Beyond Environmental Building Certification: The Impact of Environmental Interventions on Commercial Real Estate Operations*

April 30, 2019

Jim Clayton[a]
jclayton@schulich.yorku.ca
(647) 335-7127

Avis Devine[a]
adevine@schulich.yorku.ca
(519) 212-0653

Rogier Holtermans[b]
rholter@uoguelph.ca
(437) 217-4080

Abstract

We extend the well-known definition of investment in sustainability and energy efficiency from environmental building certification to include two additional types of environmentally-focused building interventions: monitoring and tenant engagement. Appealing to behavioral economics and finance theory, we test for a connection between changes in tenant and management behavior and both utility consumption and key operating statement line items. Through a partnership with a large North American institutional investment manager, this study examines fifteen years of asset-level utility consumption and operating statement data, measuring both the initial impact of such interventions as well as any adjustments observed over time. The partnering firm has been actively pursuing all three types of interventions for several years, and analysis of their proprietary intervention data allows us to further understand the impact of varied environmental interventions on the operating performance of commercial real estate. We find that all three intervention categories are associated with decreased electricity consumption, with tenant engagement providing the greatest immediate decrease and the most consistently maintained decrease over time. While the initial adoption of monitoring software does not produce immediate results, after a few years it produces the most substantial decrease in electricity consumption. Tenant engagement does not impact water consumption, but in suburban office buildings, green building certification and monitoring decrease consumption. This highlights the key role of landscaping in water use.

* We gratefully acknowledge Bentall Kennedy for providing the data, and the firm along with the Real Estate Research Institute (RERI) and Lawrence Berkeley National Laboratory for funding. All errors in analysis and interpretation are the responsibility of the authors.

[a]Schulich School of Business, York University, Toronto, Ontario CANADA

[b]Gordon S. Lang School of Business and Economics, University of Guelph, Guelph, Ontario CANADA

"You can have a very efficient car but if you drive it in the wrong manner, the car still consumes quite a lot of fuel, and it's the same with buildings."
Pieter Roozenboom, CBRE Global Investors[1]

1. Introduction

There is an extensive body of research on the environmental performance of commercial real estate (CRE), and mounting evidence that environmentally-certified buildings experience stronger financial performance in the form of higher transaction prices, higher rents, and higher more stable occupancy rates, and that they are associated with a lower cost of debt, and lower default rate.[2] The majority of studies to-date focus on the impact of environmental building certification programs, including Leadership in Energy and Environmental Design (LEED), Energy Star, and other designations. While environmental building intervention is important, both in terms of measuring and signaling environmental commitment, it is just one way in which energy efficiency and sustainability can impact commercial real estate assets.

There is growing awareness in the CRE investment management community of the need to move beyond environmental building certification and inside the buildings themselves, for a deeper look at key resource-related operating expenses (e.g. energy, natural gas, and water) as well as the behavior of occupants or users of the space.[3] Heller, Heater and Frankel (2011) suggest that a large fraction of energy use is not controlled by building design, HVAC equipment, and maintenance, but by tenants. Hence, tenant behavior can have a significant impact on overall building energy use, though is an understudied topic. They propose that various means to make tenants aware of their energy consumption might help significantly reduce their energy use. Our paper offers a unique approach to testing whether changes in this behavior has real effects.

In this research, we extend the existing literature by moving beyond the impact of environmental building certification and incorporating two additional types of environmental intervention at the property management and tenant levels: monitoring and tenant engagement. Building certification is a "hard"

[1] As quoted in the article by O'Dea (2019).
[2] See for example Miller et al. (2008), Eichholtz, Kok and Quigley (2010), Wiley et al. (2010), Fuerst and McAllister (2011), Devine and Kok (2015), Holtermans and Kok (2017), Eichholtz et al (2019), and An and Pivo (2018). Zhu (2018) provides a recent review of the body of the literature that highlights both the knowledge gains and also the gaps in existing energy efficient and sustainable real estate research to help guide the direction of future research.
[3] See O'Dea (2019).

intervention, and analysis of the impact is rooted in traditional financial economic modeling of top line property financials. We label the additional two interventions as "soft," being comprised of either relatively passive awareness and monitoring programs or more active engagement activities that strive to modify tenant and property management behavior. Generally, pursuit of these three interventions would occur in that order, moving from the technically-rooted "hard" building certification, to a passive monitoring software system, and finally to a proactive tenant engagement program. A timeline of environmental intervention adoption is visually depicted in Figure 1.

****** *insert Figure 1 near here* ******

A growing body of research in psychology, behavioral economics, and finance suggests that "soft" interventions can be powerful in changing behavior and choices. In residential real estate, Allcott and Mullainathan (2010) and Allcott and Rogers (2014) evaluate the OPOWER program, which provides personalized feedback on a household's energy consumption trends and social comparison (e.g. relative to neighbors), as well as energy conservation information. In a similar spirit, we test for a connection between changes in office space management and user behavior and both utility consumption and operating statement line items. Additionally, we explore how these interventions interact. While environmental building certification may decrease consumption, what is the effect when tenants and management are fully informed about and encouraged to capitalize on those unique improvements? The implications of these interventions, and their compounded effect, are of key importance to building owners and operators. This may provide another impetus to improve the environmental performance of the building stock through behavioral-focused interventions, potentially offering a relatively low-cost action to significantly impact outcomes.

The few studies that examine operating expenses provide evidence only at a high level.[4] In contrast, this study investigates how energy efficiency and sustainability interventions impact different aspects of building operations, and their subsequent financial impact. Through a partnership with Bentall Kennedy, a large North American institutional investment manager, we gain access to fifteen years of monthly operating statements for hundreds of assets, and carefully examine and rigorously quantify the impact

[4] The exception is utilities, owing to the emphasis to date on understanding the impact of energy efficiency. There is evidence of water-related cost savings (Kats, 2010), but results regarding power usage are mixed or inconclusive (Newsham, Mancini, & Birt, 2009; Scofield, 2009, 2013).

of third-party environmental building certification, monitoring, and tenant engagement on building performance. The firm's sustainability strategy goes beyond third party building certification to also include formal tenant and property management expense awareness and engagement programs, "EcoTracker" and "ForeverGreen," respectively. The overall portfolio is well balanced across the U.S. and Canada, providing the ability to examine the above question in two different countries. Very few studies have been able to compare green building implications across countries, and there are reasons to believe results may not be the same across markets (e.g. due to the policy environment, institutional arrangements, culture, and weather).[5]

The remainder of the paper is organized as follows: Section 2 lays out the methodology we employ to empirically test the impact of the different interventions on key operating expense lines items, while controlling for other factors and outside influences and maximizing model robustness. Section 3 details the dataset we have created from property level operating data provided to us by institutional real estate investment manager Bentall Kennedy. It also provides an overview of the firm's "EcoTracker" expense monitoring and reporting program, and the "ForeverGreen" sustainability engagement program targeted at property managers and tenants. Section 4 provides the econometric results and a discussion of key findings. Section 5 presents a summary and implications of our findings.

2. Empirical Methodology

Thaler's (2008) "Nudge Theory" posits that consumer behavior can be influenced by small suggestions and positive reinforcements. Through this lense, we explore if tenant and property management engagement acts as a stimulus or "nudge" to affect real behavior that has sustainability implications, both individually and in combination with other environmental building interventions. We explore the intervention combinations to examine whether multiple environmental interventions can enhance the impact on building operations, or if certain interventions dominate the effectiveness of others.

Bentall Kennedy's operating data allows us to create a building level dataset to study the trajectories of different utility consumption and operating cost components over time. The assets within Bentall Kennedy's portfolio received environmental building certification, monitoring, and tenant engagement interventions at a specific point in time. Our main interest is to understand how these different

[5] Two of the only studies doing such work are completed by a member of this research team (Devine and Kok, 2015; Devine and Yönder 2018).

interventions are related to electricity and water consumption, and operating statement line items (net operating income, base rent, total expenses, and management fees).

We employ the following estimation approach, designed to control for the effects of unobservable factors that also determine resource consumption and operating costs:

$$lnCONS_{i,m,t} = \beta_{i,m,t}INT + \alpha_i + \delta_m + \epsilon_{i,m,t} \quad (1)$$

$$lnOPSTMT_{i,m,t} = \beta_{i,m,t}INT + \alpha_i + \delta_{yq} + \epsilon_{i,m,t} \quad (2)$$

Where $lnCONS_{i,m,t}$ measures the natural log of electricity or water consumption per occupied square foot of building *i* in month *m* and year *t*. Similarly, $lnOPSTMT_{i,m,t}$ in equation (2) measures the natural log of net operating income, base rent, operating expenses, management fees per (occupied) square foot of building *i* in month *m* and year *t.* The INT indicator changes from zero to one after a building underwent an intervention. An intervention entails either environmental building certification (*e.g.* BOMA BEST, LEED EBOM, or Energy Star), or monitoring through Bentall Kennedy's proprietary EcoTracker program, or tenant engagement through the firm's ForeverGreen programs. Building interventions (INT) are initially specified as "yes or no" at the aggregate level, and subsequently in a more granular format to test for the differential impact of levels of building certification achieved (e.g. LEED EBOM and BOMA BEST bronze, silver, gold and platinum) and tenure (time) of enrollment in the three different intervention programs. A binary control variable is also included for any periods during which a building is certified under a LEED design and construction-related scheme. These certifications are not explored in-depth, as they are not related to operations, yet they are always included as a control variable.

Both equations include building fixed effects, α_i, to account for permanent differences in buildings' electricity and water consumption, and operating expenses. Equation (1) also includes month fixed effects, δ_m, to adjust for the average effects of time-varying factors (*e.g.* summer and winter temperature) that generate changes in average electricity and water consumption across all buildings. Equation (2) includes year-quarter fixed effects, δ_{yq}, to control for macro-economic factors that may impact operating expenditures. The parameter of interest is β, which measures the average difference in electricity or water consumption, or operating expenses subsequent to building interventions (INT), after adjustment for the fixed effects.

The two most common endogeneity concerns in measuring the impact of environmental building certification, or other building level interventions such as tenant engagement, regard asset and management quality. The assembled data provides the ability to control for both. Management quality is intrinsically controlled for given the single operator for all examined assets in Canada, and explicitly captured (and tested) given the included management company data in the U.S. Asset quality is controlled for through the inclusion of building-fixed effects, which is possible since we observe all assets over an extended time period.

3. Data

The data is derived from a partnership with Bentall Kennedy, a large institutional investment manager that operates and manages a portfolio of commercial assets in Canada and the U.S. Access to fifteen years of monthly line-item information provides us with asset-level information at a level of detail rarely observed. This provides the time horizon required to test the temporal effects of building certification, monitoring, and tenant engagement. Moreover, the sample includes assets in the U.S. and in Canada, enabling cross-country comparisons and providing further insight into how country-specific differences may influence the outcomes of the studied interventions. The fact that all information is retrieved from a single firm which provides its services to a variety of institutional owners may lead to sample selection bias, for example regarding the proportion of high-quality buildings, which are mostly situated in major metropolitan areas. Importantly, the decision to implement monitoring or tenant engagement activities does not lie with the property manager or tenant, respectively, and is therefore not necessarily voluntary to the targeted users, reducing some of the concern about observing such activities only in buildings with property managers and tenants that are more committed to energy efficiency and sustainability.

Operating information is collected on a monthly basis (or the most granular frequency available greater than monthly) covering the 2004–2017 period. The final dataset includes 261 buildings, 116 in Canada and 145 in the U.S., representing some 44 million square feet of space. The fact that our sample is comprised of a large number of existing buildings, as opposed to newly constructed properties, is another important differentiating aspect of our study. A major limitation of many existing studies' data is the focus on newly constructed buildings. Assessing the greening of existing buildings is key for the developed world as so little of the building stock is newly constructed (approximately 2% in North America on an annual basis) (CBECS, 2015).

Table 1 reports detailed descriptive statistics for key variables, including utility consumption, building characteristics and local climatic conditions. These are reported separately for the Canadian (Panels A to C) and U.S. (Panels D to F) building samples. The first column of the table displays summary statistics for the total sample in each country, and subsequent columns display the same statistics for subsamples both with and without the three forms of studied environmental intervention (building certification, monitoring, and tenant engagement). Building counts and number of building-month observations in each group are shown in the bottom two rows of the table.

We measure the impact of environmental interventions on two sets of outcome variables: utility consumption and key operating statement line items. Utility consumption is represented by consumption of electricity and water.[6] Electricity consumption is measured in kilowatt hours per occupied square footage of space in each building and water by cubic meters per occupied square foot. Operating expense and income metrics, not shown in Table 1 but included in the empirical results later in the paper, include NOI, base rent, and total operating expenses, and management fee, all measured on a per square foot basis.

****** *insert Table 1 near here* ******

Table 1 illustrates the dominant presence of building level certification, or "hard" intervention, in the sample. Environmental certification schemes included in this study are: the U.S. Green Building Councils' Leadership in Energy and Environmental Design (LEED) Existing Buildings Operations and Management (EBOM) and various design and construction-related programs (LEED D&C) in both Canada and the U.S.; Building Owners and Managers Association (BOMA) BEST program in Canada; and, the Environmental Protection Agency's Energy Star program in the U.S. Overall, 146 of the 261 buildings are certified (77 in Canada and 69 in the U.S.), governing one-third of the building-month observations. This indicates that many buildings earned certification later in the sample period. Panels A and D indicate that, on average, environmentally-certified buildings are associated with markedly lower water consumption compared to non-certified buildings, yet certified buildings in Canada, on average, consume more electricity. Electricity consumption in certified buildings is also lower in the U.S. The relative success of the U.S. over Canadian buildings in this category is likely due to the Energy

[6] Other utilities where examined, most notably natural gas. However, data was either too limited or results proved uninformative.

Star certification program (only available in the U.S. during the sample period), which focuses heavily on decreased electricity consumption. Aside from that, the finding of higher electricity consumption in certified buildings has been identified in the existing literature, related to certified buildings often being new, higher-tech "smart" buildings (Devine & Yönder, 2018).

Panel B highlights that the Canadian sample is dominated (60%) by buildings constructed in the 1970s and 80s, with nearly three-quarters originally built prior to 1990. In addition to being an older sample, the majority of the buildings are classified as class B properties and located outside the downtown core Central Business District (CBD). The age distribution, quality, and location of certified buildings generally tracks that of the total sample quite closely. However, Canadian certified buildings tend to be significantly larger properties. Panel E reports building characteristic summary statistics for the U.S. sample, revealing key differences in the samples of the two countries. Buildings in the U.S. dataset are on average newer, with more than 70% constructed post-1990, and close to half since 2000. A much higher proportion of the U.S. sample buildings are suburban (non-CBD) and class A properties. As with the Canadian properties, U.S. certified buildings skew towards larger, newer, class A assets, situated within urban cores.

In addition to the depth of Bentall Kennedy's building certification intervention data, the firm has also implemented environmentally-focused tenant and property management engagement programs, what we term "soft" interventions. The first program is a data tracking and visualization tool called EcoTracker. EcoTracker is Bentall Kennedy's sustainability data management system that provides a single reporting and management system for energy, utilities, water, and waste. It also includes a modeling tool, EcoModeler, to model reduction measures and predict reductions in consumption costs and green-house gas emissions. The original goal of this program was to assist in pursuit of environmental building certification (and recertification). However, there is evidence that the provision of this type of information to building management and tenants provides transparency into consumption, which can lead to altered user and management behavior.

The second program, ForeverGreen, focuses on creating and reinforcing awareness and collaboration among property managers and tenants in making environmentally-related decisions.[7] The goal of the

[7] Bentall Kennedy's engagement program is differentiated by properties in which tenants are working (office, industrial, retail) where it is labelled ForeverGreen@Work, and multi-family residential rental property where tenants live at which it is termed

program is increased efficiency of energy and water use, plus a healthy, productive work environment for building users. The decision to participate in the ForeverGreen program lies with the property manager. Conditional on a building being enrolled in the ForeverGreen program, individual tenants select a level of engagement from three preset levels representing increasing commitments of time and effort. Bentall Kennedy's long-term goal is increased commitment to the program, in terms of more enrolled buildings, more enrolled tenants, and tenants participating at higher levels of commitment.

At the start of each year, enrolled property managers share with tenants a calendar that identifies the timing of resources to be provided by topic, including energy, water, waste, health, and community. Each year a theme is adopted and monthly topics are depicted in posters and handouts in informative and "change-incentivizing" ways. Topics are aligned with weather and seasonal events. For example, in 2018 the ForeverGreen theme was "Repackaging the Sustainability Conversation" and monthly topics were depicted as popular products/packages with slogans that have an environmental/green connection to the product. In a previous year the theme was movies and each month the topic and a "nudge" for the behavioral change goal was woven into a popular movie title. Enrolled property managers and tenants received educational and motivational resources such as posters, newsletters, and Green Team Packs which provide actionable content around the monthly environmental themes. Any building that enrolls in ForeverGreen is co-enrolled in EcoTracker, should the monitoring software not already be in use at the building.

The fifth and seventh columns in Table 1 report descriptive statistics on buildings enrolled in the EcoTracker and ForeverGreen programs, respectively. With 88 properties (6,789 building-months) in EcoTracker and 73 properties (2,468 building-months) in ForeverGreen, the Canadian sample shows a high level of engagement that bodes well for robust empirical analysis. Engagement lags in the U.S., partially due to the programs initially being introduced in Canada, and later expanded south of the border. Panels A and D show that ForeverGreen buildings are, on average, associated with lower electricity and water consumption compared to non-ForeverGreen buildings in both countries. EcoTracker is associated with reduced electricity and water consumption in the U.S. sample (as opposed to non-EcoTracker), but only water consumption is reduced in the Canada sample, a result that mirrors the finding on building certification.

ForeverGreen@Home. Given our focus on office properties we are investigating the ForeverGreen@Work engagement program, but for simplicity will drop the "@Work" part of the label. For further information, see http://cr.bentallkennedy.com/ForeverGreen.

Figure 2 displays the cumulative adoption of the three interventions across the portfolio, broken down separately for Canada (Panel A) and the United States (Panel B).[8] The monitoring and tenant engagement programs were first introduced in Canada and were subsequently introduced into the U.S. portfolio. It should be noted that this represents the first time each building experiences an intervention while in our sample. In some cases, buildings experienced additional environmental building certification activity in prior years under different ownership/management. In connection with this fact, the graphs highlight the intervention adoption order described in Figure 1. First, environmental building certification (both within our sample and under prior ownership/management) is undertaken. This is commonly observed beginning in the early 2000s and increasing notably for a decade before leveling off. Second, monitoring is introduced by the investment management firm in the mid-2000s, originally with the goal of aiding in certification and recertification activities. Adoption of this first "soft" intervention increases quickly, as the decision to adopt lies with the investment manager, not other parties. Finally, tenant engagement programs are introduced in the mid-2010s, and with strong encouragement from the investment manager, adoption increases sharply over the first few years. While Figure 2 highlights adoption by buildings over time, the tenant engagement adoption focus now lies within assets, with the goal of increasing the number and commitment level of tenants so as to maximize the benefits of the intervention.

****** *insert Figure 2 near here* ******

Figure 3 presents early evidence of the impact of environmental interventions on utility consumption. For the combined Canada and U.S. sample, Panels A, B, and C present electricity and water consumption for buildings both with and without Environmental Building Certification, Monitoring, and Tenant Engagement, respectively. It compares median building level consumption on a square foot basis at a monthly frequency (allowing for the observation of seasonality) over the full sample period. The graphs on the left provide strong evidence of lower electricity consumption in buildings with environmental interventions. The EcoTracker and ForeverGreen soft interventions are associated with consumption benefits throughout the year, while the benefits from environmental building certification seem to be associated with significant reductions only in late spring through early fall, but they wane in the winter months. Water consumption graphs on the right of Figure 3 reveal a strong seasonal pattern, with buildings subject to intervention showing lower consumption levels during the summer months. Soft

[8] See Appendix Table A1 for a building count breakdown of all possible intervention pairings observed within our sample.

interventions are associated with higher water consumption in winter months, yet building certification retains lower consumption patterns year-round, although at a smaller relative benefit during the winter months. This early non-parametric analysis points to a common theme in water consumption: the role of landscaping. Agriculture is the single largest use of potable water, and the related aspect in CRE operations is landscaping, which would peak in use during the summer months.[9] Notably, in all six cases intervened buildings experience less utility consumption volatility. This is consistent with research indicating environmentally certified buildings are lower risk assets (Devine & Kok, 2015).

****** *insert Figure 3 near here* ******

4. Empirical Results

Two of the three building-level interventions we study, third-party environmental building certification, monitoring, and tenant engagement programs, are largely separate decisions. In our sample, monitoring is highly correlated with the other two programs, as it was introduced to support pursuit of certification, and is always in place in buildings with tenant engagement programs. However, building certification is a building owner decision encompassing building materials, design and equipment standards, while tenant engagement programming is induced and reinforced by property manager intervention and tenant demand. Recognition of this distinction guides our estimation approach, in which we test for the joint impacts of environmental building certification, monitoring, and tenant engagement on consumption of utilities and key operating expense line items, as specified in Equations (1) and (2). Hence, coefficient estimates on specific intervention variables are marginal or incremental effects after controlling for, and independent of, the impact of the other interventions.

Electricity Consumption

Table 2 reports estimates of Equation (1), testing for the impacts of hard (environmental building certification) and soft (EcoTracker and ForeverGreen) intervention on electricity consumption, on a per occupied square foot basis. The estimation strategy we employ initially specifies the intervention variables in aggregated form, just indicating whether the building has that intervention or not. These results are reported in Columns (1) and (2) separately for Canada and U.S. We include occupancy and local weather (heating and cooling days) as control variables, as well as monthly- and building-fixed

[9] https://www.oecd.org/agriculture/topics/water-and-agriculture/

effects to capture seasonal variation not captured by heating and cooling degree days and unobserved variation in building level characteristics that might impact electricity consumption.

****** *insert Table 2 near here* ******

The results provide strong evidence that all tested forms of interventions have a significant impact on electricity consumption in the Canadian sample, both in terms of statistical and economic significance. In Table 2, Column (1), electricity consumption per square foot of occupied space is on average 19% lower in buildings with both BOMA BEST and LEED EBOM certification. Participation in the ForeverGreen tenant engagement program is associated with a 13.6% decrease on average, while the EcoTracker monitoring program reports a 4.3% decrease on average. Results in Column (2) show ForeverGreen engagement also has a statistically significant impact on electricity consumption in the U.S. sample, although the economic significance is considerably smaller than in the Canadian sample (6% reduction compared to 13.6%). In contrast to the results for Canada, LEED EBOM building certification does not seem to impact electricity consumption in the U.S. data, while both LEED design and construction-related programs and Energy Star certification do.

The explanatory power of the model is strong as reflected in the adjusted R-squared goodness of fit measures in excess of 75%. Such a robust fit in a parsimonious specification reveals the importance of including time- and building-fixed effects. Despite a lack of statistical significance associated with the LEED EBOM or EcoTracker interventions, the explanatory power of the model is higher with the U.S. data, a finding that could be associated with the stronger significance of the weather-related control variables, and especially cooling degree days, shown in the bottom part of the table. An examination of control variables indicates that local weather conditions matter, and more for the U.S. sample, where both cooling and heating degree days show strong statistical significance, whereas only heating degree days is significant in Canada. In the U.S. sample, a one standard deviation increase in heating (cooling) days translates into 4.8% (4.9%) higher electricity consumption. Additionally, as noted in Figure 2, adoption of the different interventions followed unique paths in the two countries. This is why we isolate the countries in this analysis, where the differences are notable, and why we should not compare the findings against each other. Differences in findings may just as likely reflect sample distinctions as country-specific distinctions.

Columns (3) and (4) in Table 2 present more granular results with LEED EBOM and BOMA BEST environmental building certification specified by the level achieved. Both the Canadian and U.S. samples indicate that the highest levels of certification (Gold and Platinum) are consistently driving the economic and statistical significance of the aggregate results. The coefficient estimates on ForeverGreen retain their magnitude and statistical significance, as does EcoTracker in Canada.

The observed benefits to environmental interventions are not likely to be fully achieved at the time of implementation. For building certification, it takes time for the marketplace to recognize and adjust to the label and what it means. This is especially the case with LEED EBOM and BOMA BEST on existing buildings with existing tenants, long-term leases and the associated search and relocation frictions. Soft interventions such as EcoTracker and ForeverGreen that aim to build awareness, engage and nudge behavior are also expected to take time. A common finding in the psychology and behavioral economics fields is that shifts or permanent changes in human behavior require repeated reinforcement and learning.[10] To address this, we extend the model specification to allow the environmental building certification, EcoTracker and ForeverGreen variables to be measured by length of time, or "Tenure," the building has been enrolled in the respective programs.

****** *insert Figure 4 near here* ******

We find strong support that tenure matters, for both hard and soft interventions, as it applies to the impact on electricity consumption reduction. Figure 4 shows how electricity consumption is impacted by intervention tenure for all three interventions. The graphs display coefficient estimates on each intervention's tenure within a building in an expanded version of the model shown in Table 2, Columns (1) and (2).[11] Panel A indicates that both BOMA BEST and LEED EBOM exhibit electricity consumption benefits from the initial point of certification, with a continued decrease in consumption as time extends. LEED EBOM generally shows less substantial reductions in electricity consumption compared to BOMA BEST in this sample. The fact that both programs present decreased consumption as of the time of certification speaks to the required consumption requirements of the certification program, whereas further consumption decreases may reflect refined consumption behavior and the co-location of tenants desiring environmentally-certified space (and therefore, using their space with greater

[10] See for example Thaler and Sunstein (2008) for a general discussion, and Heller et al. (2011) for a tenant engagement perspective.
[11] The full estimation results are provided in Appendix A2.

environmental sensitivity). Further capital expenditures in the building may also enhance building performance.

Panel B indicates that EcoTracker takes time to impact a building's electricity consumption. Consistent, significant decreased electricity consumption for EcoTracker begins after four years, on average, but then continues to present efficiency gains year-over-year through ten years (the end of our sample period). This effect is net of the benefits associated with the other interventions, which are also captured in this analysis. Compared to the other interventions, monitoring proves to offer the greatest impact on electricity consumption in the long run. Panel C displays the coefficients on the ForeverGreen "tenure" variables, measured in six-month increments, and reveals a strong immediate benefit of enrolment. Notably, this initial effect is the largest decrease to electricity consumption of the three examined intervention categories, and it proves both highly statistically significant and consistent over time. Results from Panels B and C both support existing behavioral findings that continued priming can lead to continued results.

Water Consumption

Table 3 extends the consumption analysis to water. The sample size of buildings with observations on water is smaller than that for electricity and as a result analysis can only be completed on the combined sample (Canada and U.S. results). However, by combining the countries, we can stratify the sample by urban core (CBD) versus suburban location.[12] This stratification is key for water consumption, as the leading uses of water are agricultural, which for office buildings would be landscaping-related uses. Owing to the inherent differences in characteristics of CBD versus suburban properties, including the relative proportion of non-land to land, we expect differences in water consumption, with the higher demand for lawns and landscaping with suburban assets.

****** *insert Table 3 near here* ******

Table 3 reports the estimation results of hard and soft interventions on water consumption, including the same controls and fixed effects employed in the electricity consumption models. The impacts of the three interventions are examined sequentially in isolation before being brought together in one fully specified

[12] This stratification was also tested for electricity consumption and operating statement items and proved uninformative.

model to examine marginal effects conditional on the other interventions. Odd-numbered columns examine CBD buildings, and even-numbered columns examine Suburban buildings.

Consistent with expectations, water usage relates strongly to building location in the downtown core (CBD) or suburbs. This finding is likely attributable to landscaping and grounds maintenance and is consistent with the seasonal bump in water consumption observed in the Summer months (Figure 2). Certain environmental interventions matter in the Suburban sample but generally do not play a role in explaining variation in CBD buildings. The only exception is LEED design and construction-related certification program, which is associated with decreased water consumption in CBD assets, both in isolation (Column (1)) and in the fully specified model (Column (7)). In isolated Suburban analyses, all building certification programs except for Energy Star are associated with decreased water consumption, as are EcoTracker and ForeverGreen. When brought together in the fully specified model (Column (8)), it is BOMA BEST and LEED design and construction certification programs, and EcoTracker that stand out as the important interventions. ForeverGreen proves uninformative when the effects of other interventions are captured. This is to be expected, as the water-hungry activities related to landscaping are not user impacted. That is, decreasing water consumption is about how the property itself is designed and managed, not the users therein.

Broader Operating Income and Expense Categories

To this point the analysis has focused on the impact of interventions on utility consumption, the minimization of which relates to ESG motivations, benefits, and principles. Another key aspect of socially responsible real estate investing is the impact on the financial bottom line, and ultimately valuation and investment risk considerations. Table 4 presents estimation results that capture the impact of our environmental interventions on property NOI, the total operating expense component of it, as well as base rent and management fees, two key line items in NOI calculation that are shaped by tenancy and property management.

Many of the buildings in our sample are operated in differing manners due to different business models and investment manager conventions for property management across the two countries. Canadian investors such as Bentall Kennedy tend to be more vertically integrated and have the property management function in-house, whereas in the (much larger and more diverse) U.S., it is typical for large investors to have asset managers in house that hire best in class local third-party firms for property management. Through the separation of the sample by country and the inclusion of building-fixed effects, results are robust to these differences. However, this also heavily limits the results which consistently shine through the differing scenarios, both intra- and inter-country. This results in very few operating statement findings worth noting.

****** *insert Table 4 near here* ******

This data limitation is most obvious in measuring the impact of building certification on Base Rent. Devine and Kok (2015) examined lease-level data on many of the same buildings and identified rent premiums, yet in this analysis only the LEED design and construction scheme certifications are associated with increased Base Rent operating statement line items, in both countries (Columns (4) and (8)). Those certifications are also associated with elevated NOI in both countries (Columns (1) and (5)) and elevated total Operating Expenses (albeit only statistically significant in the U.S. sample). This finding of increased cost to operate a green building has been identified in the literature and is attributed to the propensity of new construction green buildings to also be "smart" buildings. Such buildings often require quite a bit more technology to operate, resulting in increased operating expenses. The literature also shows that in these cases, the rent premium sufficiently offsets the expense premium (Devine & Yönder, 2018).

EcoTracker is associated with elevated Base Rent in the U.S. and NOI in Canada. Both of these results, devoid of supporting results in other operating statement categories, are intriguing yet unconvincing. ForeverGreen suffers a similar fate, proving only statistically significant in its association with decreased Management Fee and Operating Expenses in the U.S. These two results align, as a lower management fees would lead to lower total cost, yet the result does not carry the statistical power to also be observed through the NOI. These concerns about model weakness are further supported by the relatively low Adjusted R-squared values on many of the U.S. results.

5. Summary and Implications

Adoption of environmental building certification has become mainstream in the CRE industry, and the focus has recently turned to additional and new ways to further improve the environmental sustainability of the built world. As new approaches are explored, there concurrently develops a need to evaluate their effectiveness, both independently and in conjunction with green building certification.

In this paper we broaden the definition of investment in sustainability and energy efficiency from exclusively environmental building certification to also include two additional types of environmentally-focused building interventions: monitoring and tenant engagement. These initiatives are "soft" interventions, passive and proactive, respectively, that strive to alter building user and management behavior. A growing body of research in psychology and behavioral economics concludes that soft interventions can be powerful in changing behavior and choices. Appealing to Thaler's (2008) "Nudge Theory" that consumer behavior can be influenced by small suggestions and positive reinforcements, we examine whether tenant and property management education and engagement acts as a stimulus or "nudge" to affect real behavior that has energy efficiency implications, beyond those achieved from building certification.

Through a partnership with a major North American institutional real estate investment manager that has been actively pursuing all three types of interventions for several years, we are able to examine the relative effectiveness of these three environmental building interventions. Beyond the firm's extensive building certification intervention, it has also implemented unique monitoring (EcoTracker) and engagement (ForeverGreen) programs ("soft" interventions) focused on the building's users and occupants. The dataset depth allows us to rigorously quantify the effect of hard and soft interventions on energy and water consumption, and key operating statement line items. Using a rigorous building fixed effects model, we are able to measure the impact of the interventions both in general and over the period of a building's exposure to the interventions.

We document that both adoption of environmental building certification and participation in ForeverGreen significantly improve the energy efficiency of Canadian assets. On average, electricity consumption is 16.5% lower in buildings certified under the LEED EBOM program, and 19% lower in buildings with both a LEED EBOM and BOMA BEST certification. Participation in ForeverGreen provides an additional 16.5% decrease, while EcoTracker further reduces electricity consumption by 4%. In the U.S., ForeverGreen also has a significant impact on electricity consumption, although the economic significance is considerably smaller compared to Canada (a 6% reduction as opposed to 13.6%). In contrast to the Canadian findings, only LEED design and construction schemes certification is associated with an increase in energy efficiency rather than LEED EBOM. As expected, an Energy Star label significantly improves the energy efficiency of an office building.

The psychology and behavioral economics literature documents that shifts or permanent changes in human behavior require repeated reinforcement and learning. We find strong support for the notion that tenure matters, as it applies to the impact on electricity consumption reduction. BOMA BEST certification and EcoTracker monitoring show no benefits early on, but have a strong impact after a few years. LEED EBOM has an immediate effect that improves over several years and generally shows smaller reductions in electricity consumption compared to BOMA BEST. The more active ForeverGreen engagement has a strong immediate benefit upon enrolment, that strengthens during the first three years before appearing to plateau by year four.

In contrast to electricity consumption, variations in water usage is more about building location (CBD or suburbs) and building certification, and less related to behavior of building users. We document that water consumption relates strongly to a building being situated in a suburban area, a finding likely attributed to landscaping and grounds maintenance. It is the building certification that matters most in the suburban sample. While EcoTracker and ForeverGreen buildings are associated with lower water consumption on average, after controlling for building certification intervention, the marginal impacts of EcoTracker and ForeverGreen in a multivariate regression are not statistically different from zero. The important role of building certification in water reduction is highlighted by the large magnitudes of reduction, -20% and -23.5%, implied by the coefficient estimates on the BOMA BEST (Canada) and LEED design and construction schemes (both Canada and the U.S).

Overall, we find significant support for the notion that both environmental building certification and ESG-related tenant awareness and engagement programs play crucial roles in reducing energy and utility consumption. Much of the previous research in this area implicitly assumes that building design and equipment efficiency at the time of certification determines energy and water related expense reductions from building operations. This paper has taken advantage of a unique dataset that includes not only building certification but also “within building” awareness, education and engagement, and reinforcement of these programs over time.

In our unique institutional office dataset, positive tenant engagement and reinforcement has a significant impact on electricity consumption, indicating that beyond the collective impacts of design, operating efficiency and maintenance of equipment, an effective strategy to engage and help tenants understand and reduce energy consumption further adds to a buildings' bottom line. These findings have important implications for building owners and managers as well as ESG related policy initiatives. It shows that the behavior of building users matters, and that communication, awareness, and active engagement provide opportunities to educate building managers and tenants on strategies to reduce carbon-footprint related expenses on a long-term basis. Building certification remains key, but certification alone does not optimize savings.

This paper has focused on a single property type and data provided by a single investment manager. A fruitful direction for future research in this area includes expanding the analysis to other property types. Retail assets, for example, increasingly have similar tenant and customer (user) programs that are less about electricity consumption and more about packaging and waste. Retail and apartment properties, like office, are also transitioning to put more emphasis on tenant experience in shared spaces demanding increased plug load that could offer opportunity for engagement type programs to benefit electricity use. Future work might also consider a deeper dive into lease structures and the impact of tenant awareness and engagement programs. Split incentives arguably play an important role in achieving energy efficiency improvements. Further, it would be interesting to consider whether these findings ultimately could affect lease structures themselves, as incentivizing and rewarding tenants for ESG successes would benefit ESG initiatives.

References

Allcott, H., & Mullainathan, S. (2010). Behavior and Energy Policy. *Science*, *327*(5970), 1204–1205.

Allcott, H., & Rogers, T. (2014). The short-run and long-run effects of behavioral interventions: Experimental evidence from energy conservation. *American Economic Review*, *104*, 3003–30037.

An, X., & Pivo, G. (2018). Green Buildings in Commercial Mortgage-Backed Securities: The Effects of LEED and Energy Star Certification on Default Risk and Loan Terms. *Real Estate Economics*.

CBECS. (2015). *A Look at the U.S. Commercial Building Stock: Results from EIA's 2012 Commercial Buildings Energy Consumption Survey (CBECS)*. *U.S. Energy Information Administration*.

Devine, A., & Kok, N. (2015). Green Certification and Building Performance: Implications for Tangibles and Intangibles. *Journal of Portfolio Management*, *41*(6), 151–163.

Devine, A., & Yönder, E. (2018). *Decomposing the Cash Flow and Value Effects of Sustainable Investment: A Test of Firm Perspective Theory*.

Eichholtz, P., Holtermans, R., Kok, N., & Yönder, E. (2019). Environmental performance and the cost of debt: Evidence from commercial mortgages and REIT bonds. *Journal of Banking and Finance*.

Eichholtz, P., Kok, N., & Quigley, J. M. (2010). Doing well by doing good? Green office buildings. *The American Economic Review*, *100*(December), 2494–2511.

Fuerst, F., & McAllister, P. (2011). Green Noise or Green Value? Measuring the Effects of Environmental Certification on Office Values. *Real Estate Economics*, *39*(1), 45–69.

Heller, J., Heater, M., & Frankel, M. (2011). *Sensitivity Analysis : Comparing the Impact of Design , Operation , and Tenant Behavior on Building Energy Performance*. *New Buildings Institute*.

Holtermans, R., & Kok, N. (2017). On the Value of Environmental Certification in the Commercial Real Estate Market. *Real Estate Economics*.

Kats, G. (2010). *Greening Our Built World: Costs, Benefits, and Strategies*. *Statewide Agricultural Land Use Baseline 2015*. Suite 300, 1718 Connecticut Ave. NW, Washington, DC 20009: Island Press.

Miller, N., Spivey, J., & Florance, A. (2008). Does green pay off? *Journal of Real Estate Portfolio Management*, *14*(4), 385–399.

Newsham, G. R., Mancini, S., & Birt, B. J. (2009). Do LEED-certified buildings save energy? Yes, but…. *Energy and Buildings*, *41*(2), 897–905.

O'Dea, C. (2019). ESG data: Check your meter readings. *IPE Real Assets Magazine*.

Scofield, J. H. (2009). Do LEED-certified buildings save energy? Not really... *Energy and Buildings*, *41*(12), 1386–1390.

Scofield, J. H. (2013). Efficacy of LEED-certification in reducing energy consumption and greenhouse gas emission for large New York City office buildings. *Energy and Buildings*, *67*, 517–524. 32

Thaler, R., & Sunstein, C. (2008). *Nudge: Improving Desicions Abouth Health, Wealth and Happiness*. *Nudge: Improving decisions about health, wealth, and happiness*.

Wiley, J. A., Benefield, J. D., & Johnson, K. H. (2010). Green design and the market for commercial office space. *Journal of Real Estate Finance and Economics*, *41*(2), 228–243.

Zhu, C. (2018). *Raising the Rent Premium: Moving Green Building Research Beyond Certifications and Rent*.

Table 1: Descriptive Statistics - Canada

Panel A: Monthly consumption metrics	Total		Certified		Non-certified		EcoTracker		Non-EcoTracker		ForeverGreen		Non-ForeverGreen	
Electricity consumption	1.929	(1.782)	2.002	(2.405)	1.860	(0.836)	1.932	(1.916)	1.911	(0.749)	1.760	(0.792)	2.004	(2.069)
(kWh/occupied sq. ft.)	*7,854*	*[88]*	*3,815*	*[70]*	*4,039*	*[75]*	*6,601*	*[87]*	*1,253*	*[54]*	*2,405*	*[72]*	*5,449*	*[78]*
Water consumption	9.219	(7.682)	7.812	(4.559)	10.578	(9.604)	8.922	(6.849)	10.897	(11.168)	7.146	(5.066)	10.222	(8.492)
(liter/occupied sq. ft.)	*1,545*	*[22]*	*759*	*[17]*	*786*	*[17]*	*1,313*	*[21]*	*232*	*[11]*	*504*	*[17]*	*1041*	*[19]*
Panel B: Building characteristics														
Size (thousand sq. ft.)	134.5	(154.2)	168.9	(201.1)	114.1	(113.1)	142.3	(148.1)	122.0	(162.9)	162.2	(176.8)	126.5	(146.1)
Occupancy Rate (%)	88.1	(19.7)	88.8	(17.5)	87.7	(20.9)	88.1	(19.1)	88	(20.6)	88.3	(15.5)	88.0	(20.8)
Building Class (%)														
Class A	28.8		41.0		21.6		34.7		19.5		33.8		27.4	
Class B	49.8		47.5		51.2		54.0		43.1		46.5		50.8	
Unknown	21.4		11.5		27.2		11.4		37.4		19.7		21.8	
Construction period (%)														
Unknown	6.0		0.0		9.4		0.0		15.7		0.2		7.7	
Pre 1950	3.7		3.0		4.2		2.4		5.9		1.8		4.3	
1950-1969	3.1		4.5		2.3		4.4		1.0		5.2		2.5	
1970-1979	23.8		25.5		22.8		25.8		20.5		26.7		22.9	
1980-1989	35.8		36.0		35.7		41.9		26.0		40.5		34.4	
1990-1999	10.6		7.8		12.3		6.6		17.1		3.8		12.6	
2000 and after	17.0		23.2		13.3		18.9		13.8		21.8		15.6	
CBD (%)	29.1		32.9		26.9		35.1		19.4		43.2		25.0	
Number of building-months	11,009		4,098		6,911		6,789		4,220		2,468		8,541	
Number of buildings	116		77		105		87		88		73		107	
Panel C: Local climate conditions														
Cooling degree days (# per month)	15.4	(32.5)	14.5	(31.7)	15.9	(32.9)	14.9	(31.8)	16.2	(33.5)	15.6	(31.5)	15.3	(32.7)
Heating degree days (# per month)	310.0	(255.7)	304.7	(254.3)	313.2	(256.4)	309.3	(256.3)	311.2	(254.7)	307.0	(260.2)	310.9	(254.4)
Number of building-months	11,009		4,098		6,911		6,789		4,220		2,468		8,541	
Number of buildings	116		77		105		87		88		73		107	

Notes: Standard deviations in parentheses. Number of building-months and number of buildings for Panel A and B in italics and brackets, respectively.

Table 1 (cont.): Descriptive Statistics - United States

Panel D: Monthly consumption metrics	Total		Certified		Non-certified		EcoTracker		Non-EcoTracker		ForeverGreen		Non-ForeverGreen	
Electricity consumption	1.911	(2.984)	1.712	(3.463)	2.229	(1.951)	1.643	(0.794)	2.193	(4.178)	1.597	(0.618)	1.954	(3.171)
(kWh/occupied sq. ft.)	*4,873*	*[72]*	*2,997*	*[51]*	*1,876*	*[57]*	*2,498*	*[39]*	*2,375*	*[63]*	*588*	*[28]*	*4,285*	*[72]*
Water consumption	7.400	(9.68)	6.395	(7.852)	8.919	(11.761)	5.721	(4.508)	9.170	(12.844)	5.726	(3.907)	7.625	(10.188)
(liter/occupied sq. ft.)	*4,974*	*[74]*	*2,992*	*[51]*	*1,982*	*[58]*	*2,552*	*[40]*	*2,422*	*[64]*	*588*	*[28]*	*4,386*	*[74]*
Panel E: Building characteristics														
Size (thousand sq. ft.)	144.5	(141)	234.0	(203.1)	108.6	(82.4)	240.5	(229.2)	124.3	(103.3)	255.9	(218.1)	139.9	(134.9)
Occupancy Rate (%)	78.0	(29.2)	87.2	(16.8)	74.3	(32.1)	87.9	(14.2)	75.9	(31)	88.6	(14.8)	77.6	(29.5)
Building Class (%)														
Class A	74.1		84.7		69.8		90.2		70.7		89.8		73.4	
Class B	25.9		15.3		30.2		9.9		29.3		10.2		26.6	
Construction period (%)														
Pre 1950	1.2		1.7		1.0		5.3		0.3		0.0		1.3	
1950-1969	6.2		5.7		6.5		3.6		6.8		6.1		6.2	
1970-1979	0.0		0.0		0.0		0.0		0.0		0.0		0.0	
1980-1989	20.9		20.4		21.0		9.5		23.2		0.0		21.7	
1990-1999	24.1		16.5		27.2		17.5		25.5		20.4		24.3	
2000 and after	47.6		55.7		44.3		64.0		44.1		73.5		46.5	
CBD (%)	17.1		31.3		11.4		45.6		11.1		46.9		15.8	
Number of building-months	14,695		4,212		10,483		2,558		12,137		588		14,107	
Number of buildings	145		69		135		40		136		28		145	
Panel F: Instruments														
Cooling degree days (#)	70.3	(116.6)	79.4	(118.6)	66.6	(115.5)	79.1	(119.7)	68.4	(115.8)	81.1	(118.6)	69.8	(116.5)
Heating degree days (#)	397.9	(385.6)	382.6	(388.2)	404.1	(384.4)	377.3	(377.9)	402.3	(387)	339.2	(349.1)	400.4	(386.8)
Number of building-months	14,695		4,212		10,483		2,558		12,137		588		14,107	
Number of buildings	145		69		135		40		136		28		145	

Notes: Standard deviations in parentheses. Number of building-months and number of buildings for Panel A and B in italics and brackets, respectively.

Table 2: Hard and Soft Interventions and Electricity Consumption

(dependent variable: natural log of electricity consumption per occupied sq. ft.)

	Canada (1)	U.S. (2)	Canada (3)	U.S. (4)
BOMA BEST only	-0.040**			
(1=yes)	[0.019]			
LEED EBOM only	-0.165***	0.043		
(1=yes)	[0.055]	[0.041]		
BOMA BEST & LEED EBOM	-0.190***			
(1=yes)	[0.058]			
LEED D&C	0.029	-0.145***	0.046	-0.149***
(1=yes)	[0.157]	[0.051]	[0.149]	[0.045]
Energy Star only		-0.097*		-0.069*
(1=yes)		[0.055]		[0.036]
LEED EBOM & Energy Star		-0.032		
(1=yes)		[0.026]		
EcoTracker	-0.043**	-0.028	-0.043**	-0.030
(1=yes)	[0.019]	[0.040]	[0.019]	[0.040]
ForeverGreen	-0.136***	-0.060**	-0.133***	-0.053**
(1=yes)	[0.024]	[0.027]	[0.024]	[0.026]
BOMA BEST Level (1=yes)				
Certified			0.014	
			[0.040]	
Bronze			-0.095***	
			[0.035]	
Silver			-0.037	
			[0.029]	
Gold & Platinum			-0.069**	
			[0.033]	
LEED EBOM Level (1=yes)				
Certified			-0.160	0.031
			[0.173]	[0.037]
Silver			-0.182*	0.098***
			[0.092]	[0.026]
Gold & Platinum			-0.115**	0.122**
			[0.057]	[0.048]
Occupancy	-1.305***	-1.490***	-1.304***	-1.493***
(percent)	[0.229]	[0.240]	[0.219]	[0.246]
Heating Degree Days	0.018**	0.049***	0.018**	0.049***
(in hundreds by month)	[0.009]	[0.006]	[0.009]	[0.006]
Cooling Degree Days	-0.003	0.048***	-0.002	0.048***
(in hundreds by month)	[0.027]	[0.015]	[0.027]	[0.015]
Constant	1.765***	1.459***	1.761***	1.448***
	[0.219]	[0.220]	[0.210]	[0.217]
Month-fixed effects	yes	yes	yes	yes
Building-fixed effects	yes	yes	yes	yes
Number of building-months	7,854	4,873	7,854	4,873
Number of buildings	88	72	88	72
Adj. R-squared	0.754	0.842	0.755	0.842

Notes: Robust standard errors, clustered at the building level, are in brackets. Significance at the 0.10, 0.05, and 0.01 level is indicated by *, **, ***, respectively.

Table 3: Hard and Soft Interventions and Water Consumption

(dependent variable: natural log of water consumption per occupied sq. ft.)

	CBD (1)	Suburban (2)	CBD (3)	Suburban (4)	CBD (5)	Suburban (6)	CBD (7)	Suburban (8)
BOMA BEST only	0.096	-0.231**					0.066	-0.200*
(1=yes)	[0.143]	[0.102]					[0.140]	[0.100]
LEED EBOM only	0.273	-0.162*					0.228	-0.135
(1=yes)	[0.232]	[0.084]					[0.189]	[0.089]
BOMA BEST & LEED EBOM	-0.099						-0.122	
(1=yes)	[0.356]						[0.321]	
LEED D&C	-0.411**	0.235***					-0.425**	0.235***
(1=yes)	[0.184]	[0.014]					[0.197]	[0.014]
Energy Star only	-0.120	-0.096					-0.121	-0.113
(1=yes)	[0.123]	[0.094]					[0.128]	[0.093]
LEED EBOM & Energy Star	-0.052	0.049					-0.008	0.050
(1=yes)	[0.150]	[0.054]					[0.138]	[0.059]
EcoTracker			0.124	-0.127**			0.116	-0.104**
(1=yes)			[0.220]	[0.052]			[0.178]	[0.051]
ForeverGreen					-0.054	-0.082*	-0.057	-0.040
(1=yes)					[0.084]	[0.049]	[0.068]	[0.045]
Occupancy	-0.178	-1.252***	-0.068	-1.277***	0.007	-1.277***	-0.199	-1.269***
(percent)	[0.638]	[0.183]	[0.682]	[0.190]	[0.746]	[0.190]	[0.608]	[0.182]
Heating Degree Days	-0.047***	-0.051***	-0.045***	-0.052***	-0.047***	-0.052***	-0.047***	-0.053***
(in hundreds by month)	[0.012]	[0.017]	[0.012]	[0.017]	[0.012]	[0.017]	[0.012]	[0.017]
Cooling Degree Days	0.020	0.033	0.020	0.033	0.021	0.032	0.020	0.034
(in hundreds by month)	[0.029]	[0.050]	[0.029]	[0.050]	[0.029]	[0.050]	[0.029]	[0.050]
Constant	-4.924***	-4.116***	-5.187***	-4.090***	-5.128***	-4.149***	-4.973***	-4.037***
	[0.564]	[0.206]	[0.699]	[0.218]	[0.660]	[0.215]	[0.594]	[0.208]
Month-fixed effects	yes	yes	yes	yes	yes	yes	yes	yes
Building-fixed effects	yes	yes	yes	yes	yes	yes	yes	yes
Number of building-months	2,312	4,207	2,312	4,207	2,312	4,207	2,312	4,207
Number of buildings	37	59	37	59	37	59	37	59
Adj. R-squared	0.556	0.697	0.536	0.696	0.533	0.695	0.558	0.699

Notes: Robust standard errors, clustered at the building level, are in brackets. Significance at the 0.10, 0.05, and 0.01 level is indicated by *, **, ***, respectively.

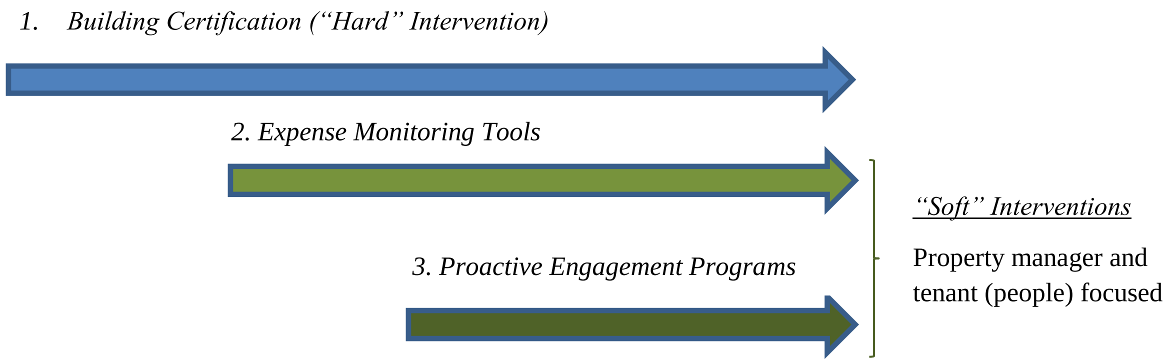
Table 4: Hard and Soft Interventions and Operating Statement Areas

(dependent variable: natural log of net operating income, expenses, management fee, or base rent per (occupied) sq. ft.)

	Canada				U.S.			
	NOI	Total Expenses	Management Fee	Base Rent	NOI	Total Expenses	Management Fee	Base Rent
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
BOMA BEST only	-0.010	-0.018	-0.015	-0.017				
(1=yes)	[0.029]	[0.037]	[0.029]	[0.032]				
LEED EBOM only	-0.016	0.161	-0.035	0.062	0.114	-0.042	-0.053	-0.170
(1=yes)	[0.036]	[0.110]	[0.083]	[0.055]	[0.071]	[0.053]	[0.056]	[0.185]
BOMA BEST & LEED EBOM	0.012	-0.053	-0.216***	0.075				
(1=yes)	[0.044]	[0.064]	[0.040]	[0.058]				
LEED D&C	0.308**	0.199	0.242	0.134**	0.350***	0.187***	-0.020	0.123***
(1=yes)	[0.118]	[0.187]	[0.212]	[0.062]	[0.061]	[0.061]	[0.150]	[0.030]
Energy Star only					0.116***	-0.012	-0.007	0.049*
(1=yes)					[0.043]	[0.025]	[0.038]	[0.029]
LEED EBOM & Energy Star					-0.023	0.006	0.010	0.169
(1=yes)					[0.050]	[0.033]	[0.042]	[0.202]
EcoTracker	0.095**	0.082	0.022	0.042	-0.104	0.074	0.053	0.133*
(1=yes)	[0.042]	[0.067]	[0.067]	[0.062]	[0.091]	[0.045]	[0.055]	[0.071]
ForeverGreen	-0.008	0.030	-0.004	0.046	-0.095	-0.084*	-0.104**	-0.138
(1=yes)	[0.053]	[0.065]	[0.057]	[0.030]	[0.077]	[0.046]	[0.047]	[0.107]
Occupancy	-0.595***	-1.815***	-1.874***	0.834***	0.868***	-1.621***	-0.228	0.064
(percent)	[0.169]	[0.295]	[0.283]	[0.170]	[0.207]	[0.107]	[0.147]	[0.050]
Constant	1.681***	-2.765***	-3.007***	-0.362**	-0.491***	0.927***	-2.775***	0.418***
	[0.150]	[0.294]	[0.280]	[0.151]	[0.173]	[0.098]	[0.132]	[0.043]
Year-quarter-fixed effects	yes	yes	yes	yes	yes	yes	yes	yes
Building-fixed effects	yes	yes	yes	yes	yes	yes	yes	yes
Number of building-months	10,452	8,912	8,732	10,519	12,695	13,496	13,356	14,430
Number of buildings	113	104	104	115	143	144	143	145
Adj. R-squared	0.639	0.828	0.809	0.726	0.391	0.773	0.380	0.731

Notes: Robust standard errors, clustered at the building level, are in brackets. Significance at the 0.10, 0.05, and 0.01 level is indicated by *, **, ***, respectively.

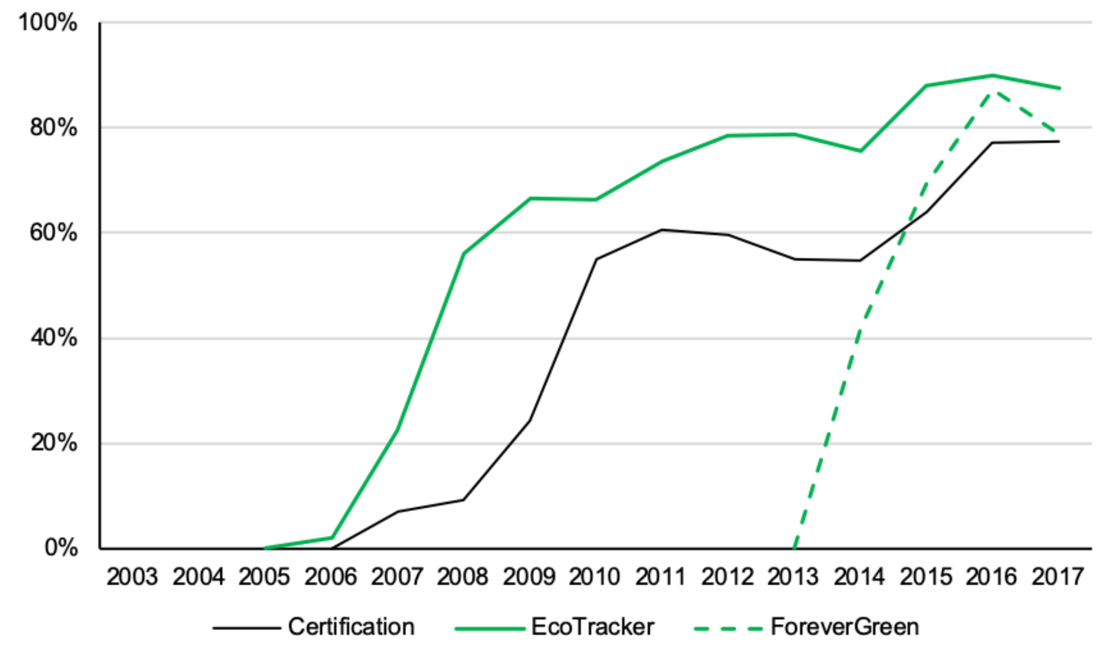
Figure 1: Environmental Interventions: Adoption/Implementation History



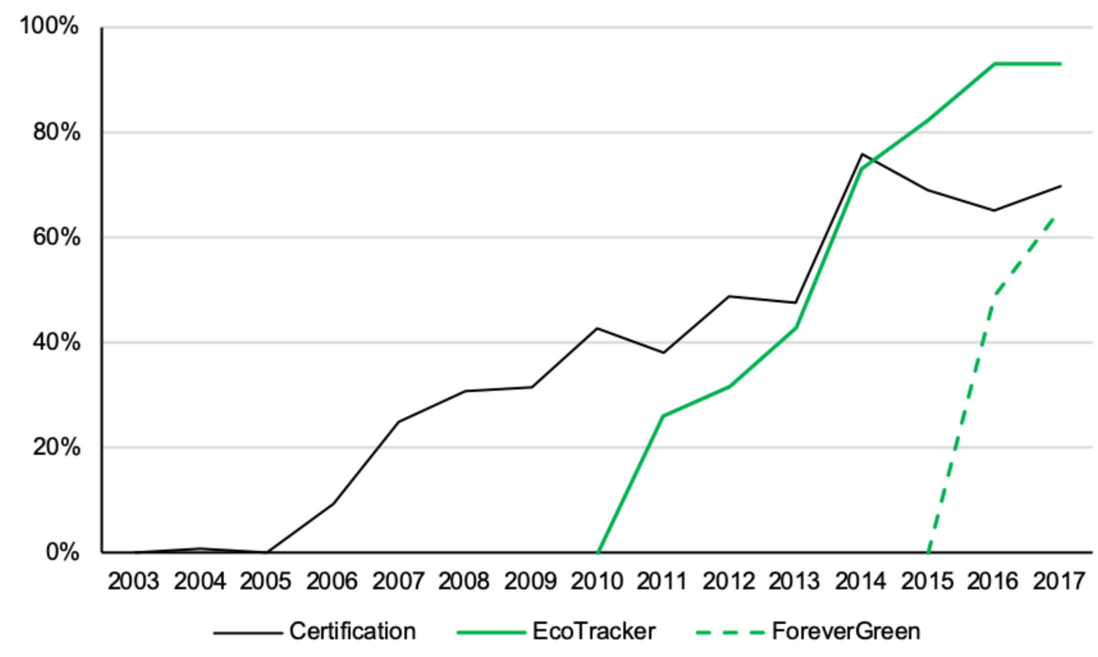
Notes: This figure represents the process, or general historical order, of environmental intervention adoption and implementation in commercial real estate in the developed world.

Figure 2: Hard and Soft Intervention Adoption, by Country

Panel A: Canada

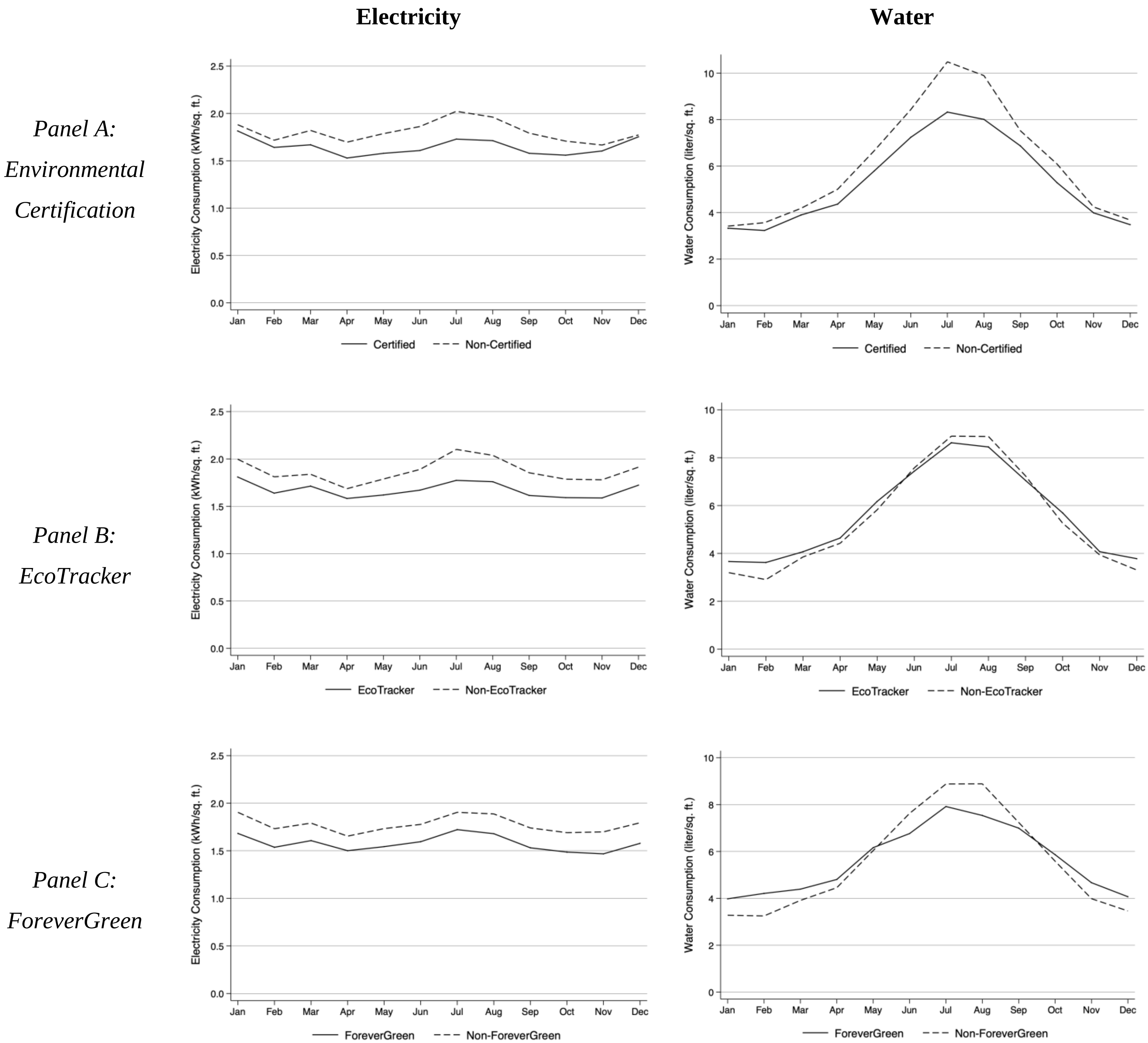


Panel B: United States



Notes: Each graph presents the percent of the sample that is governed by each intervention category, by year. It should be noted that environmental building certification activity was present in some buildings under prior ownership/management. As this falls outside the scope of our sample, that information is not portrayed in the above graphs.

Figure 3: Hard and Soft Intervention Impact on Energy and Water Consumption



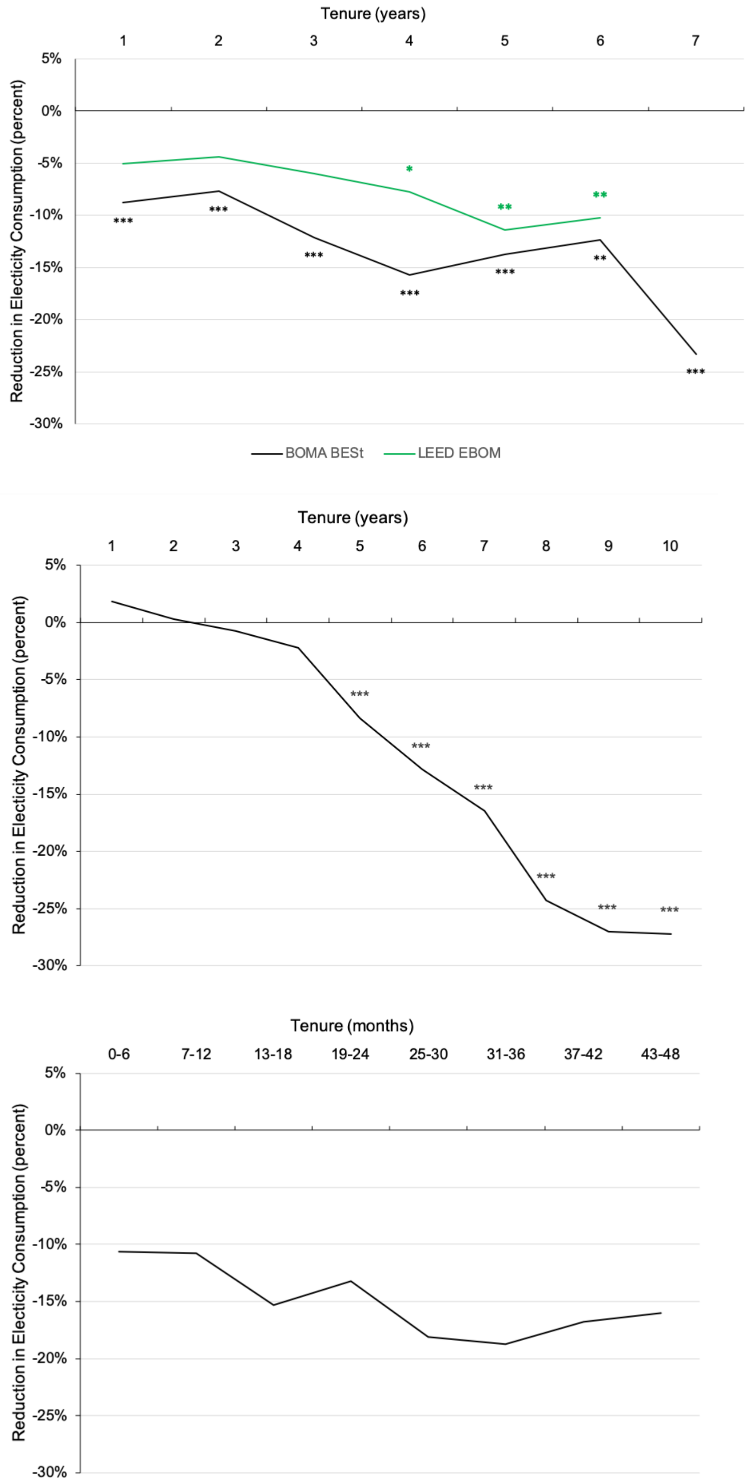
Notes: Each graph presents the seasonal median consumption of electricity (measured in kilowatt hours per sq. ft.) and water (measured in liters per sq. ft.) for the sample separated into two groups: those with and without each environmental intervention. Three interventions are examined: environmental building certification; EcoTracker; and, ForeverGreen. Certification programs include LEED programs in both the U.S. and Canada, Energy Star in the U.S., and BOMA BEST in Canada. These values are not normalized.

Figure 4: Hard and Soft Intervention Tenure Impact on Electricity Consumption

Panel A: Environmental Building Certifications

Panel B: EcoTracker

Panel C: ForeverGreen



Notes: Each graph presents how electricity consumption is affected by each intervention's tenure within a building. These point estimates are taken from regression estimates (see Appendix A2). All point estimates in the ForeverGreen analysis are highly significant; highly significant estimates in the EcoTracker and Environmental Building Certification analyses are noted with ***. Energy Star analysis is excluded due to data limitations.

Appendix Table A1: Sample Composition by Interventions

	U.S.	Canada
Total	145	116
LEED D&C	9	10
LEED EBOM	26	23
BOMA BEST	N/A	70
Energy Star	67	N/A
Uncertified	69	77
LEED D&C & LEED EBOM	4	0
LEED D&C & BOMA BEST	N/A	9
LEED D&C & EnergyStar	7	N/A
LEED D&C, LEED EBOM & BOMA BEST	N/A	0
LEED D&C, LEED EBOM & Energy Star	4	N/A
EcoTracker (ForeverGreen)	40 (28)	87 (73)
Non-EcoTracker (Non-ForeverGreen)	136 (145)	88 (107)
EcoTracker (ForeverGreen) & LEED D&C	5 (3)	8 (8)
EcoTracker (ForeverGreen) & LEED EBOM	26 (18)	21 (20)
EcoTracker (ForeverGreen) & BOMA BEST	N/A	63 (59)
EcoTracker (ForeverGreen) & Energy Star	30 (18)	N/A
EcoTracker (ForeverGreen), LEED D&C & LEED EBOM	4 (2)	0 (0)
EcoTracker (ForeverGreen), LEED D&C & BOMA BEST	N/A	7 (7)
EcoTracker (ForeverGreen), LEED D&C & Energy Star	4 (2)	N/A
EcoTracker (ForeverGreen), LEED EBOM & BOMA BEST	-	16 (16)
EcoTracker (ForeverGreen), LEED EBOM & EnergyStar	26 (16)	-
EcoTracker (ForeverGreen), LEED D&C, LEED EBOM & BOMA BEST	-	0 (0)
EcoTracker (ForeverGreen), LEED D&C, LEED EBOM & EnergyStar	4 (2)	-

Notes: Above lists building counts which experience the specified interventions at any time during the 15-year sample period. Analysis is completed monthly, so over the course of the period a building may populate multiple categories of interventions. All buildings which participate in the ForeverGreen program are concurrently enrolled in EcoTracker, should they not already have the monitoring software in place. Therefore, ForeverGreen is a subset of EcoTracker, and ForeverGreen-inclusive results are presented in parentheses following EcoTracker results. BOMA BEST and Energy Star are Canada and U.S.-specific certification programs, respectively.

Appendix Table A2: Intervention Tenure and Electricity Consumption

(dependent variable: natural log of electricity consumption per occupied sq. ft.)

	Canada	------------ Canada and U.S. ------------		
	(1)	(2)	(3)	(4)
Tenure - BOMA BEST, LEED EBOM, EcoTracker (1=yes)				
1 year	-0.088***	-0.051	0.018	
	[0.022]	[0.035]	[0.018]	
2 years	-0.077***	-0.044	0.003	
	[0.021]	[0.041]	[0.021]	
3 years	-0.121***	-0.060	-0.007	
	[0.023]	[0.045]	[0.023]	
4 years	-0.157***	-0.077*	-0.022	
	[0.028]	[0.043]	[0.029]	
5 years	-0.137***	-0.114**	-0.083***	
	[0.042]	[0.047]	[0.027]	
6 years	-0.124**	-0.103**	-0.129***	
	[0.049]	[0.049]	[0.029]	
7 years (or longer)	-0.233***		-0.165***	
	[0.056]		[0.034]	
8 years			-0.243***	
			[0.039]	
9 years			-0.270***	
			[0.041]	
10 years (or longer)			-0.272***	
			[0.050]	
Tenure - ForeverGreen (1=yes)				
6 months or less				-0.106***
				[0.019]
7 to 12 months				-0.108***
				[0.020]
13 to 18 months				-0.153***
				[0.023]
19 to 24 months				-0.132***
				[0.023]
25 to 30 months				-0.181***
				[0.024]
31 to 36 months				-0.187***
				[0.027]
37 to 42 months				-0.168***
				[0.035]
43 to 48 months				-0.160***
				[0.041]
Occupancy	-1.331***	-1.365***	-1.377***	-1.372***
(percent)	[0.231]	[0.165]	[0.165]	[0.169]
Constant	1.793***	1.574***	1.558***	1.562***
	[0.222]	[0.150]	[0.146]	[0.149]
Base intervention controls	yes	yes	yes	yes
Local climatic conditions	yes	yes	yes	yes
Month-fixed effects	yes	yes	yes	yes
Building-fixed effects	yes	yes	yes	yes
Number of building-months	7,854	12,727	12,727	12,727
Number of buildings	88	160	160	160
Adj. R-squared	0.759	0.797	0.803	0.796

Notes: Robust standard errors, clustered at the building level, are in brackets. Significance at the 0.10, 0.05, and 0.01 level is indicated by *, **, ***, respectively.