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INCOME RISK IN ENERGY-EFFICIENT OFFICE BUILDINGS

BY

NIKODEM SZUMILO, UNIVERSITY OF CAMBRIDGE

FRANZ FUERST*, CULS FELLOW, UNIVERSITY OF CAMBRIDGE

* CONTACT AUTHOR: UNIVERSITY OF CAMBRIDGE. DEPARTMENT OF LAND ECONOMY, 16-21 SILVER STREET, CAMBRIDGE CB3 9EP, UNITED KINGDOM. EMAIL: FF274@CAM.AC.UK

Income risk in energy efficient office buildings

Abstract

The study investigates uncertainty of financial performance of energy efficient office buildings to establish how making an asset energy efficient changes its financial characteristics. Two hypotheses explaining why a change may occur are presented and examined (one based on higher demand and one on higher economic efficiency). A large panel dataset, consisting of 30 time periods for 14,395 US commercial office buildings, is examined using different econometric approaches. Overall, the results seem to support theoretical predictions and show a structural change in income risk characteristics of energy efficient assets.

Keywords: Sustainability, risk management, income risk

JEL classification: Q410, G110

1. Introduction

Although sustainability is an extremely general, it is used relatively often in the world of finance and investment. The idea of sustainable investing most commonly refers to the ability to maintain a certain level of financial performance over time (Urwin and Woods 2010). The term is also sometimes used in a slightly different context and refers to the relationship between an investment and its environment. The idea assumes that the social, economic or natural environment can influence financial performance, but can also be affected by investment decisions. In this case, investment sustainability refers to a practice that does not compromise any of the resources it depends on. The concept of responsible investing concentrates on the practice of putting resources into assets that display certain characteristics of sustainability (Diltz 1995) which may include their social and environmental impact (Hill et al. 2007).

In this context energy efficient real estate has become an interesting asset class. It seems that its impact on its environment is relatively simple to evaluate and that its assets may be more likely to maintain their financial performance over time. The property market also offers returns which are traditionally considered as relatively stable against inflation (although this is increasingly questioned). In addition, they offer an opportunity to hold tangible assets which means that their ability to replicate current financial performance in the future is likely to be less uncertain (Ibbotson and Siegiel 1984, Kuhle 1987, Hudson-Wilson et al. 2003).

The ability of real estate investments to produce returns that are more replicable over time than profits from other assets remains a subject of an academic debate (see Worzala and Sirmans 2003 for a summary). However, claims that energy efficient buildings offer a superior financial performance have been repeatedly made and supported with evidence. Rental levels, capitalization rates and sale prices have all been shown to be positively affected by introducing sustainability features into a building (see the literature review chapter for a detailed discussion). However, while returns from sustainable properties seem to be favourable, the level of investment into this type of asset does not seem to fully reflect this advantage. It is important to note that, so far, researchers have been focusing on return as an indicator of financial performance while the related uncertainty seemed to have been ignored. Generally, it would seem that very little is known about financial risk associated with returns of energy efficient properties. This article examines uncertainty of the superior financial performance reported in real assets with sustainable features (Fuerst and McAllister 2011a, Eichholtz Kok and Quigley 2013).

a. Two types of effects of sustainability on risk and return

A significant number of studies has addressed the topic of how sustainability and energy efficiency should affect financial performance of real properties. Fuerst and McAllister (2011a) offer a comprehensive overview of why and how such buildings can create financial value. The authors also support their theories with empirical findings. Eichholtz Kok and Quigley (2013) present a general theoretical summary of how sustainability should relate to profitability. In addition, they present empirical evidence confirming their discussion of the subject. Szumilo (2015) as well as Szumilo and Fuerst (2013) showed that, properties with 'green' technologies in place can offer two types of benefits: a cost saving and a set of additional services delivered to tenants (reputational benefits, increased productivity etc.).

Table 1. Benefits of sustainability in real property.

	Investment efficiency	**Additional demand**
Example	Energy efficiency	Reputational benefits
Example	Increased workforce productivity	Reduced environmental impact
Time frame	Instant effect	Varies over time
Dependency on market changes	Independent of actions of market participants	Depends on how the market values the additional services
Additional risk	None	Risk of changes in demand

While the financial gain related to sustainability has been extensively researched, little attention has been given to the related financial risk. In economics, a superior return entails an increase in either investment efficiency or risk. It appears that at least some of the financial sustainability benefits may come from improved investment efficiency. For example, the cost saving of energy efficiency allows generating more profit per unit of invested capital; therefore, it can be expected to offer extra profit at no additional risk. A similar effect can be expected from benefits related to higher business efficiency available to tenants like increased workforce productivity or the lower level of employee absenteeism.

Although a favourable financial effect depends on occupants willing to pay for the added service, the market can be expected to value superior business efficiency higher at all times.

However, not all benefits expected from green buildings directly impact business efficiency. For example, in order to improve reputation of its tenants a certified building must meet certain conditions like integration with other corporate social responsibility policies or favourable attitude of the market towards sustainability. These requirements may also vary in different industries and even by geographical locations (Reed and Wilkinson 2005). In addition, the magnitude of the reputational premium paid in rents may change over time as sustainable solutions become obsolescent or because they become a widely accepted standard. In this case, the financial benefit relies on the probability that tenants are willing to pay extra for the reputational benefit at the time of signing the lease. Similar uncertainty is expected to be related to other financial benefits arising from sustainability like the reduced level of emissions or the increased morale of employees.

As a result, introducing sustainability into a real property offers two types of benefits to its financial performance (see the Table 1 for examples). First, economic efficiency improvements should attract an immediate improvement in financial performance. This effect is not conditional on actions of market agents and does not attract any additional risk. The second type of sustainability benefit is an increase in demand due to the additional services offered by sustainable buildings. If those facilities are desired by the market, agents are willing to pay extra for being able to access them which results in a rental premium. However, introducing those services would not generate a change in income, if the market is indifferent to their availability. Therefore, the second type of the financial effect of sustainability is conditional on the state of the market. In this case, the financial premium is associated with the risk of changes in the perception of sustainability and the willingness to pay for this attribute.

The above reasoning relates to general sustainability. Unfortunately, quantifying this feature poses a considerable practical challenge (Forberg and Malmborg, 2004). However, one of its subsets: energy efficiency, lends itself to considerably easier measurements. The analysis of financial benefits of sustainability presented above can easily be applied to energy efficiency. The logic of the cost-saving benefit remains applicable as energy costs are usually a significant operating expense. The argument of increased productivity is also valid as more efficient energy solutions can offer this benefit by creating a more natural and comfortable working environment (Abbaszadeh et al. 2006). In addition, a reduction in CO_2 emissions can offer reputational benefits and attract higher demand from environmentally-conscious market participants. It can be concluded that both types of sustainability benefits (business efficiency and increased demand) seem to persist when the definition is limited to energy efficiency.

b. Current literature

Hypothetical benefits and risks of green buildings.

While the fact that sustainable buildings tend to have higher average rents seems to be well documented (Fuerst and McAllister 2011a and 2011b, Pvio and Fisher, Miller, Spivey and Florance 2008, Eichholtz Kok and Quigley 2013, Szumilo and Fuerst 2014), relatively few researchers have empirically tested the drivers behind this premium. Fuerst and McAllister (2011a) consider the economic effects of sustainability on a building and focus on the willingness-to-pay as the main reason for a higher price. They outline a number of benefits which a green building could bring and show that this should be reflected in its financial performance as an asset. The authors explain that only if market participants are willing to pay more (or accept less) because of sustainability features of a building, the additional characteristics are reflected in its financial properties. They also provide a theoretical evaluation of the claim that prices should increase proportionally to the level of sustainability. In the article, benefits of sustainability are assumed to stem mainly from increased demand. The authors also recognize that this effect may vary with time. Their empirical work uses a hedonic model and finds a 4-5% rental premium for sustainability in a cross-sectional sample of 24,479 US office buildings. The level of sustainability certification is also linked to financial performance although it is not formalized econometrically.

Reitchard et al. (2012) point out that the financial premium may be related to the demand for sustainable buildings outpacing the supply of such properties. In fact, they show a strong time dependency of the rental premium. The authors attribute the growth of the benefit to an increase in awareness of the benefits offered by sustainable offices while a reduction in its value is associated with an economic downturn. Although the article notes the important dependency between the period of holding certification and its financial benefit, the relationship is not analysed in the context of exposure to risk.

In another piece of research Eichholtz Kok and Quigley (2010) explain the relationship of sustainability and corporate social responsibility and divide the possible benefits into the following categories: cost savings, improved performance due to better working environment, corporate image effects and a possibility of a higher demand for sustainable space. They also state that some of those are likely to influence the real estate market risk premia but present no deeper analysis. Once again, in a cross-sectional empirical study, significant benefits of certification for rents, sale prices and capitalization rates are found.

Szumilo and Fuerst (2013) show that the influence of energy efficiency certification on rents can be divided into two components: the cost savings and the benefits of additional services. Both effects are favourable, however, they can affect rental levels differently depending on lease agreements. The authors focus on the cost saving effect and investigate its impact on operational expense. The results presented in the article show that certification attracts a rental premium, although it does not reduce operating costs. This indicates that over a short term the benefits of certification are significant but may not come from the saving in operating expenses.

Measuring financial risk in real estate markets

Similarly to many other asset classes, financial risk in real estate can be looked at from two perspectives. The first is a volatility approach. It can be measured by standard deviation and considers an overall range and frequency of the difference between actual prices and their expected values. The second approach is based on risk coefficients of asset pricing models (Blitz et al. 2013, Ambec and Lanoie 2008). Those variables show volatility of an asset's price after adjusting for movements of other investments. The majority of studies of real estate risk adopt the later approach, although both methods can offer valuable insight into the financial uncertainty of real properties. More importantly, both can be used to examine how this uncertainty is affected by sustainability.

Most researchers looking at the risk of real estate as an asset class examine trading prices of publically traded investment funds (Hsieh and Peterson, 2000, He 2002). For example, a recent publication from Eichholtz, Kok & Yonder (2012) examined the financial performance of such companies in the context of sustainability of assets in their portfolios. Although a higher trading price has been found, volatility has not been investigated. Other studies showed that, over a short term, real estate investment trusts tend to follow changes in the stock market, rather than developments in the property market (Mueller and Mueller, 2003, Myer and Webb, 1994). In effect, this approach seems to offer limited potential for investigating property-specific risk.

An alternative risk indicator can be derived from a method of pricing real estate assets. As it relies on calculating the net present value of expected cash flows (Geltner et al.2007), financial performance of commercial office buildings can be linked to two key variables. The first is the net operating income (NOI) which equals total gross rent reduced by all costs and charges. The capitalization rate is the second indicator. It consists of a discount component required to calculate the present value of future cash flows and a growth component reflecting expected changes in rental income levels. While NOI is a key financial characteristic of a building and is based on its contemporary performance, the capitalization rate incorporates expectations regarding future income streams. In effect, the latter can be looked at as an indicator of overall risk. It incorporates sensitivity of individual structures to market risk as well as any property-specific risk factors.

This is similar to the concept of uncertainty measured in terms of exposure to market risk used in asset pricing models as properties with higher risk coefficients should have their capitalization rates increased accordingly. A positive influence of sustainability on the capitalization factor has been found by Eichholtz and co-workers (2010) as well as Miller and co-workers (2008). An interesting paper by Pivo and Fisher (2010) explained that expected changes in the net income should be directly reflected in the capitalization rate. After considering possible effects of sustainability on those variables they showed that both values were favourably affected by certification.

Demand signals can also be important determinants of the capitalization rate. The rate of vacant space is commonly used as an indicator of demand in commercial office markets (Rosen, 1984). Indirectly, it has a considerable impact on risk, as high vacancy rates are related to lower gross income and rental rates (Shilling et al 1987). In sustainable properties occupancy rates have been shown to be higher than in traditional buildings (Fuerst and

McAllister 2011b, Miller, Spivey and Florance, 2008). The theoretical foundation for this fact is best described by Wiley and colleagues (2008) who also show that higher occupancy rates related to sustainability can significantly decrease uncertainty regarding the NOI.

Volatility of rents has also been considered as an indicator of risk in commercial property markets. Tsolacos and Tony McGough (1998) show, on the example of the British property market, that this characteristic can be important not only in determining the investment uncertainty of a single building but also of the market as a whole. In addition, the authors conclude that information contained in historical volatility can be indicative of future financial performance of real assets. Hui and Zheng (2012) examine volatility of rental levels and their influence on transaction prices in Hong Kong from 2003 to 2009. They find a significant relationship between the two, which is especially stable in commercial office markets. Furthermore, Matysiak and Tsolacos (2003) show that volatility of office rents is an important determinant of their future levels. Interestingly, the authors find that over the long term this metric becomes more important. Patel and Foo Sing (2000) investigate the UK property market and its implied volatility of rental returns. They recognize uncertainty of rental levels as a good measure of risk in property markets, although their empirical tests find that the method is limited due to a number of market imperfections.

c. Research design

Changes in income do not necessarily affect value of assets directly but are first corrected for adjustments in the capitalization rate to reflect any alternations in their risk. Some evidence that cap rates are lower for sustainable buildings exists (see the literature review). However, little is known about the process of how individual components of this variable are affected and weather the positive changes to income levels occur at the same time. This research focuses on examining if energy efficiency causes any changes in expected cash flows that should be reflected in the rate of their capitalization.

Acquiring energy efficiency certification can be a significant event in the operating life of an office building. Although application for a label is a strictly operational decision, it has to be proceeded by certain actions during construction or refurbishment to ensure that the property meets required standards. A building that meets the criteria can apply for certification when it reaches an appropriate standard. If that was common practice, it would indicate that labelling is an important part of making sustainability improvements. However, data collected for this study shows that only around 5% of buildings have been refurbishment within the 2 years preceding first certification. This indicates that property managers seem to invest in sustainability with the intention of making real operational changes. However, the fact that the actual level of sustainability and holding certification are correlated (Berardi 2012, Diamond et al. 2006, Proto et al. 2007, Blumberg 2012) and the growing popularity of this kind of performance recognition (Kats 2003 p. 4, Nelissen 2002) show that most upgraded buildings eventually undergo a labelling process. The most likely reason is the intention to send a clear signal to market participants that the building has certain features (Berardi 2012, Kok and Jennen 2012, Delmas et al. 2013). The market is more likely to react to sustainability characteristics if information efficiency is increased. Examining how financial indicators react to certification allows uncovering how they behave when information about sustainability is made public.

Some features of energy efficiency are expected to cause an immediate change in net cash flows. For example, an increase in energy efficiency can be expected to reduce operating costs. Assuming constant gross rental levels, this will immediately result in an increase in the net operating income. As this benefit comes from a change in economic efficiency, no adjustment to the capitalization rate should be expected. This premium should also remain constant regardless of the time horizon. However, this is not the case for the benefits related to the increased demand for efficient properties. In favourable market conditions, those may attract a higher rent but the premium is likely to vary over time as the environment changes. Due to this uncertainty the capitalization rate needs to be adjusted for the additional volatility of rents resulting from changing market conditions.
As outlined earlier in this article, some changes in risk resulting from energy efficiency will not have a direct effect on net cash flows. For example, the reduced risk of having to comply with new environmental regulation is unlikely to be reflected in rents or current operating expenses. However, this fact reduces the expected rental volatility and future costs and its impact on asset value should be positive due to a decrease in the capitalization rate.

If the expectation of the reduction in uncertainty is true, this effect should be measurable over a sufficiently long time period as a decrease in actual volatility. In fact, all changes in risks, including those resulting from sustainability, can be expected to manifest themselves as immediate changes in the capitalization rate. Such adjustment reflects expectations about the future income stream. Over a sufficiently long term, those expectations should materialize in actual values and be measureable as statistical properties of received cash flows. For example, long-term actual volatility of rents determines what the capitalization rate risk premium for this factor should have been at the beginning of the period.

The above discussion shows that the effect of sustainability on cash flows should vary over time and depend, at least partially, on market conditions. In addition, over a longer period of time, all components of risk are also reflected in financial characteristics of the income stream. Thus, by closely studying the behaviour of rental cash flows in certified assets over time one can investigate the relationship of risk and sustainability. While gross rents are not a perfect proxy for the net operating income, they can give a very good idea of changes in its value if they are adjusted for lease terms. In effect, studying characteristics of rental cash flows appears to be a valid approach to investigating the interaction of risk and reward in real property markets.

Two hypotheses seem to follow from the above analysis. First, sustainable properties attract a rental premium which depends on how the additional features are perceived and priced by the market. In this case, the financial effect comes from changes in demand. The second hypothesis is that additional financial effects of sustainability come from higher economic efficiency of operating the real asset. In result, green buildings can generate higher returns per unit of input. This should offer a financial benefit at no additional risk. Empirical evidence can be obtained by analysing the results of the following tests:

1) Changes in the magnitude of the sustainability premium over time.

Estimating the reaction of rents to sustainability can give an idea of how the market is pricing such features. Economic efficiency benefits should be reflected by an immediate adjustment to rental levels and not vary over time. However, other effects of sustainability will be exposed to changes in the market environment. Under favourable conditions, where agents are willing to pay more for green buildings, a premium can be expected. Should environmental features not be in demand, a discount (or no effect) is more likely to be found.

2) Differences cash flow volatility between sustainable and traditional buildings over short and long terms.

After receiving a certificate, rents have to adjust to a new level. This can be associated with a process of searching for a new equilibrium and, therefore, increased volatility. Economic efficiency benefits are expected to create this effect shortly after first certification takes place but offer more stable rental values after that time. The effect of sustainability on demand for space may inflate short-term volatility persistently, as it reacts to changes in market conditions.
Information extracted from rents over a short time period is valuable but offers little evidence about changes in the structure of cash flows that should be reflected in longer term projections of their values. As explained before, those are necessary in order to estimate capitalization rates. As the examination period lengthens the uncertainty that should have been included in the discount factor at the beginning materializes.

The two components of this research reveal critical information about the reaction of the key financial risk indicators of office buildings to holding energy efficiency certification. Looking at differences between effects in different years provides an insight into exposure to changes in the market sentiment. Short-term volatility reflects not only the changing environment but also an adjustment to a new rental equilibrium. Long-term uncertainty shows structural alternations in financial indicators have materialized over time.

d. Methodology and data

This article investigates the relationship of energy certification and financial properties of rental cash flows. More specifically, it poses the question whether introducing energy certification changes their risk profile. Financial risk is defined as uncertainty of cash flows and is approximated by their volatility. Two measures are used: statistical standard deviation and changes in coefficients of independent variables over time.

The empirical analysis is performed on the full dataset of 14,395 US office buildings recorded quarterly over from Q2 2006 to Q3 2013.

The certification premium over time

Many, relatively similar, models of rental levels have been used in the literature in order to examine how sustainability affects them. Fuerst and McAllister (2011b) present examples and a broader discussion of the approach. Most academics use some variation of the hedonic pricing model (Rosen, 1974). A premium resulting from sustainability certification is found in almost every case, although different magnitudes are reported for different locations and time periods. In order to be able to externally validate its results, this research also uses a hedonic price model to relate energy efficiency to average rental values.

The dataset collected for this study allows an important modification to the commonly used models. Including dummy variables that control for certification in a particular period isolates the value of the sustainability premium in different years. Reitchard et al. (2012) use this approach in a fixed-effects model to analyse a similar sample of 40 quarterly observations starting in 2004. When this approach was applied by this study the results were similar. However, such model displayed significant challenges of serial autocorrelation. In order to address this problem an autocorrelation-corrected estimation procedure was applied (Baltagi and Wu, 1999) to a model modified in two ways. First, quarterly data has been converted into annual averages. Second, a random-effects panel model was specified, as the Hausman test (1978) indicated that it was superior to the fixed-effects alternative. As unobserved fixed effects are always a considerable concern in modelling real estate prices a method of controlling for their impact was used (Papke and Wooldrigde, 2008). Time-averages of rental levels and vacancy rates were added as independent variables and a correlated-random-effects panel model of the following specification was applied:

$$(1) \qquad \mathrm{y_{it}} = \alpha + \beta\,\mathrm{X_{it}} + \gamma\,\overline{X}_{\mathrm{i}} + \epsilon it \quad \text{with } \mathrm{i} = 1, \dots\dots, \mathrm{N},\ \mathrm{t} = 1, \dots\dots, \mathrm{T}$$

where *y* is the dependent variable taking values of the observable rents, X_{it} is the vectors of explanatory variables that determine rents, $\overline{X}_i$ is the vector of time-averages of selected variables, *i* and *t* denote an entity and time period respectively, ϵ_{it} denotes the usual error term.

Volatility of rental values

Volatility is usually measured by statistical variance which makes it difficult to estimate using linear models. Variance, defined as the squared standard deviation, is never less than zero;

hence the assumption of normal distribution may not be applicable. Although some researchers have successfully applied linear models in this context (Allen and Rachim 1996, Nazier et al. 2010), all have noted some limitations of this approach. A Tobit model is more appropriate to modelling limited values as dependant variables. Chavas and Kim (2014) show how to apply this approach to modelling variance.

In the financial literature, variance has been shown to often follow an autoregressive process and cluster around time periods (Bollerslev et al 1992). In result, this variable is most commonly modelled using autoregressive-conditionally-heteroskedastic models. This approach concentrates on the time-series characteristics of the dependant variable. It requires a large number of time periods and often makes it difficult to control for differences between individual buildings. Some economic literature (Cohen et al. 1976, Ncube 1996, Duong and Kalev 2008, Walls 1999) uses different forms of heteroskedasticity-adjusted linear regressions (like a dummy variable or a fixed-effects OLS) to identify different components of volatility. While those methods may not be able to capture the autoregressive component accurately, they offer a good level of insight into other determinants of changes in the dependant variable.

The panel data used in this study has a large number of entities and relatively few time periods. As a result, an approach focusing on determinants of volatility other than its lagged values seems appropriate. Given the longitudinal nature of the dataset, a panel Tobit model needs to be specified. The Harris–Tzavalis test showed no evidence of a unit root in the standard deviation of rents but tests for autocorrelation indicated its presence. In order to ensure that the standard errors are not biased by this fact they can be adjusted for clustering by using the Bootstrap estimation method (Berg and Coke 2004, Petersen, 2009). Following an examination of different alternatives, a random-effects panel Tobit regression was selected as optimal for this investigation (Calzolari and Magazzini 2008). A Hausman test (1978), confirmed this specification. Finally, a correlated random effects Tobit panel model of the following specification was used:

(2) $st.dev_{it}^{*} = \beta X_{it} + \epsilon_{it} + \alpha_i$

$vst.dev_{it} = max\{st.dev_{it}^{*}, 0\}$

with $\mathrm{i} = 1, \ldots\ldots, \mathrm{N}, \mathrm{t} = 1, \ldots\ldots, \mathrm{T}$

where st.dev is the observed dependent variable (in this case standard deviation of rents) for entity i in time t which only takes positive values, Xit is the vector of the independent explanatory variables for entity i in time t, β is the vector of coefficients and both ϵ_{it} (representing an error term for entity i in time t) and α_{i}(representing an overall error term for entity i) are assumed to be independently normally distributed.

The data used for the examination of long-term effects was cross-sectional which simplified the analysis. As stated previously, in the real estate literature the most common method of modelling rental values, while controlling for heterogeneity of individual buildings in a cross-sectional dataset, is the use of a hedonic price model of the following form:

(3) $\mathrm{y_i} = \alpha + \beta \mathrm{X_i} + \epsilon_i$ with $\mathrm{i} = 1, \ldots\ldots, \mathrm{N}$

where *y* is the dependent variable taking values of the observable rents, X_i is the vector of explanatory variables that determine rents, *i* denotes an entity, ϵ_i denotes the usual error term.

This method seems appropriate as it controls for measurable differences between properties in the starting period and detects their influence on rents. A simple Ordinary Least Square (OLS) regression with appropriate dummy variables seems sufficient for estimating average long-term rental levels, however, modelling long-term volatility requires a non-linear model. A Tobit model is used to estimate a variance equation of the following form:

(4) $\mathrm{var}_{\mathrm{i}}^{*} = \beta \mathrm{X_i} + \epsilon_{\mathrm{i}}$

$\mathrm{var_i} = \max\{\mathrm{var}_{\mathrm{i}}^{*}, 0\}$

with $\mathrm{i} = 1, \ldots\ldots, \mathrm{N}$

where var is the observed dependent variable (in this case 7 year variance of rents) which only takes positive values, Xi is the vector of the independent explanatory variables, β is the vector of coefficients, and the ϵ_{i}'s are assumed to be independently normally distributed.

e. Results

Table 2 shows selected results for regression models relating energy certification variables to average rental levels.

Table 2. Selected results of a correlated random effects regression estimation for average annual rental values in the period from 2006 to 2013.

	1			2		
Estimation	GLS Correlated random effects			GLS Correlated random effects		
Dep. Variable	Ln(Average Annual Rents)			Ln(Average Annual Rents)		
Var. name	Coeff.	z-stat.		Coeff.	z-stat.	
Holds certification	0.006	*1.82*	*			
Certification in year						
2006				- 0.096	*-7.22*	***
2007				0.028	*3.22*	***
2008				0.048	*7.01*	***
2009				0.010	*1.65*	*
2010				- 0.020	*-3.51*	***
2011				- 0.009	*-1.47*	
2012				0.009	*1.56*	
2013				0.021	*2.1*	**
Control variables						
Lease type	*Yes*			*Yes*		
Economic	*Yes*			*Yes*		
Property char.	*Yes*			*Yes*		
Market Location	*Yes*			*Yes*		
Model statistics						
R-squared	0.7633			0.7634		
within	0.0421			0.0427		
between	0.8726			0.8726		
Wald chi2	100334.99			100495.1		

This table reports the correlated-random-effects model for average annual rental values (in $ per square foot) in the period from 2006 to 2013, estimated using the General Least Square method corrected for first-order autocorrelation (Baltagi and Wu, 1999).***, **, * indicate significance at the 1%, 5% and 10% level respectively.

Overall, the results indicate no unexpected relationships and are similar to findings of comparable pieces of research (see the literature review). Values of the goodness-of-fit statistics are satisfactory and indicate that the models can explain a significant proportion of the variance. The base case for lease terms is a gross lease and dummy variables were included if contract terms were different at the beginning of the examined period. As a result, all lease terms variables have negative coefficients.

If energy certification is included as a dummy variable which corresponds to periods when the property holds certification, the effect is significant and positive. However, the premium is only 0.6% which is significantly less than values reported by other studies. Moreover, the coefficient is only marginally significant. This indicates that this may not be an optimal method of modelling the value of the certification premium when multiple time periods are taken into account. Nevertheless, it is important to note that the average effect of introducing energy efficiency in the analysed sample is statistically significant and positive.

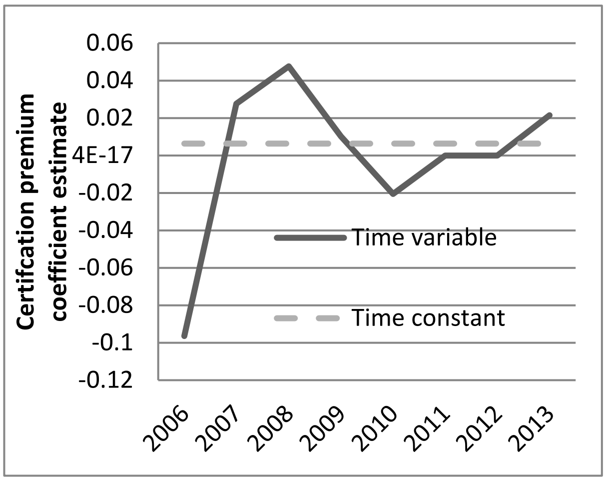

Figure 8.1. Average versus time-variable coefficient estimates of the financial effect of energy efficiency. (Own work)

Since other studies have found different values of the certification premium using cross sectional data, it would appear that using an average effect may not be the most appropriate method for a panel dataset. In order to allow for different effects in different periods, the energy efficiency dummy variable was divided into subcategories based on years of measurement. Respective coefficient estimates presented in table 2 show that the time of holding the certification can have a significant influence on its financial effect. Overall, the effect of certification is significant and varies from -9.6% to 4.8%. There seems to be a significant relationship between the time of measuring the effect of certification on rental values and the result. There also appears to be a considerable variance in the magnitude of the energy efficiency premium. Although the time series is not very long, a cyclical pattern can be identified (see Figure 8.1). From a large discount in 2006, the effect of energy certification increases for two consecutive years. A decrease in the magnitude of the premium follows for the same amount of time. Two years of no effect occur next and a premium is recorded again in 2013. While drivers of those differences cannot be inferred from the analysis, they are clearly period-specific. Moreover, the cyclical pattern indicates that variations are not random but are related to endogenous changes that occur over time.

Interestingly, the level of energy certification has not been found to have an impact on the results. This indicates that the variation in the financial effect is not related to the actual level of efficiency. The financial impact of the actual level of energy efficiency seems not to be determined by market conditions.

The results are consistent with the hypothesis of the energy efficiency premium being exposed to changes in the market sentiment. In fact, they also support the claim that only the financial benefits related to additional services suffer in this way. The findings do not indicate however, that business efficiency improvements experience the same problem.

It would appear that on average sustainability attracts a rental premium. However, the effect is significantly exposed to contemporary changes in market sentiment. In fact, in some years it would seem that energy certified properties were leased at a discount. Therefore, it may be concluded that sustainability is indeed associated with an average rental premium, although this depends on market conditions and can be volatile.

Table 3. Selected regression results for volatility of rental values.

Estimation method	Correlated random-effects panel Tobit		
Dep. Variable	Average Annual Standard Deviation of Rents		
Var. name	Coeff.	z-stat.	
Holding certification	- 0.654	*-2.09*	**
Years since first certification			
0	0.951	*2.92*	***
1	0.768	*2.28*	**
2	0.523	*1.5*	
3	0.343	*0.92*	
4	0.314	*0.78*	
5	0.368	*0.81*	
6	- 0.249	*-0.08*	
Control variables			
Lease type	*Yes*		
Economic	*Yes*		
Property char.	*Yes*		
Location	*Yes*		
Model statistics			

Log likelihood	-120663.11	
Wald chi2	14122.55	***

This table reports the Tobit correlated-random-effects model *for annual volatility of rental values* in the period from 2006 to 2013, estimated using the General Least Square method. The estimated standard errors are estimated using the bootstrap method to correct for autocorrelation (Mantalos and Shukur 2008).***, **, * indicate significance at the 1%, 5% and 10% level respectively.

Table 3 shows selected results for regression models relating energy certification variables to average short-term deviation from the mean rental value. Complete results are available in the appendix.

The results of volatility models cannot be interpreted as directly as linear models since they have been estimated using maximum likelihood. The presented standard errors were estimated using the Bootstrap method (Guan 2003) and investigated for any deviation from the assumptions of independent normal distribution. No issues were identified. An examination using the link test (Tukey, 1949) showed no evidence of misspecification of the functional form of the dependant variable.

Lease terms seem to be an important factor in determining rental volatility. A triple-net contract attracts the lowest variance. Economic indicators are also important parts of the model with the CPI factor, interest rates and unemployment all negatively related to variance. This indicates that adverse economic conditions seem to be related to lower volatility of rents. This seems plausible as the popularity of using non-price incentives (like rent-free periods or rent break clauses) results in a slow downward adjustment of real estate rental rates (Orr et al. 2003). Moreover, an increased variance of bond prices correlates significantly to the standard deviation of the rental income. This indicates that both react to changes in market risk in a similar way. Higher rents appear to be less volatile while greater vacancies are positively related to uncertainty. This is consistent with the rental adjustment process showed by Hendershott et al. (1999, 2002). Relatively little research has been published that focuses on property-specific determinants of rental volatility (Orr et al. 2003) as this variable seems to be treated largely as determined exogenously (Buetow and Albert, 1998). In effect, external validation of the detailed estimates of the model is difficult.

The influence of energy efficiency variables on short-term volatility is statistically significant. When periods of four quarters are considered, rental values are less volatile in properties that hold energy certificates. However, buildings that have received certification for the first time experience increased annual volatility. Level of certification exhibits no correlation with the short-term volatility for the first two years.

The results suggest that when a short period of time is considered rents are likely to be less volatile in energy certified properties. This is consistent with the hypothesis that energy certification lowers some short term risks such as exposure to volatility in energy prices. In fact, the results suggest that this outweighs the negative effect of the short-term volatility of the rental premium. It would appear that, despite the fact that sustainable properties are exposed to contemporary changes in the market sentiment, the overall short term volatility is reduced by energy certification.

Interestingly, the first two periods of holding certification are associated with increased rental variability. This could be a result of adjustment to a new level. As rental rates are expected to be different in certified properties (Eichholtz et al. 2013, Fuerst et al. 2011a, 2011b) it is likely that the process of adjusting to the new equilibrium can attract some volatility. This effect should reduce with time as an optimal level is established.

Overall, the results lead to the conclusion that any financial benefits of certifying a building initially come at the expense of increased volatility. Rental adjustments seem to occur as soon as the property becomes certified. The corresponding volatility increases initially but after two years is reduced to below its values in comparable non-certified structures.

Table 4. Selected regression results for long-term volatility and rental values.

Estimation	Tobit	Ordinary Least Squares
Dep. Variable	Standard deviation	Rent
Var. name	MPE	Coefficient
Holds certification	-0.31	-14.86*
	-0.34	*-1.93*
Certification score	0.007	0.18**
	0.55	*2.05*

Control variables		
Lease type	*Yes*	*Yes*
Economic	*Yes*	*Yes*
Property char.	*Yes*	*Yes*
Location	*Yes*	*Yes*
Model statistics		
left-censored	2086	
uncensored	12309	
Log likelihood	-29568.7***	
Wald chi2	1383.55***	
R squared		0.675
F statistic		333.64

This table reports a Tobit model for average volatility of rents and an Ordinary Least Squares model for average rental values over a 7 year period from 2006 to 2013. The standard errors estimated for both models are robust to heteroskedasticity using the Huber/White error estimation (Huber, 1967, White, 1980).***, **, * indicate significance at the 1%, 5% and 10% level respectively.

Table 4 presents selected results for models of long-term average cash flows and their volatility. They have been estimated using starting period values as independent variables. The presented models offer a relatively good fit which is likely attributable the fact that rents often display autoregressive patterns. As a result, the starting period values are a significant indicator of long-term averages. In most cases, individual characteristics of each property are significant. This holds true for both lease terms and location variables. The table includes two energy certification controls: a dummy variable reflecting the fact of holding certification and a semi-continuous variable containing its score.

Only three lease types influence the long-term volatility of rents differently than a gross contract. Negotiable terms seem to be associated with the largest increase in the dependant variable. This is consistent with the expectation that this type of contract correlates to the biggest variances between individual agreements within a building. Therefore, it is expected to be associated with higher differences in rental values. Class A offices seem to experience more variability in their rents than other building types. Higher starting unemployment correlates to lower long-term volatility. This suggests that rents vary less in counties with high unemployment, which is consistent with the practice of landlords offering non-monetary incentives before reducing rents. The importance of local market conditions is further shown by the fact that all location controls are significant. Some property-specific characteristics also influence rental variability. Although the model can explain less than 4%

of changes in the dependent variable, the results seem to be consistent with expectations and the economic theory of changes in rents.

Over the long term, no effect of energy certification is found. Neither the fact of receiving a certificate, nor its level are found to be important. This shows that in the long-term volatility is unaffected by certification at the beginning of the period.

Coefficient estimates of the volatility model could potentially be influenced by econometric challenges. In order to ensure that this did not dominate the results, alternative approaches were explored. Shorter time periods of six and four years, were investigated. Ordinary least squares and fixed-effects estimation methods were used and gave similar results. In effect, the conclusion of this examination seems to be that on average energy efficiency had no impact on long-term volatility of rental values.

Table 4 also shows the results of modelling the average level of rent over a year period. Based on the highest and the lowest values of energy certification found in the sample, the total effect ranges from -$1.42 to $3.08 (assuming a gross lease). The magnitude of the long-term effect of certification seems comparable with findings of other studies (Eichholtz et al 2013, Fuerst and McAllister, 2011b) but has the advantage of considering significantly longer time horizons. Three key findings seem to emerge from the examination of long term average rents. The first is the conclusion that certification is an important determinant of an average income level. The second is that certification score is a statistically significant determinant of its financial impact. The third is the fact that the range of the financial effect spans from a discount to a premium.

Overall, energy labelling seems to be an important event in the life of a building and to be reflected in its financial performance. The level of certification is important in determining the effect on income charactersitcs. Over a long time period a higher efficiency score seems to correspond to a larger rental premium but attracts no changes in volatility. This is consistent with findings of other research reports (Eichholtz et al 2013, Fuerst and McAllister, 2011b) but also with the hypothesis that benefits of energy efficiency can be related to increased business efficiency and come at no additional risk. This efficiency benefit should manifest itself in higher rental levels and lower (or unchanged) volatility. This is supported by the empirical results presented above. On average, the ratio of income level to its volatility is higher in energy certified buildings. This strongly indicates that as the time horizon increases financial gains from energy certification are increasingly reliant on economic efficiency.

2. Discussion

Table 5 presents a qualitative summary of the results presented earlier in this section. The hypotheses presented in the "research design" chapter appear to find overall empirical support. In addition, the results suggest some unexpected conclusions regarding the practical relationship between energy efficiency and financial performance of office buildings.

Table 5. Qualitative summary of regression results.

Investigated effect	**Finding**	**Income conclusion**	**Risk conclusion**
Changes in the magnitude of the sustainability premium over time.	The effect of holding certification changes between years but on average is positive.	On average, rental income increases with certification. However, in some years discounts were found.	The immediate "premium" incorporated in rental values after certification is exposed to market risk.
The difference in short-term cash flow volatility between sustainable and traditional buildings.	Short term volatility is lower in certified buildings after two years since certification.	Adjustments to rent start immediately after certification and take two years.	Annual variability of rents is reduced two years after certification.
The difference in long-term average cash flows and their volatility between sustainable and traditional buildings.	Certification can be related to a premium but it depends on its level. Volatility seems unaffected.	A long term increase in the average rental income depends on the level of energy efficiency.	There seems to be no increase in the long term volatility of rental income in certified properties.

This study begun by investigating uncertainty of the sustainability premium in rental values. Although the positive effect of energy efficiency on income levels was confirmed, after adjusting for the time of measurement large differences in the magnitude of the effect were found. In fact, in some years a discount was reported. This supports the hypothesis that the short-term effect of energy efficiency on income depends on market environment and therefore increases exposure of the total income to the risk of changes in market conditions.

However, an investigation of short-term volatility showed that on average rents vary less when a property holds energy certification. This indicates that, despite the volatility of the certification premium, energy efficiency reduces the short-term variability of the income stream. Interestingly, some evidence of a rental adjustment process was found in the first two years after certification.

The long term examination confirmed the expectation of a positive effect on income characteristics. However, the level of energy efficiency is shown to be critical in determining the direction of the change in gross income but not influence its volatility. This indicates the long-term importance of benefits related to the actual level of efficiency rather than of the simple fact of holding certification.

a. Conclusions

The study investigated uncertainty of the superior financial performance of energy efficient office buildings reported by an increasing number of studies. Two hypotheses have been presented and examined. The first posited that energy efficient properties may attract higher demand. The second hypothesis stated that many financial effects of energy efficiency are related to higher economic efficiency.

The presented results support theoretical predictions of this research. Rental levels appear to be different in buildings that hold energy certification. The average effect over the investigated period was a small premium. However, significant variations were found between different years. Interestingly, holding certification appears to have no influence on long-term volatility of rents but reduce it over a shorter horizon. Buildings with sustainability features seem to attract higher average rents at no additional long-term risk and with reduced short-term volatility. This is likely a result of the higher demand for such characteristics and increased business efficiency of operating such properties. Rental rates adjust to the new level over two years of increased volatility. After that period there are no adverse effects on overall uncertainty, despite the fact that the rental premium is sensitive to market conditions. In the long run, this translates into an increase in average rental values which is not accompanied by additional risk.

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Appendix – full regression results.

Table A1. List of variables.

Location		
	chicago	Located in Chicago
	houston	Located in Houston
	denver	Located in Denver
Lease contract type dummy variables*		
	mg	Modified gross contract
	elec	Net contract plus electricity
	util	Net contract plus all utilities
	cle	Net contract plus cleaning
	nnn	Triple net contract
	nn	Double net contract
	n	Net contract
	mix	Mixed contracts available
	neg	Negotiable contract terms
	ec	Net contract plus electricity and other charges
	charg	Net contract plus charges
Time variable property-specific characteristics		
	vacancy	Current rate of vacancy
	rent	Current asking rent in $ per square foot
	Ln(rent)	Natural logarithm of rent
	RBA	Rentable Building Area in square feet
Time invariable property-specific characteristics		
	class A	Class A office building
	Class B	Class A office building
	age	Age in number of years
	age2	Squared value of age
	age3	Cubed value of age
	stories	Number of stories
	elevators	Number of elevators
	atrium	Building has an atrium
	restaurant	Building has a restaurant
	security	Building has security facilities
	banking	Building has banking facilities
	courtyard	Building has a courtyard
	for sale	Building is for sale
	air con.	Building has air conditioning
	card access	Building has card access
	food	Building has a food court
	conference	Building has conferencing facilities
	on-site mgmt	Building has on-site management
	dry cleaning	Building has dry cleaning facilities

Energy certification variables		
	ES certified	Building is energy certified
	Years since certification	Number of years since energy certification
	ES score	EnergyStar certification score
	cert20XX	Building holds certification in year 20XX
Time average variables		
	1y vac. avr.	Annual average vacancy
	LT vac. avr.	Full sample average vacancy
	LT RBA avr.	Full sample average RBA
	LT rent avr.	Full sample average rent
	1y rent avr.	Annual average
	1y bond price avr.	Annual average 10y US gov. bond price
Economic environment variables		
	CPI factor	US Consumer Price Index factor
	CPI index	US Consumer Price Index factor
	unemployment	The rate of unemployment (county level)
	bond price	Current 10y US gov. bond price
	1y bond var.	Annual 10y US gov. bond price variance
Additional		
	full year	Measurement year includes four quarters (all apart from 2006 and 2013)
	constant	Regression constant term

Dummy variables are in italics.

* Some categories of individual lease terms may seem overlapping. Nevertheless, they have been kept separate in order to reflect the view of the selling party on the differences.

Table A2. Summary statistics of selected non-dichotomous variables.

2006 values		N=14395	Time periods=1	
	Average	St. Dev.	Min	Max
Rent	19.28813	8.310138	0.04	102.84
Vacancy	0.1283585	0.2215222	0	1
Unemployment	4.797951	0.5202587	3.8	6.6
Building Area	53177.64	128389.8	500	3781045
Age	37.98249	25.14557	2	188

Quarterly average values		N = 417455	Time periods=29	
Rent	**19.46315**	**8.518189**	**0.04**	**102.84**
between		8.06227	0.2	102.84
within		2.750218	-26.6841	82.71694
Vacancy	**0.1650085**	**0.2551479**	**0**	**1**
between		0.1611641	0	1
within		0.1978088	-0.80051	1.130526
Unemployment	**8.058157**	**2.76881**	**3**	**19**

between		1.458899	5.482759	11.74138
within		2.35331	0.616778	15.31678
Building Area	**53177.13**	**128385.7**	**500**	**3781045**
between		128390	500	3781045
within		27.95133	51646.44	60524.44
Age	**37.98353**	**25.14456**	**2**	**188**
between		25.14534	2	188
within		0.0566709	23.08698	41.08698

Overall- values for the whole sample and all observations. Between - average values for individual properties. Within- values for deviation from mean of individual property with the global average added back in (see STATA manual for details).

Table A3. Full individual property level, Correlated-Random-Effects vacancy estimation results of equation 3.

Estimation: Correlated-Random-Effects Fractional Logit Model (Papke and Wooldridge 2008)

Variable		Marginal Partial Effect	Z-stat	
	Time average rent	-0.02424	-11.56	***
	Energy certification	-0.17437	-4.5	**
	Rent	0.003067	3.14	***
Lease terms				
	Modified Gross	0.134524	9.7	***
	Inc. electricity	0.009794	0.29	
	Inc. utilities	0.138309	3.74	***
	Inc. cleaning	0.057303	0.69	
	Triple net	-0.31578	-28.34	***
	Double net	-0.13297	-1.06	
	Net	-0.04661	-1.6	*
	Mixed leases	-0.1546	-4.89	***
	Negotiable	-0.07706	-2.26	***
	Inc. electricity and cleaning	0.071019	0.89	
	Inc. all charges	0.220098	1.45	
Economic Indicators				
	Unemployment rate	0.018459	8.15	***
	local market size	7.87E-09	9.63	***
	3y bond price	0.025427	6.09	***
	US cpi factor (base Q3 2006)	-0.59776	-4.27	***
Building Characteristics				
	Class A	0.279909	6.15	***
	Class B	0.146869	6.04	***

	ln(number of stories)	-0.14824	-6.03	***
	ln(rentable building area)	-0.07244	-4.97	***
	ln(number of elevators)	0.128006	4.94	***
	Built less than 5 years ago	-0.66538	-2.6	***
	Built less than 15 years ago	-1.33888	-5.44	
	Built less than 25 years ago	-1.3857	-5.74	
	Years since renovation	0.019261	2.66	***
	24h access	-0.00843	-0.24	
	Air conditioning	0.219958	2.92	***
	Atrium	0.0355	0.97	
	Banking facilities	-0.13234	-3.63	***
	Card access	0.046325	0.94	
	Food court	0.120936	3.08	***
	Restaurant	-0.05616	-1.44	*
	Conferencing facilities	0.033499	0.93	
	Convenience store	-0.02877	-0.47	
	On-site management	-0.08852	-2.85	***
	Property manager on site	-0.05346	-1.85	**
	Security	0.119324	2.37	**
	Dry cleaning	0.006317	0.1	
	Fitness	0.050102	1.12	
	Day care	0.03097	0.34	
	Courtyard	0.042532	0.81	
Location				
	Chicago	0.653024	14.96	***
	Houston	0.737222	9.98	***
	Denver	0.866932	9.81	***
Time				
	Time period	-0.02896	-22.3	***
	Quarter 1	-0.0004	-0.13	
	Quarter 2	0.017652	5.25	***
	Quarter 3	0.011224	3.75	***
	Observations	364587		
	pseudo–*R*-squared	6.02%		
	Wald chi2(49)	4459.58		

Papke and Wooldridge correlated-random-effects model of office vacancy rates for a panel data, based on quarterly observations over the period 2006–2013, estimated using the General Linear Model and Quasi Maximum Likelihood optimization. Reported standard errors are robust to heteroskedasticity using the Huber/White error estimation (Huber, 1967, White, 1980).). ***, **, * indicate significance at the 1%, 5% and 10% level respectively.

Table A4. Full individual property level, fixed-effects absorption estimation results (equation 4)

Dep. Variable	Absorption as a percentage of total space			
Estimation	Autocorrelation robust fixed-effects panel model			
Variable		Coefficient	Z-stat	
	Constant	0.214	43.87	***
	Energy certification t-1	0.012	0.007	*
	Rent t-1	-0.001	0.001	
Lease terms				
	Modified Gross	-0.011	-1.43	
	Inc. electricity	-0.041	-2.32	**
	Inc. utilities	-0.058	-2.37	**
	Triple net	0.010	1.51	
	Double net	0.071	0.81	
	Net	-0.002	-0.11	
	Mixed leases	-0.028	-3.14	***
	Negotiable	-0.040	-0.86	
	Inc. electricity and cleaning	-0.039	-0.8	
	Inc. all charges	-0.027	-0.48	
Economic Indicators				
	3y bond price t-1	-0.006	0.001	***
	US cpi factor (base Q3 2006) t-1	0.213	0.115	*
Building Characteristics				
	Vacancy t-1	0.713	22.19	***
	Amount of unleased space t-1	0.313	9.68	***
Time				
	Quarter 1	0.000	-0.13	
	Quarter 2	0.018	5.25	***
	Quarter 3	0.011	3.75	***
	Year 2012	0.039	8.34	***
	Year 2013	0.067	9.86	***
	Observations	28900		
	Groups	7831		
	F-stat	938.59		
	Overall R-sq.	0.385		
	Within R-sq.	0.094		
	Between R-sq.	0.129		

This table reports the autocorrelation-adjusted fixed-effects model of office absorption rates for an unbalanced panel data, based on quarterly observations over the period 2010–2013, estimated using the within estimator adjusted for autocorrelation in the first-order error term following the procedure described in Baltagi and Wu(1999). ***, **, * indicate significance at the 1%, 5% and 10% level respectively.