



The effect of green building certification on potential tenants' willingness to rent space in a building

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ABSTRACT

This study examines the effect of a building's green building certification on potential tenants' willingness to rent by conducting a vignette-based experiment. The building sector accounts for a significant portion of global energy consumption and greenhouse gas emissions, and increasing attention has focused on the expansion of green buildings that are designed to minimize such negative environmental impacts. While green building certification is generally regarded an important driver expanding green buildings, researchers have given little attention to the relation between green building certification and potential tenants' willingness to rent space in a building. This study examines whether green building certification can enhance potential tenants' willingness to rent space in a building. It also explores under what conditions the effect of such certification can be heightened by considering the characteristics of potential tenants, buildings, and certifications. To test our hypotheses, 220 participants responded to a virtual office space rental scenario and 219 to an apartment rental scenario. The results show that (a) a green building certification increased potential tenants' willingness to rent; (b) however, a higher certification grade did not further enhance potential tenants' willingness to rent; and (c) potential tenants with higher levels of eco-friendliness exhibited higher willingness to rent buildings with a green certification.

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1. Introduction

The building sector accounts for 20% of global energy use, an amount projected to increase by an average of 1.5% per year by the mid-twenty-first century (EIA, 2016). The U.S. Environmental Protection Agency (US EPA, 2016) also reported that buildings produce approximately 6% of global greenhouse gas (GHG) emissions. Given such negative impacts on the environment, the potential role of green buildings in reducing GHG emissions and energy use has received increasing attention from researchers and policy makers (Olubunmi et al., 2016).

A green building is one designed to reduce its negative environmental impact by operating efficiently and minimizing emissions or the discharge of pollution (USGBC, 2010). Jeong et al. (2016) reported that buildings certified by Leadership in Energy and Environmental Design (LEED) used 15% less energy per floor area

than conventional buildings. Using the life-cycle assessment database, Suh et al. (2014) estimated that green-certified buildings can potentially reduce GHG emissions by 22%.

Thanks to the merits of green buildings, many governments and other organizations have developed programs that encourage the number of green buildings (Newsham et al., 2009). Many governments offer such financial incentives as tax deductions for building owners (Olubunmi et al., 2016). Several organizations have also develop tools or platforms aimed at increasing the number of green buildings. For instance, China Green Building Codes and Standards Online, a web-based information technology infrastructure, was developed to facilitate communication between various stakeholders in the building industry (Lam et al., 2013).

In addition to the aforementioned drivers, green building certification is regarded as one of the important ways to encourage the growth of green buildings (Pérez-Lombard et al., 2009). The green building certification evaluates a building's eco-friendliness, including its energy efficiency, GHG emissions, and material recycling, and grades the building, based on the evaluation results (Vierra, 2016). Certification thus provides stakeholders, including

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tenants, with accurate information on the building's eco-friendliness (Qiu et al., 2016; Soulti, 2016) and helps them understand and evaluate the value of green buildings (Olubunmi et al., 2016). Without such a certification, tenants who rent space from lessors often do not have sufficient environmental information about buildings, such as potential energy expenditures or savings (Brohmann et al., 2013).

Accordingly, many countries have adopted certification schemes for green building expansion. For instance, the LEED certification developed by the US Green Building Council, one of the most popular green building certifications, is used in more than 150 countries (Long, 2015). Furthermore, countries such as Japan and South Korea are making efforts to expand green buildings by developing their own green building certification schemes. Accordingly, the number of buildings that are certified as green buildings has been steadily increasing around the globe. In the U.S., green-certified buildings comprised 13% of commercial buildings in 2015 (CBRE, 2015). South Korea has also witnessed a steady increase in green-certified buildings. In the Seoul metropolitan area, about half of the gross floor area of new buildings constructed in 2015 met the Green Standard for Energy and Environmental Design (G-SEED) certification from the Korean government (Mahendriyani, 2016).

Due to the increasing popularity and importance of green building certification, several studies have recently looked into its impact on the increase in green buildings (Olubunmi et al., 2016; Robinson et al., 2016). Nonetheless, few studies have examined the relation between green building certification and the perceptions of potential tenants (hereafter referred to as tenants for the sake of brevity) about buildings with such certification. While green building certification is intended to provide green-related information to tenants, existing studies have focused mostly on demonstrating the relationship between green building certification and a building's rent premium (e.g., Fuerst and McAllister, 2011; Gabe and Rehm, 2014) or the diffusion pattern of green building certification (e.g., Qiu et al., 2015; Qiu et al., 2016). Only a few (e.g., Zhang et al., 2016; Robinson et al., 2016) have considered the impact of green building certification on tenants' willingness to rent space in a building. It is thus worthwhile to ask whether green building certification can enhance tenants' willingness to rent certified buildings and, if so, under what conditions certification can most effectively do so. Furthermore, current studies on green building certification have focused mostly on commercial buildings in which tenants rent spaces to run their businesses (see, Fuerst and McAllister, 2010 and Robinson et al., 2016), which calls for an investigation of the certification effect for different types of buildings in order to increase the generalizability of its results.

To address these current gaps in the literature, our study explores how green building certification influences a tenant's willingness to rent the space in the building with certification compared to the one without certification by reflecting on several situational characteristics. First, we employ a certification that has a grading system of two grades, A (higher grade) and B (lower grade), which are determined on the basis of its evaluation criteria. Second, since the effect of certification may depend on the buildings to be certified, we compare responses to a building with low rent with those to a building with high rent. Third, we measure individual tenants' eco-friendliness and green building-related knowledge and examine their impact on willingness to rent a building with certification, given that a green building aims to reduce negative environmental impacts. Lastly, we examine tenants' rental decisions regarding both residential buildings and commercial buildings. This reflects that residential buildings also use a significant portion of energy consumption and produce GHG emissions. In South Korea, apartments made up 16% of the total building

sector's GHG emissions in 2015 (KOSIS, 2015). In sum, this study aims to address the following research questions:

- Does green building certification enhance a tenant's willingness to rent space in a certified building?
- If so, under which circumstances does certification reap the biggest effects? How do certification characteristics (certification grade), building characteristics (rent), and individual characteristics (tenants' level of eco-friendliness and green building-related knowledge) influence the effect of the certification?

To explore these questions, we conducted a vignette-based experiment, a method widely used in examining consumer perceptions or judgments regarding eco-labeling and green products (Grankvist et al., 2004; Luchs et al., 2010; Seo et al., 2016). In each of the rental situations, i.e., a commercial building and a residential building, participants were presented with space rental advertisements whose information was manipulated to examine the effect of certification. Given this information in a vignette, participants exhibited their willingness to rent, measured by relative preference for the building with certification over one without certification, as in such similar studies as Luchs et al. (2010).

Our study contributes to the green building certification literature by being the first study to delve into the cognitive effects of green building certification for two different types of buildings from a tenant's perspective and possible moderating factors on tenants' willingness to rent. Our findings also have managerial implications for building owners, such as real estate development and investment companies, and for policy makers wishing to increase the number of green buildings, as they identify circumstantial conditions that can increase the effect of a green building certification.

The rest of this article proceeds as follows. Section 2 reviews the relevant literature. Section 3 presents this study's hypotheses, and Section 4 outlines the experiment's methodology. Section 5 describes the experiment results and discusses their implications. Section 6 presents the conclusion.

2. Literature review

Our work is grounded in two research streams: (i) green building expansion and the role of green building certification within it and (ii) the impact of eco-labeling/certification on consumer perceptions and the factors that moderate its effectiveness.

Recently, the environmental benefits of growth in the number of green buildings have increased scholarly interest in this area. Existing studies have identified several barriers to the transition to green building as well as factors that facilitate its deployment. Hwang and Tan (2012) have proposed several strategies for overcoming barriers to implementing green building construction projects, including adopting green building certifications, providing subsidies for R&D, and educating owners on the benefits of green buildings. Xie et al. (2017) have suggested that pro-environment behavior can play an important role in green building deployment based on an empirical investigation of the relationship between pro-environment behavior and willingness to pay for a green building. Gou et al. (2013) assessed the readiness of developers to adopt green construction and specified the factors that influenced their voluntarily adopting green building construction. Hwang et al. (2017) ranked the reasons for the higher construction cost of green building. Robinson et al. (2016) examined office tenants' willingness to pay for each of the green features of a building to help guide property developers' decision making.

Among the many factors, green building certification plays an

important role in green building deployment (Olubunmi et al., 2016). In particular, several studies have investigated whether green building certification increases consumers' preference for a given building. Examining the relationship between green building certification and rent levels using data from the U.S. and Australia, respectively, Fuerst and McAllister (2011) showed that buildings with green certification recorded higher rents than those without, although Gabe and Rehm (2014) found no correlation between green building certification and rent levels. Millar and Baloglu (2011) empirically confirmed that a green certification on the building increased travelers' preference for a hotel room. Similarly, Zhang et al. (2016) showed that green building certification positively impacted tenants' willingness to pay for a green building in a residential space purchasing context. See, Table 1 for the summary of the literature in this stream.

In line with the aforementioned studies, our work discusses the role of green building certification on preferences for green buildings. Unlike them, however, this study focuses on the cognitive effect of green building certification on potential tenants' willingness to rent in the context of both office and residential space rentals. It also differs in considering factors that may moderate the effect of certification upon those willingness to rent.

Another research stream closely related to our work is consists of studies on eco-labeling (or environmental labeling/certification), which refers to providing environmental information regarding the use of a product or production process (Amacher et al., 2004). Examples include green building certifications and food-safety and energy-efficiency labels. Studies on eco-label have confirmed the positive effect of eco-labeling on consumer willingness to pay for products (e.g., Borin et al., 2011; Sammer and Wüstenhagen, 2006; Teisl et al., 2002). In the green building context, Robinson et al. (2016) analyzed the demand for green-labeled office building features among U.S. office tenants and found that willingness to pay for green building show a 9.3% premium. Zhang et al. (2016) similarly found that dwellers living in green-certified complexes in Beijing showed a significantly higher initial willingness to pay for greenness. This study is similar to these studies in confirming the effect of certification on consumer (tenant) willingness to rent.

Beyond confirming green labeling's influence on consumers' choices, several studies in this stream investigated the situation where green labeling can effectively enhance consumers' valuation of a product. Thøgersen et al. (2010) found that consumers' intention to buy sustainable products and issue-related knowledge impacted the adoption of eco-labels. D'Souza et al. (2006) empirically investigated the association between consumers' demographic profiles and their attitudes toward such labels. Qiu et al. (2017) considered building characteristics and showed that some of them (e.g., building age and lot size) had an impact on green building certification adoption. Schuitema and Groot (2015) showed that carbon footprint labels have more impact on consumers' decisions regarding low-price products than high-price

products. Cai et al. (2017) demonstrated that consumers' perceptions of the credibility of eco-labels had a positive and significant impact on their future purchase intentions. Heinzle et al. (2013) found that the price premium achieved by a green building depended on its green building certification level.

Collectively, these studies suggest that the factors that impact eco-label adoption (or consumers' valuation for a product) can be classified into the three categories: personal characteristics, labeling characteristics, and product characteristics as in Thøgersen et al. (2010). While this study considers such factors in line with previous studies, it differs by considering all three categories in a green building certification context. Furthermore, the theory of consumption value proposed by Sheth et al. (1991) also provide the theoretical underpinning to our research question 2. It aims to identify the factors that influence the consumption behaviors (Sheth et al., 1991), and the identified factors – functional, emotional, and epistemic value – are closely related to the three factors that we have identified from the literature review. Table 1 summarizes the literature in the second stream.

3. Hypotheses development

The first objective of this study was to determine whether green building certification can increase tenants' willingness to rent space in a building. Green building certification ensures that the building has the merit of energy saving, recycling material, air quality, etc. In the literature, eco-labeling is known as an effective marketing tool for the consumer by providing relevant information (Cai et al., 2017) and thus many studies empirically confirmed the effect of eco-labeling on consumer's valuation for the product (e.g., Teisl et al., 2002 and Grankvist and Biel, 2007). In green building context, Millar and Baloglu (2011) and Zhang et al. (2016) showed that tenants exhibit higher valuation for the building with certification. Accordingly, this study proposed the following hypothesis:

H1. Green building certification increases tenants' willingness to rent.

Once we were able to verify the certification effect, we next examined under which circumstances the effect of certification is maximized as a second objective. Drawing from the extensive literature review and the theory of consumption value (Sheth et al., 1991), this study identified the three characteristics that potentially moderate the certification effect: labeling, product, and consumer characteristic (see, Table 1). We then selected the representative factors in each of the three characteristics considering our green building certification context. First, certification level is employed as a *labeling characteristic*, as it has been popularly considered in the green building literature (e.g., Heinzle et al., 2013). Second, this study selected building rent as a *product characteristic*. Building rent is a collective measure that represents the building value (Rosen and Smith, 1983) where distance to the subway, indoor air

Table 1
Summary of the literature.

Author	Product Type	Key Variable	Relevant Question
Millar and Baloglu (2011)	Building (hotel)	Green building certification	Research Question 1
Robinson et al. (2016)	Building (office)	Green building certification	
Zhang et al. (2016)	Building (residence)	Green building certification	
Thøgersen et al. (2010)	Food	Consumer characteristics (related knowledge)	Research Question 2
D'Souza et al. (2006)	Products in supermarket	Consumer characteristics (demographic profile)	
Qiu et al. (2017)	Building	Product characteristics (building age and lot size, etc.)	
Schuitema and Groot (2015)	Moisturizer	Product characteristics (product price)	
Cai et al. (2017)	Furniture	Certification characteristics (label credibility)	
Heinzle et al. (2013)	Building	Certification characteristics (certification level)	

quality, etc. are collectively reflected. Third, this study selected green building–related knowledge and eco-friendliness to represent *consumer characteristics*, as these have been shown to be factors in labeling effectiveness in the eco-labeling literature (Thøgersen et al., 2010). These three factors are also closely related to the functional, emotional, and epistemic values that, according to the theory of consumption value, influence consumers' decision making. Certification level and rent reflect functional value in that they affect consumers' perception of the product; green building–related knowledge corresponds to the knowledge that determines epistemic value; and eco-friendliness is the factor that determines the feeling in the decision making and thus regarded as emotional value. The projected effect of these factors was the focus of our remaining hypotheses, as described below.

The first of these factors is the certification grade. In our certification scheme, a higher grade (grade A) indicates that the building is more eco-friendly than one with a lower grade (grade B). In the literature, Grankvist et al. (2004) suggested that a higher level of certification increases consumers' preferences for the product. Robinson et al. (2016) verified that tenants exhibit higher willingness to pay for the building with higher certification level. Accordingly, this study hypothesized that certification will have a higher effect when a building obtains a higher certification grade, as stated in the following hypothesis:

H2. The impact of certification on tenants' willingness to rent decreases as certification grade is heightened.

The next influencing factor we examined is rent, which reflects the value of the building, including the building's location, condition, and facilities. This implies that a low-rent building has more room to improve its value through green building certification that does a high-rent building. It is thus expected that the certification on the low-rent building will generate a higher certification effect than on the high-rent one. This prediction is based on earlier findings by Vanclay et al. (2011) and Schuitema and Groot (2015) that a carbon label can be more effective if the product price is low. Akdeniz et al. (2012) provides another ground for this hypothesis. They argued that a product's price moderates the relationship between the level of the product's warranty and consumers' perception of product quality. The product warranty has a signaling effect that complements incomplete information about the product, and therefore, it is similar to green building certification, while product price is equivalent to rent. Accordingly, this study proposed the following hypothesis:

H3. The impact of certification on tenants' willingness to rent decreases as room rent increases.

Our final hypotheses consider two characteristics of individual tenants, their level of eco-friendliness and of green building–related knowledge, both of which are regarded as important individual factors that may influence consumers' sustainable purchasing behavior (e.g., Joshi and Rahman, 2017). In hypothesis 4a, we explore whether a person who has a higher level of eco-friendliness is more likely to prefer a building with certification. Intuitively, an eco-friendly person is more likely to evaluate eco-products higher. Grankvist and Biel (2007) confirmed that an individual's higher level of eco-friendliness generates a positive effect on liking a product more strongly. Hence, we propose that a more eco-friendly person takes greater interest in certification, as delineated below.

H4a. The impact of certification on tenants' willingness to rent increases as tenant's level of eco-friendliness increases.

Regarding green building knowledge, Mostafa (2007)

demonstrated that people with higher levels of environmental knowledge exhibit more positive attitudes toward eco-products and Joshi and Rahman (2017) contended that individuals' knowledge about sustainability issues positively affects their sustainable purchase behavior. In line with these findings, we propose Hypothesis 4b:

H4b. The impact of certification on tenants' willingness to rent increases as tenant's level of green building–related knowledge increases.

4. Experiment methods

4.1. Vignette-based experiment

We conducted a vignette-based experiment to test the above hypotheses. In a vignette-based experiment, different versions of a descriptive vignette convey scripted information about specific levels of factors of interest to human subjects (Rungtusanatham et al., 2011). This allows subjects to access only information controlled by a researcher and enables a researcher to examine the relationship upon which the study is focused (Hora and Klassen, 2013). This type of experiment can also minimize bias resulting from individual knowledge and experience and reduce selection bias through the random assignment of subjects (Hora and Klassen, 2013). Accordingly, the vignette-based experiment methodology has been widely used in examining consumer perceptions or evaluations regarding eco-labeling and green products (e.g., Grankvist et al., 2004; Luchs et al., 2010; Seo et al., 2016).

In the context of our research, a tenant's decision to rent space is affected by many factors – rent, year built, certification, and nearby facilities – and their interaction. While they are difficult to control, a vignette-based experiment allows us to extract the only impact of the certification due to consistent treatments to manipulate the factors we focus on. Nonetheless, this methodology also contains some limitations, most importantly that it provides virtually designed vignettes and thus does not directly measure willingness of actual tenant who considers renting space but rather measures of the intended willingness to rent of participants. To reduce this weakness of the experiment, we designed our vignettes to reflect real tenants' decisions, as delineated in the following section.

4.2. Experiment design

The vignettes of our experiment were carefully developed to investigate the effect of certification and its determinants. We followed Luchs et al. (2010)'s approach to improve validity during our experimental design and vignette development. To improve the realism of our vignette, we designed two types of vignettes in the form of rental advertising for an office space and for an apartment to represent commercial and residential rentals. In each type of vignette, participants were in a position to compare spaces in two buildings, a benchmark building with no certification and a building with green building certification. They were asked to evaluate their relative preference between them, based upon information that we manipulated. The relative preferences were measured by Likert scales, as in Grankvist et al. (2004) and Luchs et al. (2010).

Fig. 1 presents sample vignettes from the office rental case. The vignettes for the apartment rental purpose were designed in the same way, except that the title was changed to “R-Square City Apartment for rental.”

We manipulated information in our vignettes in the following ways. We considered two grades of green certification for certified buildings, A (representing a higher grade) and B (representing a lower grade), reflecting that current green building certifications,



Fig. 1. Sample vignette in our experiment.

such as LEED and Energy Star, have multiple grades depending on evaluation scores. The rental price of the certified building was manipulated as either a high rental price (33 m², \$1000/month) for a space close to a subway (1 min away) or a low rental price (33 m², \$300/month) for a space far from a subway (15 min away). Here, we used distance to the subway station as ancillary information to the rent, as it has been reported that subway accessibility has a positive correlation with building rents (Kim, 2007). We fixed the rental price of the benchmark building as low (i.e., \$300/month) to focus on the effect of the rental price of a certified building on tenants' relative preferences between them. The rental prices were chosen based on real rental prices observed in Seoul to improve the realism of our vignette. We assumed that all other conditions were equally given between the two buildings, except for the aforementioned manipulation variables. The building and region were given fictional names to minimize biases from the previous experiences of participants.

Based on a manipulation of two variables (i.e., the certification grade of the certified building and the rental price of the certified building), we considered four groups of participants for each of two different rental purposes to test the hypotheses, as shown in Table 2. In other words, a 2 (A or B) * 2 (high or low) between-subjects design was employed. As shown in the table, for example, participants in Group 3 were asked their relative preference between the benchmark building with a low rental price and the certified building with a low rental price and an A certification.

Prior to the main experiment, we conducted a pretest with a group of students to assess and modify the vignettes so as to maintain internal consistency and plausibility (Hartmann and Moeller, 2014). The students were asked to check the realism of the vignette and the validity of the manipulation. In addition, we received feedback from several researchers with expertise in such experiment-based research. Based on the results of the pretest and

feedback, we refined our experiment, especially the vignettes.

4.3. Measurement

To develop measurement, we conducted an extensive literature review on adjacent stream (e.g., studies that examine consumer perception in green product context) and choose the items which are most relevant to green building certification context. We also modified the items if necessary. To measure tenants' willingness to rent, we use relative preference for space in a building with certification over one without certification. In studies examining green products, such relative preference is popularly used to measure consumers' valuation for a product. Rokka and Uusitalo (2008) provided three options of products whose attributes were different to the participants, who were asked to select their preferred product. Grankvist et al. (2004) asked participants to indicate their preference between two products using a 21-point scale using a questionnaire that included the following items: "I would definitely choose product A" (1)/"I would definitely choose product B" (21). Luchs et al. (2010) adopted a measurement similar to that in Grankvist et al. (2004) to measure consumer preferences between products. In line with these studies, we asked participants to disclose their relative preference between the buildings by using a 7-point Likert scale as employed by the aforementioned studies. In our scale, a 7 indicated that a tenant strongly preferred the certified building, while a 1 indicated that a tenant strongly preferred the benchmark building.

As previously explained, we examined two important aspects of individual characteristics in our green building certification context: eco-friendliness and green building-related knowledge. Using a 7-point Likert scale, eco-friendliness was measured by four items, and green building-related knowledge was measured by three items that were adopted from the existing literature. The

Table 2
Group information.

		Rental price of certified building	
		High	Low
Certification grade	A	Group 1	Group 3
	B	Group 2	Group 4

survey items to measure eco-friendliness were adopted from Schuhwerk and Lefkoff-Hagius (1995) and D'Souza and Taghian (2005). In measuring green building-related knowledge, we adopted and modified the items in Gleim et al. (2013) and Chen and Deng (2016) to reflect green building certification context. We also obtained personal information for each participant (gender, age, and province where participants lived) to control the effect of individual characteristics. Table 3 shows all of the measurement items used in our experiment.

5. Result and discussion

5.1. Data collection

The experiments regarding the tenants' willingness to rent about office and apartment rentals proceeded as follows. First, we asked participants to respond to questions regarding their individual characteristics, i.e., their eco-friendliness and green building-related knowledge. Second, we provided participants with an instruction to the experiment, which included an explanation of the experimental process and that green building certifications are categorized as A or B depending on the evaluation of the building's green features (e.g., recycled materials, energy efficiency, indoor air quality). Next, we presented participants with a vignette in which we manipulated information regarding the certification and rental price and asked them to reveal their relative preference between the two buildings. Lastly, we asked participants to provide some personal information, including gender, age, and province where they lived. Fig. 2 shows the experimental procedure in this study.

This experiment was conducted with individuals who had experience in renting space in order to improve external validity. The participants were recruited from the database of a South Korean-based panel provider. Participants included 220 people in this experiment with the office context and 219 people with the apartment rental context, for a total of 439 participants. All of the participants received a \$2 award for their participation in the experiment. Table 4 presents a profile of the sample.

5.2. Validity test

To test the effects of personal characteristics, this study tested the validity and reliability of the measures. First off, an exploratory factor analysis (EFA) using principal component analysis with varimax rotation was conducted to determine the underlying structure of the personal characteristics measures including four items for individual's level of eco-friendliness and three items for individual's level of green building-related knowledge. A confirmatory factor analysis (CFA) was also conducted to evaluate the construct validity, reliability, and unidimensionality of the personal characteristics measures.

The results of EFA are presented in Table 5. Prior to EFA, we performed the Bartlett and Kaiser–Meyer–Olkin (KMO) tests and the results indicate that factor analysis was possible; the p value in the Bartlett test was $p < 0.001$ and the KMO ratio value was 0.835. Table 5 also shows that the factor loadings of all seven factors explained 71.32% of the total variance, indicating that the questions intended to measure each concept (i.e., the level of eco-friendliness and the level of knowledge) were grouped into the respective two concepts as intended.

The results of CFA are presented in Table 6. It first shows that validity of the constructs was verified and sufficient enough for hypotheses testing. While construct validity consists of three dimensions (content, convergent, and discriminant validity), the value of standardized path loadings and the criterion of (Fornell and Larcker, 1981) were all sufficient enough to ensure convergent validity and discriminant validity, respectively in line with the guideline in (Braunscheidel and Suresh, 2009). In addition, the content validity was ensured by the pretest mentioned in Section 4.2. Second, unidimensionality of the items were tested by several absolute and incremental fit measures (GFI, TLI, CFI, NFI, SRMR). All the fit indices for the questionnaires were satisfied recommended cutoff values, indicating that unidimensionality was confirmed. See, footnote of Table 6 for the detail. Lastly, the results confirmed the reliability of the constructs. Specifically, Cronbach's α value was 0.845 for eco-friendliness and 0.806 for green building-related knowledge, which were higher than the recommended cutoff

Table 3
Measurement items used in our experiment.

Variable	Item	Question	Scale	Reference
Certification D_A		A certification = 1 (Group 1, 3) B certification = 0 (Group 2, 4)		
Rental price D_High		High rental price = 1 (Group 1, 2) Low rental price = 0 (Group 3, 4)		
Tenant Preference TP		Which of these two buildings would you prefer to rent?	7-point Likert scale (Definitely Certified building [1] to Non-certified building [7])	Grankvist et al. (2004) and Luchs et al. (2010)
Eco-friendliness	EF1	I am concerned about the environment.	7-point Likert scale	Schuhwerk and Lefkoff-Hagius (1995), D'Souza and Taghian (2005), and Grimmer and Bingham (2013)
	EF2	The conditions of the environment affect the quality of life.		
	EF3	I am willing to make a sacrifice to protect the environment.		
	EF4	My actions impact the environment.		
Green building-related knowledge	KGB1	I am familiar with the green building concept.		Chen and Deng (2016) and Gleim et al. (2013)
	KGB2	When I rent space, I check the environmental information regarding the building.		
	KGB3	I trust the testing and identification of green buildings by certification organizations.		
Gender		Male = 1, Female = 0	Dummy	
Age		_____ years old	Numerical	
Province		1. Seoul, 2. City, 3. Others Province D_Seoul: Living in Seoul = 1, otherwise = 0 Province D_City: Living in City = 1, otherwise = 0	Dummy	

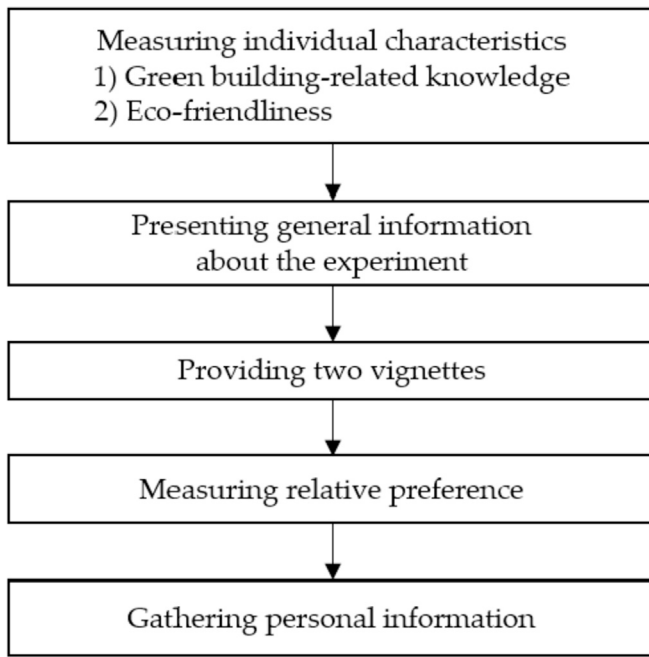


Fig. 2. Experimental procedure.

value of 0.7 (Hair and Black, 2014). The value of composite reliability and AVE were all higher than 0.70, which is the recommended rule of thumb by (Nunnally, 1978).

5.3. Hypothesis testing

We employed a one-sample *t*-test to confirm the impact of the green building certification on the tenants' willingness to rent (Hypothesis 1) because our dependent variable was the tenants' relative preference for the certified building over the benchmark building. Put differently, the dependent variable itself already contained the effect of the green certification, and thus the hypothesis could not be tested via regression analysis. Recall that we fixed the rental price of the benchmark building as low (\$300/month) for all groups. Therefore, to control for the effect of rental price on the tenant's relative preference, we used Groups 3 (A grade is used) and 4 (B grade is used) whose certified building also had a low rental price. As shown in Table 7, tenant preferences for the certified building were significantly higher than 4 (4 indicating no difference between the two buildings) for both groups. This indicates that tenants preferred a building with green certification to

Table 5
EFA test results.

Construct	Item	Validity		% Variance
		Factor Loading		
		Factor 1	Factor 2	
Eco-friendliness	EF2	0.824	0.157	39.10
	EF4	0.798	0.087	
	EF3	0.786	0.245	
	EF1	0.761	0.410	
Green building— related knowledge	KGB1	0.043	0.860	32.22
	KGB2	0.261	0.834	
	KGB3	0.393	0.749	

a building with no certification, and thus Hypothesis 1 is supported.

To test Hypotheses 2, 3, and 4, we conducted a multiple linear regression analysis, including certification grade, rental price, green building—related knowledge, eco-friendliness, and control variables. Multiple linear regression analysis is widely employed to test the collective contribution of independent variables to a dependent variable and thus suitable for testing these hypotheses. In our analysis, we conducted four multiple regressions by including independent variables step by step. First, we included only control variables (Model 1). Second, we added the certification and rental price dummy variables to Model 1 (Model 2). Third, we added individual characteristics variables—knowledge of green building and eco-friendliness—to Model 1 (Model 3). Finally, we combined all the independent and control variables (Model 4). This approach allowed us to check whether the impact of an independent variable on the dependent variable is significant even if the other independent variables are not controlled. To conduct the analysis, we coded the certification grade as a dummy variable that took a value of 1 if the certification was an A grade. The rental price was also coded as a dummy variable that took a value of 1 if the rental price was high. Since the variables related to personal characteristics were originally measured as continuous type, they were suitable to use in the regression analysis.

Table 8 (a) and (b) reports the results of the multiple linear regression analyses for the two different types of buildings we considered. It was evident that all of the results were consistent, regardless of whether the tenants' purpose was to rent commercial or residential space. The table shows, first, that there was no significant relationship between the certification grade and tenant preference, suggesting that a higher certification grade may not enhance tenants' preference for the building with certification over one without certification. We infer that once the building was certified, the difference between the grades might be a minor factor in determining tenants' preferences and its effect was not significant enough to exhibit a statistical difference between the grades.

Table 4
Sample profile.

Office experiment						
Gender	Male			Female		
	126			94		
Age	Mean	Standard deviation		Max		Min
	46.26	12.53		73		24
Province	Seoul		City		Others	
	90		61		69	
Apartment experiment						
Gender	Male			Female		
	123			96		
Age	Mean	Standard deviation		Max		Min
	46.74	11.93		65		22
Province	Seoul		City		Others	
	95		56		68	

Table 6
CFA test results.

χ^2	GFI	TLI	CFI	NFI	SRMR
75.279 ($p < 0.005$)	0.952	0.927	0.955	0.946	0.048
Recommendation ^a	≥ 0.90	≥ 0.90	≥ 0.90	≥ 0.90	≤ 0.08
Model construct	Standardized path loadings	Critical ratio ^b	Composite reliability	Cronbach's Alpha	AVE
Green building–related knowledge	KGB1 0.646	—	0.884	0.806	0.719
	KGB2 0.819	13.191			
	KGB3 0.825	13.222			
Eco-friendliness	EL1 0.872	—	0.895	0.845	0.681
	EL2 0.754	17.308			
	EL3 0.744	17.031			
	EL4 0.650	14.357			
Fornell and Larcker's criterion		Product Knowledge		Eco-friendliness	
Green building–related knowledge		0.825^c			
Eco-friendliness		0.552d		0.848	

Note.

^d The off-diagonal element is the correlation between construct.^a In order for the CFA result to be significant, it is suggested that GFI \geq 0.90, TLI \geq 0.90, CFI \geq 0.90, RFI \geq 0.90, and RMR \leq 0.08 (Hu and Bentler, 1999; Menor and Roth, 2007).^b All t-values are significant at $p < 0.001$ level.^c The diagonal elements in bold are the square roots of AVE.

Second, the table shows that the rental price variable was significant with a positive coefficient, indicating that tenants preferred a certified building with a low rental price over one with a high rental price. Lastly, it was observed that there was no relationship between individuals' green building–related knowledge and their relative preference but a significant relationship between individuals' eco-friendliness and their relative preference. This indicates that people with a higher level of eco-friendliness preferred the building with green certification to the building without green building certification (i.e., exhibited higher willingness to rent) but that knowing more about green buildings per se did not necessarily strengthen the green building certification effect. Lastly, we found a significant relation between several control variables and tenants' relative preferences. In the case of the office rental experiment, younger people preferred the certified building. In the apartment rental experiment, people living in urban areas (Seoul and other cities) exhibited a higher preference for a building with green certification. In sum, as shown in Fig. 3, Hypotheses 3 and 4a are supported, whereas Hypotheses 2 and 4b are rejected.

Before ending this section, we checked the robustness of our results by implementing a logit regression considering that tenant preference for the building with green certification over one without certification can be discrete, i.e., prefer the certified building or not compared to the other. Recall that we measured tenants' relative preference by using a 7-point Likert scale item in which 7 indicated that a tenant definitely preferred the certified building. We thus converted this scale into two categories, *prefer* (from 5 to 7) and *do not prefer* (from 1 to 4) and conducted the logit regression with them as in Epstein and Widener (2011). We found that all the results remained the same except that the relation between eco-friendliness and the tenant preference (hypothesis

Table 8 (a)
Multiple linear regression analysis result: Office experiment.

Office Experiment	Dependent variable: Relative preference of tenant			
	Model 1	Model 2	Model 3	Model 4
Constant	4.106**	4.724**	4.220**	4.811**
<i>Independent variables</i>				
Certification D_A		−0.122		−0.112
Rental price D_High		−1.415**		−1.386**
Green building–related knowledge			0.198	0.161
Eco-friendliness			0.281*	0.267*
<i>Control variables</i>				
Gender	−0.409	−0.446*	−0.375	−0.408
Age	0.026**	0.029**	0.024*	0.027**
Region D_Seoul	0.127	0.109	−0.004	0.001
Region D_City	−0.029	0.043	−0.077	0.003
F	2.664*	9.095**	3.293**	8.090**
R ²	0.047	0.204	0.085	0.235
Adjusted R ²	0.029	0.182	0.059	0.206

Note: ** and * represent statistically significant coefficients at 0.01 and 0.05 levels, respectively.

Table 8 (b)
Multiple linear regression analysis result: Apartment experiment.

Apartment experiment	Dependent variable: Relative preference of tenant			
	Model 1	Model 2	Model 3	Model 4
Constant	5.080**	5.367**	5.183**	5.447**
<i>Independent variables</i>				
Certification D_A		0.329		0.335
Rental price D_High		−1.426**		−1.381**
Green building–related knowledge			0.093	0.105
Eco-friendliness			0.404**	0.361**
<i>Control variables</i>				
Gender	−0.433	−0.369	−0.395	−0.343
Age	−0.005	0.001	−0.007	−0.001
Region D_Seoul	0.839**	0.670*	0.800**	0.637*
Region D_City	0.659*	0.727*	0.629*	0.696*
F	2.940*	9.446**	4.044**	8.842**
R ²	0.052	0.211	0.103	0.252
Adjusted R ²	0.034	0.189	0.077	0.223

Note: ** and * represent statistically significant coefficients at 0.01 and 0.05 levels, respectively.

4a) for the office building became weakly significant, such that $p < 0.1$ (see Table 9).

6. Conclusion

This study investigated the impact of green building certification on tenants' willingness to rent using a vignette-based experiment. The participants were asked to compare their relative preference for a green-certified over non-certified building to verify the effect of green building certification. This study also sought to determine the moderating effect of certain certification, building, and personal characteristics to determine under what circumstances the effects of green building certification are maximized.

Table 7
One-sample t-test result.

	Office Experiment				Apartment Experiment		
	N	Relative preference	t-test		N	Relative preference	t-test
Group 3 (A grade)	55	5.71	8.907 **		55	6.02	10.945 **
Group 4 (B grade)	56	5.86	9.454 **		54	5.72	8.181 **

Note: ** represents statistically significant coefficients at 0.05 level.

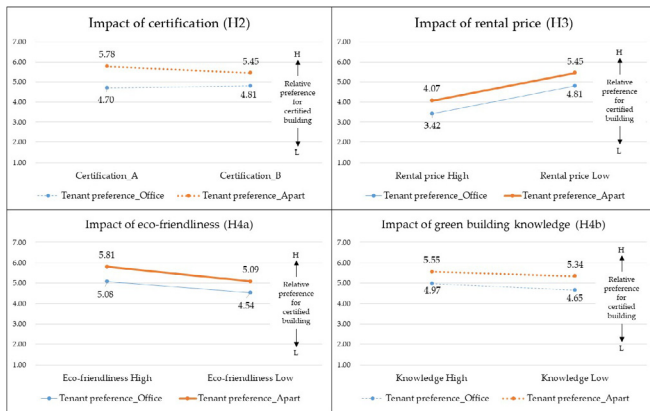


Fig. 3. Summary of the regression results. Note: One standard deviation above and below the mean (i.e., $\mu \pm \sigma$) are used to represent high and low level of eco-friendliness and green building-related knowledge, respectively. Solid lines indicate that the slope is significant ($p < 0.05$), while dashed lines indicate that the slope is insignificant.

Table 9
Logit regression result.

	Dependent variable: Relative preference of tenant dummy	
	Office experiment	Apartment experiment
Constant	0.234	0.953
<i>Independent variables</i>		
Certification D_A	−0.147	0.344
Rental price D_High	−1.800**	−1.472**
Green building-related knowledge	0.340*	−0.013
Eco-friendliness	0.276	0.491**
<i>Control variables</i>		
Gender	−0.522	−0.246
Age	0.048**	0.005
Region D_Seoul	−0.321	0.294
Region D_City	−0.033	0.931*
Overall percentage correct	72.7	66.7
Log-Likelihood	223.915	239.672
Chi-square	48.169	37.715
d.f.	8	8

Note: ** and * represent statistically significant coefficients at 0.01 and 0.05 levels, respectively.

This is one of the first studies to investigate the cognitive effect of green building certification on potential tenants as well as situational factors that moderate the certification effect in the context of office and apartment rentals.

The findings of this work have implications for green building stakeholders such as building owners and governments. First, the results indicate that green building certification increased a tenant's willingness to rent space in a building but that a higher grade of certification did not necessarily lead to a higher willingness to rent, supporting a similar observation by Addae-Dapaah and Chieh (2011). For building owners (e.g., real estate development and investment companies) whose buildings are not likely to obtain a high certification grade, this suggests that obtaining a lower grade might be a good strategy considering the cost to improve buildings to get a higher certification grade. From the perspective of governments, these results suggest that it is worthwhile to implement the policy that promotes green building certification adoption by building owners. For instance, the Korean government integrated different certification schemes to effectively spread green building certification across the buildings by avoiding confusion for building owners (Shin et al., 2005). The new certification G-SEED developed

in 2002 has four different grades depending on the evaluation scores for eight criteria, including land use, energy and environment, etc. It is reported that over 8000 buildings have been certified by G-SEED by 2016 (Yun et al., 2018). However, the government should notice that tenants might not discern the difference between the certification grades, as intended. OECD guideline (2012) stressed that such unintended outcome may result from individual cognitive bias. Governments are then encouraged to examine how tenants perceive the certification grade and reflect the results to certification design. For instance, if they find it difficult to discern the difference in grades, using different colors for different grades might be helpful (Pancer et al., 2017). Second, the finding that a low-rent building reaped a higher certification effect than a high-rent building from obtaining a green building certification suggests that owners of low-rent buildings whose location is not close to a subway station might increase the value of their buildings or reduce their vacancy ratio by obtaining a green building certification. Third, the finding that the effect of certification was heightened among consumers with a higher level of eco-friendliness. Although it is in line with intuition, this suggests that policies that promote elevating eco-friendliness (e.g., public advertisements and eco-education programs for children) may help intensify the certification effect, which in turn may catalyze the expansion of green buildings. In sum, the findings of this work provide useful guidelines to the public sector (governments and NGOs) in designing green building certification and to the private sector (building owners) in making decisions regarding green building certification.

This study also has several limitations in providing an understanding of the relation between green building certification and tenants' perceptions of buildings. First, it did not fully incorporate various kinds of factors in tenants' decision making, such as indoor air quality and access to natural light. We encourage future researchers to incorporate such important green building features and investigate how they interact with green building certification, which could also help identify which green features might be particularly important to potential tenants. For instance, further information on green building features (e.g., air quality and energy efficiency) can be provided with the certification to estimate relative importance among them. Second, the concept of green building may be different across the participants and may distort the results. Future studies could provide more specific definitions of green buildings to the participants to avoid this potential problem. Third, it would be meaningful to ask whether willingness to rent indeed results in tenants' satisfaction on green building. Finally, the certification scheme used in this study had only two grades (A and B), and it would be worthwhile to investigate whether more certification grade levels would enhance tenants' willingness to rent space in a building.

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