Environmental Certification and Performance in Services: LEED Adoption in the Hospitality Industry

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Abstract

The Leadership in Environmental and Energy Design (LEED) certification has gained increased acceptance in building design and construction ever since its introduction in 2000. LEED is increasingly recognized and promoted by designers, government agencies, special interest groups, and commercial developers. However, little research has examined the impact of LEED certification on the financial performance of adopting firms. In this study, we investigate how the adoption of LEED certification affects financial performance in the hospitality industry. We

use an event study approach where we match LEED certified hotels with their uncertified peer hotels and then use a difference-in-differences analysis. Our results indicate that LEED certified hotels outperform their uncertified counterparts. To better understand the drivers of the differential performance, we use a multi-level longitudinal model and find that higher occupancy and revenues per available room for the LEED certified hotels contribute to their improved financial performance as compared to their non-certified peers. We discuss the implications of these findings within the hospitality industry and beyond.

1. Introduction

Buildings have a significant impact on the environment. In the United States, buildings account for 37% of the primary energy use, 68% of all electricity use, 40% of non-industrial solid waste, 12% of potable water use, 35% of carbon dioxide emissions, and 49% of sulfur dioxide emissions (Howard 2003). "Green building" evolved as a means to reduce this negative environmental impact throughout the complete building life cycle. The United States Green Building Council (USGBC) was founded in 1993 as a nonprofit organization that seeks "to transform the way buildings and communities are designed, built and operated, enabling an environmentally and socially responsible, healthy, and prosperous environment that improves the quality of life." The USGBC constituted a broad based committee including architects, realtors, owners, lawyers, environmentalists, and industry representatives to develop the LEED (Leadership in Energy and Environmental Design) green building rating system, which was launched in 2000 and which facilitates design, construction, and operation of high performance green buildings. Ever since the launch of the LEED green building rating system, it has gained increased acceptance. As of 2015, over 76,000 projects have been registered and certified to the LEED rating system.

Along with the growing acceptance of the LEED green building rating system, several studies have sought to investigate the benefits provided by this rating system. This has generated a debate on the benefits of LEED certification. On the one hand, scholars have demonstrated that LEED adoption has lowered operational costs and improved productivity (e.g., Fowler and Rauch 2008, Kats 2003). On the other hand several studies have shown that LEED certification does not produce financial improvements (Scofield 2009, Eichholtz et al. 2010, Fuerst and McAllister 2011). One potential explanation for the mixed evidence could be that the

comparisons in the literature have been mainly been restricted to snapshots of performance. For example, a LEED certified building may obtain higher rental price as compared to a comparable building immediately. However, over time because of various modifications and changes to the comparable buildings the difference in rental prices may erode. The restricted comparison is mainly because the literature has not been able to track the performance of LEED certified buildings and non-certified comparable buildings consistently over time. This study uses data from the hotel industry which overcomes these challenges. An additional advantage of using data from the hotel industry is that buildings play a central role in determining competitive outcomes in this industry

To overcome the challenge of measuring financial performance of LEED certified buildings over time; we implement a mixed methods approach. Our first goal is to establish that there is a difference in performance between LEED certified hotels and their competitors. We use a traditional event study methodology (Swink and Jacobs, 2012) to answer this question. We demonstrate abnormal financial improvements of LEED certified hotels relative to a matched set of their non-certified peers. While effective at demonstrating abnormal performance, this form of event study analysis does not adequately answer the question of why these hotels outperform their peers. To investigate the reasons as to why LEED Hotels outperform their non-certified peers over time, we utilize longitudinal multilevel modeling—also referred to as Hierarchical Linear Modeling (HLM) or Random Coefficient Modeling (RCM). This approach has gained increased acceptance in research studies because it controls for variance across both individuals and groups (for example: Chesteen et al. 2005, Azadegan and Dooley 2010, Liu et al. 2014).

Our results indicate that, in general, hotels benefit from LEED certification. However, the advantage obtained from LEED certification is transient. LEED certified hotels exhibit superior financial performance as compared to their non-certified peer hotels for a period of two years; after which the difference in financial performance is no longer significant. Our analysis reveals that the superiority of LEED certified hotels can be attributed to two factors. First, LEED certified hotels obtain a significant improvement in average room occupancy rates subsequent to certification as compared to non-certified hotels. Second, LEED certified hotels realize higher average revenues per available rooms (RevPAR) as compared to non-certified hotels. These results suggest that LEED certification not only increase the number of customers but increases the contribution per room. However, we also observe that the higher occupancy rates and

revenues for each available room get eroded after a period of two years. Additionally, we find that LEED certification remains a significant contributor to the improved financial performance of hotels even after accounting for the newness of a hotel.

This paper has two main contributions. First, we establish the benefits of LEED certification in the hotel industry and show that the competitive benefits are transient in nature. Thus, our results provide one potential explanation for the mixed evidence on the benefits of LEED certification that has been observed in the prior literature. Second, we are able to identify how the improvement in performance is driven by increases in average occupancy and average revenues per available rooms for LEED certified hotels. Thus, we are able to highlight the mechanisms that enable LEED certification to improve competitive positions, an important finding for the hospitality industry.

The rest of the paper is organized as follows. In section 2, we discuss the relevant literature. In section 3, we present our hypotheses. In section 4, we describe the data and the measures used in our analysis. Section 5 discusses our methodology and in section 6 we present the results. Finally, in section 7 we discuss the implications of our findings and the limitations of our analysis.

2. Literature

2.1 Impact of Certification on Performance in OM Literature

An important focus area of the operations management (OM) literature is to understand how various certification programs can impact operational performance. For instance, Gray et al. (2015) classify the large body of work that has examined the impact of ISO 9000 certifications on operational performance. Along similar lines the OM literature has examined the impact of other quality certifications, such Six Sigma (e.g., Swink and Jacobs 2012, Braunscheidel et al. 2011), Lean (e.g., Shah and Ward 2007, Ward and Zhou 2006), and TQM (e.g., Martinez-Costa et al. 2009).

With the increased recognition of the importance of environmental issues, several recent studies have sought to investigate the impact of environmental certifications on performance (e.g., Konar and Cohen 2001, Repetto and Austin 2000, Molina-Azorin et al. 2009). LEED is

one such certification whose effects have been debated by scholars. Since its creation in 2000, the impact of LEED certification on financial performance has been a fertile area of research (Kok et al. 2011, Eicholtz et al. 2009, Dermisi, 2009). Most of the work in this area has followed one of two broad approaches. The first approach compares the performance of a LEED certified building to a baseline such as an industry average or an estimate of a non-certified equivalent. These studies often include case studies, and many conclude that adoption lowers operational costs and improves productivity (Fowler and Rauch 2008, Kats 2003, Von Paumgartten 2003). The second approach compares performance of a LEED building with a comparable non-certified building or set of comparable buildings. Using this approach, scholars have found mixed evidence on the benefits obtained from green buildings. On the one hand, several studies have shown that certification to the LEED green building rating system leads to higher market assessment of the buildings (Dermisi 2009), to higher commercial rents (Eichholtz et al. 2009), and reduces costs associated with regular operations (Miller et al. 2008). On the other hand, several studies have also shown that the certification to LEED green building rating system does not provide higher market assessment (Fuerst and McAllister 2011), nor additional energy savings (Scofield 2009), nor higher rents (Eichholtz et al. 2010).

In either case, most of the work done in this area has posed the LEED certification question in terms of reducing operational costs (Newsham et al. 2009, Scofield 2009, Kneifel 2010), analyzing investment trends (Fuerst 2009, Jacobs et al. 2010), and measuring asset valuations (Eichholtz et al. 2013) . Few studies have attempted to address this question from the perspective of how LEED impacts the revenue side of the financial equation (a few noteworthy exceptions include: Eichholtz et al. 2009, Fuerst and McAllister 2009). We contribute to the growing literature on certification by investigating the impact of an environmental certification (i.e. LEED certification) on revenue generation in the hospitality industry.

2.2 Hospitality Industry

The hospitality industry is an ideal setting to investigate the impact of LEED certification on financial performance because buildings constitute the core of the offering provided in this industry. Up until now, the scholarly work in the hospitality industry regarding LEED certification has been primarily descriptive in nature (Buckley 2002, Font 2002, Font and Harris

2004). This study contributes by providing deeper understanding of the factors that contribute to improved financial performance for the hospitality industry.

The hospitality industry has been slow to adopt LEED. While the LEED certification program started in 2000, the first hotel was not certified until 2004. It was not until 2007 that certification began to trend in an increasingly positive direction. This trend continued as the number of certified hotels grew annually until 2010 when—in the wake of the global economic recession—the number of certified hotels took a step backward. One simple explanation for this reversed trend is that the number of new hotels in the development pipeline was dramatically curtailed. Because LEED certification correlates highly with new hotels, it is natural that the number of certifying hotels would decrease dramatically.

---Insert Table 1 here---

This study contributes to the hospitality literature in two ways. First, we rigorously test the impact of LEED certification on hotel financial performance with longitudinal industry data. To date, most studies in this area have been descriptive in nature or case studies. Second, we investigate the drivers of revenue performance. These results have the potential of impacting the way in which hotels are conceptualized and constructed in the future. Currently, hoteliers are reluctant to pursue environmental certification because they don't understand the associated benefits. One executive at a global hospitality company that we interviewed said that they have a hard time convincing their franchisees to certify because the franchisers interpret certification as an additional cost. She mentioned that a deeper understanding of the impact of environmental certification on hotel revenue—as performed in this study—could improve hotelier's willingness to participate in the program, thus influencing the entire industry.

3. Hypotheses

Our principle question—what is the impact of environmental (i.e. LEED) certification on hotel performance?—can be studied from three perspectives that relate to: 1) cost reduction, 2) improved asset valuation, and 3) enhanced revenue generation. In what follows, we lay down the

reasons as to why we do not consider the first two perspectives and instead focus on examining the impact of LEED certification only from the revenue generation perspective.

First, LEED certification can facilitate process improvements that could reduce costs. LEED, and other environmental, certifications have traditionally been studied from a cost reduction perspective (Scofield 2009, Kneifel 2010). This approach has been well documented, and therefore we do not focus on this perspective.

Second, LEED certification could impact financial performance by affecting hotel valuations. Eichholtz et al. (2013) find that environmental certification can impact valuation in commercial real estate properties. Corbett et al. (2005) measured ISO 9000 impact on the stock market valuation of the adopting firms. Asset valuation is important in the hotel industry because increasingly Hotel Real Estate Investment Trusts (H-REITs) own many hotel properties and they buy and sell hotels regularly; often holding properties for short periods of time. However, as on date, there is limited information on the impact of LEED certification on asset valuation. This is because of the limited population of LEED certified hotels and the even fewer changes in ownership of LEED certified hotels. Therefore we do not focus this perspective.

Finally, LEED certification can impact financial performance by increasing revenue. This perspective incorporates customer's response to certification, an important aspect that has been relatively understudied. Moreover, customers do not observe cost reductions or asset valuations directly, but they can observe differences in room rates and occupancy. As a result, we focus our analysis on examining the certification's impact on revenue performance, and ask the natural question -- Are customers willing to pay a premium for LEED certified hotels? Many OM scholars have demonstrated a positive impact of certifications on customer driven measures. For example, Corbett et al. (2005) highlight the impact of ISO 9000 on stock market valuation and Swink and Jacobs (2012) demonstrate the impact of six sigma on sales growth. In a similar vein, we expect that customers in the hospitality industry will react favorably to LEED certification. Additionally, several features of the LEED certification such as improved indoor air quality, increased daylight, reduced VOC (volatile organic compounds), etc. will contribute to improved customer stay experience. These factors will positively influence hotel revenue. In the hotel industry it is standard practice to measure revenue (revenue per available room or RevPAR) as a

product of room occupancy and average daily rate (Kimes 1999). This not only gives a measure of revenue but also gives evidence as to the drivers of revenue (occupancy or rates). Thus, when an existing hotel undertakes LEED certification, we expect the LEED certified hotel will realize higher revenues as compared to its' non-certified peers. A similar mechanism will provide higher revenues for a new hotel when it is built conforming to the LEED standards. However, in the hotel industry, it is well understood that new hotel properties realize higher revenues. As a result, for new LEED certified hotels, the boost in revenue performance from certification will be augmented by the newness of the hotel. Due to the distinct differences between existing and new hotel properties, based on the above discussions we examine the impact of LEED certification on existing and new hotel properties separately in the following two hypotheses:

H1: Existing hotels which undergo LEED certification outperform their non-certified peers following adoption (measured by RevPAR).

H2: New LEED hotels outperform their non-certified peers (measured by RevPAR)

Finally, once we establish that there is a difference in the performance of a LEED hotel (or a new hotel), what happens to that advantage over time? Decades of strategy research suggests that firms should use their unique resources to try to first create, and then sustain a competitive advantage (Barney 1991, Oliver 1997). However, under conditions of uncertainty firms begin to mimic each other (DiMaggio and Powell 1983). Lieberman and Asaba (2006) give two explanations for why firms imitate each other: 1) a competing firm mimics a leading firm that is perceived as having superior information; 2) a competing firm mimics a leading firm to maintain competitive parity or limit rivalry. Often this imitation game comes in the form of strategic clustering (Gul and Lundholm 1995) or interorganizational mimicry (Gimeno et al. 2005). In perhaps the most famous example in the hospitality industry Baum and Haveman (1997) demonstrated how hotels in Manhattan tended to cluster around certain product dimensions (i.e. price) to take advantage of agglomeration, but differentiated based on another product dimension (size). In the case of LEED hotels, where financial returns remain uncertain, it is likely that hoteliers will begin to mimic the behavior of their LEED adopting competitors. This means that once a non-certified hotel realizes that their LEED certified competitors are superior performers, they will likely try to mimic the attributes of certified hotels that customers observes (e.g. new

carpets with less VOC, more energy efficient lighting, more daylight, etc.). This mimicry will erode the advantage of LEED certification over time. The above discussion leads to our third hypothesis:

H3: The initial boost that LEED hotels get over their non-certified peers diminishes over time (measured by RevPAR).

4. Data and Measures

4.1 Data Collection

The data used in this study is obtained from two sources: (1) the USGBC database of registered and certified LEED properties, which is publicly available; and (2) hotel performance data from Smith Travel Research (STR), which we obtained based on our closing working relation with STR. Our data includes descriptive and annual performance information of 565 hotels of which 93 hotels are certified to the LEED standard. The information pertains to an eight year period from 2005 to 2012. The distinguishing feature of our data is that we have information on the entire population of LEED certified hotels up through 2012.

4.1.1 USGBC Certification Database

The United States Green Building Council (USGBC) is a non-profit organization that certifies the completion of LEED certification requirements for buildings across the globe. The USGBC maintains a public database of all building projects that have applied for certification, including: completed, ongoing, planned, or abandoned projects. By 2012 over 35,000 projects were either registered or certified to the LEED standard. From this data of over 35,000 projects, we identified 361 projects as pertaining to the hotel industry in the United States. Of these, 108 were certified and 253 were registered—meaning they showed interest in certification—but were not yet completed and certified. These 108 properties represent the population of LEED hotels in the US, not a sample of certified hotels.

4.1.2 Smith Travel Research Hotel Performance Database

Smith Travel Research (STR) is one of the largest research firms and data consultants in the hospitality industry. In the hospitality industry, data consultants play the important role of collecting performance data from individual hotels for benchmarking purposes. For example, a Hilton hotel in Washington DC will report their daily measures to STR along with the names of similar competing hotels located close by (STR and the hotel industry refers to these competing hotels usually 4-6 hotels as 'compset'). STR then approaches those 4-6 hotels for the same information and reports back to each hotel the performance of their hotel relative to their competition (with the names of the hotel masked to protect their anonymity). STR currently collects daily transactional data from roughly 75% of all hotels in the United States. Through STR we secured annual performance data for 87 of the 108 certified hotels in the US (i.e. data for 81% of the LEED certified hotels in the US up to 2012). STR also supplied the financial data for 472 non-certified competitors ('compset') of our 87 LEED certified hotels. STR also provided us with descriptive data regarding each of the properties (Table 2). By merging the USGBC and STR data we are able to track the performance of LEED certified hotels and non-certified comparable hotels consistently over time, something that has not been done in previous work on LEED certification. We also supplemented our analysis with visits to a LEED Platinum hotel (one of three in the US) and interviews of senior executives in hotel companies that have responsibility over environmental sustainability.

---Insert Table 2 here---

4.2 Variables and Measures

4.2.1 Dependent Variables

In the hospitality industry there are three primary revenue measures: Occupancy (the % of rooms occupied on a given night), Average Daily Rate or 'ADR' (the average rate collected for each room), and Revenue per Available Room or 'RevPAR' (the product of occupancy and ADR). RevPAR is probably the single most important number hoteliers track because it captures information about occupancy and rate (Kimes 1999). For this reason, RevPAR has become a common dependent variable in many studies in the hospitality literature (e.g., Kim et al. 2003, O'Neill and Carlbäck, 2011, Xiao et al. 2012, Anderson and Lawrence 2014).

4.2.2 Independent Variables

The primary analysis in this study incorporates three elements: (1) LEED certification, (2) time, and (3) matched sets. First, the primary research question of this study regarding the impact of LEED certification on hotel performance indicates that LEED certification (binary variable measured as 1 = LEED certified, 0 = not certified) is the primary independent variable. Second, as with all longitudinal analysis, time is an important variable to capture, which we do using time before/since certification as an independent measure. In the initial difference-in-differences analysis 't' denotes the certification event (Corbett et al. 2005) and we measure performance changes in annual periods (-3 to -2, -1 to t, t to +1, etc.). In the supplemental multilevel model time is a scale between -7 and 8 that represents the time since certification. Finally, the matched set represents a critical element because it allows us to measure change at the individual property level and at the group or compset level, which is one of the primary benefits of multilevel models. We can include compsets as fixed effects by using indicator variables for each compset in the model (Eichholtz et al. 2010) or as random effects that preserve the variance across the compsets (Singer and Willett 2003). In this study we use both fixed and random effects models to test the robustness of the data and the measured effects.

4.2.3 Control Variables

A major benefit of our data is that the matching of peer hotels was done by the managers of each hotel property. Since the matching is done by the hoteliers themselves, it is in their best interest to identify their peer hotels (compsets) as properties that are similar in location, size, class, and price. By creating a group level variable for the entire compset we can control for most of the differences in characteristics across hotels within a particular compset. Our final dataset includes 87 groups (87 subjects and 472 matched peer hotels). We performed a t-test to compare the characteristics of the subject properties with the mean and median of the competitors (Table 3). There is no significant difference between the class and size of the subject property and the mean or median class and size of the competitors. Hotel age is significantly different among our subject properties and competitors, the subject properties being much newer buildings. For this reason we include age of hotel as a control variable in our model. We also added an indicator variable "new hotel" for newly completed hotels because we believe there may be a connection between new hotels and performance. This also allows us to

capture unique sources of variance among new hotels as many LEED hotels are also new hotels. Our final control variables are time variant controls necessary for the multilevel model in the follow-up analysis

---Insert Table 3 here---

5. Methodology

When an hotelier does decide to certify their hotel, they generally pursue one of two types of certification: 1) existing hotels undergo renovation and are certified to the LEED standard as existing buildings, 2) new hotels are designed, built, and certified to LEED standards as new construction. Our first area of exploration is the impact of LEED certification on existing buildings. This is consistent with most traditional event studies in the literature which take a before and after approach to an exogenous shock. The second type of certified hotel does not lend itself to the traditional event study methodology as well. When a certified building is new, how do you collect pre-certification data? To do this we use a multi-level model that allows us to analyze 'newness' and LEED certification separately.

5.1 Event Study Methodology

In this study we conducted an event study following a difference-in-differences methodology similar to other OM scholars (Corbett et al. 2005, Swink and Jacobs 2012) as adapted from economics and finance (Barber and Lyon 1996). The main purpose of an event analysis is to detect abnormal performance of a firm following an event, in this case LEED certification. We use the same definition for abnormal performance (AP) as Barber and Lyon where AP of firm i in year t (AP_{it}) is defined as actual performance (P_{it}) minus expected performance ($E(P_{it})$):

$$AP_{it} = P_{it} - E(P_{it}) \quad (1)$$

where performance is measured as one of three outcome variables: (1) Occupancy, (2) Average Daily Rate (ADR), or (3) Revenue Per Available Room (RevPAR); and expected performance is the mean/median performance of the non-certified hotels in the compset. Barber and Lyon suggest that measuring the change in performance relative to the change in the benchmark is a more accurate test than measuring the level performance relative to the benchmark (static annual

performance). This helps to minimalize the chance impact of boom or bust economies on the year of certification. One disadvantage of this method is that it masks relative position of the firms. For example a new hotel upon opening may begin in a disadvantaged position entering a new market relative to the incumbents. However, it likely will improve performance at a quicker rate, so this analysis would show that it is outperforming the competition year over year when in fact is merely catching up.

To control for difference amongst groups and location (assuming all hotels in a group are in the same location) it is common practice in the hospitality industry to create an index of hotel performance for each group where abnormal performance of firm i in year t (AP_{it}) is defined as actual performance (P_{it}) divided by expected performance ($E(P_{it})$):

$$AP_{it} = P_{it}/E(P_{it}) \quad (2)$$

where performance is measured as one of the three outcome variables of interest and expected performance is the mean/median performance of the non-certified hotels in the compset. In this analysis a performance index > 1 and a change in performance > 0 represent superior performance. This model appropriately captures the starting point of the entrant and incumbents and the change in the performance indexes. Additionally, in line with Swink and Jacobs (2012) we focus on the median competitor performance in our analysis because the median is less influenced by outliers as opposed to the mean. In our analysis we test both median (Swink and Jacobs 2012) and mean (convention in the hospitality industry) for abnormal performance.

We followed the difference-in-difference approach outlined by Barber and Lyons (1996) which involves three discrete steps: (1) match properties with similar characteristics (already done by hoteliers as described above), (2) assess relative levels of annual performance and more importantly, change in annual performance, (3) test whether the annual performance and change in annual performance for the subject group (LEED) is significantly different from the compset using a non-parametric Wilcoxon Sign-Ranked Test (Barber and Lyons 1996, Swink and Jacobs 2012). If we observe a significant difference then we can say that the subject hotel exhibits abnormal performance. If we do not observe a significant difference in annual performance of LEED hotels prior to certification, but post certification there is a significant difference in performance, than we can infer that LEED certification results in an abnormal performance relative to non-certified hotels.

5.2 Multi-level Model

In this dataset there are two types of hotels that certify: (1) existing hotels that go through a renovation and subsequent certification process (26 total), and (2) new hotels that are designed to be LEED certified (61). In the first case, years of pre-certification data is available and the analysis is similar to that conducted by others studying ISO 9000 (Corbett et al. 2005) or Six Sigma (Swink and Jacobs 2012). The second type is more complex however because the effects of the certification must be teased out of the effects of the newness of the hotel. Many new hotels are constructed with the intent to be LEED certified, but certification typically lags behind completion by a year or more. Additionally, there is a new hotel effect which can confound the LEED effect since the variables 'new' and 'LEED' can be highly correlated. Difference-in-differences is useful for identifying differences in performance before and after a specific event (i.e. LEED Certification) when data is available on both sides of the event, but it is limited in its ability to provide evidence as to why the differences occur. It is also limited in its usefulness when data is only available on one side of the event. For example, in the case of the new LEED hotel a difference-in-differences approach cannot separate the boost in performance a hotel may get from being new, from the boost that it may get from being LEED certified. We therefore constructed a longitudinal multilevel model (Singer and Willett 2003) to control for the unique variance of new hotels and LEED hotels and address the questions: (1) Does abnormal performance come from newness or LEED certification? (2) Why do LEED hotels outperform competitors?

6 Results

We first examine the summary performance measures for the LEED hotels in our data. Taken as a group, the 87 LEED certified hotels had a lower occupancy rate (62% vs 67% for non-certified hotels) and RevPAR ($104 vs $106), but a higher ADR ($164 vs $154).

---Insert Table 4 here---

6.1 Difference-in-Differences Analysis

While it is interesting to look at mean/median values they don't provide a complete picture. This aggregate data was matched by the mean / median of the competitive group, but did not take into account the certification event. Using the difference-in-difference approach described earlier we were able to not only match the properties but also measure their performance before and after the event (LEED certification). The following four charts exhibit the results of this analysis. Tables 5-6 display the data on existing hotels (those not designed to be LEED certified, but renovated during their life cycle to become certified). Tables 7-8 show results from new certified hotels—those designed to be certified. In each table year t represents the certification year and the '-' represents the years before and the '+' represents the years following certification. We included the data from three years prior to certification up through three years post-certification recognizing that the data is quite limited for some of these years.

---Insert Tables 5-6 here---

Tables 5-6 demonstrate that there is no significant difference in hotel performance before and after LEED certification in existing hotels that underwent a certification event. Table 5 presents an absolute comparison of LEED hotels to their non-certified competitors using by measuring the index value (Index > 1 signals superior performance). Table 6 presents a relative performance (Δ Index > 0 signals superior performance). Certified hotels tended to outperform non-certified hotels in RevPar at an absolute level and relative level prior to, and post certification, but the difference is not significant. Thus, these results do not support H1 that existing hotels that adopt certification will outperform their non-certified peers.

---Insert Tables 7-8 here---

Tables 7-8 present difference-in-difference analysis results on new hotels that were designed and constructed to be LEED certified buildings. Table 7 presents the absolute comparison (Index) while Table 8 presents a relative comparison (Δ Index). New LEED hotels begin in a significantly disadvantaged position with respect to occupancy levels but they charge more than their competitors. We suspect that the slow start in occupancy is due to existing competition for the new entrant in the market—a feature which is pertinent for all new hotels.

Traditional difference-in-difference analysis which measures changes in the levels of absolute performance (i.e. Table 8) clearly shows that LEED hotels are outperforming their non-certified competitors. Using this approach, our results support H2 that new certified hotels outperform their non-certified peers. However, this alone does not tell the whole story. One of the major reasons for the dramatic change in annual performance is the disadvantaged starting point of new hotels (Table 7). The new hotels are 'closing the gap' and as they do, the change in annual performance (or relative performance) diminishes from year to year until eventually it goes away and one is left with only absolute performance differences. For this reason, in this study we focus on both relative and absolute performance, while most event analysis studies focus on relative performance.

One important contextual insight to this data is that LEED certification lags behind the opening of the hotel—sometimes by as many as three years. As noted before, occupancy and RevPAR lags in these start up years but catches up very quickly. By the time a hotel is certified 1-2 years after opening the occupancy gap has been closed and the higher ADR results in a RevPAR advantage. Using a difference-in-difference approach we cannot tell whether post-certification financial performance is due to certification or the natural cycle of a new hotel.

6.2 Multilevel Modeling Analysis

It is clear from the initial difference-in-differences analysis that hotel age clearly has an impact on hotel performance (i.e. new LEED hotels outperform non-certified hotels, but existing LEED hotels do not). Difference-in-differences analysis however, does not allow for controlling unique variance introduced by individual variables (i.e. hotel age or a hotel being new). The primary purpose of this multi-level model is to account for these factors that are not adequately incorporated in the difference-in-differences approach, and to add controls at the group level—which cannot be done by typical OLS regression. Table 9 presents Pearson bivariate correlations for our variables of interest. We notice that LEED hotels are correlated with new hotels at a very high level (0.52). We expected this as most of the LEED hotels in our dataset are also new hotels. We also notice that LEED hotels are negatively correlated with chain operated and franchised hotels, validating what we already noticed in the descriptive analysis (Table 2) that LEED hotels are more commonly independent hotels in our dataset. New hotels however are

positively correlated with franchise operations and negatively correlated with independent and chain operations.

---Insert Table 9 here---

Another advantage of a multilevel approach is that we can measure the impact of time on the model. We model a discontinuous growth model with three linear change variables and two quadratic change variables (Table 10). The variable 'Year' models the annual change within individual hotels. 'LEED Adoption' captures the impact of the event occurrence. This is similar to our 'LEED' variable but there is an important difference. The 'LEED' variable is a categorical variable at the individual level that does not change over time. 'LEED Adoption' however changes based on the timing of the event occurrence so it allows us to measure pre-certification performance against post-certification performance (similar to diff-in-diff). Finally, 'Years Since Adoption' captures the post certification performance of the hotel. Modeling change in this way detects a shift in magnitude and a change in slope of post-certification hotels.

---Insert Table 10 here---

There is debate in the literature on the appropriate use of fixed and random effects in multilevel model. For our purposes fixed effects are those which do not change in the individuals in the population. For example, we specify a LEED certified hotel as a LEED hotel over every period, regardless of when it received certification. Random effects however do allow for variability (i.e. randomness). In our model specification, the treatment of fixed vs. random effects is particularly important in how we treat the group level variable. Our subject hotels were grouped with competitors in 87 groups (1 LEED, 4-8 non-LEED per group) and each group was given a number 1-87. We recognize that this group level variable could be treated as a fixed effect (group does not change over data collection period) or random (hotels come and go from the group). For this reason and to ensure the robustness of our analysis we modeled the group level variable (compset) as both a fixed (Table 11) and random effect (Table12). In Table 11 where compset is modeled as a fixed effect we added 87 dummy variables to the model to control for variability among the different compsets (Eichholtz et al. 2010). In Table 12 where compset is modeled as a random effect we inserted only one additional variable at the group

level. Our results are robust to the fixed and random effect approaches as the results are consistent across both models.

---Insert Table 11 here---

In Table 11 above, model 1 represents the unconditional mean model, followed by the unconditional growth model (model 2). According to Singer and Willett (2003) the first step in any discontinuous growth model should be to establish these as a baseline. The unconditional mean model represents the sample mean before any predictors are added to the model, while the unconditional growth model only measures the effect of time on the response variable. In model 3 we add the 87 dummy variables for the compsets, as well as the primary variables of interest (*LEED* and *New*) and notice that newness of a hotel emerges as a significant predictor but not LEED certification. We then add additional control variables (*log_age* and *operation*) as well as an interaction term *LEED*New* (Model 4). This interaction is important because it allows us to look at the LEED hotels that are also new as a separate group from the existing hotels that went through a certification process. Here we notice a negative coefficient for age meaning that an increase in the hotels age predicts a decrease in RevPAR. This is consistent with the positive significant coefficient for new hotels. Up to this point it would appear that LEED certification is not a significant predictor of financial performance and that the increased performance measured in the diff-in-diff approach is primarily due the fact that most LEED hotels are also new. In our final two models (5-6) we added change terms in addition to linear measurement for year. This strategy allows us to measure the impact of the certification event (*LEED Adoption*) and the post-event (*Years Since Adoption*) performance (Singer and Willet 2003, Lang and Bliese 2009). This method more accurately reflects the longitudinal nature of this data and returns more meaningful results. We notice first that the main effects of *LEED* and *New* are significant but not the interaction. This means that both the newness and LEED certification contribute to higher RevPar but the combination of the two does not give any additional benefit. Further, at the time of adoption RevPar among certifying hotels drops significantly (-13.12) but is quickly recovered (10.01 per year after certification). In Model 6 we specify a curvilinear model by adding quadratic change terms for *Year* and *Year Since Adoption*. In this model *New* and *LEED* predictors continue to be significant along with *Log_age*, *Year,* and *Year Since Adoption*. The

quadratic term $Year^2$ is a significant predictor of RevPAR indicating a curvilinear or quadratic growth model for time, but not for time since adoption.

The random component specified in all models in Table 11 is time (*Year*). By specifying the model in this manner we are able to observe changes at the individual hotel (Level 1) and the impact of time (Level 2). We use three test for model fit, all of which demonstrate better fit as we added variables to improve the model.

---Insert Table 12 here---

Table 12 reports the results of our discontinuous growth model with *compset* modeled as a random effect. Specifying the model in this way confirmed the results from the fixed effects model and provides additional support for our results. In this result we see that *LEED* and *New* continue to be significant predictors (Models 8-10) while their interaction is not significant. Additionally, the change variables are all significant predictors of financial performance, just as they were in the fixed effects model. In the random portion of the model we continue to measure individual change (Level 1) and the impact of time (Level 2), but we also add a second Level 2 component which accounts for variance at the group (or compset) level. The addition of this one variable at the group level removes the need for the 87 dummy variables used in the fixed effects model. We also report model fit with the same three measures as the fixed effects model and notice that the model improves as we add relevant predictors.

We report the results for the fixed effects and random effects models (Tables 11-12) to demonstrate the robustness of the results regardless of whether the group level variable (compset) is modelled as a fixed or random effect. For the remainder of the paper we will refer to results from the fixed effects model for clarity and because it is more consistent with how the hospitality industry views group level variables. The results from the multi-level model complete the story of the impact of LEED certification on hotel performance. We find support for the main effect that *LEED* (individual level fixed effect) impacts absolute performance (H1 & H2) in a positive way but the interaction of *New* * *LEED* does not indicate even greater absolute performance (H2). Of the two (*LEED* & *New*), new is more impactful on RevPar at an absolute level ($43.70 vs $17.21 respectively).

The random variables that model time complete the story with relative performance measures. When a hotel is certified (new or existing) RevPar quickly drops $13.12 (disadvantaged starting point) but the hotel then recovers with a $10.01 annual increase in each of the following years. This means that LEED hotels (new and existing) outperform their non-certified competitors by realizing an additional $10.01 in RevPar per post-certification year (H1-H3).

In the final step of our analysis we attempt to explain why the differences in RevPar occur among certified and non-certified hotels. We do this by analyzing the individual components of RevPar, Occupancy and Average Daily Rate (ADR).

---Insert Table 13 here---

In Table 13 above we report the results of specifying the *Compset* as a fixed effect (models 11-14) and a random effect (models 15-18). Models 11-12 and 15-16 report the results with Occupancy as the dependent variable while models 13-14 and 17-18 report ADR as the dependent variable. Similar to our previous results on RevPAR, the model returned consistent results irrespective of whether we specified *Compset* as a fixed or random effect. For the same reasons stated above, we will focus on the fixed effects model for the remainder of this section. Regarding *Occupancy*, we see the main effect of *New* is not a significant predictor while *LEED* is a significant predictor. Their interaction is also significant. This means that the LEED certified hotels that are also new predict greater occupancy relative to their non-certified peers. Other significant predictors of occupancy include *Log_age* (greater age predicts lower occupancy), *Years Since Adoption* (as post adoption time increases so does occupancy), and *LEED Adoption* (adopting hotels get a boost in occupancy). The curvilinear model shows that the quadratic change variables are significant.

Considering ADR we notice that *LEED*, *New*, nor their interaction could significantly predict ADR. The only significant predictor of ADR in the linear model is *Log_age* (at the $p<0.1$ level), *Years*, and *Years Since Adoption*, while in the curvilinear model the only significant predictors are *Log_age* (at the $p<0.1$ level), *Years, and Years*^{2}.

We interpret these results as LEED certification boosting occupancy (which in turn boosts RevPar) in both new and existing LEED hotels from the time of certification. We also see an annual increase in post-certification in occupancy (*Years Since Adoption)*. We note however that while superior absolute levels of occupancy are possible (*LEED* variable), it is not possible to maintain superior relative performance. Occupancy in the hospitality industry typically average between 60-70% and rarely exceed levels of 75-80%. Because LEED hotels are not outperforming their competitors on price (ADR), only occupancy, the relative superior performance of occupancy must eventually erode (H3).

7 Discussion, Limitations, and Future Research

Other event studies have primarily dealt with certification of existing companies (Corbett et al. 2005, Swink and Jacobs 2012). In this study on LEED certification in the hospitality industry we study the impact of certification on both existing and new properties over time, something that has not been done in the literature on LEED certification. Using a difference-in-differences approach to consider existing properties that underwent a certification event we find no significant difference in the pre/post event financial performance (RevPAR, Occupancy, and ADR) of certifying properties relative to their non-certified peers. This holds for both absolute levels of performance and year-over-year changes in performance. However, when this analysis is augmented by a multi-level model we see that existing and new LEED hotels outperform their competitors. This analysis begins to answer the question: what is the financial impact of certification? Our data and analysis show that positive financial performance from LEED certification is primarily driven by increased occupancy rates relative to their competitors and that this advantage is maintained for several years.

To provide richer insight into the hospitality industry we spoke with sustainability officers in several multinational hotel companies and asked them why hotels certify. Their explanation was that hotel owners/managers are motivated by environmental and social issues when choosing to certify. Many luxury owners choose to certify to signal quality. Some branded hotels do it do add to the brand, or attract certain types of customers. From our discussion however, they did

not know whether certification led to improved financial performance. This is why one manager said that they have difficulty selling LEED to their economy and mid-scale owners. In the price dominated economy and mid-scale segments owners are reluctant to invest in programs that do not produce quick returns. The uncertainty surrounding financial returns of LEED hotels has led to reluctance to adopt. This study provides evidence supporting the adoption of LEED certification as a means of boosting hotel revenue.

One major difference with this study and previous studies is our attempt to analyze the impact of certification on new properties, which cannot be accomplished with traditional event studies. The result of our discontinuous growth model confirms that the abnormal performance of LEED certified hotels is attributable to LEED certification *and* the newness of the hotel. In fact, even after accounting for the fact that the newness of the hotel can contribute to the abnormally high financial performance, we find that LEED certification remains a positive contributor to RevPAR. Being both LEED and new (interaction term) however, does not contribute significantly beyond the main effects. LEED hotels tend to take an immediate hit in RevPAR upon certification (mainly due to lower occupancy) then quickly recover and surpass their non-certified counterparts. Breaking down RevPAR into its component parts, the abnormal performance is primarily due to higher ADR generally among LEED hotels and the increasing occupancy a LEED hotel gets as time elapses after certification. In fact, LEED certification and newness are predictors of hotel occupancy but not ADR. This finding has important implications to hotel managers and owners because it illustrates the financial advantage that can accrue from LEED certification over time.

To further our understanding of the impact of LEED certification on performance we visited a LEED Platinum hotel (one of three in the US) to speak with their management team. They explained that their decision to certify was not motivated by financial performance, but rather the mission of the company and the personal interests of the owner. We were surprised to find that, while they did get some incidental press coverage upon certification, they did not actively market their LEED Platinum status to their guests. We followed up by asking how customers do find out about the platinum status. They responded that they leave that up to the customer, “People seek us out”. To investigate further if customers are aware of their LEED status we analyzed 123 reviews for this hotel that appeared on trip adviser over a two year period from January 2013

to December 2014. Of these reviews 10 % mentioned that this is a LEED certified hotel while 15% more highlighted that the hotel was 'green' or environmentally conscious. While the remaining reviewers did not recognize the hotel as a LEED certified or 'green' hotel, an additional 18% highlighted 'cool' aspects of the hotel that were integral in reaching LEED Platinum status (e.g. reclaimed floors, repurposed building, location, etc.), though they failed to connect the 'cool' aspects to environmental sustainability. Thus, the detailed analysis for a specific LEED certified hotel lends credence to the idea that customers recognize 'green' practices (43% in this sample) and this can lead to improved revenues.

7.1 Limitations

One perceived limitation of our study is that the final dataset of US LEED certified hotels from 2007-2012 includes only 87 hotels. One may contend that this represents a small sample, but the key point to note that this date represents the population of all US LEED certified hotels (minus a few that were excluded for data inadequacies). The fact that we are studying data on the population of LEED certified hotels and not just the sample enables us to draw insightful conclusions. Additionally, our data is in the form of a panel with many measurement periods for all of our subject properties and competitor properties. Our data includes information on 87 LEED certified hotels, as well as information on 472 non-certified hotels. Overall, we have nearly 5,000 measurement points, which is substantial compared with many similar studies.

Another possible limitation to this study is that we rely on the subject properties to identify competitors that are operationally similar. Many methods of statistical analysis rely on additional variables to control for demographic differences among subjects or the use of random assignment to negate the differences. In this study hotel owners were asked to identify their competitors. While hoteliers have an economic incentive to select similar hotels, we cannot control which competitors they choose.

One final perceived limitation may be our focus on hotels within the United States. Outside of the US there were 268 registered hotels and 31 certified hotels in 16 different countries (India was the most common with eight) as of 2012. While we could expand our analysis to all international LEED hotels, this is problematic for several reasons. First, there is very little

available data on a limited number of countries. Second, while the USGBC markets its program overseas, it is not the norm in every country. Other environmental certification standards, such as BREEAM (U.K.), Green Mark Scheme (Germany), and Greenstar (Australia) have achieved higher adoption as compared to LEED. Extending this study outside the US may be an area of future research if the program becomes more popular internationally and the data becomes available.

7.2 Future Research

In this paper we analyzed only the revenue side of the profitability equation. The next step is to investigate the cost side of the equation. While it is the express mission of LEED to reduce operating resources—and therefore costs—there can be a premium on initial investment (mentioned by several executives we spoke to). The payback period for LEED certification from a cost perspective is unclear and requires additional investigation. We may also be interested in segmenting the dataset further to see if there are differences in impact among hotel classes, locations, or sizes.

Another important area of future research is to investigate the impact of LEED certification on the valuation of hotels. This is important as property transactions are common in today's market where corporate ownership (H-REITs) is increasing. Limited data makes it difficult to study LEEDS impact on valuation at present, but as data becomes more available this will provide a fruitful area of research.

One final area of future research could be to compare our results to other environmental certification programs used by hotels around the globe. While LEED certification is popular in the US, it is not the market leader in Europe and other areas of the world. We could extend this research by doing a similar assessment of other certification programs that are popular in other countries.

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Tables & Figures

Table 1: LEED certification by year and level

Year	N	Certified	Gold	Silver	Platinum
2007	3	1	1	1	0
2008	7	0	2	4	1
2009	20	4	10	6	0
2010	29	6	13	10	0
2011	25	3	9	12	1
2012	18	4	6	8	0
Missing	6	1	2	2	1
	108	19	43	43	3

Table 2: Percentages of hotels within each category in population of LEED hotels and US hotels

Variable	LEED	US Avg	Variable	LEED	US Avg
Class			***Location***		
Economy	2.8%	46.1%	Airport	4.6%	4.3%
Midscale	1.9%	15.7%	Interstate	2.8%	14.1%
Upper Midscale	13.9%	10.4%	Resort	9.3%	7.3%
Upscale	34.3%	10.4%	Small Metro/Town	15.7%	31.3%
Upper Upscale	16.7%	5.3%	Suburban	35.2%	33.7%
Luxury	30.6%	2.1%	Urban	32.4%	9.3%
Operation			***Size***		
Chain Management	25.0%	8.2%	< 75	13.9%	55.2%
Franchise	36.1%	49.2%	75 -149	40.7%	32.4%
Independent	38.9%	42.6%	150 - 299	24.1%	8.4%
			300 - 500	11.1%	2.2%
			> 500	10.2%	1.0%

LEED hotels: N = 108. US hotels: n = 52,548 as of 2013 (obtained from STR). The data in the table represent the percentage within each category from the population data of LEED hotels and total US hotels

Table 3: Class, Size, and age of Matched Sample

Characteristic	N	Mean	t Stat	P value (two tail)	Median	t Stat	P value (two tail)
Class							
Subject	87	4.61	0.943	0.347	4.61	0.507	0.613
Competitor	87	4.46			4.53		
Size							
Subject	87	2.66	-1.105	0.271	2.66	-1.175	0.242
Competitor	87	2.82			2.84		
Opening Year							
Subject	87	1999.2	4.982	0.000***	1999.2	3.915***	0.000
Competitor	87	1983.5			1987.0		

Results of a t-test (two sample with equal variance). Comparison of values of subject properties to the mean/median of the 4-6 competitor properties in a grouping. ***Significant at the $p < 0.01$ level.

Table 4: Occupancy, ADR, and RevPAR values for LEED and non-LEED matched sample

	Comp. Mean Performance			Comp. Median Performance		
	Occ.	ADR	RevPAR	Occ.	ADR	RevPAR
All LEED Hotels (N = 87)						
Mean	0.615	163.70	104.26			
Std. Dev.	0.163	88.00	66.63		all the same	
Max	0.913	709.25	590.98			
Min	0.056	43.03	2.95			
Competitor Hotels (n = 472)						
Mean	0.673	154.06	106.04	0.682	151.82	105.53
Std. Dev.	0.091	78.31	59.08	0.092	76.46	57.48
Max	0.893	567.71	483.40	0.914	559.73	460.28
Min	0.396	56.62	31.15	0.377	56.55	31.52

For LEED hotels data indicates aggregate of 87 subject hotel performance over 8 year collection period. The left panel aggregates mean performance of matched compset over the 8 year horizon. Right side aggregates median performance of matched compset over 8 year horizon.

Table 5: Abnormal performance in Occupancy, ADR, and RevPAR Indices for *EXISITING* LEED hotels for years -3 through +3

	Subject matched to competitor's mean					Subject matched to comp. median			
	N	Index	z-stat	% Pos.	z-stat	Index	z-stat	% Pos.	z-stat
Occupancy									
-3 to -2	24	0.958	-1.073	0.330	-1.696	0.966	-0.829	0.420	-0.811
-2 to -1	24	0.994	-0.160	0.380	-1.238	0.984	-0.399	0.380	-1.238
-1 to t	25	0.995	-0.200	0.440	-0.592	0.992	-0.262	0.480	-0.196
t to +1	21	0.997	-0.108	0.430	-0.645	1.001	0.034	0.480	-0.213
+1 to +2	16	0.930	-1.345	0.440	-0.488	0.916	-0.652	0.310	-1.567
+2 to +3	8	0.869	-2.004	0.380	-0.683	0.863	-2.153	0.380	-0.683
ADR									
-3 to -2	24	1.072	1.540	0.580	0.811	1.084	1.791	0.580	0.811
-2 to -1	24	1.076	1.686	0.630	1.238	1.092	1.958	0.630	1.238
-1 to t	25	1.053	1.190	0.600	1.000	1.064	1.401	0.600	1.000
t to +1	21	1.064	1.374	0.570	0.645	1.086	1.692	0.620	1.096
+1 to +2	16	1.078	1.484	0.560	0.488	1.102	1.484	0.630	1.000
+2 to +3	8	1.079	0.822	0.630	0.683	1.089	0.833	0.500	0.000
RevPAR									
-3 to -2	24	1.021	0.390	0.580	0.811	1.020	0.354	0.580	0.811
-2 to -1	24	1.082	1.293	0.710	2.198	1.076	1.215	0.670	1.696
-1 to t	25	1.058	1.019	0.680	1.890	1.058	1.047	0.640	1.429
t to +1	21	1.065	1.062	0.670	1.581	1.077	1.331	0.620	1.096
+1 to +2	16	0.998	-0.024	0.560	0.488	0.999	-0.017	0.500	0.000
+2 to +3	8	0.941	-0.577	0.500	0.000	0.937	-0.604	0.500	0.000

Dataset includes 26 existing hotels that became certified and 149 competitor hotels
Index = Actual Performance/Expected performance. Left panel (mean), right panel (median) of competitive set.
Z-Statistic for means and medians are obtained using a Wilcoxon Signed-Rank test
% Pos. = The percentage of LEED certified hotels in the dataset that outperformed competitors (i.e. Index > 1).
Z-Statistic for % positive are obtained using Binomial Sign test.
** Significant at the $p < .05$ level (two-tailed)

Table 6: Abnormal Annual changes in Occupancy, ADR, and RevPAR Indices for *EXISTING* LEED hotels for years -3 through +3

		Subject matched to competitor's mean				Subject matched to comp. median			
	N	Δ Index	z-stat	% Pos.	z-stat	Δ Index	z-stat	% Pos.	z-stat
Occupancy									
-3 to -2	21	0.014	0.544	0.620	1.096	0.036	1.377	0.570	0.645
-2 to -1	23	0.016	0.532	0.430	-0.617	0.002	0.062	0.350	-1.499
-1 to t	24	0.004	0.186	0.420	-0.811	0.011	0.470	0.500	0.000
t to +1	21	0.017	0.681	0.520	0.213	0.026	0.883	0.570	0.645
+1 to +2	15	0.011	0.721	0.530	0.250	0.002	0.135	0.470	-0.250
+2 to +3	8	0.006	0.130	0.500	0.000	0.004	0.080	0.380	-0.683
ADR									
-3 to -2	21	0.027	1.206	0.620	1.096	0.022	0.986	0.570	0.645
-2 to -1	23	0.000	0.024	0.570	0.617	0.006	0.402	0.610	1.045
-1 to t	24	-0.009	-0.666	0.380	-1.238	-0.014	-1.142	0.420	-0.811
t to +1	21	0.008	0.512	0.620	1.096	0.016	1.030	0.670	1.581
+1 to +2	15	-0.009	-0.823	0.470	-0.250	-0.015	-1.361	0.330	-1.323
+2 to +3	8	0.003	0.077	0.500	0.000	-0.017	-0.485	0.500	0.000
RevPAR									
-3 to -2	21	0.026	1.129	0.520	0.213	0.019	0.855	0.480	-0.213
-2 to -1	23	0.041	1.147	0.480	-0.204	0.034	1.016	0.480	-0.204
-1 to t	24	-0.007	-0.387	0.420	-0.811	-0.001	-0.040	0.330	-1.696
t to +1	21	0.020	0.857	0.520	0.213	0.040	1.531	0.570	0.645
+1 to +2	15	0.002	0.130	0.530	0.250	-0.004	-0.256	0.530	0.250
+2 to +3	8	0.043	1.213	0.630	0.683	0.029	0.811	0.630	0.683

Dataset includes 26 existing hotels that became certified and 149 competitor hotels
Δ Index = Change in index from previous year. Left panel (mean), right panel (median) of competitive set.
Z-Statistic for means and medians are obtained using a Wilcoxon Signed-Rank test
% Pos. = The percentage of LEED certified hotels in the dataset that outperformed competitors (i.e. Δ Index > 0).
Z-Statistic for % positive are obtained using Binomial Sign test.
** Significant at the $p < .05$ level (two-tailed)

Table 7: Abnormal performance in Occupancy, ADR, and RevPAR Indices for *NEW* LEED hotels for years -3 through +3

	Subject matched to competitor's mean					Subject matched to comp. median			
	N	Index	z-stat	% Pos.	z-stat	Index	z-stat	% Pos.	z-stat
Occupancy									
-3 to -2	9	0.837	-1.991	0.220	-1.890	0.848	-1.667	0.440	-0.316
-2 to -1	42	0.666	-7.395**	0.140	-6.535**	0.655	-7.575**	0.140	-6.535**
-1 to t	60	0.884	-4.692**	0.270	-4.053**	0.878	-4.853**	0.280	-3.693**
t to +1	50	0.975	-1.340	0.380	-1.731	0.957	-2.372**	0.360	-2.042
+1 to +2	35	0.975	-1.529	0.400	-1.190	0.958	-2.638**	0.340	-1.930
+2 to +3	17	0.982	-0.868	0.590	0.717	0.974	-1.425	0.470	-0.236
ADR									
-3 to -2	9	1.091	1.230	0.780	1.890	1.125	1.474	0.780	1.890
-2 to -1	42	1.028	0.890	0.550	0.613	1.049	1.360	0.550	0.613
-1 to t	60	1.099	3.185**	0.680	3.027**	1.119	3.369**	0.650	2.416**
t to +1	50	1.117	3.382**	0.720	3.430**	1.145	3.522**	0.720	3.430*
+1 to +2	35	1.126	2.826**	0.690	2.333**	1.158	3.080**	0.690	2.333*
+2 to +3	17	1.139	2.268	0.710	1.807	1.194	2.245	0.590	0.717
RevPAR									
-3 to -2	9	0.910	-0.824	0.560	0.316	0.927	-0.646	0.560	0.316
-2 to -1	42	0.712	-4.836**	0.240	-3.937**	0.719	-4.540**	0.260	-3.467**
-1 to t	60	0.978	-0.532	0.430	-1.033	0.997	-0.069	0.450	-0.772
t to +1	50	1.089	2.252**	0.660	2.364**	1.099	2.340**	0.660	2.364**
+1 to +2	35	1.095	2.007	0.660	1.930	1.119	2.349**	0.660	1.930
+2 to +3	17	1.119	1.835	0.710	1.807	1.158	1.904	0.650	1.231

Dataset includes 61 new LEED hotels and 323 competitor hotels
Index = Actual Performance/Expected performance. Left panel (mean), right panel (median) of compset.
Z-Statistic for Means and medians are obtained using a Wilcoxon Signed-Rank test
% Pos. = The percentage of LEED certified hotels in the dataset that outperformed competitors (i.e. Index > 1).
Z-Statistic for % positive are obtained using Binomial Sign test.
** Significant at the $p < .05$ level (two-tailed)

Table 8: Abnormal Annual changes in Occupancy, ADR, and RevPAR Indices for *NEW* LEED hotels for years -3 through +3

		Subject matched to competitor's mean				Subject matched to comp. median			
	N	Δ Index	z-stat	% Pos.	z-stat	Δ Index	z-stat	% Pos.	z-stat
Occupancy									
-3 to -2	0	NA	NA	NA	NA	NA	NA	NA	NA
-2 to -1	9	0.118	3.230**	1.000	††	0.103	2.185	0.780	1.890
-1 to t	42	0.274	7.377**	0.930	10.655**	0.282	7.664**	0.900	8.829**
t to +1	49	0.109	6.075**	0.840	6.312**	0.100	5.393**	0.760	4.110**
+1 to +2	35	0.023	2.217**	0.630	1.552	0.025	2.578**	0.630	1.552
+2 to +3	17	0.007	0.366	0.650	1.231	0.012	0.867	0.590	0.717
ADR									
-3 to -2	0	NA	NA	NA	NA	NA	NA	NA	NA
-2 to -1	9	0.043	1.694	0.670	1.000	0.074	2.556**	0.780	1.890
-1 to t	42	0.074	3.871**	0.760	3.937**	0.082	3.953**	0.690	2.638**
t to +1	49	0.010	0.799	0.670	2.563**	0.015	0.997	0.630	1.906
+1 to +2	35	0.020	2.726**	0.690	2.333**	0.019	2.002**	0.660	1.930
+2 to +3	17	0.021	2.154	0.590	0.717	0.031	1.808	0.710	1.807
RevPAR									
-3 to -2	0	NA	NA	NA	NA	NA	NA	NA	NA
-2 to -1	9	0.177	3.189**	1.000	††	0.166	2.350**	0.780	1.890
-1 to t	42	0.329	7.773**	1.000	††	0.337	8.112**	1.000	††
t to +1	49	0.124	5.683**	0.900	9.108**	0.120	4.547**	0.920	10.586**
+1 to +2	35	0.044	4.175**	0.770	3.769**	0.054	4.515**	0.770	3.769**
+2 to +3	17	0.016	1.403	0.710	1.807	0.016	0.481	0.470	-0.236

Dataset includes 61 new LEED hotels and 323 competitor hotels. ** Significant at the $p < .05$ level (two-tailed).
Δ Index = Change in index from previous year. Left panel (mean), right panel (median) of competitive set.
The first year appears as N/A because there was no data from the previous year (-4 to -3) to compare with the current year (-3 to -2) in the new hotel condition.
Z-Statistic for Means and medians are obtained using a Wilcoxon Signed-Rank test
% Pos. = The percentage of LEED certified hotels in the dataset that outperformed competitors (i.e. Δ Index > 0).
Z-Statistic for % positive are obtained using Binomial Sign test.
†† All hotels have Δ Index>0

Table 9: Pearson Bivariate Correlations Coefficients: Hotel Level Variables, Total Sample (n = 5,016)

	LEED Hotel	New Hotel	Year	Log Age	Op: Chain	Op: Fran.	Op: Ind.	LEED Adopt
New Hotel	0.52*							
Year	0.00	0.00						
Log Age	-0.44*	-0.79*	0.00					
Operation: Chain	-0.05*	-0.09*	0.00	0.07*				
Operation: Franchise	-0.07*	0.14*	0.00	-0.23*	-0.58*			
Operation: Independent	0.13*	-0.07*	0.00	0.18*	-0.39*	-0.52*		
LEED Adoption	0.59*	0.31*	0.25*	-0.23*	-0.05*	-0.05*	0.11*	
Yrs. Since Adoption	0.21*	0.13*	0.21*	-0.10*	-0.03	0.01	0.01	0.35*

*Significant at the $p < 0.01$

Table 10: Coding and Interpretation of Change Variables in Discontinuous Growth Model Used in this Study

	Measurement Occasion								
Variable	1	2	3	4	5	6	7	8	Interpretation
Coding of Change Variable									
Year	0	1	2	3	4	5	6	7	Linear time intervals
LEED Adoption	0	0	0	1	1	1	1	1	Impact of event occurrence (certification)
Yrs Since Adopt	0	0	0	0	1	2	3	4	Linear time since event occurrence
Change Term Entered in Linear Model									
Year	0	1	2	3	4	5	6	7	Linear change in pre-certification period
LEED Adoption	0	0	0	1	1	1	1	1	Performance change as a result of certification
Yrs Since Adopt	0	0	0	0	1	2	3	4	Linear change in post-certification period relative to pre-certification period
Change Term Entered in Curvilinear Model									
Year	0	1	2	3	4	5	6	7	Linear change in pre-certification period
LEED Adopt	0	0	0	1	1	1	1	1	Performance change as a result of certification
Yrs Since Adopt	0	0	0	0	1	2	3	4	Linear change at the start of post-certification period relative to pre-certification period
$Year^2$	0	1	4	9	16	25	25	25	Quadratic change in pre-certification period
Yrs Since $Adopt^2$	0	0	0	0	1	4	9	16	Quadratic change in post-certification period

Adapted from Lang & Bliese (2009) and Singer & Willett (2003)

Table 11: Discontinuous Growth Model Predicting Hotel Performance (RevPAR) as a Function of LEED Adoption with 'Compset' Modeled as Fixed Effects

	1	2	3	4	5	6
Fixed Effects						
Intercept	107.88	98.65	87.78	99.29	108.95	107.52
	[2.86]**	[2.81]**	[13.51]**	[14.80]**	[14.78]**	[14.97]**
Compset			++	++	++	++
			**	**	**	**
LEED			4.01	7.27	17.21	14.54
			[4.32]	[5.24]	[5.40]**	[5.15]**
New			24.61	41.44	43.7	43.25
			[4.70]**	[10.51]**	[10.63]**	[10.69]**
LEED*New				-5.73	-14.69	-12.48
				[9.53]	[9.68]	[9.62]
logAGE				-7.55	-7.41	-7.705
				[2.65]**	[2.63]**	[2.67]**
Operation				+++	+++	+++
				**	**	**
Change Terms						
Year		1.88	1.66	1.62	0.9	10.97
		[0.28]**	[0.24]**	[0.24]**	[0.23]**	[0.46]**
Years Since Adoption					10.01	8.24
					[1.31]**	[2.60]**
LEED Adoption					-13.12	-13.91
					[2.59]**	[2.50]**
$Year^2$						-2.3
						[0.09]**
Years Since $Adoption^2$						-0.74
						[0.77]
Variance Components						
Level 1						
Within-hotel	424.47	301.24	321.89	323.06	311.25	257.57
	[9.81]**	[8.04]**	[8.70]**	[8.71]**	[8.15]**	[6.78]**
Level 2						
In initial status	4611.95	4238.92	1160.65	1101.6	1093.14	1138.65
	[276.60]**	[264.64]**	[87.36]**	[83.94]**	[82.15]**	[84.82]**
In rate of change		33.35	21.12	20.6	16.97	18.74
		[3.51]**	[2.34]**	[2.27]**	[1.78]**	[1.82]**
Model Fit						
-2 Log-likelihood (Deviance)	40868.34	40402.81	39032.57	38989.31	38497.58	37911.90
AIC	40872.34	40408.81	39038.57	38995.31	38503.58	37917.90
BIC	40885.08	40427.92	39057.62	39014.35	38522.60	37936.92

Dependent Variable = RevPAR. **Significant at the $p < 0.05$ level, *$p<0.1$ level. Standard errors in brackets.
++ Note: 87 dummy variables added as fixed effects, one for each compset. We did not include individual lines for each of the 87 dummy variables in this table.
+++ Three operational dummy variables added as fixed effects (chain management, franchise, independent). We did not include individual lines for these operational variables but used them as control variables.

Table 12: Discontinuous Growth Model Predicting Hotel Performance (RevPAR) as a Function of LEED Adoption with 'Compset' Modeled as a Random Effect

	7	8	9	10
Fixed Effects				
Intercept	89.82	98.31	103.16	101.19
	[6.96]**	[8.28]**	[8.55]**	[8.60]**
LEED	2.51	7.37	17.05	13.52
	[4.81]	[6.42]**	[6.70]**	[6.76]**
New	13.97	30.65	34.39	34.47
	[4.40]**	[10.13]**	[10.43]**	[10.54]**
LEED*New		-5.89	-11.35	-9.03
		[10.04]	[10.34]	[10.45]
logAGE		-7.56	-7.13	-7.30
		[2.38]**	[2.40]**	[2.43]**
Operation		+++	+++	+++
		**	**	**
Change Terms				
Year	1.27	1.25	0.71	10.81
	[0.36]**	[0.36]**	[0.34]**	[0.53]**
Years Since Adoption			10.20	9.77
			[1.26]**	[2.61]**
LEED Adoption			-13.39	-14.20
			[2.56]**	[2.48]**
$Year^2$				-2.31
				[0.09]**
Years Since $Adoption^2$				-1.00
				[0.76]
Variance Components				
Level 1				
Within-hotel	339.62	339.84	321.75	266.99
	[9.20]**	[9.16]**	[8.46]**	[7.09]**
Level 2				
In initial status (compset)	2997.67	2825.66	2896.90	2853.32
	[471.00]**	[450.87]**	[462.20]**	[455.76]**
In rate of change (compset)	9.00	9.01	7.86	7.85
	[1.89]**	[1.89]**	[1.68]**	[1.67]**
In initial status (individual)	1001.56	957.74	975.16	1001.53
	[70.84]**	[68.58]**	[69.70]**	[71.46]**
In rate of change (individual)	8.40	8.34	7.81	9.42
	[1.55]**	[1.51]**	[1.29]**	[1.32]**
Model Fit				
-2 Log-likelihood (Deviance)	40056.95	40008.84	39518.18	38944.03
AIC	40066.95	40018.84	39528.18	38954.03
BIC	40098.80	40050.68	39559.98	38985.83

Dependent Variable: RevPAR. **Significant at the $p < 0.05$ level, *$p<0.1$ level. Standard errors in brackets.
+++ Three dummy variables added to control for the operation type of the hotel (chain management, franchise, and independent). We did not include individual lines for these operational variables but used them as control variables.

Table 13: Discontinuous Growth Model Predicting Hotel Performance (Occupancy & ADR) as a Function of LEED Adoption with 'Compset' Modeled as a Random Effect

	Compset Modeled as a Fixed Effect				Compset Modeled as a Random Effect			
Dependent Variable:	Occupancy		ADR		Occupancy		ADR	
	11	12	13	14	15	16	17	18
Fixed Effects								
Intercept	0.65 [0.049] **	0.64 [0.050] **	186.44 [20.32]**	189.04 [20.94]**	0.61 [0.025] **	0.58 [0.026]**	174.12 [11.70]**	174.28 [11.85]**
Compset*	++ **	++ **	++ **	++ **				
LEED	-0.09 [0.026] **	-0.09 [0.026] **	3.16 [5.92]	0.10 [5.50]	-0.10 [0.026] **	-0.10 [0.026]**	2.08 [8.98]	-0.35 [9.15]
New	-0.01 [0.036]	-0.01 [0.036]	9.48 [14.35]	5.80 [14.69]	-0.01 [0.035]	-0.01 [0.035]	3.01 [14.19]	-0.69 [14.47]
LEED*New	0.08 [0.035] **	0.08 [0.036] **	-8.95 [12.55]	-5.61 [12.67]	0.08 [0.022] **	0.08 [0.035]**	-3.12 [14.05]	-0.34 [14.33]
logAGE	-0.02 [0.009] **	-0.02 [0.009] **	-5.81 [3.63]*	-6.55 [3.75]*	-0.01 [0.008] *	-0.01 [0.008]*	-4.90 [3.28]	-5.23 [3.34]
Operation	+++ **	+++ **	+++ **	+++ **	+++ **	+++ **	+++ **	+++ **
Change Terms								
Year	0.00 [0.001]	0.01 [0.004] **	0.92 [0.26]**	11.09 [0.46]**	0.00 [0.001]	0.01 [0.004]**	0.93 [0.38]**	11.08 [0.53]**
Years Since Adoption	0.02 [0.009] *	0.08 [0.023] **	4.71 [1.33]**	0.51 [2.48]	0.02 [0.009] *	0.08 [0.023]**	5.15 [1.30]**	1.18 [2.49]
LEED Adoption	0.09 [0.021] **	0.11 [0.022] **	2.47 [2.55]	1.71 [2.42]	0.10 [0.021] **	0.11 [0.023]**	1.67 [2.53]	1.01 [2.40]
$Year^2$		0.00 [0.001] **		-2.34 [0.09]**		0.00 [0.001]**		-2.34 [0.09]**
Years Since $Adoption^2$		-0.02 [0.006] **		-0.18 [0.74]		-0.02 [0.007]**		-0.18 [0.74]
Variance Components								
Level 1								
Within-person	0.02 [0.001] **	0.02 [0.001] **	282.70 [7.33]**	224.68 [5.96]**	0.02 [0.001] **	0.02 [0.001]**	287.04 [7.43]**	229.49 [6.07]**
Level 2								
In initial status (individual)	0.01 [0.001] **	0.01 [0.001] **	2226.93 [161.80] **	2397.72 [175.30] **	0.01 [0.001] **	0.01 [0.001]*	1887.62 [131.57] **	1980.99 [138.71] **
In rate of change (individual)			25.57 [2.23]**	29.14 [2.46]**			16.55 [1.73]**	19.38 [1.89]**
In initial status (compset)					0.00	0.00	5648.44	5638.87

					[0.001]**	[0.001]*	[896.32]**	[896.47]**
In rate of change (compset)					0.00	0.00	8.91	8.77
					0.00	0.00	[2.11]**	[2.11]**
Model Fit								
-2 Log-likelihood (Deviance)	-2669.4	-2671.0	38641.4	37968.5	-2852.6	-2853.0	39725.0	39065.6
AIC	-2663.4	-2665.0	38647.4	37974.5	-2842.6	-2843.0	39735.0	39075.6
BIC	-2644.4	-2646.0	38666.4	37993.5	-2810.8	-2811.2	39766.8	39107.5

Left panel = Fixed effects model. Right panel = random effects model

Dependent Variables = Occupancy & ADR. **Sig. at the $p < 0.05$ level, *$p<0.1$ level. Stand. Error in brackets.

++ Note: 87 dummy variables added as fixed effects, one for each compset. We did not include individual lines for each of the 87 dummy variables in this table.

+++ Three operational dummy variables added as fixed effects (chain management, franchise, independent). We did not include individual lines for these operational variables but used them as control variables.