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Are Green Labels More Valuable in Emerging Real Estate Markets?

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ABSTRACT

This article investigates how emerging real estate markets price information conveyed by voluntary environmental certification schemes. In addition to low incidence of green buildings, developing countries typically exhibit weaker environmental performance due to limited capacity to enforce existing regulation. Therefore, we exploit the role of internationally accredited third-party environmental audit schemes. In addition to comparing labelled and non-labelled properties in a hedonic framework, we also examine pricing discrepancies related with the intention to certify (registration), but failure to achieve actual certification in a timely manner. Our results systematically indicate that labelled office properties in emerging markets yield a larger green premium than their peers from developed countries. Findings also suggest that failed applicants do not receive any green premiums and may be subject to discounts, depending on specification, beyond that of other non-green office buildings. These findings provide further evidence of the relevance of market diffusion and economic governance linked to the implicit pricing of environmental labels.

Key words: eco-certification, office markets, emerging economies, signaling effects

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1. INTRODUCTION

The environmental social governance (ESG) and financial benefits of real estate eco-certifications, such as Leadership in Energy and Environmental Design (LEED), encompasses a wide and growing body of literature. Recent research suggests uniformity of major drivers for green buildings across countries and regions (Darko *et al.*, 2017). However, Qin *et al*. (2016) identify unique risk factors to China, applicable more broadly to developing countries, such as government bureaucracy and unclear goals for green buildings. Much of the initial green building literature (Fuerst and McAllister, 2011; Wiley *et al.*, 2010) identified premiums in developed economies; however, increased market diffusion and adoption yielded changing premium levels and underlying mechanics in those markets (Robinson *et al.*, 2017; Reichardt *et al.*, 2012). The diffusion literature also references different stages of evolution and developing economies are in an earlier phase of this cycle (Sanderford *et al.*, 2017; Kok *et al.*, 2011). This paper advances the literature in two areas – an empirical analysis the impact of voluntary certifications on a developing economy and the economic impact between registration for and achievement of an eco-certification.

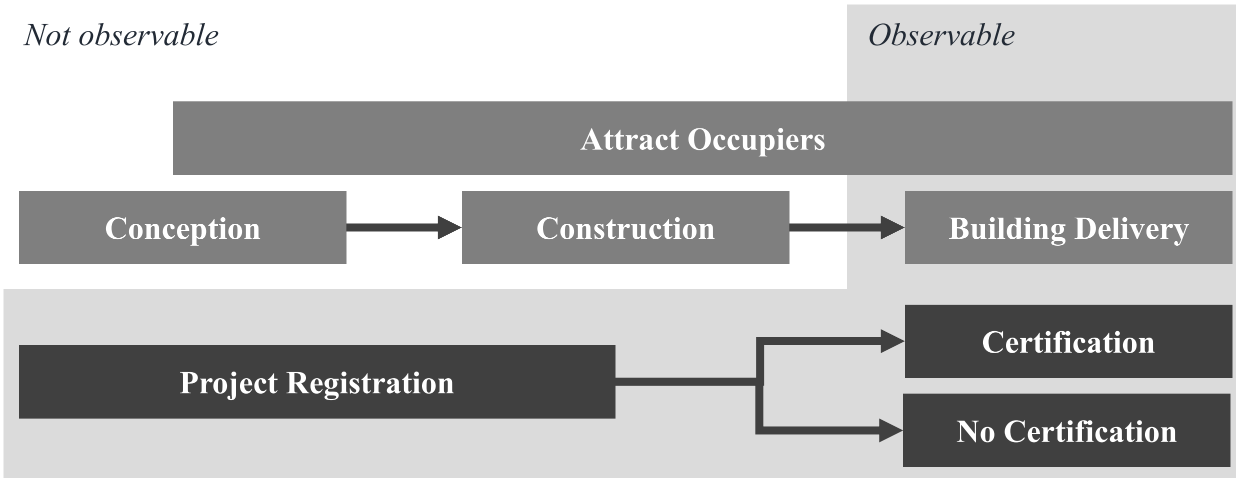
Labelling schemes in developing economies represent an important group as these countries hold some of the world's largest metropolitan areas and experience rapid growth in both economic development and greenhouse gas emissions. Some research identifying qualitative motivations for environmental certifications exists. In addition to above, Singh *et al*. (2015) identify competitive landscape and corporate image as key drivers for adoption of ecologically sound management techniques using an Indian sample. In contrast, Ma and Cheng (2017) employ algorithms to identify which Chinese submarkets could be prominent candidates to receive green properties based on economic, demographic and geographical features.

Our sample explores more quantitative aspects of measurable financial benefit for voluntary certification in Sao Paulo (Brazil). The city is the world's 5th largest urban agglomeration with 20.8 million inhabitants (United Nations, 2014a). Sao Paulo´s office market was the 12th most expensive in terms of net lease prices worldwide in 2014 and contains 11.5 million sqm of gross leasable area - GLA (Colliers International, 2014). Given some level of eco-label maturity in the real estate markets of developed countries, investigation of developing economies may yield new and meaningful insights. For example, inflated premiums could be found through the introduction effect caused by the relative scarcity of labelled properties and the lag between supply and demand for green buildings (Fuerst and Van de Wetering, 2015).

The process of LEED certification for new construction (LEED-NC) involves first registering the intent to certify a new project and then earning certification through a post-construction inspection. During the construction cycle, most large office buildings establish a reasonable level of pre-leasing which can vary from a small percentage to 100% pre-leased, depending on market conditions. Almost the entirety of the sustainable real estate literature focuses on certified buildings or buildings that have achieved the requirements set forth in the voluntary sustainable standards (Eichholtz *et al.*, 2010)[1]. The unique data set used in this paper permits us to address an important gap in the literature, that is to investigate the market consequences, if any, of failing to achieve eco-certification after a registration. LEED is the prevailing certification scheme in Brazil and representative of other major eco-certifications.

[1] Standards such as Building Research Establishment Environmental Assessment Method (BREEAM), Energy Star, LEED, among others.

Figure 1: Illustration of the Eco-Certification Process Timeline



The market may interpret delays or failure to achieve certification for a registered building as a signal of ineffective management; alternatively, an observed difference in rent may be the realized value of the label in otherwise comparable buildings. Finally, the possibility of contractual reductions as penalties for failure to achieve eco-certification also exists. Of course, some combination of these factors along with unobservable lease level impacts may combine for a discount[2]. Sedlacek and Maier (2012) highlight the role of Green Building Councils (GBCs) in reducing informational problems in real estate markets by creating a label that signals the true quality of a property (not only environmental). Certifying institutions can therefore be viewed as a complementary mechanism of economic governance to developers, occupants and investors. The importance of GBCs in emerging markets could perhaps be extended as many of these countries lack comparable information on building quality or are simply unable to enforce existing regulation. In this context, third-party auditing schemes from accredited and internationally recognized institutions could provide industry stakeholders an additional assurance above and beyond that of local environmental standards.

This paper explores two research questions. **Do developing countries exhibit greater eco-certification premiums than currently found in developed economies? Does a discount exist for proposed buildings that register for an eco-certification but do not earn the label upon completion?**

The article is structured as follows. The next section provides some background to the research questions. The third section presents the research hypotheses. In the fourth section, we describe the empirical model, the data, the sample and the working method employed. The empirical baseline results and robustness tests are discussed in the fifth section. The final section presents the conclusion.

2. THEORETICAL BACKGROUND

As described above, an eco-label primarily functions as a signaling device between various stakeholders in the real estate market. However, to obtain the label, a developer or building owner

[2] While unobservable by the authors, reductions in face rent as a consequence for failure to achieve certification would be reasonable clauses in pre-leases.

must make efforts to fulfill the requirements of the labeling scheme. Investments to meet these requirements may, in turn, lead to additional economic benefits such as lower energy costs or higher worker productivity in the labeled building. Hence, every developer first needs to decide to which level of building sustainability, if any, they would like to aspire. This decision and the profit maximization strategy ensuing from it can be written in Cobb-Douglas form as follows:

$$E(\pi_n) = \alpha \sum_{n=1}^{N} (g_n^{\beta} + x_n^{\gamma}) \qquad (1)$$

Where $E(\pi_n)$ is the expected developer's profit on a building project *n* which comprises a level of greenness (g) along with all other characteristics of the building (x). Next, the developer decides on a budg*et al*location that distributes the available funds to sustainable building features and other characteristics with weights β and γ respectively to maximize their expected profit. The developer's investments are profitable under the condition:

$$E(\pi_n): p \leq \sum_{n=1}^{N} (g_n^{\beta} + x_n^{\gamma}) \qquad (2)$$

The chosen level of sustainability is part of a larger bundle of property characteristics including location, building specification, *inter alia*, and is potentially correlated with some of these factors. For example, a LEED Platinum certified office building is likely to be in a prime location and to be larger, better maintained and better managed than properties without the label or with a lower label level. Matisoff *et al*. (2014) use firm production functions to show that higher sustainability or energy efficiency (g) not only entails cost savings via lower energy consumption but also creates a competitive advantage via a "green" signal to consumers from environmentally friendly investment. Recent evidence suggests that these strategic and signaling considerations may be as important or even more important for sustainability investments than the underlying energy cost savings or other material improvements in building and environmental quality (Gliedt and Hoicka, 2015; Cooreman, 2011). Hence, the signaling value may exceed the value of the underlying economic benefits of a green building, particularly at the higher end of certifications. Fuerst *et al*. (2016) show for the residential real estate market that the utility a buyer derives from sustainability investments is a combination of the linear utility of the energy cost savings (*cs*) and the convex utility of the signaling value (*sv*).

$$e_n = cs_n + sv_n \qquad (3)$$

Consequently, a buyer should be willing to pay a premium for an increase in sustainability that equals the combined marginal utility from the linear cost savings and the non-linear signaling value. In the context of real estate markets in developing economies such as the one studied in this analysis, the signaling value of a green label may be even greater as it is likely to be bundled with a number of attractive features. For example, it signals that a developer is willing to subject their project to international certification standards in a market that is otherwise much less regulated than equivalent markets in high-income countries. This can also be interpreted as a gesture of reducing the information asymmetry between developers, owners and occupiers and aspiring to transparent and superior building management. As demonstrated below, these signals are mainly directed at a group of large international and domestic corporate tenants and investors who are themselves able to derive signaling benefits from occupying an eco-certified building to their client base.

2.1 State of Empirical Research

Most of studies find a positive relationship between real estate rents (asking- and transaction-based) and environmental labels after controlling for locational, temporal and property-specific attributes. The results obtained are reasonably consistent and the estimated premiums range from 3 to 5%. Fuerst and McAllister (2011a), Eichholtz *et al.* (2010) and Wiley *et al.* (2010) used the CoStar US database to compare the rental premiums of LEED and/or Energy Star certified office space in the US. Research from other developed economies, namely the United Kingdom and Australia, also find similar correlations (Gabe and Rehm, 2014; Fuerst and McAllister, 2011b).

Many of these studies; however, adopt hedonic models, which are prone to omitted variable bias as controls for inherent heterogeneity are bound to be imperfect and correlated with unobserved variables (Ghysels *et al*, 2013). For instance, Chegut *et al.* (2014) and Fuerst and Van de Wetering (2015) use observed transaction-based data from the UK and estimate a green rent premium of over 20% associated with BREEAM-rated properties. The first study lacks controls for building quality and makes it difficult to distinguish BREEAM properties from other top-tier assets. The latter authors recognize that such a high premium may not be fully attributable to BREEAM alone as there could be additional design and technical specifications which are not captured in their proxy for building quality. Fuerst and Van de Wetering (2015) use a dummy variable that indicates properties of the highest building classes as defined by CoStar UK (4- or 5-star rated buildings), but caveat their findings due to possible omitted variables correlated with eco-certification status.

As an attempt to overcome the omitted variable problem, Reichardt *et al.* (2012) adopt a difference-in-difference and a fixed effect model to control for time-invariant unobservable variables when estimating the premium in the US. Another advantage of these approaches is that they also allow researchers to estimate time variations in green rental premiums. For the fixed effect model, the authors obtained an average rent premium of 2.5% (2.9%) for Energy Star (LEED) properties. Their results also show that Energy Star premiums peaked at 7% until the second quarter of 2008, but then declined to 3.7% at the end of 2009.

Other researchers rely on propensity score matching to ensure their sample distribution mimicked a randomized distribution of the label treatment across the sample based on observables (Chegut *et al*., 2014; Eichholtz *et al*., 2013; Parkinson and Cooke, 2012; Kok *et al*., 2011). Their results were quantitatively analogous to those found in the aforementioned studies. Using data from CoStar US, Robinson and Sanderford (2016) employ non-parametric tests to show that labelled buildings do not necessarily share common features with other top-tier buildings in the market. Therefore, this alternative technique may not necessarily improve the reliability of regression results in green building estimations.

Stylized facts from previous studies also show that eco-certified properties still represent a small fraction of the wider office stock and often coincide with higher-end space. These properties tend to be larger, newer and better located than non-labelled peers. Many studies emphasize a positive relationship between affluence and the rate of adoption (Fuerst and Shimizu, 2016; Fuerst *et al.*, 2011; Kok *et al.*, 2011) as well as green certified stock and differences in local demographics and preferences (Ma and Cheng, 2017; Robinson *et al.*, 2017).

Some authors show that eco-certified office space became part of the mainstream and is no longer a niche product when we consider top-tier properties in the US. Fuerst *et al.* (2017) show that labelled properties represented nearly half of all Class A office space sales that took place between 2007 and 2012. Robinson and McAllister (2015) suggest that larger market penetration of green space may have a negative impact on rental and price increments. Drawing from the CoStar US database, they show that only smaller value office segments demonstrate green premiums. These authors consider a sample from 2011:Q4 for the rental data and 2001 to 2011 for the sales data (only buildings over 10,000 square foot are taken into account). In addition to the standard hedonic framework, Robinson and McAllister (2015) also employ quantile regressions as a robustness check to their findings.

Apart from case studies of individual and small groups of properties, quantitative research in emerging markets is bound by the low incidence of green buildings in the overall market and by the lack of reliable commercial real estate (CRE) data. Therefore, existing studies typically focus on qualitative aspects related to environmental accreditations. For instance, Smith (2015) discusses recent growth trends for green space in India. Honda (2016) emphasizes the creation of local certification schemes which may be more suitable for the Brazilian economic reality.

2.2 Real Estate Environmental Programs in Brazil

Esty and Porter (2005) show that environmental performance primarily varies with income levels, regulatory sophistication and its broader economic and social context. Policy agendas in developing countries have historically prioritized economic development and social welfare improvement over sustainability matters. For instance, government bureaucracy is viewed as a key risk factor towards the development of green buildings in China (Qin *et al*., 2016). Not surprisingly, emerging markets are often in the lower ranks of environmental performance measures (Hsu, 2016). The Latin American urbanization context also poses a challenge to the development of environmental initiatives in the construction sector. Major cities "tend to disperse along large territories due to low costs of peripheral land […] and the loss of density signifies an increase on infrastructure costs" (United Nations, 2014b).

In Brazil, initiatives to incorporate a broader concept of sustainability and foster the development of green buildings only gained importance in recent years. National Decree No 7,746, delivered in 2012, establishes sustainability guidelines for the acquisition of public goods, including building contracts, and defines criteria for the reduction of energy and water consumption, utilization of low environmental impact materials, *inter alia*. It also includes the possibility to consider voluntary certification schemes as a compliance mechanism to assure these standards. Many municipalities have also introduced green building incentives, including real estate tax benefits, in their local construction codes. Despite these improvements, environmentally certified properties remain a niche market, mainly associated with high-end office buildings delivered in the last few years.

The rise of the market for eco-certified properties in emerging markets took place much later than in developed economies. In Brazil, the two main certifications schemes are LEED and Acqua-HQE (Honda, 2016; United Nations, 2014b), which were largely based on the US LEED and the French Demarche HQE. These accreditations were launched in 2007 and 2010, respectively. Green Building Council Brazil (GBC-BR) and Fundacao Vanzolini are responsible for evaluating applicants for these certifications.

By the end of 2014, GBC-BR reported a total of 926 applications and 217 LEED-certified properties of all types in the country; whereas Fundacao Vanzolini evaluated 231 projects during conception phase in the period. Local technical bodies are also developing complementary labels, but these have not yet been widely adopted by the Brazilian real estate market (Honda, 2016).

3. HYPOTHESES

Anchored in the signaling literature presented in the previous sections, we depart from the premise that there is no link between registration for an environmental label and financial benefits to developers and owners. This is because registration considered on a stand-alone basis does not translate in any relevant signal to the market.

H_1: *Eco-registration has no impact on rent value.*

We then test the same hypothesis on projects that reportedly failed to obtain the label or were unable to successfully achieve eco-certification upon delivery. Differently from other non-green properties, these projects publicly manifested an initial interest in obtaining the label during conception and construction stages. If such signal is indeed irrelevant, then the market may not necessarily translate this information into realized value.

H_2: *Registration for, but failure to obtain certification on a timely manner, has no impact on rent.*

The final hypothesis derives from the literature on the economic benefits of voluntary certification programs in developed countries. The objective of **H_3** is to empirically estimate realized value, if any, in a market with lower environmental performance (Hsu, 2016) and relatively smaller diffusion of green buildings (Sanderford *et al*., 2017; Robinson and McAllister, 2015; Fuerst and Van de Wetering, 2015). We initially assume the overall context of third party audit schemes, a mechanism of economic governance (Sedlacek and Maier, 2012), does not translate into quantitative pricing discrepancies relative to past research.

H_3: *No difference exists between financial premiums in developing economies and those previously found in developed markets.*

4. METHOD

Before proceeding to the empirical estimates, we present details about the construction of the dataset and some stylized facts about registered and certified properties in the Brazilian market. We then introduce the techniques used to formally test **H_1**, **H_2** and **H_3**.

4.1 Data and Descriptive Statistics

We created a new dataset for office buildings located in the city of Sao Paulo based on two sources: GBC-BR and Buildings. As the most widespread label in the country, our study focuses on LEED. The data cover 10,799 quarterly property-period observations from 2010:Q1 to 2014:Q3. There are 464 (1,033) buildings in the first (last) sample period. The sample is divided in 14 locational submarkets inside the city and contains the following property-characteristics unless otherwise noted.

Table 1: Definition of Variables

Variable	Description	Authors (year)
Rent	The natural logarithm of inflation-adjusted rent (asking) per square meter denominated in Brazilian real (BRL)	Bollinger *et al*. (1998), Glascock *et al*. (1990),
LEED-registered	A dummy variable to capture the effect of LEED registration. The qualitative variable is defined as one after a property applied for LEED and was delivered (whichever occurred later) and zero otherwise. This variable includes both certified and failed applicants and aims to measure any average pricing differences between properties that have once manifested an interest to obtain the label prior to delivery and those that have not.	
LEED-certified	A dummy variable to capture the effect of LEED certification. The qualitative variable is set to one after a property successfully obtained any type of LEED label and zero otherwise.	Fuerst and McAllister (2011), Reichardt *et al*. (2012)
Registered (failed to certify)	A dummy variable to capture the effect of LEED registration, but no in-sample certification. The qualitative variable is set to 1 after a property applied for LEED and was delivered (whichever occurred later) and zero otherwise. This covariate treats properties as 0 once they become certified.	
Size	The natural logarithm of the gross leasable area measured in squared meters	Bollinger *et al*. (1998), Glascock *et al*. (1990),
Age	Measured from the year of construction or the year of a major refurbishment (whichever occurred more recently). We also include non-linear measures, namely age squared, to account for potentially time-varying age effects.	Munneke and Slade (2001)
Large rental area	A dummy variable defining whether rental areas of a given property are large. Buildings defines these niches based on the average size of leasable units inside a given property and sets a cut-off threshold of 100 sqm. This variable is set to one when an asset is larger than the threshold and zero otherwise. The data provider, as is custom in the market, uses this variable to identify properties more likely to house large corporate tenants. We make no such distinction but include it as a locally appropriate control.	Credit Suisse (2016), Colliers International (2014)
Rating	A dummy variable to capture each building class (standard categories AAA, AA, A, BB, B and C) as defined by the data provider. This variable is set to one when an asset belongs to a certain class and zero otherwise. All C class buildings were set to zero to avoid perfect collinearity. Thus, all other classes are measured as premiums relative to this class. Details on this property classification system are reported in the appendix.	Fuerst and McAllister (2011), Reichardt *et al*. (2012)
Vacancy Rate	The percentage of vacancy relative to the gross leasable area	Eichholtz *et al*. (2010), Reichardt *et al*. (2012)

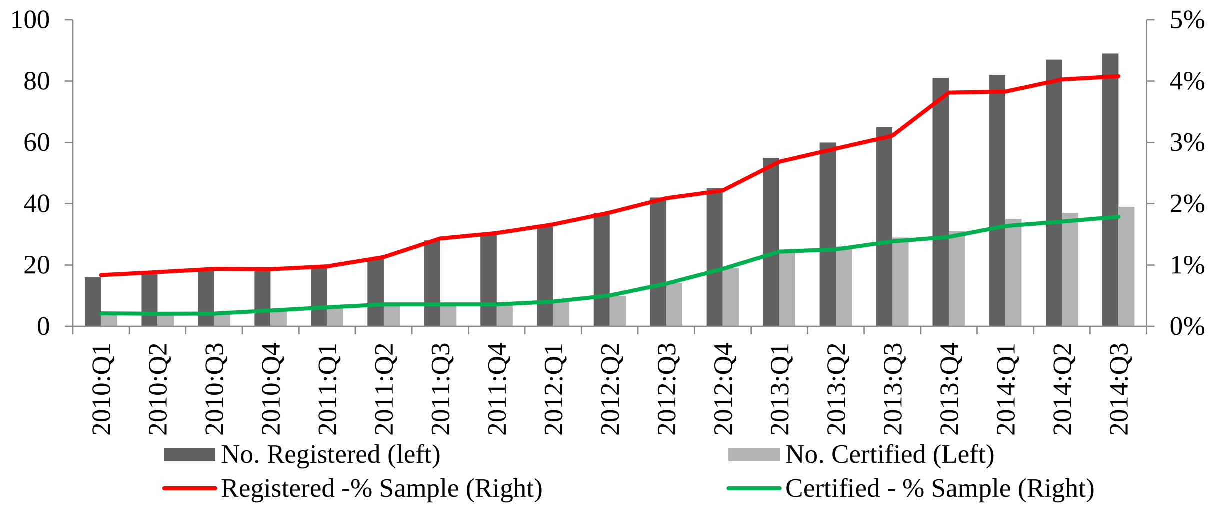
Submarket	a dummy variable characterizing broker-defined submarkets as defined by Buildings.	Chen *et al.* (2009), Bourassa *et al.* (2003), Dunse *et al.* (2002)

Information on LEED registration and certification dates was obtained from public data through GBC-BR. The data were cleaned to remove properties that registered more than once. Separate application submissions at building and project level (e.g. multiple buildings or a land area) are common practice for LEED registration. This reduces the risk that one or more properties in the group may negatively affect the certification process of the remainder. Also, certain buildings contain certifications at various levels (LEED Core & Shell and LEED Commercial Interiors). In these situations, the first registration date and the first certification date (when applicable) were considered for consistency.

The remaining variables were extracted from the Buildings dataset, which requires a paid subscription. Buildings is one of the most comprehensive local sources of information on Brazilian office properties. Perhaps comparable to the CoStar databases in the US and UK, this data source also contains detailed information on property features. According to the provider, all data are collected from landlords, brokers and/or through visits in each property and is updated on a quarterly basis.

The two datasets were merged based on building names and location. The inclusion of the quarter of registration and certification allowed us to track the penetration of all LEED-certified office space and map its profile. As expected, Figure 2 shows that the market for green labels has experienced significant growth in recent years, but remains very small when compared with the overall sample. In 2014:Q3, there were 51 registered and 19 certified buildings reporting valid rent and vacancy fields, although there were a total of 89 registered and 39 certified properties in the city.

Figure 2: Cumulative Penetration of LEED-certified Office Properties



This figure shows the cumulative penetration of LEED-registered and LEED-certified office properties in the city of Sao Paulo from 2010:Q1 to 2014:Q3. The numbers were obtained from Green Building Council Brazil. Market-wide figures comprise all office properties in the Sao Paulo dataset from Buildings. These numbers consider properties with and without valid rent and vacancy fields.

Table 2 provides basic statistics, along with a comparison of rent, vacancy rate, building features, and submarket concentration of the properties in the sample. In 2014:Q3, average rent per sqm of certified (registered) buildings was BRL 70.81 (BRL 43.45), higher than the sample average and BRL 38.13 (BRL 10.77) higher than that of A-rated properties (AAA, AA, A).

Certified buildings are substantially newer, larger, superior with regards to quality and more concentrated in upscale locations than the full sample. For instance, 57.9% of the properties in the first group are up to 4 years old, whereas only 15.3% of the buildings in the latter group hold the same characteristic. These figures become less discrepant as we compare features of labelled buildings with those in the A-rated and LEED-applicant groups. A-rated properties had lower average vacancy rates (28.8%), followed by LEED-certified properties (29.3%) and LEED-applicants (40.1%). Some differences also exist for size, with certified buildings being the largest and A-rated the smallest. LEED-registered buildings are quite like labelled properties in terms of age, whereas the A-rated sample is on average slightly older than these two groups. Virtually all registered and certified properties held large rental units (*Large rental area*), while most A-rated properties carried the same attribute (69.2%).

Differences among the three groups also arise in the control variable *Rating.* While A-rated properties are more concentrated in the lower-end (71.9% are defined as A), registered and labelled buildings are more evenly distributed across all rankings (AAA, AA, and A). Some authors criticize the use of latent variables as they summarize a bundle of objective and subjective attributes (Fuerst *et al.* 2015; Robinson and McAllister, 2015). Nonetheless, we leave these best available controls as they add relevant information with regards to overall building quality (Fuerst and Van de Wetering, 2015).

Properties from the three subsamples co-exist in a few affluent locations. Yet, the concentration of LEED-applicants and labelled buildings in these submarkets is higher than that of A-rated properties. For instance, Faria Lima/Itaim accounted for 52.6% of LEED-certified, 41.2% of the LEED-applicants and 20% of A-rated properties in the sample.

Table 2: Descriptive Statistics – 2014:Q3

Variable	Total Sample			AAA, AA, A-Rated			Registered			Certified		
	Obs.	Mean	Std. Dev.	Obs.	Mean	Std. Dev.	Obs.	Mean	Std. Dev.	Obs.	Mean	Std. Dev.
Panel A: Continuous Variables – Attributes												
Rent/sqm	1,033	65.73	28.54	146	98.41	34.77	51	109.18	36.48	19	136.54	27.64
Size (sqm)	1,033	4,804.8	7,024.2	146	14,653.0	10,697.5	51	17,604.5	13,082.5	19	22,609.7	13,563.5
Vacancy Rate	1,033	24.2%	29.9%	146	28.8%	24.7%	51	40.1%	27.4%	19	29.3%	24.3%
Panel B: Qualitative (Dummy) Variables – Attributes												
Total	1,033	100.0%		146	100.0%		51	100.0%		19	100.0%	
Age (years)												
0 to 4		15.3%			49.3%			60.8%			57.9%	
5 to 9		6.9%			15.8%			7.8%			21.1%	
10 to 14		16.7%			24.0%			21.6%			15.8%	
15 to 19		18.3%			10.3%			3.9%			5.3%	
20 to 24		9.9%			0.7%			3.9%			0.0%	
25 to 29		3.6%			0.0%			0.0%			0.0%	
30 +		29.3%			0.0%			2.0%			0.0%	
Large rental area		41.7%			69.2%			94.1%			100.0%	
Rating												
AAA		1.2%			8.2%			19.6%			31.6%	
AA		2.8%			19.9%			31.4%			42.1%	
A		10.2%			71.9%			37.3%			15.8%	
BB		7.2%			0.0%			3.9%			5.3%	
B		34.8%			0.0%			5.9%			5.3%	
C		43.8%			0.0%			2.0%			0.0%	

This table shows descriptive statistics for 2014:Q3 of the panel data. The final quarter best represents the evolving maturity of the green building market in Sao Paulo (Brazil) and is also representative of the data. The entire data set (2010:Q1-2014:Q3) consists of 10,799 observations and descriptive statistics are available upon request.

Table 2 (cont'd): Descriptive Statistics – 2014:Q3

Variable	Total Sample			AAA, AA, A-Rated			LEED-Registered			LEED-Certified		
	Obs.	Mean	Std. Dev.	Obs.	Mean	Std. Dev.	Obs.	Mean	Std. Dev.	Obs.	Mean	Std. Dev.
Panel C: Qualitative (Dummy) Variables - Locational Submarkets												
Total	1,033	100.0%		146	100.0%		51	100.0%		19	100.0%	
Faria Lima/Itaim		19.6%			20.0%			41.2%			52.6%	
Marginal Pinheiros		2.3%			10.6%			13.7%			21.1%	
Berrini		6.7%			12.7%			11.8%			5.3%	
Vila Olímpia		7.8%			9.4%			13.7%			10.5%	
Chacara Santo Antonio		2.4%			2.9%			3.9%			5.3%	
Paulista		18.4%			8.6%			7.8%			5.3%	
Morumbi/Jardim Sao Luiz		3.7%			9.0%			3.9%			0.0%	
Saude/Jabaquara		1.8%			2.9%			0.0%			0.0%	
Santo Amaro		1.9%			2.4%			0.0%			0.0%	
Barra Funda		4.2%			5.7%			2.0%			0.0%	
Centro		11.2%			0.8%			0.0%			0.0%	
Moema / Vila Mariana		10.1%			4.9%			0.0%			0.0%	
Pinheiros/Perdizes		2.0%			0.8%			0.0%			0.0%	
Other		7.9%			9.0%			2.0%			0.0%	

4.2 Model Specification

As in most previous studies (e.g. Fuerst and McAllister, 2011b; Eichholtz *et al.*, 2010; Wiley *et al.*, 2010), our baseline estimation procedure for the label-related premium is the quintessential log-linear hedonic model, which takes the following form:

$$R_{imt} = c_{imt} + \beta_l L_{imt} + \beta_n Z_{imt} + \beta_n D_m + \beta_n D_t + e_{imt} \quad (4)$$

where R_{imt} is the natural logarithm of *Rent* per square foot for asset "i" on submarket "m" at time "t", L_{imt} is a dummy variable which is set to 1 after a building applied for (or obtained) a green label or 0, otherwise, Z_{imt} is a vector of asset-specific control variables, namely *Rating*, *Size*, *Age*, *Large Rental Area* and *Vacancy Rate*. These covariates are explained in Table 1. The remaining controls, D_m, a vector of location dummies used to capture the impact of submarket "m" which may be common to all assets in each region, and D_t, a vector of time dummies used to isolate macroeconomic shocks common to all assets at a given period. c_{imt} and e_{imt} are a constant and an error term, respectively. The hypotheses $\mathbf{H_1}$ and $\mathbf{H_2}$ are rejected if β_l is different than zero.

We also adopt a propensity-score weighting approach to limit potential selection bias associated with spatial concentration and quality features. This is particularly relevant in the sustainable real estate literature as most certified buildings are often located in prime submarkets and of superior overall quality. The first step includes a logistic regression of our certification dummy (L_{imt}) on observable building features (Z_{imt}). This regression allows us to estimate propensity weights for each building based on its probability of being certified. We then apply these weights and re-estimate our baseline hedonic model as in equation (4). Similar techniques were also adopted by Robinson and McAllister (2015), Chegut *et al*. (2014), Eichholtz *et al*. (2013), Parkinson and Cooke (2012), and Kok *et al*. (2011). The hypotheses are tested in the same way as our previous model.

5. RESULTS AND DISCUSSION

This section tests hypotheses $\mathbf{H_1}$ and $\mathbf{H_2}$ empirically and compares the results obtained with previous findings from developed markets ($\mathbf{H_3}$). As a robustness test, output from alternative specifications are also reported.

5.1. Baseline Hedonic Regression Estimates on Observed Rent

Table 3 reports regression results of equation (4) and considers properties with all observed characteristics available at a given quarter. Standard errors in the hedonic estimates are clustered at submarket level as suggested by Reichardt *et al.* (2012).

Table 3: Hedonic Regression Estimates of Observed ln(Rent/sqm)

Variables	(1)	(2)	(3)	(4)
LEED-registered		-0.03		
		(-0.7)		
Registered (failed to certify)			-0.08	
			(-1.4)	
LEED-certified				0.08**
				(2.3)
ln (Size)	0.12***	0.12***	0.12***	0.12***
	(4.9)	(4.8)	(4.9)	(4.9)
Age	-0.02***	-0.02***	-0.02***	-0.02***
	(-17.4)	(-18.1)	(-17.7)	(-17.5)
Age^2	0.00***	0.00***	0.00***	0.00***
	(19.2)	(20.5)	(19.9)	(19.3)
Large rental units	0.13**	0.13**	0.13**	0.13**
	(2.8)	(2.7)	(2.8)	(2.8)
Rating				
AAA	0.20***	0.23***	0.22***	0.17**
	(3.2)	(3.4)	(3.9)	(2.4)
AA	0.23***	0.25***	0.26***	0.22***
	(3.9)	(3.2)	(3.5)	(3.6)
A	0.14***	0.14***	0.14***	0.14***
	(3.2)	(3.2)	(3.2)	(3.1)
BB	0.11	0.10	0.10	0.11
	(1.4)	(1.4)	(1.4)	(1.4)
B	0.02	0.02	0.02	0.02
	(0.7)	(0.7)	(0.7)	(0.7)
Vacancy rate	-0.01	-0.01	-0.01	-0.01
	(-1.2)	(-1.1)	(-1.1)	(-1.2)
Constant	3.17***	3.17***	3.16***	3.17***
	(15.5)	(15.1)	(15.2)	(15.6)
Time dummies	Yes	Yes	Yes	Yes
Submarket dummies	Yes	Yes	Yes	Yes
Observations	10,799	10,799	10,799	10,799
R-squared	0.68	0.68	0.68	0.68

Each model is a multivariate regression with a dependent variable of the natural log of rent per square meter on a Sao Paulo (Brazil) office building sample from 2010:Q1 to 2014:Q3 (see Table 1 for definition of other variables). Model (1) shows baseline results with no green controls. Model (2) tests all buildings that registered for LEED certification during the sample period regardless of certification status. Model (3) tests buildings that registered for but did not achieve LEED certification during the sample period. Model (4) tests buildings that achieved LEED certification during the sample period. T-statistics are reported in parenthesis. ***, ** and * indicate whether coefficients are significant at 99%. 95% and 90% level, respectively. Standard errors are clustered at submarket level.

Regression (1) exhibits the pricing scheme of the principal building attributes, namely *Size*, *Age* and *Large Rental Area*. The relevance and sign directions of these features is consistent with those found in previous studies (e.g. Bollinger *et al.*, 1998; Glascock *et al.*, 1990). The importance of building quality, measured by letter grades, is validated in more recent research (e.g. Robinson and McAllister, 2015; Fuerst and Van de Wetering, 2015; Reichardt *et al.*, 2012; Eichholtz *et al.*, 2010; Fuerst and McAllister, 2011a; 2011b). The advantage of the property classification system adopted by Buildings is that it contains more rating layers than that of traditional CoStar US (A, B and C) and CoStar UK (up to five stars) as well as more details on how these ratings are constructed (it considers subjective measurements of technical specifications, corporate image and occupation profile). The inclusion of more refined letter grades not only alleviates some of the concern of omitted variable bias with regards to building quality and location, but also partially compensates for the lack of unavailable variables (e.g. height, HVAC, accessibility, *inter alia*). The model explains 68% of the variation in rents[3].

Regressions (2) and (3) quantify the premium among properties that registered for LEED before and during the sample period. Regression (2) includes all observable properties that applied for the certification scheme, including those that obtained the label in-sample. Regression (3) only considers LEED applicants prior to obtaining the certification and those that did not obtain it. In both cases, the pseudo green premium is not statistically different than zero. The same approach for properties that obtained the LEED label before and during the sample period is employed in Regression (4), which identifies a statistically significant green premium of approximately 8% among certified properties. The shadow prices of other features appear to be rather stable across these different specifications, providing some comfort with regards to omitted variable bias (Sirmans *et al*., 2006).

These results indicate a rejection of $\mathbf{H_1}$ at a 99% confidence level in the base specification. Although the sign for registered, but not certified buildings is negative, no statistical significance is found. Therefore, the base analysis fails to reject $\mathbf{H_2}$. Regression (4) reveals a statistically significant premium which is roughly two times larger than those found in research from developed economies. Although no formal statistical test against the extant literature is performed, the large difference in the premiums appears to reject $\mathbf{H_3}$**.**

Note that micro-locational quality is unlikely to be an important driver of the estimated green premium. As discussed in the previous sections, there is a reasonably homogeneous and evenly distributed concentration of LEED-registered and LEED-certified buildings in the same submarket areas.

The green label premium may have been partially inflated by *a priori* superior attributes associated with labelled properties (and not necessarily with the label itself). The sample of AAA- rated properties, which often coincides with our group of eco-certified buildings highlights this potential impact. The next sections, a subsample regression in Table 4 and a propensity weighted regression, control for this potentially confounding effect.

5.2. Large Unit Only Hedonic Regression Estimates on Observed Rent

Since the local market often segregates the office space based on buildings with and without *Large Rental Area*, a separate regression is run on the larger, more institutional ready buildings subsample; the majority *Rent* are rated AAA, AA and A, which help control for building quality. As noted before, these properties carry a higher propensity to hold a green label and have superior objective and subjective features (see appendix for a detailed definition of minimum criteria). This procedure allows us to compare buildings that are more like LEED peers and test whether a green premium exists in higher-end segments. Despite the small sample of 989 observations, the models explain 65% of the variation in rent. The results obtained are qualitatively analogous to those in our previous estimates. Registered properties do not exhibit any green premium while certified buildings do.

[3] We also employed variants of equation (1) with slightly different specifications, such as the inclusion of time-submarket fixed effects and age cohorts. The results remained very similar.

Table 4: Hedonic Regression Estimates of Observed ln(Rent/sqm) – Large Unit Only Buildings

Variables	(5)	(6)	(7)	(8)
LEED-registered		-0.02		
		(-0.5)		
Registered (failed to certify)			-0.05	
			(-1.5)	
LEED-certified				0.04*
				(1.8)
ln (Size)	0.11**	0.11**	0.11**	0.11**
	(2.3)	(2.3)	(2.3)	(2.3)
Age	-0.00	-0.00	-0.00	-0.00
	(-0.1)	(-0.1)	(-0.3)	(-0.1)
Age^2	-0.00	-0.00	-0.00	-0.00
	(-1.4)	(-1.2)	(-0.9)	(-1.3)
Rating				
AAA	0.09*	0.10**	0.10**	0.08*
	(2.1)	(2.3)	(2.2)	(1.8)
AA	0.10***	0.11***	0.12***	0.10***
	(4.2)	(3.8)	(4.5)	(3.9)
Vacancy rate	-0.00	0.00	0.00	-0.00
	(-0.0)	(0.0)	(0.1)	(-0.1)
Constant	3.74***	3.74***	3.73***	3.73***
	(8.9)	(8.8)	(8.6)	(9.0)
Time dummies	Yes	Yes	Yes	Yes
Submarket dummies	Yes	Yes	Yes	Yes
Observations	989	989	989	989
R-squared	0.65	0.65	0.65	0.65

These models are analogous to those reported in Table 3; however, the regressions only consider a subsample of buildings with large rental units which are also AAA-, AA- and A-rated. These properties are more institutional ready and, therefore, more similar to labelled peers. T-statistics are reported in parenthesis. ***, ** and * indicate whether coefficients are significant at 99%. 95% and 90% level, respectively. Standard errors are clustered at submarket level.

Regression (8) reports a marginally significant premium of 4%, lower than the 8% obtained in regression (4). These numbers corroborate with the findings of Robinson and McAllister (2015), who suggest that the concentrated supply of eco-labeled offices among large, high quality buildings may cause green incremental rent to be lower. These authors; however, do not find a localized premium in top-tier segments of the US office market. Our basic statistics show that 17 out of 146 AAA-, AA- and A-rated properties were eco-certified in 2014:Q3 (13%). Despite the small penetration, this figure is substantially larger than that of the overall sample (19 out of 1,033 in 2014:Q3). These findings suggest that emerging market cities may still exhibit a positive premium due to the relative scarcity of eco-labelled office space (Fuerst and Van de Wetering, 2015), offering further evidence to reject $\mathbf{H_3}$.

5.3. Propensity-weighted Hedonic Regression Estimates on Observed Rent

Using the baseline specification as a benchmark, we also report findings from the propensity-weighted hedonic models. Our first step logistic regression on the likelihood of certification considers weights from the full sample of buildings available in 2014:Q3 (2,192). This initial regression includes properties with valid rent and vacancy fields (1,033) and those without these features (1,159). We do not show this estimate for brevity, but, as expected, higher probability of certification coincides with superior characteristics, such as larger size and higher rating. Therefore, the second step regressions apply larger weights on buildings which are more likely to be certified due to better *a priori* quality. In other words, the model attributes adequate populational weights to applicants that obtain certification, despite the existence of vacant areas after delivery.

Broadly speaking, $\mathbf{H_1}$ test results are analogous to those considered in our previous estimates (rejection at a 99% confidence level). However, in set of regressions, which more effectively control for buildings quality in this evolving market, a statistical discount is found for properties that register but fail to achieve certification. Regression (11) reports a discount of 9% for applicants that had not yet achieved in-sample certification (potentially due to a delay or failure during the GBC-BR audit process). This rejects $\mathbf{H_2}$ at a 99% confidence level. The benefit obtained (6%) is still in the upper bound relative to those reported by studies from developed countries.

Table 5: Propensity-weighted Regression Estimates of Observed ln(Rent/sqm)

Variables	(9)	(10)	(11)	(12)
LEED-registered		-0.04		
		(-1.2)		
Registered (failed to certify)			-0.09***	
			(-3.3)	
LEED-certified				0.06***
				(3.3)
ln (Size)	0.09**	0.09**	0.10**	0.09**
	(2.5)	(2.5)	(2.6)	(2.5)
Age	-0.00	-0.01**	-0.01**	-0.00
	(-1.4)	(-2.2)	(-2.3)	(-1.1)
Age^2	-0.00**	-0.00*	-0.00	-0.00**
	(-2.3)	(-1.8)	(-1.7)	(-2.4)
Large rental units	0.28***	0.30***	0.31***	0.27***
	(6.9)	(7.1)	(8.4)	(6.4)
Rating				
AAA	0.28***	0.28***	0.24***	0.26***
	(3.7)	(3.8)	(3.2)	(3.2)
AA	0.28***	0.28***	0.26***	0.27***
	(4.1)	(4.1)	(3.8)	(3.9)
A	0.18***	0.16***	0.14***	0.18***
	(3.6)	(3.3)	(3.0)	(3.5)
BB	0.04	0.03	0.00	0.03
	(0.5)	(0.3)	(0.0)	(0.4)
B	0.06*	0.05*	0.05	0.06*
	(1.9)	(1.7)	(1.6)	(1.9)
Vacancy rate	-0.01***	-0.01***	-0.01***	-0.01***
	(-4.2)	(-4.1)	(-4.3)	(-4.3)
Constant	3.50***	3.49***	3.43***	3.46***
	(11.5)	(11.5)	(10.6)	(11.2)
Time dummies	Yes	Yes	Yes	Yes
Submarket dummies	Yes	Yes	Yes	Yes
Observations	10,799	10,799	10,799	10,799
R-squared	0.78	0.78	0.78	0.78

Each model is a propensity-weighted multivariate regression using same sample as Table 3. The propensity weights were derived from a logistic regression of LEED-certified on other building features to mitigate risk of selection bias associated with the green treatment. T-statistics are reported in parenthesis. ***, ** and * indicate whether coefficients are significant at 99%. 95% and 90% level, respectively. Standard errors are clustered at submarket level.

6. CONCLUSIONS

This article extends research on the economic benefits associated with voluntary eco-labeling programs to the context of developing economies. Our empirical estimates show that the green rent premium in Sao Paulo's office market is larger than that found in previous studies from developed countries. These results reflect the relatively late development of initiatives to bolster a broader concept of sustainability in the local CRE sector. In Brazil, for instance, the first accreditation institution only emerged in 2007, whereas the UK and the US already had accreditation bodies in the 90s. The supply of labelled office properties rose substantially in recent years, although from a negligible base. The relative scarcity as well as the lack of standardized sustainability signals to the public contribute to the relatively larger willingness to pay for labelled properties.

Given the economic governance nature of accrediting institutions, often beyond that of local environmental standards (Sedlacek and Maier, 2012), we also test whether the intention to certify (registration), but non-achievement of actual certification, translates into any realized value. The empirical evidence for this hypothesis suggests that non-certified applicants may be subject to discounts, depending on model specification, beyond that of other comparable non-green properties.

The cross-sectional nature of this study and lack of historical data records limit our ability to examine whether such emerging market "green" and "brown" alphas would remain steady in the long-run. Researchers from developed economies show that the rent premium associated with green office buildings is negatively correlated with the supply of these properties (Robinson and McAllister, 2015; Chegut *et al.*, 2014) and economic cycles (Reichardt *et al.* 2012). This may represent a challenge for further development of sustainable buildings in growth economies as infrastructure costs are historically higher than in developed countries. Long-term economic viability of sustainable real estate projects in emerging markets is an issue that will have to be addressed as data availability as well as the level of detail and accuracy improve over time.

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8. APPENDIX

Table 6: Details of the Property Rating Classification System

Macro Classification		**A**			**B**		**C**
Micro Classification		**AAA**	**AA**	**A**	**BB**	**B**	**C**
Objective Criteria	Floor Plate Area (sqm)	>=1500	>=1000	>=500	>=500	>=250	N/A
	Gross Leasable Area (sqm)	>= 20,000	>= 10,000	>=5,000	>=5,000	>=2,500	N/A
	Age (Deliver/Retrofit)	<=20 Years		<=40 Years		N/A	
Subjective Criteria (Grades)	Sum of Grades	>=13	>=11	>=8	>=5	>=5	>=3
	Technical Specifications	1 to 5	1 to 5	1 to 5	1 to 5	1 to 5	1 to 5
	Corporate Image	1 to 5	1 to 5	1 to 5	1 to 5	1 to 5	1 to 5
	Occupation Profile	1 to 5	1 to 5	1 to 5	1 to 5	1 to 5	1 to 5