings compose the majority of downtown urban areas in major cities, yet extrapolating data exclusively from commercial office buildings risks ignoring the possible differences in the economic value of green building certification across different property types. Multifamily residential buildings such as apartment and condominium buildings are often forgotten because they fall in the grey area between commercial and residential real estate.

I expect the relationship between energy efficiency and economic value for residential buildings to differ from commercial office buildings, since residential real estate entails a

[34] Chegut, Eichholtz, and Kok, "Supply, Demand and the Value of Green Buildings."
[35] Robinson and McAllister, "Heterogeneous Price Premiums in Sustainable Real Estate?"
[36] Costa et al., "Are Green Labels More Valuable in Emerging Real Estate Markets?"
[37] Yudelson, *Reinventing Green Building*.

different set of market participants, stakeholders, and mechanisms. Firstly, decision-making in the residential real estate market is dictated by individuals, whereas participants in commercial office space market are corporations. Corporate decision-making, such as leasing decisions, may be dictated by mission statements and corporate policies, both of which are at least partially driven by a desire to maintain a positive public image. On the other hand, individuals involved in residential purchasing or leasing decisions are not bounded by these policies. Secondly, commercial office real estate is generally leased, whereas residential real estate can be both owned and leased by occupants. The extent to which owning rather than leasing property affects price premiums has yet to be established. Similarly, the difference between individual versus corporate decision-making on real estate choices has not been fully explored.

Although the number of large multi-family residential buildings in any given city's downtown area is dwarfed by the number of commercial buildings, the lack of quantitative studies on the relationship between green building certification and residential property values represents a substantial gap in the existing literature—a gap that my project seeks to bridge.

Generalization of Green Building Certification Programs

The two most commonly studied green building certification programs are LEED certification and ENERGY STAR Certification, the two most widely adopted programs in the United States. These two certification programs are conceptually different—one focuses solely on energy usage while one takes a much broader and prescriptive approach to defining environmentally sustainable building practices. However, existing literature often commits one of two flaws: a) clumping multiple certification programs together and generalizing them as green building certification and b) using a single certification program as a proxy for green building certifications in general.

Colloquially, LEED certification has become a generic term for 'green buildings'.[38] Even in academic literature, LEED Certification and ENERGY STAR Certification are often used interchangeably with 'green building certification'; however, they should not be equated with one another in the context of studying the economic costs and benefits associated with certification. Their respective certification process and costs are fundamentally different, as are their market penetration, goodwill value, value proposition, etc. We can therefore reasonably expect that their economic benefits will differ as well, yet many studies treat one or a combination of both as representative of green building certification as a whole.

Energy Benchmarking and Disclosure Policies

Perhaps due to the debatable evidence regarding the economic value of green building certification, adoption rates have remained woefully low since its conception. Recognizing that market forces alone were not sufficiently leading to widespread adoption of sustainable building practices due to the unclear financial upside of certification, urban planners turned to a policy-driven approach to supplement private sector (voluntary) solutions. As a result, mandatory energy benchmarking and disclosure policies for commercial and residential buildings have become increasingly common as part of cities' and municipalities' sustainability strategies.

Conceptually, energy benchmarking and disclosure policies can help bridge the energy efficiency gap—the difference between the socially-optimal and actualized energy efficiency

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[38] Yudelson.

level due to market failures[39,40]—by solving the energy consumption information asymmetry problem, thereby allowing consumers in the real estate marketplace to make the most informed decisions in regards to their sustainability choices.

Information asymmetry can lead to rational inattention to energy efficiency attributes of residential buildings. Without easily-accessible and reliable energy efficiency data, the time and effort required to calculate energy costs associated with residential buildings may cause consumers to ignore the attribute when making purchasing decisions.[41] Similar phenomenons have been observed in purchasing behaviors in the refrigerator and car markets.[42] Studies have shown that peer comparison effects have a positive effect on attentiveness to energy consumption.[43,44,45] The publicization of energy benchmarking data can allow building owners to easily compare energy performance with their peers, thus improving attentiveness.[46]

Practically speaking, early case studies have yielded mixed results. Beginning in the late 2000s and continuing throughout the 2010s, several major cities adopted building energy disclosure policies, including Washington D.C., Austin, New York, Seattle, San Francisco, Philadelphia, Boston, and Chicago.[47]

Chicago's Energy Benchmarking Ordinance has been studied, both by government and independent researchers, for how these mandatory disclosure policies affect green building certification adoption. For example, the city-commissioned 2016 Energy Benchmarking Report, which tracked energy usage data for buildings larger than 50,000 square feet in Chicago between

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[39] Hirst and Brown, "Closing the Efficiency Gap."
[40] Jaffe and Stavins, "The Energy-Efficiency Gap What Does It Mean?"
[41] Palmer and Walls, "Using Information to Close the Energy Efficiency Gap."
[42] Palmer and Walls.
[43] Allcott, "Social Norms and Energy Conservation."
[44] Costa and Kahn, "Energy Conservation 'Nudges' and Environmentalist Ideology."
[45] Ayres, Raseman, and Shih, "Evidence from Two Large Field Experiments That Peer Comparison Feedback Can Reduce Residential Energy Usage."
[46] Palmer and Walls, "Using Information to Close the Energy Efficiency Gap."
[47] Palmer and Walls.

2013 to 2016, found that the benchmarking and disclosure policy had a significant impact on energy costs, estimated savings, and ENERGY STAR scores. The report claimed that buildings with three consecutive years of reporting since 2013 had an average of 4% reduction in energy cost, $11.6 million per year in estimated savings, and a 6.6% improvement in ENERGY STAR score.

However, a recent independent study that used a single-group interrupted time series model did not find strong evidence that the 2013 Chicago Energy Benchmarking policy had any impact on the trend of ENERGY STAR Certified buildings—there was no significant correlation between the implementation of the benchmarking policy and an increase in the number of energy-efficient buildings.[48] The study hypothesized that this finding could be due to the pre-existing relatively high ratio of certified versus non-certified buildings in Chicago, which leads to the potential conjecture that the impact of benchmarking policies on the number of energy-efficient buildings may be limited for a city that already has a relatively high ratio of energy-efficient buildings.

This study contributes to the existing literature by re-examining the relationship between green building certification and economic benefits but with residential buildings rather than commercial office buildings and within the additional context of the introduction of mandatory building performance disclosure policies. The case study will study two green building certification standards—ENERGY STAR and Chicago Energy Rating—separately to determine whether the implementation of the Chicago Energy Benchmarking Ordinance and Chicago Energy Rating has contributed to any changes in the economic benefits of these certification programs. Not only will the study address the literature gap created by the introduction of

[48] Shang et al., "Impact of Energy Benchmarking and Disclosure Policy on Office Buildings."

mandatory building performance disclosure policies, but it will also be an early contributor to the academic discourse on the practical effects of Chicago's Energy Benchmarking Ordinance and the development of the Chicago Energy Rating.

DATA & METHODS

In this study, I quantify the relationship between green building certifications and property value among residential condominium buildings in downtown Chicago. I evaluate residential units within buildings over 50,000 square feet based on the following two green building certification programs: ENERGY STAR and Chicago Energy Rating. For each certification program, I observe whether sales prices are significantly correlated with certification rating (and status if applicable). To achieve this, I utilize the statistical analysis software R to create regression models based on publicly available data.

Study Area

The study area I have chosen to use for my research is downtown Chicago, defined by the ZIP codes 60601, 60602, 60605, 60606, 60607, 60610, 60611, 60654, and 60661. This area roughly corresponds to the Loop, River North, Streeterville, Fulton Market, and parts of South Loop and West Loop. Since real estate values are heavily influenced by location, I attempt to control for location by limiting the geographical scope of the study.[49, 50] For example, property values in downtown Chicago are significantly higher than in the Far Southeast Side, Far Southwest Side, or other areas further away from the city center. The selection of the study area was predicated on the following factors: 1) its approximation of the ambiguously-defined ‘downtown Chicago’, 2) the size and density of its building stock, and 3) the high density of green-certified buildings relative to other areas of Chicago.

Focusing exclusively on Chicago’s central business district (CBD), defined colloquially as the Loop but recognized by the Municipal Code of Chicago to consist of the Loop community

[49] Klimczak, “Determinants of Real Estate Investment.”
[50] Haider and Miller, “Effects of Transportation Infrastructure and Location on Residential Real Estate Values.”

area as well as parts of the Near West Side and Near North Side community areas, makes sense for studying commercial and office buildings; however, a broader study area is necessary for residential buildings. Whereas office buildings are primarily concentrated within Chicago's CBD boundaries, high-rise condominium buildings are more spread out across downtown Chicago. Ideally, the less variation in geographical location, the more we can eliminate the location effect on property values. After all, the adage that real estate is all about '*location, location, location*' has been around since at least the 1920s.[51] However, narrowing the study area reduces the sample size, which reduces the likelihood of statistically significant findings. Therefore, limiting the study area to the downtown Chicago area rather than individual community areas is the best balance between controlling for location and maintaining a large enough sample size.

Furthermore, the downtown Chicago area has the greatest concentration of eligible buildings. A geospatial analysis of the 2020 Chicago Energy Benchmarking Report data shows that the vast majority of buildings over 50,000 square feet are concentrated in the Loop, the Near North, West Loop, and to a lesser extent South Loop.[52] The Near North Side had the largest number of eligible buildings with 554, followed by the Loop with 358 and the Near West Side with 294.[53] A visual depiction of the distribution of buildings over 50,000 square feet by community area is displayed in the map below.

[51] Safire, "Location, Location, Location."
[52] City of Chicago, "Chicago Energy Benchmarking Homepage."
[53] City of Chicago.

Map of Buildings over 50,000 Square Feet by Chicago Community Area

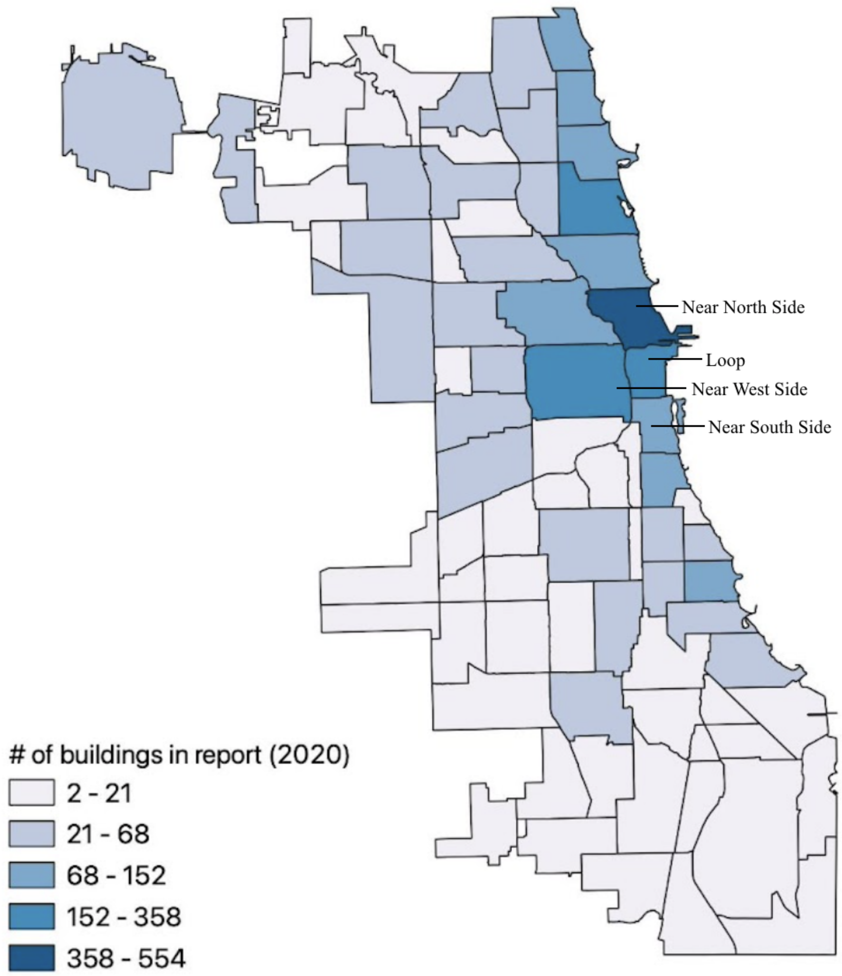

Figure 1: *Geospatial Map of Buildings over 50,000 Square Feet by Chicago Community Area*. Created with QGIS using data from the 2020 Chicago Energy Benchmarking Report.[54]

Lastly, the study area ideally has both a high density of green-certified buildings and a large enough sample across all certification levels. Overall, the downtown areas of the Loop, the Near North Side, the Near West Side, and the South Loop fulfill this specification the best by virtue of higher building densities. The Loop and the Near West Side are particularly

[54] City of Chicago, “2020 Chicago Energy Benchmarking Report.”

'green'—the mean Chicago Energy Rating was 3.23 on the 4-star scale for eligible buildings in the Loop and 3.28 for eligible buildings in the Near West Side. A full map of the average Chicago Energy Rating of eligible buildings by community area is shown below.

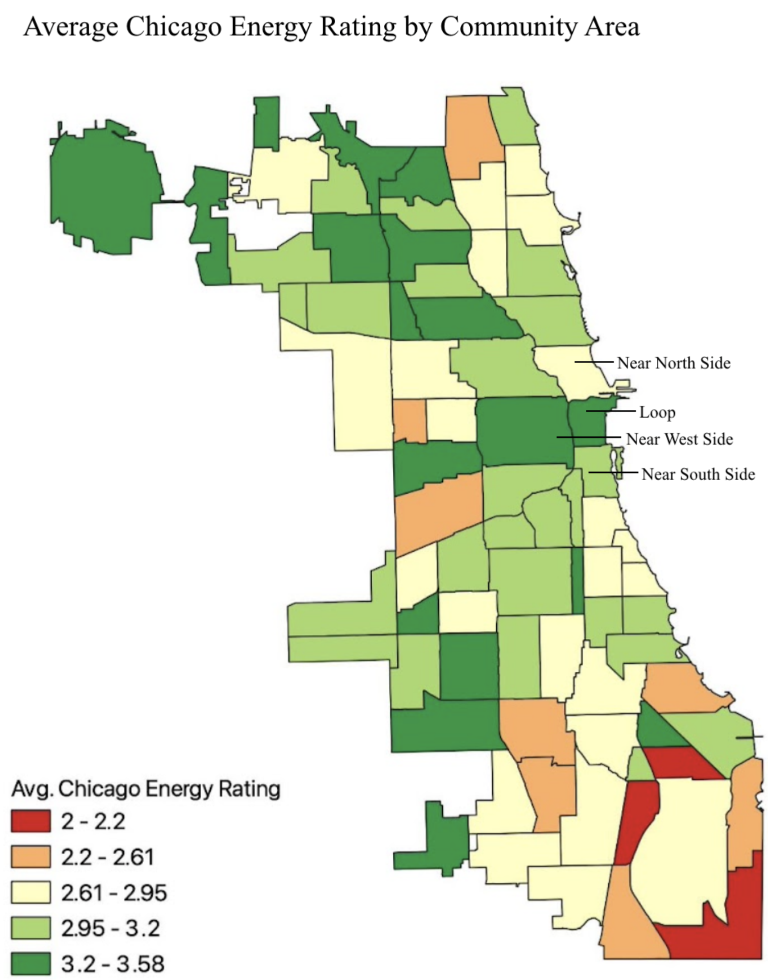

Figure 2: *Mean Chicago Energy Rating for Buildings over 50,000 Square Feet by Chicago Community Area*. Created with QGIS using data from 2020 Chicago Energy Benchmarking Report.[55]

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[55] City of Chicago.

In sum, the study area of ZIP codes 60601, 60602, 60605, 60606, 60607, 60610, 60611, 60654, and 60661 was chosen for this study because it best represents the conventional boundaries of downtown Chicago, has the highest density of buildings larger than 50,000 square feet, and has a good distribution of buildings across certification levels.

Data

This study primarily draws data from two sources: annual Chicago Energy Benchmarking Report data published by the city of Chicago and public property records accessed from real estate data provider PropertyRadar's database.[56,57]

Under the Chicago Energy Benchmarking Ordinance, all buildings larger than 50,000 square feet (with limited exceptions) are mandated to report and submit data to the city, which is then released to the public through annual Energy Benchmarking Reports.[58] In addition to basic property-level descriptive data such as building ID, property name and address, primary property type, year built, and gross floor area, the Chicago Energy Benchmarking Reports also contain important green building certification information and energy performance metrics. The dataset reports each individual property's ENERGY STAR score (1 to 100 scale), Chicago Energy Rating (0 to 4 scale), Electricity Use Intensity (EUI), and Water Usage, among other variables. This dataset allows me to identify and sort properties by ENERGY STAR score and Chicago Energy Rating, two green building certifications that this paper will be studying.

Property-level residential real estate transaction data was obtained from Property Radar, an online database that draws from public property records. The key variables that I was

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[56] City of Chicago, "Chicago Energy Benchmarking Homepage."
[57] "PropertyRadar - Discover."
[58] Theoretically, the benchmarking reports represent fairly accurate and complete depictions of the city's building stock that satisfies the size requirements; however, their actual accuracy and completeness are unknown but most likely a fair degree lower due to imperfect compliance rates and enforcement mechanisms.

interested in for this study are location (geospatial coordinates), ZIP code, address, property type, number of bedrooms, square footage, sales price, and sales date. I filtered the transaction data on Property Radar to only include properties that were classified as condominiums, located in the 60601, 60602, 60603, 60604, 60605, 60606, 60610, and 60611 ZIP code areas (which correspond to the 'downtown Chicago' area), were 300 square feet or larger in size, and have been purchased for a price of at least $50,000 since the start of 2016. The square footage and minimum price requirements were instated to filter out parking spots, which are often sold as separate deeds and therefore show up in public property records as individual transactions. After creating the list of usable properties, I downloaded the newly-created dataset in a .csv format.

I then joined the Property Radar dataset with the Chicago Energy Benchmarking Report dataset by street address to create a merged dataset. This merged dataset contained all condominium units that satisfied the above criteria and the Energy Benchmarking data of the condominium buildings they are located in. For example, a given unit would have all its individual unit-level information such as transaction price, square footage, etc., as well as building-level data such as ENERGY STAR score, EUI, etc.

Methodology

After creating the merged dataset, the next step of the study was to identify and account for potential external factors that may affect property values. Since my analysis focuses only on residential property values, I restricted primary property type/usage to multifamily residential buildings.

Other factors such as location, number of bedrooms, square footage, and real estate market state are also key drivers of property values. In order to control for the most important factor—location—I narrowed down the geographical scope of my analysis. To determine the best way to partition the building stock, I created geospatial visualizations in QGIS that analyzed the Chicago Energy Benchmarking Reports by community areas. Ultimately, I restricted my analysis to properties within the ZIP codes 60601, 60602, 60605, 60606, 60607, 60610, 60611, 60654, and 6066.[59]

Beyond location, the most important unit-level property value determinants are the number of bedrooms and square footage. Since one-bedroom and two-bedroom units constitute the vast majority of condominium units, the number of bedrooms variable was accounted for by filtering out any units with three or more bedrooms, separating the remaining one-bedroom and two-bedroom units, and repeating each analysis on both sets independently. The effect of square footage on property values was also neutralized by dividing purchase prices by the square footage of the unit to obtain the purchase price per square foot. Using purchase price per square foot allows comparisons across different-sized condo units.

The actual data analysis in this study was conducted using the statistical computing software R. After conducting the necessary steps to merge datasets and filter by additional variables as described above, I conducted two types of data analysis on the different sets of data I had created using the R base package and ggplot.

Firstly, I conducted simple linear regression analyses. To accomplish this, I grouped observations by purchase year. The explanatory variable used was the chosen certification rating and the dependent variable was the purchase price per square foot. I then created a visual depiction of each linear regression analysis using scatterplots and regression lines. A separate linear regression was created for each combination of the number of bedrooms (either one or two), certification program (either ENERGY STAR or Chicago Energy Rating), and purchase

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[59] See Study Area portion of this section above for a full explanation and analysis of the chosen study area.

year. Certification ratings were based on the Energy Benchmarking Reports of each corresponding purchase year. For example, the regression for purchases in 2019 used the ENERGY STAR and Chicago Energy Rating scores from the 2019 Energy Benchmarking Report. From running the regressions, I obtained a correlation coefficient and associated p-value for each of the datasets.

Building upon the foundation created by the simple linear regression analyses, I analyzed the monthly median purchase prices for condominium units in buildings with ENERGY STAR scores above and below 75. In doing so, I was able to conduct a month-by-month comparison of purchase prices between ENERGY STAR certification-eligible and ineligible buildings. The primary benefit of this type of analysis was that it accounted for intra-year market fluctuations—an external factor that was not addressed in the simple linear regression analyses.

Limitations

The choice to restrict the study by certain variables such as ZIP codes (as a proxy for geographical location) and property type is a tradeoff between reducing the amount of idiosyncratic shock—unobserved determinants of real estate economics—and maintaining a large enough sample size for significant conclusions to be drawn. While I could further narrow down the parameters of the study, I would run the risk of diluting the sample size to the point that the only analysis that can be done is individual case study comparisons. On the other hand, there are many other determinants of real estate valuation/desirability beyond the variables listed. The most obvious of these variables is building age, which undoubtedly influences property values and rental prices. However, filtering buildings by year built yields too few results to make meaningful conclusions. Furthermore, this measurement fails to account for renovations, which may have similar effects as new construction.

Any analysis of public energy benchmarking data relies on the assumption that the disclosed data is accurate; however, the validity of this assumption must be questioned.

Studies based on New York's Energy Benchmarking data found non-trivial errors relating to a lack of standardized variable definitions and improper collection methods of building- and lot-specific data.[60] For example, inconsistent methods for measuring square footage can lead to inaccurately-reported building and unit area sizes. Since energy efficiency is measured on a per-square-foot basis, even minor inconsistencies in building area can have an outsized impact on building energy performance metrics. Overestimating gross building area causes an underestimation of energy consumption per square foot, which consequently leads to higher-than-deserved ENERGY STAR and Chicago Energy Rating scores.

Chicago Energy Benchmarking energy data is self-reported annually and verified every three years by an 'in-house or third-party professional engineer, licensed architect, or other trained individual'.[61] Thus, there is considerable freedom for building managers to determine the actual specifications of the verification process. Additionally, while verification of energy data is required, basic building information such as building age and square footage is taken as given.

Because of the wide leash that the ordinance allows, the possibility of inaccurate data exists—whether it be intentional or unintentional. Even though the ordinance requires building owners to comply with reporting requirements, explicit deterrents for non-compliance do not currently exist. As a result, some building owners have taken a loose interpretation of making

[60] Kontokosta, *New York City Local Law 84 Benchmarking Report, August 2012 (Provided Data Analysis with David Hsu)*.
[61] City of Chicago, "Chicago Energy Benchmarking Homepage."

'good-faith effort[s] to collect and report actual values' and submitted incomplete property information.[62]

Overall, the Chicago Energy Benchmarking dataset, and thus this study, is somewhat limited by potential non-compliance, which further restricts the sample size and introduces additional errors to my study. Filtering out incomplete building entries not only reduces sample size but may also yield an unrepresentative sample, since buildings that have poor energy performance metrics may potentially be more likely to submit incomplete data.

[62] "2021 Chicago Benchmarking Guide."

RESULTS & DATA ANALYSIS

When the City of Chicago announced the implementation of the Chicago Energy Benchmarking Ordinance in 2013 and the Chicago Energy Rating system in 2019, real estate developers, investors, and policymakers surely hoped and anticipated that Chicago Energy Ratings (and by extension ENERGY STAR scores) would be positively correlated to property values. After all, numerous studies have associated green building certifications with sales and rental premiums. Furthermore, other studies have shown an inverse relationship between property values and variable costs, suggesting that energy cost savings could be reflected in higher sales prices.

Despite these factors, there is, at least so far, no significant relationship between Chicago Energy Rating nor ENERGY STAR Certification and property values in residential condominium buildings in downtown Chicago. Furthermore, I suggest that the lack of a ‘sales premium’ is a result of an inability to bridge the information asymmetry problem due to a lack of widespread recognition of the newer certifications, as well as several potentially confounding factors such as building age, building amenities, and building location factors.

ENERGY STAR Score

I found a negative correlation of -0.129 between 2019 ENERGY STAR Score and the purchase price per square foot for two-bedroom units purchased in 2019. The p-value for this correlation was 0.0769, indicating no significance at 0.05 but significance at 0.10. One-bedroom units under the same conditions yielded similar results: correlation coefficient of -0.091 and p-value of 0.2424. Likewise, 2020 ENERGY STAR scores were not significantly correlated with the purchase price per square foot for both one- and two-bedroom units. Scatterplots showing the relationships between ENERGY STAR Score and the purchase price per square foot are shown below.

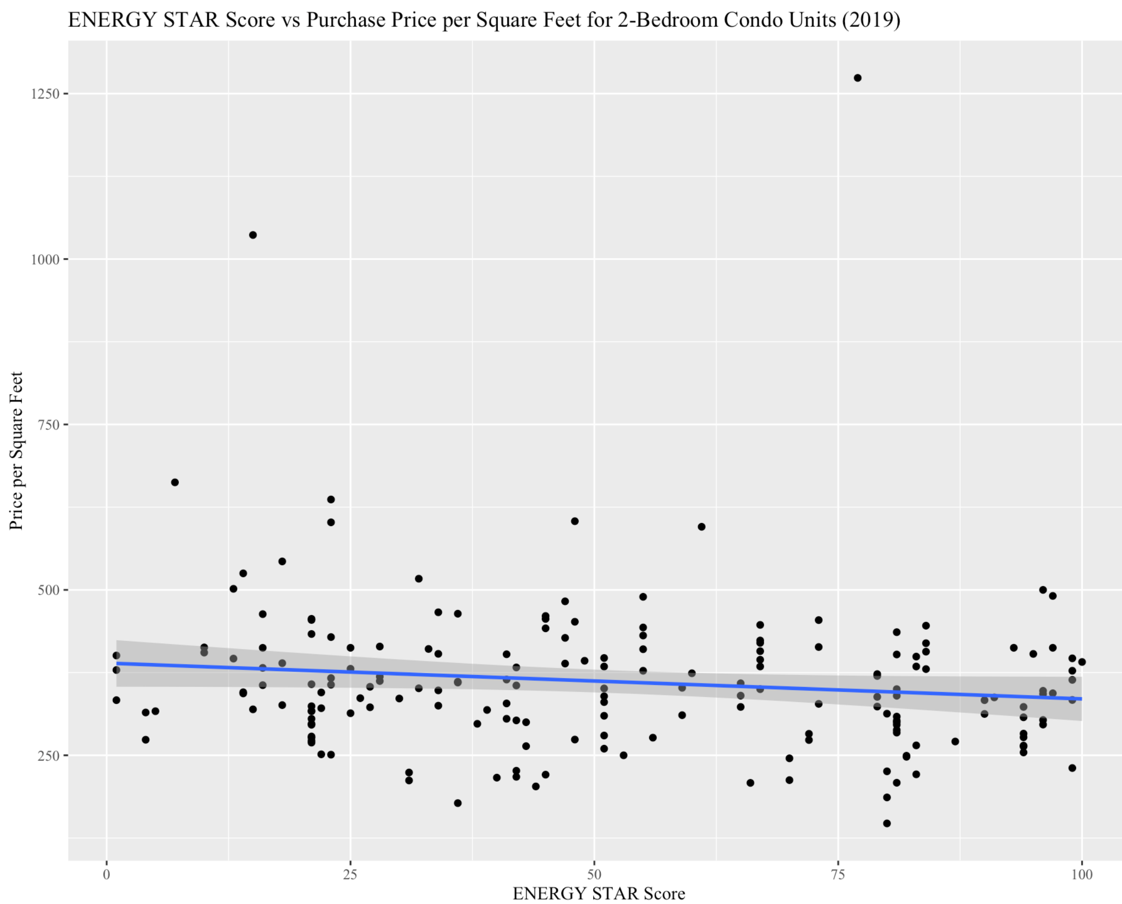

Figure 3: *Scatterplot and Regression Line of ENERGY STAR Score vs Purchase Price per Square Feet for 2-Bedroom Condo Units (2019)*. Created using ggplot package in R using building data from Chicago Energy Benchmarking Reports and public property records from PropertyRadar.

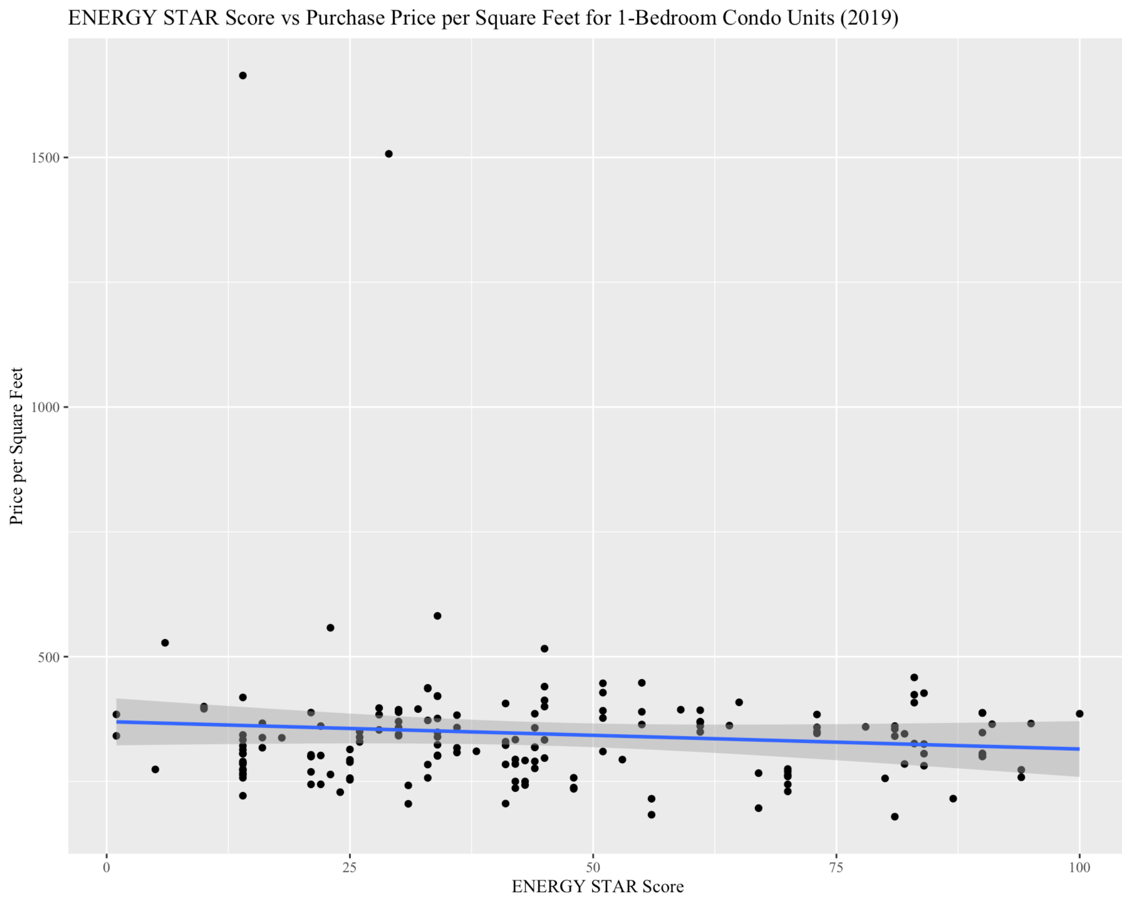

Figure 4: *Scatterplot and Regression Line of ENERGY STAR Score vs Purchase Price per Square Feet for 1-Bedroom Condo Units (2019)*. Created using ggplot package in R using building data from Chicago Energy Benchmarking Reports and public property records from PropertyRadar.

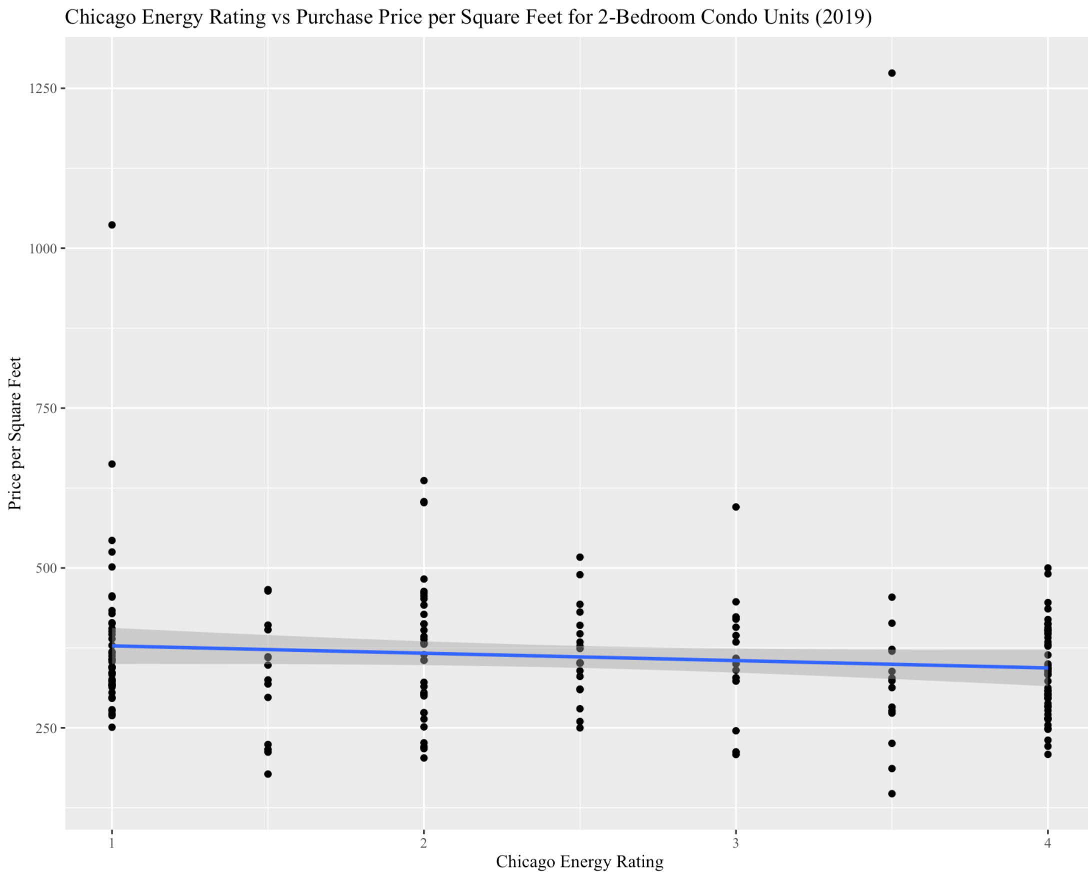

Figure 5: *Scatterplot and Regression Line of Chicago Energy Rating vs Purchase Price per Square Feet for 2-Bedroom Condo Units (2019)*. Created using ggplot package in R using building data from Chicago Energy Benchmarking Reports and public property records from PropertyRadar.

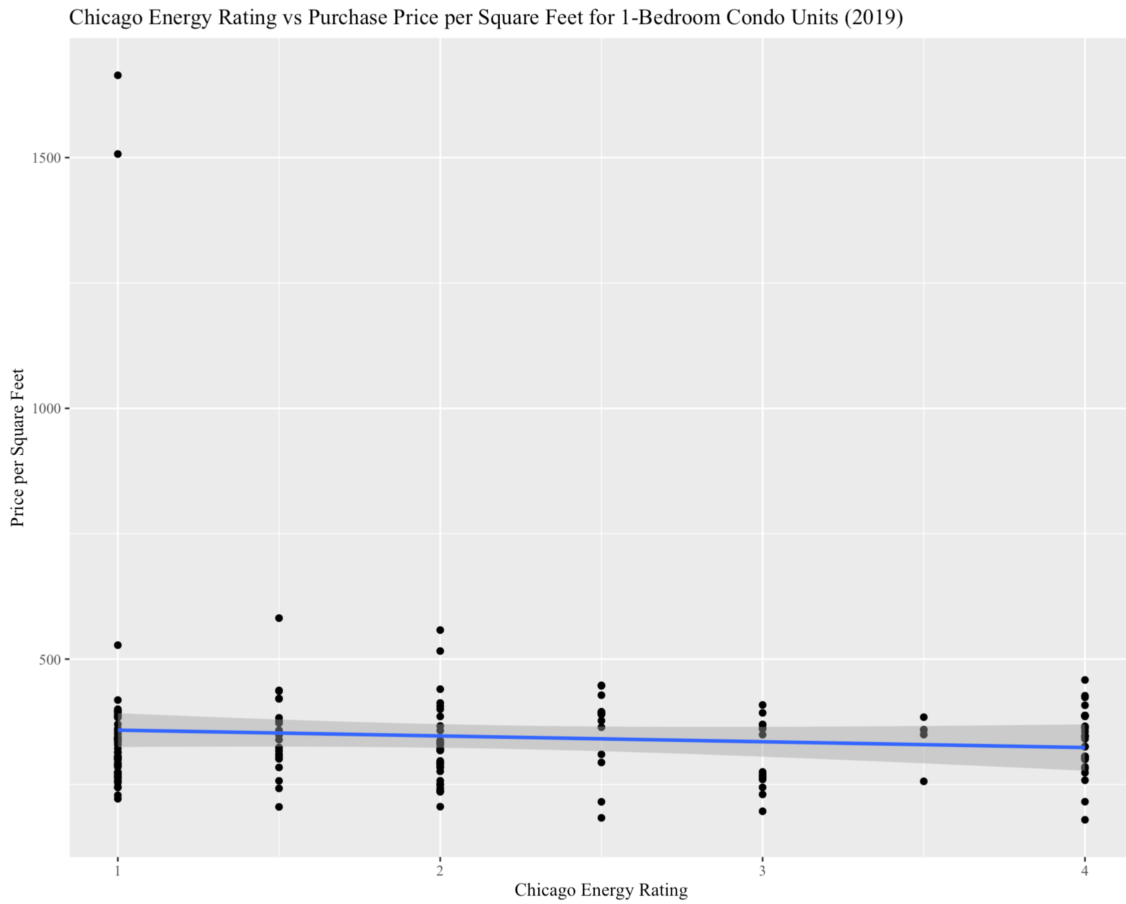

Figure 6: *Scatterplot and Regression Line of Chicago Energy Rating vs Purchase Price per Square Feet for 1-Bedroom Condo Units (2019)*. Created using ggplot package in R using building data from Chicago Energy Benchmarking Reports and public property records from PropertyRadar.

Chicago Energy Rating

I also found negative, albeit statistically insignificant, correlations between Chicago Energy Rating and property values. For two-bedroom units, 2019 Chicago Energy Ratings had a correlation coefficient of -0.110 with property values and a p-value of 0.132. For one-bedroom units, the 2019 Chicago Energy Ratings had a correlation coefficient of -0.0826 and a p-value of

0.287. Based on these findings, I cannot reject the null hypothesis that Chicago Energy Rating and property values do not have any relationship with 90% confidence.

Certification	# of bedrooms	Certification Year	Transaction Year	# of obs.	Correlation Coefficient	P-value	Sig. at 0.05	Sig. at 0.10
ENERGY STAR	2	2019	2019	187	-0.1289986	0.07688	no	yes
ENERGY STAR	1	2019	2019	166	-0.09069131	0.2424	no	no
ENERGY STAR	2	2018	2018	51	-0.0205934	0.8836	no	no
ENERGY STAR	1	2018	2018	51	0.1746413	0.211	no	no
Chicago Energy Rating	2	2019	2019	187	-0.1099753	0.132	no	no
Chicago Energy Rating	1	2019	2019	166	-0.082626	0.287	no	no

Figure 7: *Summary Table of Results.*

It is reasonable to question whether we can expect a linear relationship; after all, certain cutoff points in the certification scores may create non-linear 'jumps' in the relationship. For example, although the ENERGY STAR Score is scaled from 0 to 100, the US EPA also designates a score of 75 as the minimum score cutoff to be eligible for ENERGY STAR certification. Unlike other green building certifications, an ENERGY STAR score of at least 75 is a necessary, but not sufficient, requirement for ENERGY STAR certification; in other words, we cannot simply assume equivalency between a score above 75 and ENERGY STAR certification. Nonetheless, evaluating buildings above and below this threshold may yield important information on the brand value of certification.

A score of 75 represents the given building being more energy efficient than 75% of buildings nationwide with the same primary use after adjusting for climate and weather. While the cutoff is arbitrary by itself, the EPA's decision to choose that arbitrary point as the cutoff makes it potentially significant. Even without assuming equivalency between a score above 75 and actual certification, there may still be a 'jump' at the cutoff point.

To address this potential cause of non-linearity, I compared the monthly median purchase prices for condominium units in buildings with ENERGY STAR scores above and below 75. In the eleven months that there were transactions for two-bedroom units in both buildings with ENERGY STAR scores above and below 75, eight saw lower median purchase prices for units in buildings with scores above 75. Furthermore, none of the monthly median differences were significant. Similarly, no significant correlation existed for one-bedroom units. Importantly, the sample size becomes restrictively small when isolating transactions to individual months. The number of monthly transactions for two-bedroom units ranged from eight to twenty-five and the number of monthly transactions for one-bedroom units ranged from six to twenty-six, with a seasonal trend that tended to increase in the summer months and decrease in the winter months. The small sample sizes do not necessarily mean that only a handful of transactions occurred each month; rather, the small sample sizes only represent transactions that occurred in eligible buildings and that were properly recorded with all input fields. The small sample size limits the conclusions we can draw from the findings.

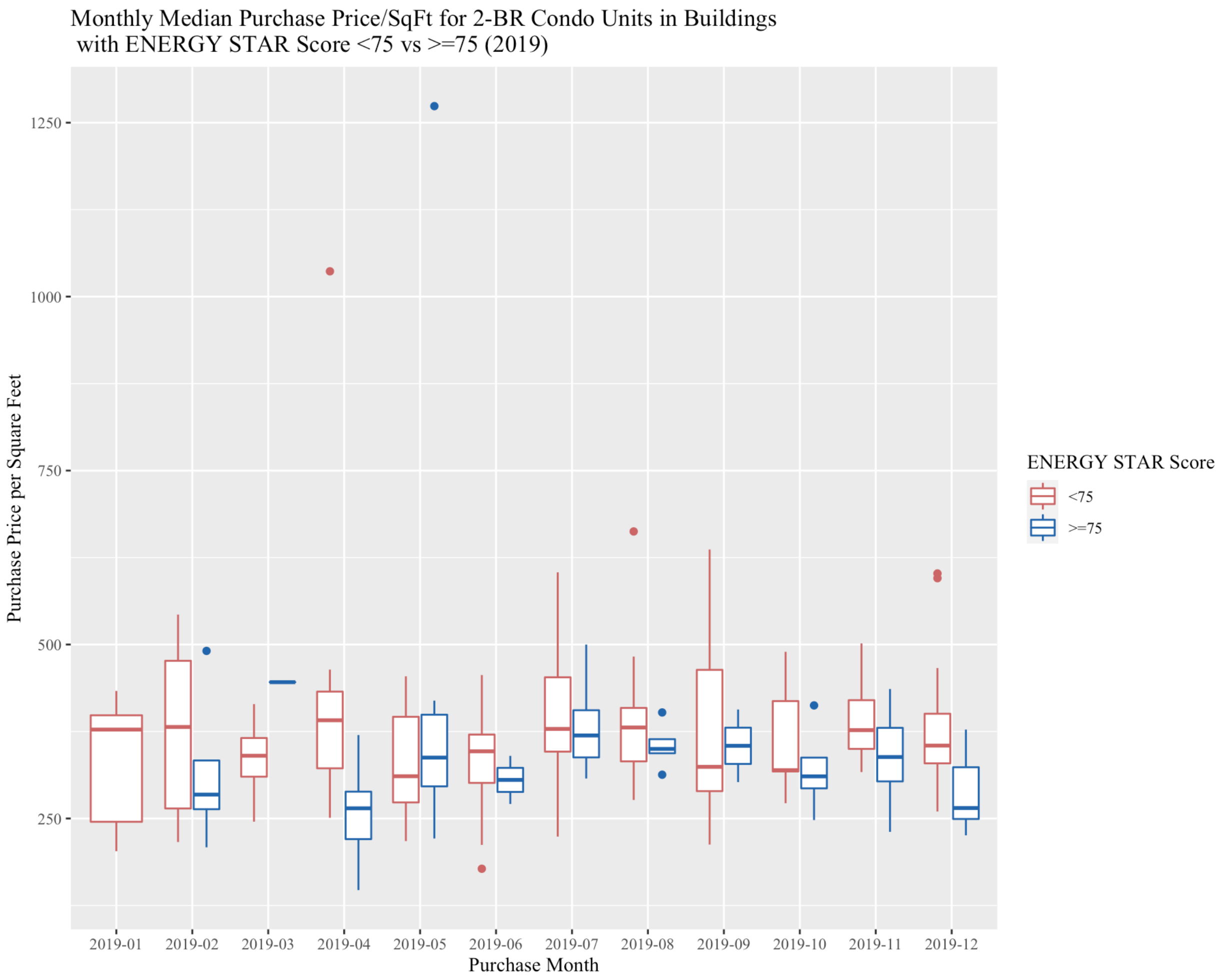

Figure 8: *Boxplot Comparing Monthly Median Purchase Price per Square Feet for 2-Bedroom Condo Units in Buildings with ENERGY STAR Score <75 vs >=75 (2019)*. Created using ggplot package in R using building data from Chicago Energy Benchmarking Reports and public property records from PropertyRadar.

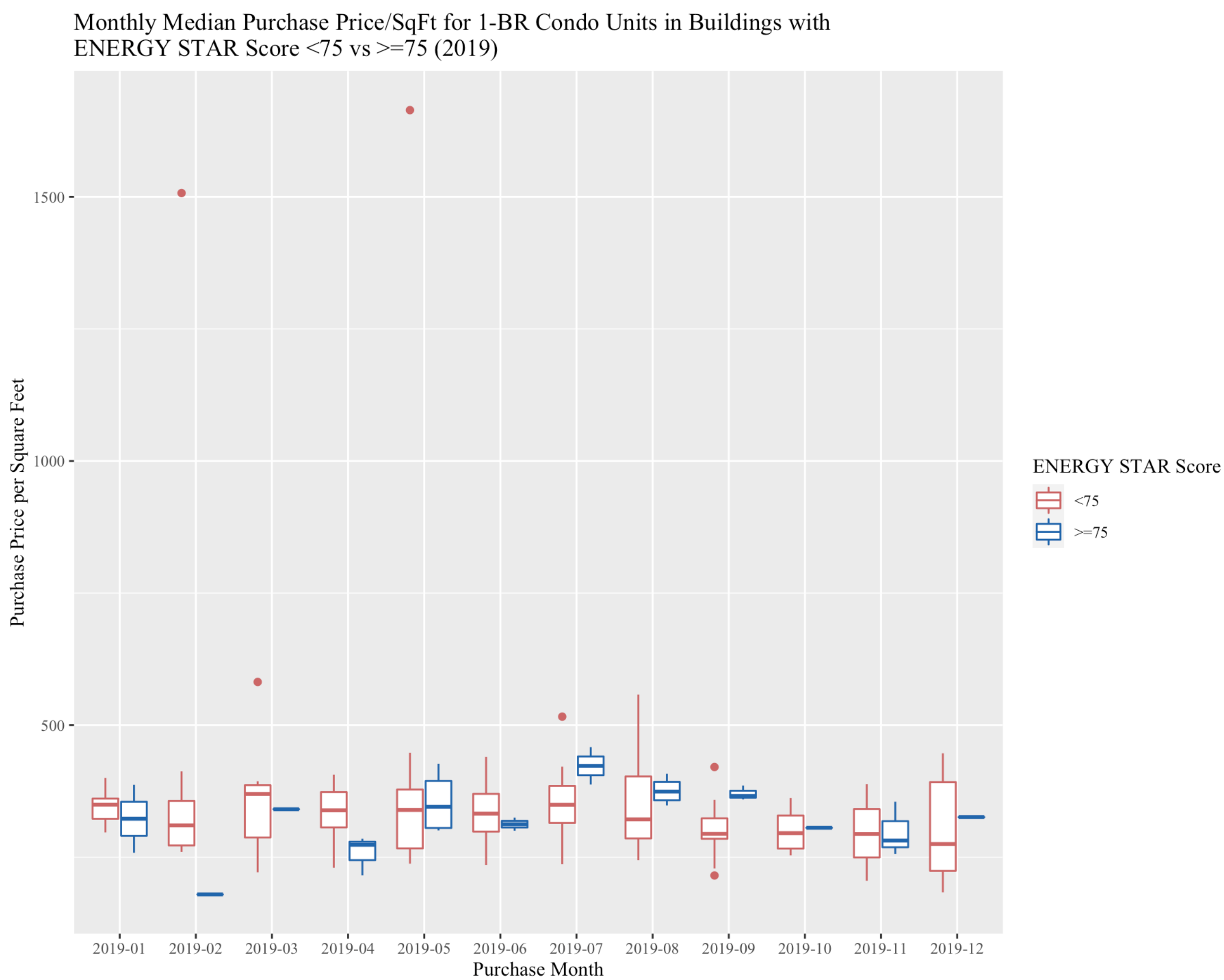

Figure 9: *Boxplot Comparing Monthly Median Purchase Price per Square Feet for 1-Bedroom Condo Units in Buildings with ENERGY STAR Score <75 vs >=75 (2019)*. Created using ggplot package in R using building data from Chicago Energy Benchmarking Reports and public property records from PropertyRadar.

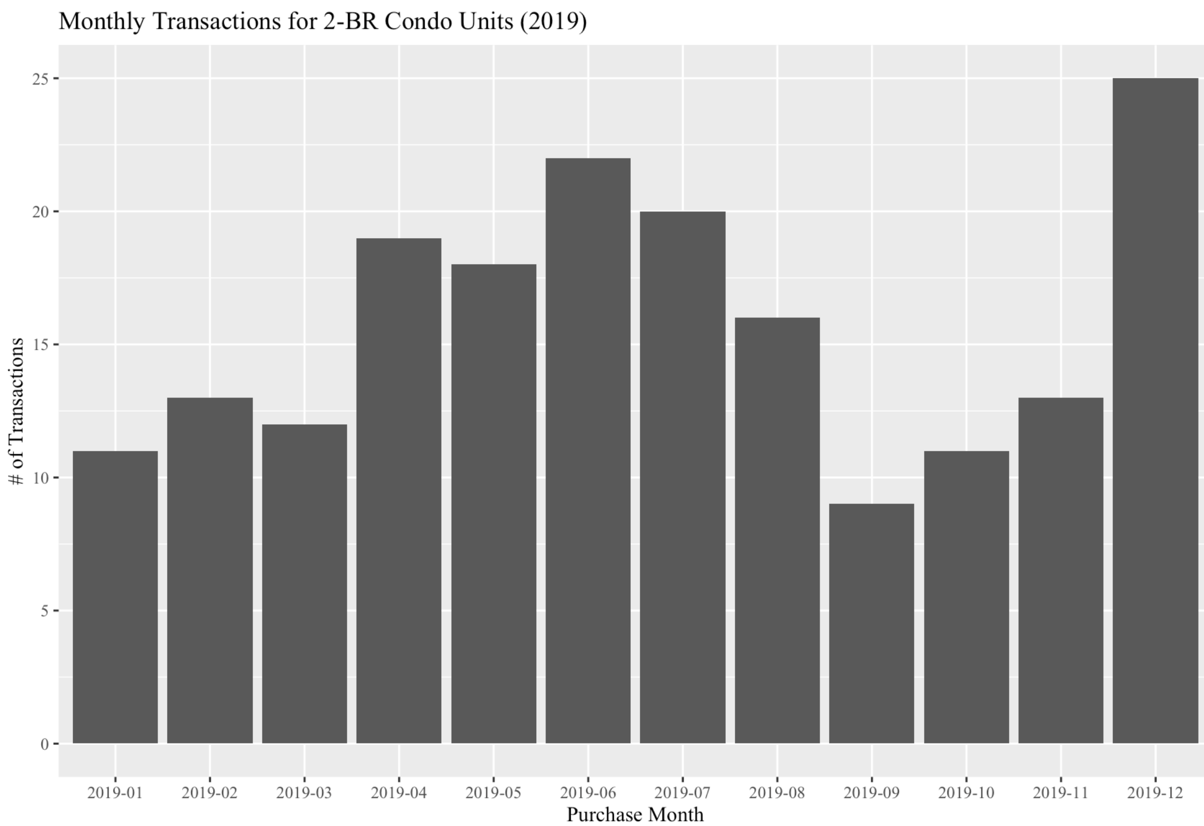

Figure 10: *Bar Graph Displaying Sample Size (Number of Transactions) for 2-Bedroom Condo Units in Buildings (2019)*. Created using ggplot package in R using building data from Chicago Energy Benchmarking Reports and public property records from PropertyRadar.

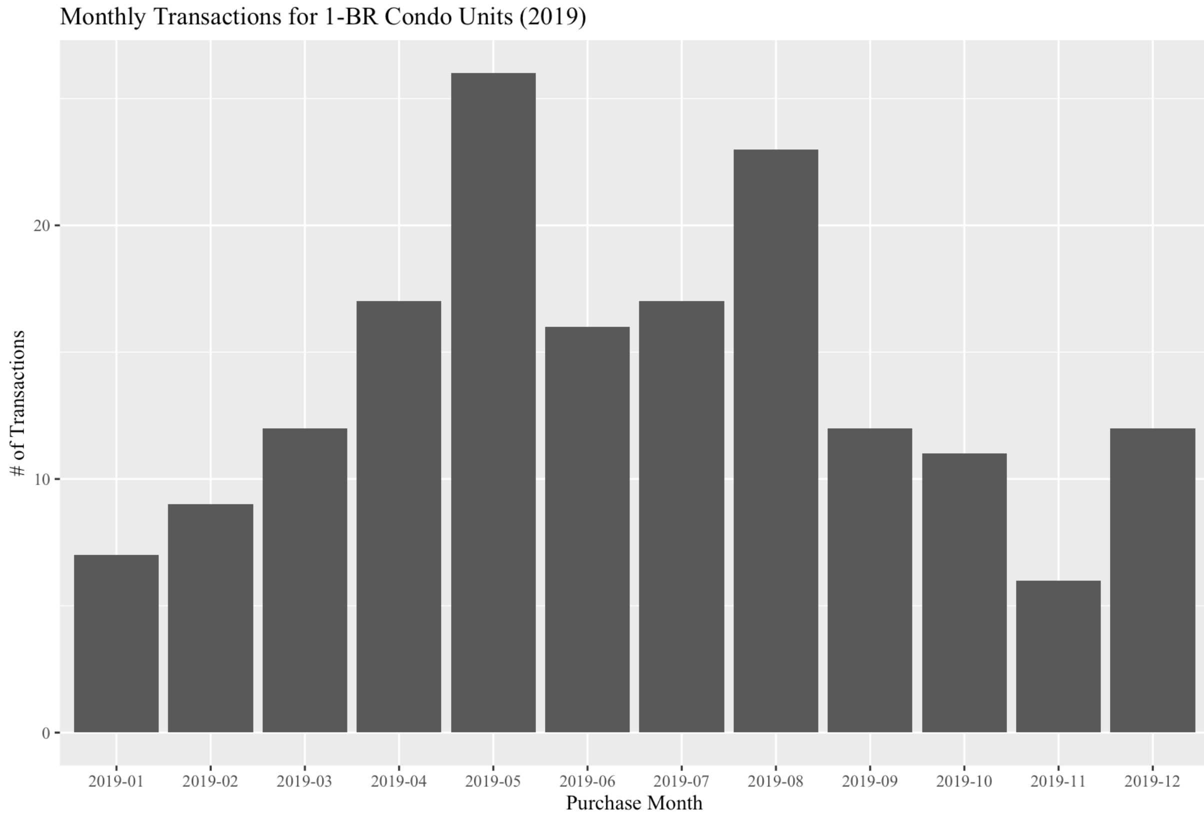

Figure 11: *Bar Graph Displaying Sample Size (Number of Transactions) for 1-Bedroom Condo Units in Buildings (2019)*. Created using ggplot package in R using building data from Chicago Energy Benchmarking Reports and public property records from PropertyRadar.

Discussion

In sum, the study found no evidence of a relationship between either Chicago Energy Rating or ENERGY STAR Score and property values in downtown Chicago condominium buildings. The broader implication is that the study found no evidence that the Chicago Energy Rating system, under the context of mandatory disclosure policies, can be a viable low-cost green building certification program with the ability to influence residential real estate values in a meaningful way. Without the ability to translate environmentally-friendly building design and practices, through market forces, into meaningful economic premiums, developers have little economic incentive to build 'green' buildings (without policy incentives).

In the context of the general green building certification landscape, this finding maintains LEED's importance. Despite the complaints of high costs, regulatory hurdles, unnecessary bureaucracy, and declining ROIs, LEED remains the 'go to' certification for developers hoping to extract premiums for 'green' buildings. As of now, the Chicago Energy Rating system is not yet capable of replicating LEED's sales premiums, nor is it yet able to achieve green building certification's fundamental goals: to bring recognition to sustainable building design practices and to translate that recognition into economic value.

The caveat to this statement is 'as of now'. The biggest limitation of this study is that the Chicago Energy Benchmarking requirement has only been fully-operational since 2015 and the Chicago Energy Rating system has only been in place since 2019.[63] Given the COVID-19 pandemic's unique effect on global residential real estate markets, property transaction data from 2020 onwards may not be an accurate representation of non-pandemic trends. Therefore, there is only one year of pre-pandemic Chicago Energy Rating data available.

Due to the relatively short time between implementation and testing, the lack of a significant relationship between certification and property value may be caused by a lack of market recognition. As with any public policy, time is needed for awareness to build among the general populace. Over time, we can expect market recognition to increase, thereby allowing the market to adjust to this new certification.

On a conceptual level, flaws in the design and implementation of Chicago's energy benchmarking policy may also explain its inability to close the energy efficiency gap. Most

[63] City of Chicago, "Chicago Energy Benchmarking Homepage."

significant of these factors are low visibility due to lack of enforcement and an unintuitive rating system.

The current structure of Chicago's energy benchmarking policy is bereft of an effective mechanism for ensuring compliance. The Chicago Energy Benchmarking Ordinance does not explicitly outline punishments for noncompliance or incorrect data. Studies based on energy benchmarking policies in New York have shown that levying fines for non-compliance is insufficient to deter violators, particularly if the amount of the fine is smaller than the perceived cost of compliance.[64] In addition to implementing the proper structure to ensure building managers properly input all components in the ENERGY STAR Portfolio Manager, more must be done to ensure the rules regarding placement of Chicago Energy Rating score signage (both in terms of the physical placement in a visible and conspicuous place at the building entrance and digitally) are properly followed. Only then will consumers have full access to the energy efficiency information when making their purchasing decisions.

The Chicago Energy Rating's effectiveness is further constrained by its confusing and unintuitive rating system, which is based on a four-star scale. While star-based rating systems are widely-adopted and thus ubiquitous in our day-to-day decision-making, they are generally based on five-star scales. For example, product reviews, hotel ratings, app store, rideshare app ratings, and collegiate recruiting rankings all use star ratings with five-star as the maximum rating. Furthermore, in the context of a four-star rating scale, what is the minimum rating that should be considered a 'good' score? If consumers are unable to accurately discern the actual energy performance from the scoring scale, then its effect on decision-making becomes a moot point. Other cities such as New York have opted for a letter-grade system, with A indicating highest performance and F indicating lowest (or in this case non-compliance).

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[64] Kontokosta, "Energy Disclosure, Market Behavior, and the Building Data Ecosystem."

Additionally, the zero (or in some cases negative) correlation may be explained by the potential existence of negative selection biases. Buildings with higher ratings may be associated with unaccounted confounding variables that lead to lower property values. For example, perhaps luxury condo buildings are more likely to have energy-intensive amenities, thus causing lower energy ratings. Additional confounding factors may include building age, size of building common areas, unit views, monthly condo fees, unit floor heights, etc—all of which have the potential to influence property values yet are difficult to isolate.

The distinction between residential and office buildings may also explain the difference between my findings and previous studies, most of which are focused on commercial buildings. The variation of shared amenities is greater in residential buildings than in office buildings, thereby introducing a major determinant of property values that cannot be easily isolated in regression models. A potential explanation that future research may be interested in exploring is the claim that individuals are less willing to pay premiums for 'green' properties than corporations, many of whom have sustainability statements that explicitly outline the certification statuses of office spaces they are allowed to lease.

Overall, I concluded that there is no current relationship between ENERGY STAR/Chicago Energy Rating and property values in downtown Chicago condominium buildings. While this result may be disheartening for property developers hoping for a cheaper alternative to LEED certification, my findings do not indicate that the ENERGY STAR and Chicago Energy Rating certifications are not without their merits and uses.

Most importantly, this study does not account for the distribution of certified buildings. The creation of a low-cost, easily accessible certification system fundamentally alters the pathway toward achieving more sustainable buildings. Whereas the onus of LEED certification has predominately been on developers and occurred in one of two phases, new construction and major renovations, the annual Chicago Energy Benchmarking requirements provide individual building managers with much more agency to improve energy efficiency and obtain certification at any time in a building's life cycle. This shift creates far more certification opportunities for buildings that would have been locked out of the previous paradigm. Even if the magnitude of premiums is smaller than other certifications, the Chicago Energy Benchmarking and Rating combination can still have important implications for the democratization of green building certifications in Chicago.

CONCLUSION

This research study was initially motivated by a desire to understand the interactions between mandatory energy benchmarking policies, green building certifications, and property values, as well as the economic benefits of certification in the context of these policies. Although no significant correlation was found between either ENERGY STAR scores or Chicago Energy Rating and property values amongst residential condominium buildings in downtown Chicago, there are still many important conclusions that can be gleaned from the study.

Firstly, mandatory energy benchmarking policies, along with their bespoke rating systems, are currently unable to completely replicate LEED's ability to translate recognition of sustainable building practices into economic premiums. This conclusion implies that LEED, despite its many flaws, remains useful to property developers, sustainability advocates, and policymakers. However, we cannot discount the possibility that LEED adoption rates are at least partially influenced by public policies that directly incorporate LEED certification language, many of which provide administrative, tax, or zoning incentives to developers for achieving LEED certification. Conceptually, this would suggest that LEED's sales premiums are paid by public funds to developers. Without these policy incentives, perhaps LEED's sales premiums would not be as high or the average ROI of LEED certification would be negative, which would further reduce its already declining adoption rates.

Conversely, policy incentives may be an economic lever for artificially increasing the economic value of pursuing energy efficiency in accordance with the Chicago Energy Rating. Mandatory energy benchmarking establishes a standard metric to measure energy performance, which can then be used within a policy incentive framework to incentivize improving energy efficiency. Not only would this policy framework eliminate the questionable use of a non-public prescriptive building sustainability metric 'middle man', but it would also drastically reduce the costs associated with proving energy efficiency (so money can be spent on actually improving energy efficiency). Furthermore, a descriptive rather than prescriptive model for sustainable buildings allows market participants to achieve their desired level of sustainability in the most efficient way possible—something not always available to other green building certifications.

While the idea behind the Chicago Energy Rating—a bespoke scoring system that not only considers energy usage performance but also year-to-year improvements—is conceptually sound, it suffers from a lack of recognition and portability. Outside of the sustainable buildings and real estate industries, the Chicago Energy Rating remains relatively anonymous. The unintuitive four-star scoring scale contributes to the problem—if people do not understand what a good score and a bad score are, they cannot easily differentiate between high and low performers.

Furthermore, the usage of a Chicago-specific rating system limits the scope of comparison, which reduces the certification standard's portability. One of the fundamental purposes of energy benchmarking is the ability to make comparisons between buildings. While the Chicago Energy Benchmarking Ordinance allows for comparisons between buildings within the city of Chicago, the Chicago Energy Rating limits the ability to make comparisons on a national (or even international) scale. The Chicago Energy Rating of a given building has no relevancy elsewhere in Illinois or the country; thus, we cannot compare a building's energy performance relative to a building in New York solely based on Chicago Energy Rating. This lack of portability limits the broader applications of mandatory benchmarking policies since it prevents standardized comparisons of the effects of mandatory benchmarking policies across cities and municipalities nationwide.

The findings from my research also reiterate the importance of marketing green building certifications. Mandatory benchmarking ensures a near 100% reporting rate, yet adoption rates by themselves will not create an incentive for developers and building managers to improve their energy efficiency.

Chicago, under the Chicago Energy Benchmarking Ordinance, remains just a singular case study on mandatory energy benchmarking policies. Therefore, extrapolating the findings from this study to other localities may not be accurate due to differences in factors including, but not limited to, state legislations, local laws, political contexts, real estate market quirks, green building certification acceptance, building stock size, building density, and average building energy efficiency. To gain a more comprehensive understanding of the effects of mandatory energy benchmarking policies as a whole, additional case studies situated in other cities with mandatory energy benchmarking policies need to be conducted.

Within the specific context of Chicago's mandatory energy benchmarking policies, future research can explore whether my findings will hold as more time passes since the implementation of the Chicago Energy Rating or whether, as I predict, a positive relationship will form once public awareness of the certification system increases.

BIBLIOGRAPHY

Allcott, Hunt. “Social Norms and Energy Conservation.” *Journal of Public Economics*, Special Issue: The Role of Firms in Tax Systems, 95, no. 9 (October 1, 2011): 1082–95. https://doi.org/10.1016/j.jpubeco.2011.03.003.

Ayres, Ian, Sophie Raseman, and Alice Shih. “Evidence from Two Large Field Experiments That Peer Comparison Feedback Can Reduce Residential Energy Usage.” *The Journal of Law, Economics, and Organization* 29, no. 5 (October 1, 2013): 992–1022. https://doi.org/10.1093/jleo/ews020.

Chegut, Andrea, Piet Eichholtz, and Nils Kok. “Supply, Demand and the Value of Green Buildings.” *Urban Studies* 51, no. 1 (January 1, 2014): 22–43. https://doi.org/10.1177/0042098013484526.

City of Chicago. “2020 Chicago Energy Benchmarking Report,” 2020.

———. “2021 Chicago Benchmarking Guide,” 2021.

———. “Chicago Energy Benchmarking Homepage.” Accessed December 7, 2022. https://www.chicago.gov/content/city/en/progs/env/building-energy-benchmarking---transparency.html.

———. “Chicago Energy Rating.” Accessed December 7, 2022. https://www.chicago.gov/content/city/en/progs/env/ChicagoEnergyRating.html.

Costa, Dora L., and Matthew E. Kahn. “Energy Conservation ‘Nudges’ and Environmentalist Ideology: Evidence from a Randomized Residential Electricity Field Experiment.” *Journal of the European Economic Association* 11, no. 3 (2013): 680–702. https://doi.org/10.1111/jeea.12011.

Costa, Odilon, Franz Fuerst, Spenser J. Robinson, and Wesley Mendes-Da-Silva. “Are Green Labels More Valuable in Emerging Real Estate Markets?” SSRN Scholarly Paper. Rochester, NY, June 1, 2017. https://doi.org/10.2139/ssrn.2982381.

Devine, Avis, and Nils Kok. “Green Certification and Building Performance: Implications for Tangibles and Intangibles.” *The Journal of Portfolio Management* 41, no. 6 (September 30, 2015): 151–63. https://doi.org/10.3905/jpm.2015.41.6.151.

Eichholtz, Piet, Nils Kok, and John M. Quigley. “Doing Well by Doing Good? Green Office Buildings.” *American Economic Review* 100, no. 5 (December 2010): 2492–2509. https://doi.org/10.1257/aer.100.5.2492.

———. “The Economics of Green Building.” *The Review of Economics and Statistics* 95, no. 1 (March 1, 2013): 50–63. https://doi.org/10.1162/REST_a_00291.

Fuerst, Franz, and Patrick McAllister. “The Impact of Energy Performance Certificates on the Rental and Capital Values of Commercial Property Assets.” *Energy Policy*, Sustainability of biofuels, 39, no. 10 (October 1, 2011): 6608–14. https://doi.org/10.1016/j.enpol.2011.08.005.

Gabe, Jeremy, and Michael Rehm. “Do Tenants Pay Energy Efficiency Rent Premiums?” Edited by Professor Susan Bright and Dr Peter Mallaburn Professor Tim Dixon. *Journal of Property Investment & Finance* 32, no. 4 (January 1, 2014): 333–51. https://doi.org/10.1108/JPIF-09-2013-0058.

Haider, Murtaza, and Eric J. Miller. “Effects of Transportation Infrastructure and Location on Residential Real Estate Values: Application of Spatial Autoregressive Techniques.” *Transportation Research Record* 1722, no. 1 (January 1, 2000): 1–8. https://doi.org/10.3141/1722-01.

Hirst, Eric, and Marilyn Brown. “Closing the Efficiency Gap: Barriers to the Efficient Use of Energy.” *Resources, Conservation and Recycling* 3, no. 4 (June 1, 1990): 267–81. https://doi.org/10.1016/0921-3449(90)90023-W.

Jaffe, Adam B., and Robert N. Stavins. “The Energy-Efficiency Gap What Does It Mean?” *Energy Policy*, Markets for energy efficiency, 22, no. 10 (October 1, 1994): 804–10. https://doi.org/10.1016/0301-4215(94)90138-4.

Klimczak, Karol. “Determinants of Real Estate Investment” 3, no. 2 (2010).

Kontokosta, Constantine. *New York City Local Law 84 Benchmarking Report, August 2012 (Provided Data Analysis with David Hsu)*. New York, NY: Mayor’s Office of Long-Term Planning and Sustainability, 2012.

Kontokosta, Constantine E. “Energy Disclosure, Market Behavior, and the Building Data Ecosystem.” *Annals of the New York Academy of Sciences* 1295, no. 1 (2013): 34–43. https://doi.org/10.1111/nyas.12163.

Leskinen, Niina, Jussi Vimpari, and Seppo Junnila. “A Review of the Impact of Green Building Certification on the Cash Flows and Values of Commercial Properties.” *Sustainability* 12, no. 7 (January 2020): 2729. https://doi.org/10.3390/su12072729.

Livingstone, Nicola, and Jessica Ferm. “Occupier Responses to Sustainable Real Estate: What’s next?” *Journal of Corporate Real Estate* 19, no. 1 (January 1, 2017): 5–16. https://doi.org/10.1108/JCRE-03-2016-0016.

Mergens, Michael, and Julie Perrus. “The Legal and Business Case for LEED Certification in the Post-Recession World,” 2011. https://www.americanbar.org/groups/business_law/publications/blt/2011/01/03_mergens/.

Newsham, Guy R., Jennifer A. Veitch, and Yitian (Vera) Hu. "Effect of Green Building Certification on Organizational Productivity Metrics." *Building Research & Information* 46, no. 7 (October 3, 2018): 755–66. https://doi.org/10.1080/09613218.2017.1358032.

Palmer, Karen, and Margaret Walls. "Using Information to Close the Energy Efficiency Gap: A Review of Benchmarking and Disclosure Ordinances." *Energy Efficiency* 10, no. 3 (June 1, 2017): 673–91. https://doi.org/10.1007/s12053-016-9480-5.

"PropertyRadar - Discover." Accessed March 6, 2023. https://app.propertyradar.com/#!/discover.

Reichardt, Alexander. "Operating Expenses and the Rent Premium of Energy Star and LEED Certified Buildings in the Central and Eastern U.S." *The Journal of Real Estate Finance and Economics* 49, no. 3 (October 1, 2014): 413–33. https://doi.org/10.1007/s11146-013-9442-z.

Robinson, Spenser, and Pat McAllister. "Heterogeneous Price Premiums in Sustainable Real Estate? An Investigation of the Relation between Value and Price Premiums." *Journal of Sustainable Real Estate* 7, no. 1 (November 1, 2015): 1–20. https://doi.org/10.1080/10835547.2015.12091868.

Safire, William. "Location, Location, Location." *The New York Times*, June 26, 2009, sec. Magazine. https://www.nytimes.com/2009/06/28/magazine/28FOB-onlanguage-t.html.

Shang, Luming, Hyun Woo Lee, Sofia Dermisi, and Youngjun Choe. "Impact of Energy Benchmarking and Disclosure Policy on Office Buildings." *Journal of Cleaner Production* 250 (March 20, 2020): 119500. https://doi.org/10.1016/j.jclepro.2019.119500.

Szumilo, Nikodem, and Franz Fuerst. "The Operating Expense Puzzle of U.S. Green Office Buildings." *Journal of Sustainable Real Estate* 5, no. 1 (January 1, 2013): 86–110. https://doi.org/10.1080/10835547.2014.12091847.

US EPA. "ENERGY STAR." Accessed December 7, 2022. https://www.energystar.gov/home.

———. "ENERGY STAR Certification for Buildings." Accessed December 7, 2022. https://www.energystar.gov/buildings/building_recognition/building_certification.

Veld, Hans Op 't, and Martijn Vlasveld. "The Effect of Sustainability on Retail Values, Rents, and Investment Performance: European Evidence." *Journal of Sustainable Real Estate* 6, no. 1 (January 1, 2014): 163–85. https://doi.org/10.1080/10835547.2014.12091863.

World Green Building Council. "Global Status Report 2017." World Green Building Council, 2017. https://worldgbc.org/article/global-status-report-2017/.

Yudelson, Jerry. *Reinventing Green Building: Why Certification Systems Aren't Working and What We Can Do about It*. Gabriola Island, BC, Canada: New Society Publishers, 2016. https://catalog.lib.uchicago.edu/vufind/Record/11406075.