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Green Noise or Green Value? Measuring the Effects of Environmental Certification on Office Values

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This study investigates the price effects of environmental certification on commercial real estate assets. It is argued that there are likely to be three main drivers of price differences between certified and noncertified buildings. These are additional occupier benefits, lower holding costs for investors and a lower risk premium. Drawing upon the CoStar database of U.S. commercial real estate assets, hedonic regression analysis is used to measure the effect of certification on both rent and price. The results suggest that, compared to buildings in the same submarkets, eco-certified buildings have both a rental and sale price premium.

Given that buildings are estimated to be responsible for 20% of greenhouse gas emissions, there is growing awareness within the real estate sector of global warming and the role of real estate in reducing the environmental effects of business (Stern *et al.* 2007). Whether a purely market-driven approach or mandatory environmental regulations imposed by governments and supranational organizations can be expected to be more effective in reducing carbon emissions from the building stock is a highly contested issue. In the real estate sector, a blend of mandatory government regulation and voluntary industry standards has emerged in response to pressure to reduce the environmental impact of the building stock. As a result, required building standards have tended to become more stringent. Mandatory certification has been introduced. A good example is the introduction of a requirement for buildings to publicly display Energy Performance Certificates following the EU Directive on the Energy Performance of Buildings in 2003. However, additionally, the growth of environmentalism has lead to the emergence of market-based approaches in the form of a range of voluntary environmental certification systems for buildings such as Green Star (Australia), LEED (United States, Leadership in Energy and Environmental Design), Energy Star (United States), Green Globes (United States) and

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BREEAM (United Kingdom, Building Research Establishment Environmental Assessment Method).

Price signals are central to the operation of markets providing the information basis for the allocation of resources. For market-based solutions to be successful, prices need to reflect environmental costs and benefits. In a real estate context, higher risk-adjusted returns of certified assets potentially provide a signal that is transmitted from the investment market to the space market subsequently causing an increase in the supply of green buildings. Although "green markets" have expanded dramatically in some sectors of the economy in response to pricing signals, there is little empirical evidence that commercial real estate prices are influenced by their sustainability characteristics despite widely propagated financial and environmental benefits.

This article investigates the price differentials between LEED/Energy Star certified buildings and noncertified commercial buildings in the United States. The contributions are twofold. First, it seeks to provide a theoretical grounding for the expected price differential between certified and noncertified buildings. Given that the literature suggests that certified buildings may offer a bundle of benefits linked to lower operating costs, improved employee productivity, tax credits and image benefits relative to noncertified buildings, we use a static partial equilibrium framework to demonstrate short-run price effects of certification. Assuming that the benefits of certification outweigh the costs, the theoretical analysis suggests short-run rental price premium for green buildings due to inward shifts in the demand curve for noncertified buildings. However, in the long run the persistence of rental price premia is contingent upon the level of market penetration and changes in regulation and technology. It is argued that asset price premia are a reflection of higher rental incomes, lower holding costs and/or reduced risk premia.

The second contribution of the article is empirical. We measure both the effect of voluntary certification on occupational prices (rents) and on asset prices (sales). In the empirical analysis, certified buildings are compared to a sample of noncertified buildings which were selected to include properties in the same submarket areas as the certified sample. For the whole sample, rents and prices are related to a set of hedonic characteristics of the buildings such as age, location and number of stories, *inter alia.* Essentially, our hedonic model is measuring price differences between certified buildings and randomly selected noncertified buildings in the same submarkets controlling for differences in age, height, quality, submarket, *etc*. We first estimate the rental regression for a sample of 197 LEED and 834 Energy Star as well as over 15,000 benchmark buildings. The results suggest that certified buildings have an average rental premium of 4–5%. Furthermore, based on a sample of sale prices for 559 Energy

Star- and 127 LEED-certified buildings, we find price premia of 26% and 25%, respectively with higher levels of certification achieving higher premia.

This article is organized as follows. The first section provides a background discussion focusing on the growth in environmental certification, the nature of environmentally responsible buildings and previous research on their costs and benefits. This is followed by a theoretical analysis of the anticipated price effects of environmental certification for commercial real estate assets in both occupier and investment markets. Next, the main empirical section outlines the data and methods used in the study followed by a discussion of the results. Finally, conclusions are drawn.

Background

The market for eco-friendly products has been expanding for a range of consumer products in response to a willingness-to-pay (WTP) premium for goods and services which are considered to have reduced environmental costs. This global growth in the market for products with lower environmental costs has stimulated an array of voluntary certification and labeling codes in a number of industries. Reinforcing this shift is the fact that many certification and labeling codes are viewed as contributing to a price-based solution to promote what is, essentially, private provision of environmental public goods (Kotchen 2006). The LEED Green Building Rating System and the Environmental Protection Agency's Energy Star are two schemes that have been developed for the commercial real estate sector in the United States.

The LEED Green Building Rating System, developed by the U.S. Green Building Council, consists of a set of standards for the assessment of environmentally sustainable construction. The rates of growth in numbers of green buildings have been rapid with numbers doubling nearly every 2 years. As of May 1, 2009, there are 657 LEED-certified office buildings and 2,393 Energy Star-rated commercial buildings in the CoStar database. In common with the major regional certifications such as Green Star and BREEAM, the LEED rating system focuses on six broad categories related to sustainability of location, water efficiency, energy and atmosphere, materials and resources, indoor environmental quality and innovation and design process.

There are different levels of LEED accreditation based upon a scoring founded upon the six major categories listed above. The thresholds are mainly absolute in the sense that all buildings put forward that meet the required standards are certified. In LEED for new construction and major renovations for commercial premises, buildings may qualify for four levels of certification: Certified, Silver, Gold and Platinum. In contrast to the rather comprehensive assessment of buildings under the LEED scheme, Energy Star certification considers solely the energy performance of a property. Buildings are awarded a score out of 100. Another difference to LEED is that Energy Star is a measure of *relative* energy efficiency and environmental performance. Only buildings that are in the top quartile of buildings put forward are eligible for Energy Star accreditation.

It is notable that there have been reports of some real estate developers making fraudulent claims about having obtained LEED certification in the early stages of construction (see Burr 2009). This underlines the perceived attractiveness of the LEED certification scheme. Furthermore, LEED certification is more costly to obtain in terms of fees, encompasses a broader range of sustainable attributes and is comparable to other real estate eco-certification schemes in the Uinted Kingdom, Germany and Australia. There is an expectation that premia should vary between Energy Star and LEED certified buildings and also within the different levels of LEED buildings.

There is a large body of work on the attractions of and case for green buildings. Depending on the linkage between price and production cost, the existence and size of a cost premium to construct certified buildings may be relevant to price premia. There are two main types of additional costs associated with obtaining eco-certification for commercial buildings. The first are the payments to the certifying body for rating the building. The second are the additional production costs associated with meeting the certification standards. In terms of the latter, there have been a number of studies of the construction cost premium associated with achieving certification (see, *e.g.*, Kats 2003, Morrison Hershfield 2005, Berry 2007). These studies suggest small construction cost premia of around 2% on average. The most recent and authoritative studies have come from Davis Langdon (a global construction consultancy). Their most recent study compared 83 building projects with a primary goal of LEED certification with 138 similar building projects without the goal of sustainable design (Mathiessen and Morris 2006). Confirming the findings of earlier studies, they found no significant difference in average costs for building projects with a primary goal of LEED certification as compared to noncertified buildings.

In return, a range of benefits are attributed to green buildings or associated with features common in green buildings. Owners, developers and occupiers may obtain benefit from the diverse range of subsidies and tax benefits[1] that have appeared for LEED-certified buildings. For tenants these are related to reduced operating costs of the building (mainly associated with energy and other utility savings), improved productivity of the occupying business (associated with

[1]A number of states have introduced various incentives to encourage greater supply of certified buildings.

reduced staff turnover and absenteeism, *inter alia*), possible tax and other incentives and other competitive advantages linked to marketing and image benefits. It is expected that these benefits will produce increased rental bids from potential tenants. It should be noted that the nature of the lease contract will determine whether tenants benefit directly from reduced energy and other utilities. Tenants with net rental contracts pay these costs directly and therefore should be attracted to premises with lower operating costs, whereas tenants on gross rental contracts will not benefit directly from such savings.

In addition to the possible rental premiums, owners may also benefit from reduced holding costs (due to lower vacancy rates and higher tenant retention), reduced operational costs (due to energy and other utility savings), reduced depreciation (linked to the use of latest technologies) and reduced regulatory risks. *Ex ante*, microlevel studies have found that the present value of the reduced operating costs alone is sufficient to cover the construction cost premium (see Kats 2003, Ecofys 2003). The crucial question is then if and to what extent occupiers of certified space exhibit WTP for the cost savings and other benefits associated with eco-certified space. In this sense, WTP reflects the amount of money a consumer is willing to contribute to equalize a utility change (Mäler 1974, Field and Field 2009). Besides observing revealed preferences, WTP is primarily measured through contingent valuation surveys (Becker, DeGroot and Marschak 1964). In a real estate context, contingent valuation surveys have revealed that occupiers are prepared to compensate owners for the additional costs of green buildings through higher rents (see GVA Grimley 2007, McGraw Hill Construction 2006 for examples). However, the value of such stated preference studies is limited by the "cheap talk" problem. It is important to distinguish between what occupiers and investors state that they are ready to pay from what they really pay.

Notwithstanding the high growth rates of eco-certified buildings in recent years—albeit from a low base—the buildings' relatively low proportion of the overall market may appear puzzling given the apparent benefits of certified relative to noncertified buildings. This may be attributed to market failure—when allocations resulting from rational agents operating in decentralized markets are suboptimal. This is widely implied in the literature and research to date (see, *e.g.*, Guy 1998, Upstream 2004, Royal Institution of Chartered Surveyors (RICS) 2005, United Nations Environment Programme (UNEP) 2007). The lack of adoption of sustainable features is linked with the lack of an appropriate investment return through the pricing process. This has been explained by imperfect information, split incentives, risk aversion, high discount rates and skills shortages, *inter alia*. In addition, there may be other reasons that, despite its importance, sustainability may not be reflected in the prices of buildings. The pricing process may be dominated by the weight placed by market participants on a number of overriding attributes such as location and appearance. Further, the heterogeneity of real estate may also be hindering the measurement of price impacts.

An alternative perspective that must be considered is that there is no market failure and that firms are not systematically making nontrivial mistakes in their evaluation of investments in environmentally beneficial investments. It has been found that the high discount rates applied by businesses to investments in energy-saving technologies and investment opportunities are not unique to energy (Anderson and Newell 2004). In a similar vein, Sanstad, Hanemann and Auffhammer (2006) point out that many of the barriers identified above are normal features of markets. They examine the suggestion that what seems to be evidence of irrational underinvestment may therefore reflect measurement error, the omission of relevant costs and other analytical failures.

Much of the research of the pricing effect of sustainable features in commercial property assets has been normative (*i.e.*, analyzing what the price effect should be) rather than positive (*i.e.*, what the price effect actually has been). Studies have focused on quantifying expected price effects of sustainable features in commercial real assets rather than measuring observed effects (see Ellison, Sayce and Smith 2007). In many cases, it is clear that the researchers are frustrated and disappointed at the absence of empirical evidence to validate their deductive reasoning on price effects (see RICS 2005).

Additionally, although it is indisputable that some attributes of buildings have clear effects on market price, it is not always clear that increased cost due to higher specification leads to increased value. To compensate for the additional costs of construction of certified buildings, rational investors will require a combination of higher income and/or reduced risk. In research on the pricing of variations in lease terms, the standard assumption of lease pricing models is that real estate investors will extract the same value from the property regardless of leases structure (see Grenadier 1995, Booth and Walsh 2001, Ambrose, Hendershott and Klosek 2002). In short, investors are assumed to be fully compensated for the costs of providing attributes that occupiers demand. However, in practice, institutional features of the rent determination process may prevent the transmission of expected price effects to actual prices. For instance, researchers have been unable to identify empirically an expected term structure of rents (see Englund *et al.* 2004, Bond, Loizou and McAllister 2008).

It is clear from the discussion above that real estate investors may be rewarded for the additional costs of providing certified buildings in three main ways: higher rents, lower holding costs and/or lower risk. Effects may be identified in either the occupier and/or the investment market. Failure to observe price premia in certified buildings would provide an economic disincentive to real estate investors to supply certified buildings given the additional costs of certification.

Anticipated Price Effects—Theoretical Considerations

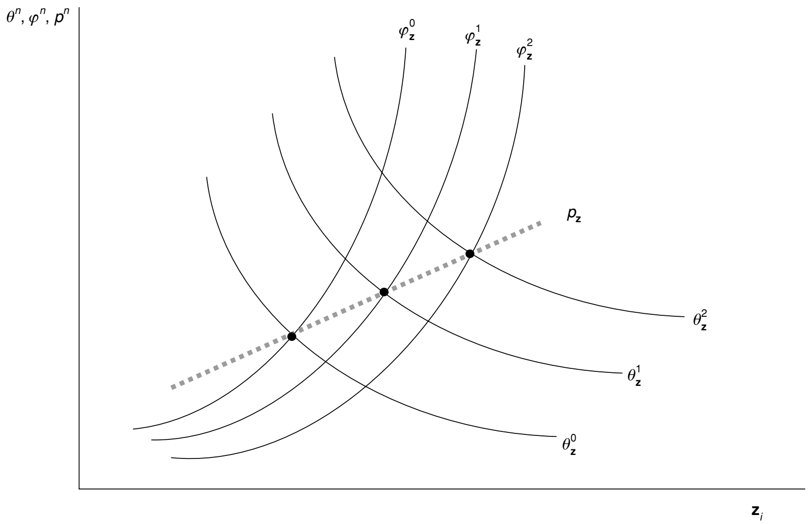
Before proceeding to our empirical analysis, we analyze the anticipated or theoretical price effects. We do so first by demonstrating the marginal price effect of a single hedonic characteristic (eco-certification) and second by showing aggregate market outcomes in a partial equilibrium framework. The first part of this analysis is based on Rosen's analytical framework, which starts with the assumption that any good or service consists of a variety of utility-bearing characteristics $(z_1, z_2, \ldots, z_n)$ making up the hedonic price function (Rosen 1974). In the context of office rent determination, these characteristics consist of various structural, locational and lease characteristics that enter into the empirical model as independent variables. The empirically determined hedonic prices are indicative of an implicit market so that demand and supply functions can be derived for both short-run and long-run competitive equilibria. Although certified and noncertified properties may not be close substitutes in the marketplace—particularly for the group of eco-consumers—we assume in the first step that they are variations of an ingredient i which represents eco-certification in this analysis. In a vector $\mathbf{z}$ of bundles of relevant characteristics, $\mathbf{z}_i$ represents the presence and level of eco-certification of a given building. The resulting bid or value function of a consumer is determined by the concave utility values of u_{zi} (the utility of certification in the presence of all other relevant attributes), u_x (the utility of all other products consumed) and y (the budget constraint). The bid function θ_{zi} is thus described as

$$\theta_{\mathbf{z}_i} = {}^{U_{\mathbf{z}_i}}\!/_{U_x} > 0, \theta_u = {}^{-1}\!/_{U_x} < 0 \text{ and } \theta_y = 1. \qquad (1)$$

At a given utility and budget, this function reveals a consumer's implicit WTP for a given vector of building attributes $\mathbf{z}$. Within the space of possible indifference surfaces arising from this, utility is maximized where the consumer's bid function equals the market price as θ_{zi} $(\mathbf{z}^*, u^*, y^*) = p_i(\mathbf{z}^*)$ where $*$ denotes optimum quantities.

Turning to producers, the offer function φ is determined by the vector of characteristics containing among others eco-certification (or lack thereof) z_i, a profit-maximizing condition π and a shift parameter β reflecting the cost minimization of factor prices and production function parameters. Taking into account the optimal number of units produced with specification $\mathbf{z}_i$, the producer's equilibrium function is determined at the intersection or tangency between the profit-attributes-costs indifference curve and the market characteristics–implicit price surface in the form φ $(\mathbf{z}_i^*, \pi^*, \beta^*) = p_i(\mathbf{z}^*)$. Figure 1 shows implicit equilibrium prices for the characteristic $\mathbf{z}_i$ representing eco-certification. The

Figure 1 ■ Marginal hedonic prices of eco-certification resulting from equilibrium reservation prices.

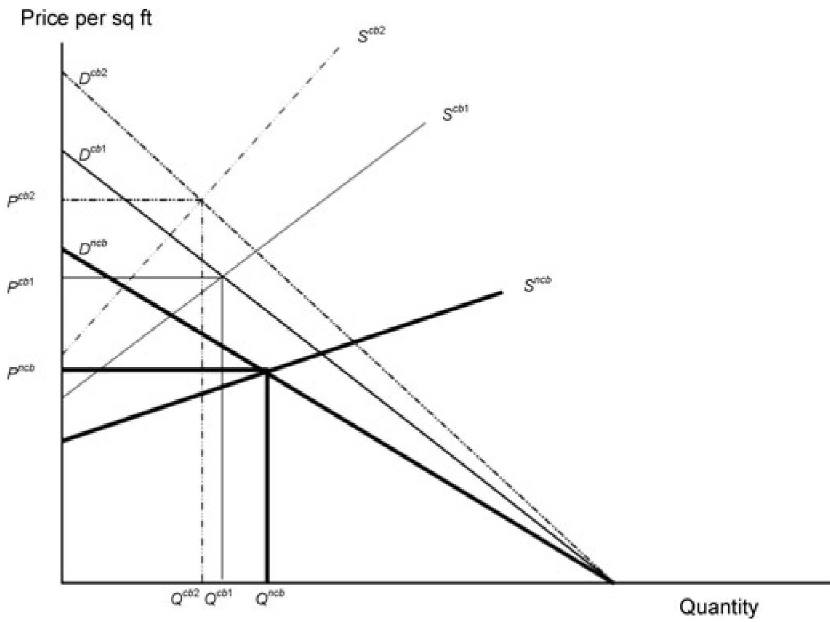


Note: This figure shows derivatives of a consumer's bid function $\theta_{\mathbf{z}i}$ representing demand-reservation prices for buildings with various levels of eco-certification and the producer's function $\varphi_{\mathbf{z}i}$ representing reservation supply prices of an increment in the level of eco-certification $\mathbf{z}_i$. The resulting dashed line $p_i(\mathbf{z})$ is then the marginal price of incremental levels of eco-certification $\mathbf{z}_i$ where reservation demand prices and reservation supply prices intersect.

marginal price of eco-certification is shown by $p_i(\mathbf{z})$ where the optimal level of $\mathbf{z}$ is defined as the intersection of the marginal value to the consumer and the marginal cost to the producer. Overall, the graph demonstrates how higher levels of eco-certification are associated with higher marginal prices.

To further demonstrate the effect of a set of implicit marginal prices on aggregate supply, we use a static partial equilibrium framework (see Sedjo and Swallow 2002). In line with our basic assumption of the first part of this analysis, we hypothesize that both types of products are not perfect substitutes but operate in a closely interrelated market so that an increase in demand for certified buildings will be reflected in a fall in demand for noncertified buildings. As demand for certified buildings increases, it will lead to an increase in their rents/prices and, given short-run inelasticity of supply, a premium will be observed. The key issue is the extent to which (or indeed whether) eco-certification changes the demand and supply functions for certified and noncertified buildings. Key factors are the additional costs associated with certification and occupiers' WTP an additional sum for certified buildings. The additional costs and WTP are also expected to increase as the level of certification increases producing

Figure 2 ■ Short-run effect of introducing certification into the market.



Note: This figure shows the various aggregate demand and supply curves for noncertified buildings and for buildings with different qualities of eco-certification. Certification is assumed to increase production costs so that there is an upward shift in the supply curve. It is assumed that higher levels of certification have higher costs and that the supply curve shifts further upwards and the supply becomes more inelastic ($S^{ncb} \rightarrow S^{cb1} \rightarrow S^{cb2}$). In the same manner, the demand curve for certified buildings shifts outwards to reflect an assumed increase in WTP for certified products ($D^{ncb} \rightarrow D^{cb1} \rightarrow D^{cb2}$). Thus, different partial equilibrium quantities and prices are established.

different equilibrium prices and quantities for different levels of certification.

In Figure 2, the rental supply and demand curves for space are plotted for certified and noncertified buildings. The central assumption is that the supply and demand curves are different for certified and noncertified buildings and among the different levels of certification, for example, LEED Silver relative to LEED Platinum. Assuming increased costs associated with certification, supply is more inelastic as developers require increased prices to offset these costs ($S^{ncb} \rightarrow S^{cb1}$).[2] In addition, the demand curve for certified buildings shifts outwards as occupiers are assumed to be prepared to pay more for certified

[2]There is also a possibility, however, that the ratio of differential value of certified space to total marginal value depends on the level of price. This would produce a different set of demand curves and ultimately different equilibrium prices.

products ($D^{ncb} \rightarrow D^{cb1}$). The resulting equilibrium prices and quantities P^{ncb}, P^{cb1} and Q^{cb1}, Q^{cb1} indicate higher prices and lower quantities for certified buildings. However, the demand curves converge because it is assumed that the marginal WTP a premium by eco-consumers diminishes as the quantity supplied increases.[3] This means that, when large quantities are consumed at a low price, the premium disappears. *In extremis,* when the price is effectively zero, the quantities demanded are equal for certified and noncertified space.

However, the market for certified buildings is not homogeneous. The additional costs and WTP are assumed to increase as the level of certification increases producing different equilibrium prices and quantities for different levels of certification. Again, assuming a simplified two-tier certification system, prices increase from P^{cb1} to P^{cb2} where $cb2$ is a higher level of certification than $cb1$.

Although the discussion above essentially analyzes possible market outcomes in a static partial equilibrium framework, the dynamic aspects of market entry and diffusion pertaining to price effects need to be explored. In the long run, the dynamic interaction between the markets for certified and noncertified space is more intricate depending on, among other factors, the market share of certified space. As market penetration of the new product progresses, the supply curves of certified space shift downwards which increases aggregate quantities and reduces prices.

When measuring the change in demand arising from the introduction of a new product, two separate effects have to be disentangled: a variety effect resulting from increased product differentiation in a particular market and a pure price effect resulting from changes of prices of existing products following the introduction of the new product (see Hausman and Leonard 2002, Brynjolfsson, Hu and Smith 2003). Leaving aside the variety effect on both certified and noncertified space, we hypothesize that economies of scale in eco-building production and services will tend in the longer term to reduce the marginal and average costs of certification. The comparatively more advanced production technology involved in producing eco-certified buildings is expected to command a price premium that is relatively large at the time of initial market entry but declines with increasing standardization and market share of the certified product. Thus, the price premium is simultaneously eroded by both supply-side factors, that is, lower cost of producing a unit of certified space, and demand-side factors,

[3]An alternative demand curve rotation could be hypothesized. For instance, it could be argued that, if occupiers gain less utility from consumption of the first unit of a certified product relative to subsequent units, the premium that occupiers are willing to pay increases as their total consumption of the certified product increases. Following this assumption, the demand curves pivot around the intercept on the vertical axis.

that is, diminishing image benefits to consumers as certified space becomes the norm. In this setting, premiums are expected to decline to a level that purely reflects the cost savings.

However, long-run price differentials are likely to be driven by technological progress, market penetration rates and regulation, all of which are very difficult to foresee at this point. If regulatory standards were both static and absolute and market penetration increased, utility from eco-certification would be expected to decrease as an increasing proportion of the building stock reached the level of environmental performance required for certification. Where environmental performance standards are relative (*e.g.*, certification granted based on evidence of environmental performance in the top quartile of all buildings), there will by definition be a group of buildings that are considered a separate market segment irrespective of general standards. Premia for this group of buildings are likely to persist. However, where there are absolute certification standards, required environmental performance thresholds are unlikely to remain fixed at current levels and definitions. When environmental standards become more stringent in absolute terms, buildings certified under a previous regime will be affected by regulatory obsolescence and may become regarded as an inferior market segment. As a result, in the long run, rental price effects are contingent upon changes in the regulatory regime and upon the blend of relative and absolute thresholds that are introduced. These changes will also influence capital values.

In addition to rental premia, as discussed above there are additional ways in which asset pricing of marginal investors may be affected by certification. The net operating incomes of certified buildings may be higher than those of non-certified buildings due to rental premia, higher occupancy rates, incomes from incentives and subsidies and reduced outgoings due to lower operating costs. Expected income growth may also be higher than noncertified buildings due to reduced depreciation and obsolescence. In terms of the denominator of the standard valuation equation, it could be argued that the reductions in regulatory risk (sometimes referred to as future-proofing) associated with certified buildings and the relative reductions in uncertainty of income may mean that investors apply a lower risk premium. Although many of these anticipated effects on costs and incomes are, at present, largely conjectures, below we investigate whether expected effects on prices can be observed empirically.

Actual Price Effects—Empirical Research

Few studies have attempted to measure the price effects of green building certification. Studies that have identified higher rents and improved returns based on the views and experiences of expert professions still require empirical verification. Recent reviews of the extant literature agree on the centrality of pricing to adoption but have found little convincing evidence of a certification premium (see Berry 2007). In a further study, Nelson (2007) examines the performance differences between certified and noncertified buildings using a number of criteria. Drawing upon the CoStar database, the author compares LEED rated buildings and Energy Star buildings with a vastly larger sample of noncertified buildings in the CoStar database. He acknowledges the significant differences between the sample and the wider population and finds that certified buildings tend to be newer, owner-occupied or single tenanted and concentrated geographically and sectorally (in the office sector). Recognizing that it did not control for these differences, the study identifies lower vacancy rates and higher rents in LEED-rated buildings.

There has been a group of studies that draw upon the CoStar database of U.S. properties to identify the effect of environmental certification on sale prices and rents. To control for differences between their sample of certified buildings (927 buildings) and a much larger sample of noncertified buildings, Miller, Spivey and Florance (2008) include a number of control variables such as size, location and age in their hedonic regression framework. They find that dummy variables for Energy Star and LEED ratings show the expected positive sign, but tests show that these results are not significant at the 10% level. Using the same data, Miller, Spivey and Florance (2008) also report respective sale price premiums of approximately 6% and 11% for Energy Star- and LEED-certified offices, respectively. Wiley, Benefield and Johnson (2010) focused on the effect on rent, occupancy rate and sale price of eco-certification for Class A buildings in 46 office markets across the United States.[4] Using a hedonic pricing approach, they found rental premia ranging from approximately 15–18% for LEED-certified buildings and 7–9% for Energy Star-certified buildings depending on the model specification. In terms of sales transactions, they estimated premia of $130 per square foot for LEED-certified buildings and $30 for Energy Star. However, although plausible, these results need to be treated with some caution. A limitation of their hedonic model is their control for location. In essence, they identify rental and sale premia for certified buildings relative to noncertified buildings *in the same metropolitan area*. However, if certified buildings tend to be more likely to be in better quality locations within a metropolitan area, observed premia may include a location as well as a certification premium.

Eichholtz, Kok and Quigley (hereafter EKQ 2009) use a hedonic framework to investigate the effect of certification on the asking rents of 694 office buildings which were either LEED- or Energy Star-certified. Using geographical

[4] Sales data were available for 26 office markets.

information systems techniques, they control for location effects by identifying other office buildings in the CoStar database within a radius of 0.2 miles of each certified building. The authors identify a statistically significant rent premium on asking rent per square foot of 3.3% for Energy Star-certified buildings. Surprisingly, they find no significant rent premium for LEED-certified buildings. However, when they use "effective" rents which reflect the effect of different occupancy levels in the rental income of properties (nominal asking rent multiplied by the occupancy rate), the premium increased to around 10% for Energy Star-certified buildings and they find 9% premium for LEED-certified buildings (although the latter is not significant at the conventional levels). They also report similar results for 199 sales that took place between 2004 and 2007. They find a substantial 19% sale price premium for Energy Star-certified buildings but no statistically significant sale price premium for LEED-certified buildings. If these findings are confirmed, the implications for developers considering LEED certification as well as green investors would be considerable. It is therefore important that the absence of a premium for LEED buildings is either corroborated or refuted by other studies using a comparable analytical framework and dataset.

As noted, the size and nature of the rental and sale price differentials between LEED- and Energy Star-certified buildings identified by EKQ (2009) is contrary to expectations and, if genuine, have major implications for the adoption of LEED certification in particular. Our prior expectation for this study was that the LEED label is more prestigious than the Energy Star label. Miller, Spivey and Florance (2008) and Wiley, Benefield and Johnson (2010) find that LEED-certified offices command a larger premium than Energy Star-certified offices.

There are a number of potential problems with the approach adopted by EKQ (2009). A crucial part of any hedonic analysis is obviously the control for spatial and locational features of properties. The controls applied by EKQ (2009), that is, using a standard 0.2 mile radius for all markets, may not produce a proxy for actual submarkets. Within some of their clusters, there are likely to be different qualities of location. In addition, there is an implicit assumption that a 0.2-mile radius is an appropriate geographical size for all locations. However, there can be significant variations in the density of development and size of submarket between different locations.

It is also possible that the definition of effective rents may be a source of bias in their results. If there are systematic differences in the proportion of single tenanted and multitenanted buildings between the certified and noncertified samples, the results may be biased. For instance, if certified buildings have a higher propensity to have a single occupier, an effective rent premium would be identified separate from any certification effect. For instance, Fuerst and

McAllister (2009) estimate that less than 10% of Energy Star-certified offices have a single occupier compared to approximately 30% for the overall CoStar database. However, this source of potential bias may be mitigated by the fact that asking rents tend only to be recorded for multitenanted offices. Compared to EKQ (2009), we apply a similar hedonic methodology to a similar data set. In contrast, we control for location effects using actual submarkets (as defined by CoStar) rather than arbitrary submarkets as this should reflect more accurately the varying density of office submarkets at both the metropolitan and the national level and incorporates the local market knowledge of experts who are likely to define these relatively homogenous markets better than an arbitrary fixed radius.

The Empirical Model

Rent determination is central to the revelation of WTP by occupiers. There is a long established literature on the determinants of office rents that investigates the effect on rental levels of locational, physical and lease characteristics of commercial property assets. Following our theoretical exposition on hedonic prices and product differentiation in the real estate market, we apply a standard hedonic model to empirically test for the existence of a price and rent premium for eco-certified properties.

Hedonic Analysis

Hedonic regression modeling is the standard methodology for examining price determinants in real estate research. We use this method in our study primarily to isolate the effect of LEED and Energy Star certification. As described in the literature review section of this article, higher mean rents or transaction prices may simply be due to the fact that certified buildings are newer, higher or located in more attractive locations or markets. The quintessential log-linear hedonic rent model takes the following form:

$$\ln\ R_i = \alpha_i + \beta \mathbf{x}_i + \phi \mathbf{Z}_i + \varepsilon_i, \tag{2}$$

where R_i is the natural log of average rent per square foot in a given building, $\mathbf{x}_i$ is a vector of the natural log of several explanatory locational and physical characteristics,[5] and β and φ are the respective vectors of parameters to be

[5]We acknowledge the substantial body of literature on the rental effects of age, vacancy levels, size and number of stories. For a more comprehensive discussion of vacancy rates see Sirmans, Sirmans and Benjamin (1989), Sirmans and Guidry (1993), Clapp (1993) and Mills (1992); for floor area see Clapp (1980), Gat (1998) and Bollinger, Ihlanfeldt and Bowes (1998); for age see Bollinger, Ihlanfeldt and Bowes (1998), Slade (2000) and Dunse, Leishman and Watkins (2003); for height see Shilton and Zaccaria (1994).

estimated. $\mathbf{Z}_i$ is a vector of time-related variables, and ε_i is a random error and stochastic disturbance term that is expected to take the form of a normal distribution with a mean of zero and a variance of σ_e^2. The hedonic weights assigned to each variable are equivalent to the characteristic's overall contribution to the rental price (Rosen 1974).

For the purpose of this study, we specify two types of hedonic models. The first type explains rents and the second explains price per square foot in sales transactions.

Hedonic Rent Model

$$\begin{aligned} \ln R_i = {} & \beta_0 + \beta_1 \ln A_i + \beta_2 \ln S_i + \beta_3 \ln L_i + \beta_4 \ln T_i \\ & + \beta_5 \ln G_i + \beta_6 N_i + \beta_7 BC_i + \beta_8 SU_i + \beta_9 GR_i + \varepsilon_i. \end{aligned} \tag{3}$$

In this model, A_i represents the age of the property, measured from the year of construction or the year of a major refurbishment (whichever occurred more recently), S_i is the number of stories of the property, L_i represents the lot size, T_i and G_i are the latitude and longitude geographic coordinates of the property which capture any large-scale effects of the spatial distribution of properties across the country, N_i is a dummy variable indicating a net lease (taking the value of zero for a gross or full-service lease), BC_i are controls for building class (standard categories A, B, C and F) and SU_i are controls for submarkets (853 in total) and ε_i is the error term which is assumed to be independent across observations and normally distributed with constant variance and a mean of zero. A rent premium for LEED and/or Energy Star rated buildings is captured by the GR_i term, a dichotomous variable that takes the value of 1 for certified buildings and a value of 0 otherwise. In alternative model specifications, the GR_i dummy variable is replaced by separate terms for LEED and Energy Star certification (Model 2) and level of LEED certification (Model 3).

Hedonic Transaction Price Model

Similarly, the regression for estimating price per square foot in sales transactions is estimated in the following way:

$$\begin{aligned} \ln R_i = {} & \beta_0 + \beta_1 \ln A_i + \beta_2 \ln S_i + \beta_3 \ln L_i + \beta_4 \ln T_i + \beta_5 \ln G_i \\ & + \beta_6 E_i + \beta_6 MC_i + \beta_7 BC_i + \beta_8 SU_i + \beta_9 GR_i + \varepsilon_i. \end{aligned} \tag{4}$$

where E_i is a time trend variable which accounts for general price inflation and other unobserved trends over time. This variable increases in semi-annual increments. Beyond this control for the overall trend, we also included MC_i, which indicates market conditions at the time of sale proxied by the average quarterly return of the NAREIT index. All other variables are the same as in the rent model.

The type of specification used in the rent and transaction price models allows us to detect differences in the weight of parameter estimates across submarkets, building class categories and market conditions by estimating separate intercepts. This least squares dummy variable (LSDV) approach has the advantage of controlling for a number of omitted variables, for example small-scale spatial effects at the submarket level that we could not model explicitly as the data necessary to do this were not available to us. The LSDV approach allows intercepts of the regression to differ across markets while assuming constant variable coefficients. This is important not only because of the difference in price levels across markets but also because it controls for tax and other incentives that several states and cities grant for buildings that are certified including tax credits, reduced permitting fees and property tax abatements (Roberts 2007).

Data

In the environmental valuation research, different methodological approaches have been taken to the estimation of WTP. This study attempts to measure the revealed preferences of market participants. Garrod and Willis (1999) evaluate the relative advantages and disadvantages stated versus revealed preference methods used in environmental valuation studies. A key issue is the existence and quality of the market data. To estimate revealed preferences, this study draws on CoStar's comprehensive national database which includes approximately 42.9 billion square feet of commercial space in two million properties, making it the largest available real estate database in the United States. In an effort to provide details on the environmental performance of buildings, the CoStar Group began tagging LEED and Energy Star buildings approximately two years ago in collaboration with the U.S. Green Building Council and the U.S. Environmental Protection Agency. This enables researchers to identify numbers and types of LEED- and Energy Star-certified buildings in the database. For the purpose of a rigorous analysis of certified buildings, a key issue is the benchmark against which the sample of certified buildings can be compared. Our benchmark sample consists of approximately 24,479 office buildings in 853 submarkets in 81 metropolitan areas spread throughout the United States. This means that our hedonic model is measuring price differences between certified buildings and randomly selected noncertified buildings in the same metropolitan area controlling for differences in age, size, height, location, lease type, building class and submarket.

In the first step, we drew details of approximately 1,900 eco-certified buildings of which 626 were LEED certified and 1,282 were Energy Star certified. Of the LEED buildings, 31% (n = 192) are certification-level, 29% (n = 180) are Silver, 32% (n = 201) are Gold and 7% (n = 45) are Platinum level. In the second step, buildings were selected in the same metropolitan areas and submarket as the certified sample. Sample selection was based on the criteria (a) same submarket or market as certified buildings and (b) at least 10 comparable observations for each certified building in the database. Although the market weightings may be different between the benchmark and the certified samples, our regression model controls for market-specific effects. In total, we have used 9,806 observations of transaction prices and 18,519 (asking) rent observations. Although transaction prices are considered over a period of 10 years from 1999 through 2008 to obtain a sufficiently large sample, all rent observations are as of Q4 2008.

Results

Descriptive Statistics

The descriptive statistics are displayed in Table 1. There are clearly some differences between eco-certified and noncertified buildings. The former tend to be newer. In particular, the median age of LEED-certified buildings is 5 years. The comparable figure for the benchmark sample is 23. Although there is relatively little difference between buildings with Energy Star certification and the benchmark sample in terms of age, the former tend to be dominated by tall buildings suggesting that they are mainly located in central business district locations. This is supported by the fact that Energy Star buildings tend to be on average nearly 20 times larger than noncertified buildings. Without controlling for the differences between the samples, certified buildings have higher asking rents and lower vacancy rates than noncertified buildings. Median asking rents are approximately 35% higher in LEED- and Energy Star-certified buildings. There are also some notable differences in terms of the proportions of each sample that are on triple let leases compared to gross or full service leases. Energy Star buildings have 12% and LEED buildings have 10% on net leases. The comparable figures for the control sample is 22%. More thorough investigation is required, however, to infer a general prevalence of gross leases in certified buildings as the higher share may simply be reflective of differences in property types (particularly mono- vs. multitenanted properties) between the certified and the noncertified samples. If confirmed, this would be consistent with the expectation that owners of certified buildings attempt to capture operating cost savings by offering primarily gross or full-service leases.

Hedonic Regression Results—Rental Rates

To further investigate the hypothesis of a rent and price premium for certified buildings, we estimate hedonic regressions as outlined above. Two

Table 1 ■ Descriptive statistics of overall sample with LEED and Energy Star sample.

Overall	*Rent* $/sq. ft.	*Price* $/sq. ft.	*% Leased*	*Size* (sq. ft.)	*Stories*	*Age*
Mean	19.50	141.19	63.82	52, 771	3.32	28.37
Median	18.00	113.81	79.80	10, 800	2.00	23.00
Std. Dev.	9.16	112.50	38.87	145, 147	5.75	27.48
Skewness	2.40	1.77	−0.69	7.57	5.92	1.97
Kurtosis	14.47	8.77	1.88	92, 807	50.21	8.42
Observations	16,488	9,120	24,951	16,488	24,479	21,147
LEED	*Rent* $/sq. ft.	*Price* $/sq. ft.	*% Leased*	*Size* (sq. ft.)	*Stories*	*Age*
Mean	26.39	247.07	90.89	176, 080	6.39	12.14
Median	24.50	240.00	100.00	94, 945	4.00	5.00
Std. dev.	10.34	137.85	22.95	25, 882	8.22	19.46
Skewness	1.53	0.41	22.95	467	3.04	3.17
Kurtosis	7.23	3.37	−2.87	48.46	13.20	13.91
Observations	197	127	626	626	581	469
Energy Star	*Rent* $/sq. ft.	*Price* $/sq. ft.	*% Leased*	*Size* (sq. ft.)	*Stories*	*Age*
Mean	27.50	254.95	91.52	283, 045	11.85	19.39
Median	25.00	231.47	96.15	201, 014	8.00	19.00
Std. dev.	11.32	137.00	12.78	262, 829	11.32	13.26
Skewness	1.75	1.42	−3.15	2.02	1.68	2.38
Kurtosis	7.75	6.32	18.16	8.19	5.90	13.49
Observations	834	559	1,282	1,282	1,256	1,276

Table 2 ■ Results from hedonic model estimation of rental rates.

Dependent Variable	Model 1 Rent p.s.f. (log)	Model 2 Rent p.s.f. (log)	Model 3 Rent p.s.f. (log)
Constant	**3.73*****	**3.72*****	**3.65*****
Eco – certified	**0.05*****		
LEED		**0.05****	
Certified			**0.09****
Silver			0.04
Gold			0.03
Platinum			**0.16*****
Energy Star		**0.04*****	**0.04*****
Net lease	**−0.11*****	**−0.11*****	**−0.11*****
No. of stories (log)	**0.06*****	**0.06*****	**0.06*****
Size sq. ft. (log)	**−0.01*****	**−0.01*****	**−0.01*****
Site area (log)	**0.01***	**0.00***	**0.00***
Age (log)			
3–6 years	**−0.06*****	**−0.06*****	**−0.06*****
7–10 years	**−0.12*****	**−0.12*****	**−0.12*****
11–19 years	**−0.14*****	**−0.14*****	**−0.14*****
20–23 years	**−0.16*****	**−0.16*****	**−0.16*****
23–26 years	**−0.18*****	**−0.18*****	**−0.18*****
27–31 years	**−0.19*****	**−0.19*****	**−0.19*****
32–42 years	**−0.20*****	**−0.20*****	**−0.20*****
43–62 years	**−0.23*****	**−0.24*****	**−0.24*****
>62 years	**−0.23*****	**−0.23*****	**−0.23*****
Longitude (log)	**−0.01*****	**−0.01*****	**−0.01*****
Latitude (log)	**−0.43*****	**−0.43****	**−0.41****
Class A	**0.21*****	**0.21*****	**0.22*****
Class B	**0.09*****	**0.09*****	**0.09*****
Submarket controls included	yes	yes	yes
Adjusted R^2	0.63	0.61	0.63
F test	26.32***	26.27***	26.15***
Included observations	10,970	10,970	10,969

Note: *** indicates significance at the 1% level; ** indicates significance at the 5% level; * indicates significance at the 10% level.
Hedonic Regression Results—Sale Prices.

separate regressions are estimated to model rent and transaction price separately. Continuous numeric variables were transformed to log values to (1) reduce nonnormality found in initial examinations of the dataset, (2) to reduce heteroskedasticity and (3) to be able to interpret the results as elasticities. The results are summarized in Tables 2 and 3. Observations for building age were segmented into deciles to allow for potentially time-varying age effects.

When controlling for the most important rent determinants such as age, height, size and submarket location, we find a statistically significant rent premium of

Table 3 ■ Results from hedonic model estimation of sales prices.

Dependent Variable	Model 1 Sale Price p.s.f. (log)	Model 2 Sale Price p.s.f. (log)	Model 3 Sale Price p.s.f. (log)
Constant	1.25	1.08	1.51
Eco − certified	**0.30***		
LEED		**0.25***	
Certified			0.12
Silver			**0.33***
Gold			**0.26**
Platinum			**0.67**
Energy Star		**0.26***	**0.27***
No. of stories (log)	**0.16***	**0.16***	**0.16***
Size sq. fe. (log)	**−0.23***	**−0.23***	**−0.21***
Site area (log)	**0.09***	**0.09***	**0.09***
Age (log)			
3–6 years	**0.15***	**0.15***	**0.16***
7–10 years	**0.51***	**0.51***	**0.52***
11–19 years	**0.45***	**0.45***	**0.46***
20–23 years	**0.40***	**0.40***	**0.41***
23–26 years	**0.38***	**0.38***	**0.38***
27–31 years	**0.38***	**0.38***	**0.38***
32–42 years	**0.28***	**0.28***	**0.28***
43–62 years	**0.27***	**0.27***	**0.28***
>62 years	**0.29***	**0.29***	**0.30***
Longitude (log)	**−0.01***	**−0.01***	**−0.01***
Latitude (log)	**0.78***	**0.82***	**0.79***
Class A	**0.44***	**0.45***	**0.45***
Class B	**0.06***	**0.06***	**0.06***
Time trend variable	**0.03***	**0.03***	**0.03***
Moderately strong market	**−0.08***	**−0.08***	**−0.08***
Moderately weak market	**−0.10***	**−0.10***	**−0.10***
Weak market	**−0.10***	**−0.10***	**−0.10***
Submarket controls included	yes	yes	yes
Adjusted R^2	**0.42**	**0.42**	**0.42**
F test	**8.68***	**8.68***	**8.64***
Included observations	6,157	6,157	6,156

Note: *** indicates significance at the 1% level; ** indicates significance at the 5% level; * indicates significance at the 10% level.

4–5% in eco-certified buildings compared to noncertified buildings in the same submarket area. The control variables used in the regression show the expected signs and most of them reach the desired significance levels. This regression explains just over 60% of the cross-sectional variation in rents in the entire sample.

Model 2 shows the results of the regression with separate dichotomous variables for LEED and Energy Star certification. Both types of certification are found to exert a positive and significant impact on rents. Although the premium for LEED is higher as expected, there is very little difference between the premia for LEED and Energy Star buildings. A further common assumption that we set out to test is that the rent premium of LEED buildings is increasing with the level of certification. Model 3 in Table 2 reports the estimation results with a LEED-level variable. In this specification, the dichotomous LEED variable is modified to reflect the certification standard, that is, Certified, Silver, Gold and Platinum. Although the coefficients have the expected signs, only the Certified and Platinum levels are significant.

Although it is not a central part of the study, it is interesting to compare the results of the control factors with the findings of other studies of office rent determinants. Given a variation in data sources and model specifications, previous studies do not always provide consistent findings on the relationship between variables such as age and height, *inter alia*, and office rents/prices. As expected, we find that the coefficient for the age variable is negative. In addition, consistent with previous research (see, *e.g.*, Bollinger, Ihlanfeldt and Bowes 1998, Shilton and Zaccaria 1994), we find that there is a significantly positive relationship between height and rent. We also find a negative relationship between size and rent. In common with Laverne and Winson-Geideman (2003), we find a negative relationship between triple net leases and the rental level.

Hedonic Regression Results—Sales Prices

Table 3 reports the results of the hedonic regressions with sales price per square foot as the dependent variable. Three separate models were estimated with the same independent variable. All models display similar results and have similar explanatory power. The explanatory power of this model is lower relative to the regressions for the sample of rents. For most of the independent variables, the coefficients have the expected signs. Compared to buildings in the age segment 0 to 2 years, the coefficient for the other age segments is positive. It is notable that buildings constructed in the first 2 years tend to sell at a discount compared to older buildings. The coefficient on the age variable increases for buildings aged up to 10 years and then starts to decline. Model 1 suggests a sales premium of just below 30% for eco-certified buildings. In Model 2, we distinguish between LEED and Energy Star and find premia of 25% and 26%, respectively.[6]

[6]The larger average premium of 30% for eco-certified buildings compared to LEED and Energy Star premia is due to the existence of a number of buildings that hold both types

When we break down the LEED sample into its various levels, we find significant premia for Silver-, Gold- and Platinum-rated buildings. Although the size of the premia appears extremely high, it should be noted that the sample size for Platinum-rated buildings is very small. From a total of 6,153 sales, only 8 involved Platinum rated buildings. The sample sizes for Certified ($n = 35$), Silver ($n = 47$) and Gold ($n = 34$) are higher, and the raw data support the case for substantial premia with median sale prices of \$194, \$252 and \$232 compared to a whole sample mean sale price of \$113.

The results suggest a much higher relative sales price premium compared to rental price premia. There are a number of potential explanations. A possible reason may be the combined effects on capital value of higher rental income, lower operating costs, increased occupancy rates, image benefits (to investors) and a lower risk premium.

Conclusion

Growing global concern about climate change is increasingly affecting the preferences of consumers and investors. In addition, throughout the regulatory hierarchy, international, national and local governmental institutions are expanding the scope of environmental regulation affecting commercial real estate assets. Similar to other product markets, a voluntary environmental certification system for new buildings and refurbishments has emerged in most mature real estate markets. Despite the publicity and promotion, the voluntarily certified sector is miniscule in terms of the current total commercial real estate stock. However, it is likely that eco-certification of commercial buildings will become progressively more important.

A priori inference suggests that eco-certified buildings should obtain a rental and an asset price premium. It is expected that investors' holding costs should be lower due to attractiveness to occupiers associated with business performance, image, fiscal and/or other government incentives and lower running costs. This can lead to a rental premium and/or lower vacancy rates. For investors, there may be higher net operating income due to increased demand from occupiers, lower void rates, lower costs of ownership and an element of protection from future regulatory changes. The results of the empirical analysis confirm these expectations. The hedonic regressions suggest that there is a rental premium of approximately 5% for LEED certification and 4% for Energy Star certification.

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of certification. For these buildings, the rental premium will effectively be split between the LEED and Energy Star coefficients resulting in a lower premium compared to the overall eco-certified variable.

For sales prices, we find price premia of 25% for LEED-certified buildings and 26% for Energy Star.

Yet, there are a number of caveats attached to the interpretation of this and similar empirical studies of *typical* price differentials. First, the controls for inherent heterogeneity between certified and noncertified buildings are bound to be imperfect even when applying the most diligent sample selection process and the most comprehensive set of variables in the hedonic model. For example, it is possible that the eco-certification process is only one element of additional investment to create a market-leading product. To control for all facets of such an approach to positioning an asset in the upper segment of the market is virtually impossible in the framework of a hedonic model. Second, these empirical studies provide a cross-sectional snapshot of price differentials for a specific sample in a specific time period. It is expected that price differentials for certified buildings should vary over time and between buildings. Attempts to profit from any current or historic price premia are faced with the standard "developer's dilemma"—that their supply response to *current* price differentials between certified and noncertified buildings is likely to affect the *future* price differential. Although the results are in line with the findings of the majority of studies on price premia of certified buildings, this is a study of a niche market with relatively small sample sizes. As data availability as well as level of detail and accuracy is likely to improve over time, future research will be able to address a number of more specific issues such as the individual contributions of image benefits, higher productivity or lower operating costs to the green premium.

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