The incorporation of sustainability into the real estate investment portfolio

Does sustainability influence the financial performance of office buildings in the Netherlands?

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Preface

In order to accomplish the MSc-degree at the TU Delft, a graduation research is conducted. This graduation report describes the findings of a research in the area of Real Estate Management, section Building Economics. The subject of the research relates to the added value of sustainable offices in the real estate investment portfolio.

The question which is leading throughout this report is whether the extent of sustainability influences the financial performance of office buildings in the Netherlands. But on which grounds are these assumptions made? The gathered information compares actual energy consumption in relation to theoretical knowledge of a governmental regulated energy performance scheme.

To find an accurate answer a quantitative research has been conducted at a sustainability-driven organization, the Dutch Green Building Council (in short: DGBC). An extensive literature review provided me with a solid background to investigate the relation of financial performance compared to sustainability features. This knowledge enabled me to define a hedonic pricing model which enabled me to look into financial benefits of better performing assets. This model is used to highlight significant locational, asset-related and sustainable features that act as predictors for offices. Especially the degree of sustainability comes to mind when this data is compared with actual consumption instead of theoretically defined through a standardized calculation. This resulted into recommendations and eventually discussions gathered at the end of this report.

This report aims not only on the change of one's mind about the importance of sustainability but also on the added value of information flows for operational management.

Luc Baas
28 June 2013

Word of thanks

The moment of enlightenment came approximately a year ago. During a company's case which required us to look for some financial alternatives, sustainability came to mind. While I was looking out the window at the South-Axis, I stumbled upon the notion that the building across the highway had a better energy certificate. Should I assume that this is an indication of a higher rent? From that point on the subject advanced into this graduation report which (hopefully) enlightens the reader as well.

First I would like to thank my parents and my girlfriend Viv for their unconditional support. Their interest in real estate got bigger during the last half year as a tried to explain (or complain) about the importance and added value of sustainable offices. Although I pictured them as uninformed, they kept me on track by asking in-depth questions but more importantly also with lovely diners, kind words and a lots of humor.

Second, the professional support I've got from both the university and the Dutch Green Building Council. Numerous hours with on discussing specific financial topics and hedonic models with Philip, the truth about energy consumption and governmental regulations with Eric and benchmarking Dong proved to be a great learning experience. They all made it possible to finish this product within the rather short time limits. What should be mentioned is that sustainability is "not a walk in the park" as I personally found out myself.

Lastly, the support of my friends which provided me with some needed amusement, distraction and relaxation. Without you guys my student time would not be the same.

Be sure to cover this report from word to word, letter to letter to get affiliated with the added value of sustainability and the sensitive balance of the rental gains versus the energy costs.

Executive summary

The context of the real estate sector is drastically changing, as traditional ways of working are not aligned with renewed sustainable interests. The global crisis in 2007 and onwards forced the real estate sector to think different and discover new opportunities and challenges. Sustainability should be taken seriously and companies should shift their attention and combine innovative ideas such as a Corporate Social Responsibility strategy (CSR). Perhaps a full commitment to sustainable operation is a bridge to far, but the generated benefits could be eminent when considering the sustainable opportunities that lie in front of us. Being socially responsible is often set aside as being too expensive. But is it? When continuing regular business as usual, indeed sustainability will be expensive. Consider change as facilitator of sustainable success and likewise benefits in image, productivity and investment returns. Sustainability emerged in the late 60s in correspondence to environmental degradation. Since the late 60s there has been a lot of change in the view towards the general concept of 'sustainability'. Commonly known among researchers and scientists is the UNCED report (1987), 'Our common future'. This report contains a definition of sustainable development which has currently a widespread influence: *'Sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs.'*

Especially after a boiling summer, the effect of sustainability comes to mind. The resource consumption to keep the air conditioning running is part of the energy scheme of a building. Sustainability in real estate can be traced back to the eco-output of a building, especially related to concepts of energy, water and carbon emissions, but also the reachability, and used materials among others. There are evident relationships between the notions of CSR, responsible property investments (RPI) and eco-labeling, while scale is the major difference. CSR-performance is part of the general strategy of an organization, while RPI often is the financial part of a company's strategy. Environmental labels are examples of measures that influence the outcomes of sustainable reporting. Although there are several definitions for responsible property investing, these notions are more a general overview of the various choices a professional organization could make. Not only occupiers of the involved assets, but also investors can benefit from aligning physical real estate to sustainable operation. Currently investors are increasingly integrating sustainable principles within their asset management activities to respond to tenants being increasingly concerned about the environmental performance and operational efficiency of the assets they occupy.

Due to the clutter of sustainable principles and the lack of transparency in the real estate industry, sustainable certification systems were introduced some time ago. Sustainable certification systems such as BREEAM and LEED or energy performance such as EPC and Energystar are nowadays certified measuring systems to assess and quantify the degree of sustainability. One could possibly argue that only financial performance matters in case of real estate funds, but these benefits are also dependent on other criteria. Based on research of Nelson & Frankel (2012) there are five crucial drivers that influence the relative sustainable performance or attitude in the real estate market. These are respectively: enhanced operating efficiency, investor criteria, regulatory compliance and incentives, tenant demand, and competitive positioning.

The literature provides a baseline towards the added value of green assets. Eichholtz et al. (2009a) discussed the financial possibilities of green buildings and stated that it increases rents (approx. 3%) and asset value (approx. 16%). Others such as Pivo and Fisher (2009), Fuerst and McAllister (2011b), and Miller et al (2010) also acknowledge this evidence, however with different values for rents and asset value. Besides quantitative figures, various authors stated the importance of the incorporation of sustainability. Certified properties tend to have a rental premium and an improved occupancy rate. In addition to premiums, there is an increased market value and a lower risk-profile regarding the property. More and more commercial buildings apply for a sustainable certification, which results in an increasing share of

green buildings in the market. In most cases RPI does not harm total return as the following stipulates: “companies can do good and well, even if they don’t do well by doing good” (Pivo & Fisher, 2010). The bottom-line of this quote is that sustainable assets are not likely to perform inferior compared to their inefficient peers, because in most cases the green asset performs better. So, why not invest in sustainability?

As an investment portfolio is subject to constant change during its lifetime, current knowledge of rating systems or benchmarks does not operationalize data on asset level. Moreover, it does not provide the investor with the importance of sustainable variables, such as detailed information about energy use, locational factors, waste management, carbon emissions, and water usage between investors. Especially at asset level it is important to discover which variables are significantly influential on financial performance. Consequently related to the preceding explanation the problem statement will be as follows:

Does sustainability influence the financial performance of office buildings in the Netherlands?

Considering that real estate investment portfolios can be improved using benchmark data and related literature, the accompanying variables should prove to be significant thus show an impact on financial performance. These variables shape the backbone of a hedonic pricing analysis to calculate the added value of sustainability. It could be of great value to identify, interpret and benchmark indicators extracted out of the theoretical framework to separate variables which influence the financial performance of an asset.

Besides sustainable features, the model should consist of variables relating to location quality, asset quality and reachability. As such the primary objective of the statistical model is to assess the relationship between EPC and the transacted rent. Besides the obvious influence of locational factors such as the distance to Schiphol international airport or a type of location corresponding with a central business district, the energy performance does matter. Already in the descriptive statistics preliminary evidence gave a sneak peek into the added value of energy performance certificates (EPC). To be specific; the rental premium between G-certified and A-certified properties is estimated to be approx. 7.0% (using a sample case). Additionally “green properties” (labels A-C) obtain a premium of approx. 10-11% compared to their inefficient peers (labels D-G). This finding is in line with other authors who also found a green premium (Kok & Jennen, 2011) and (vd Erve, 2011). The results should be interpreted with some caution due to the diverse nature of transaction years and model estimation.

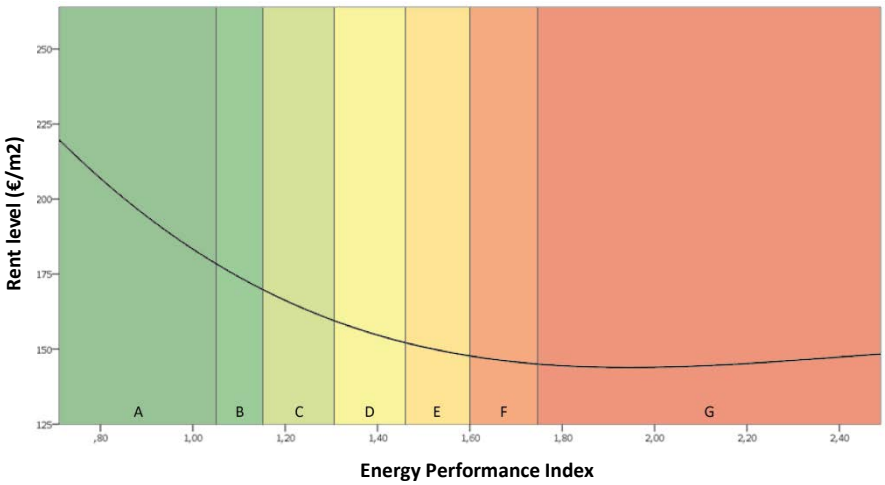


Figure 1; Rental income versus the energy performance index

But to what extent is this rental premium covered by energy savings? Does the green premium paid by tenants fade out when comparing the higher rental income with the saved energy costs? In the subsequent analysis the energy costs are estimated through the actual energy consumption of the office properties. The theoretical energy consumption takes up a big chunk in the calculation for the Energy Performance Index (EPI), therefore the EPI could be used to make a comparison with the actual energy consumption. Evidence shows that the relationship between actual energy consumption and theoretical energy consumption is rather vague.

The results imply that energy savings exceed the rental premium. To actually report on a percentage grade is maybe a bit premature regarding the sample set of only 47 office buildings. What can be observed is that indeed the savings are higher than the rental premium that is paid by the tenant. In this report the work of two preceding graduates has been used as evidence (Snoei, 2008; Visser, 2010). The authors respectively mentioned 32% (Visser) and 76% (Snoei) as the percentage of energy savings that occupiers were willing to pay as additional rent. When an asset was certified with an A-label, the energy savings were generally approximately € 47,- per square meter lower compared to a G-certificate. This implies that the additional rent that an occupier is willing to pay is around € 15,- per square meter extra for the same A-certified asset (considering the conservative 32% of energy savings). Indeed, the sample case estimates a rental premium of 7.0% between the A –and G certificates which is equal to approximately € 12,- per square meter.

These outcomes are positive for both the investor and the occupier, since the balance between savings and premiums is rather convincing. The investor indeed does obtain a rental premium on greener properties while the tenant saves energy costs while he is situated into a green asset. Regarding these two notions, the key-issue described as the split-incentive can be discussed and mutual communication should ensure sustainable operation of the property (possibly through a green lease).

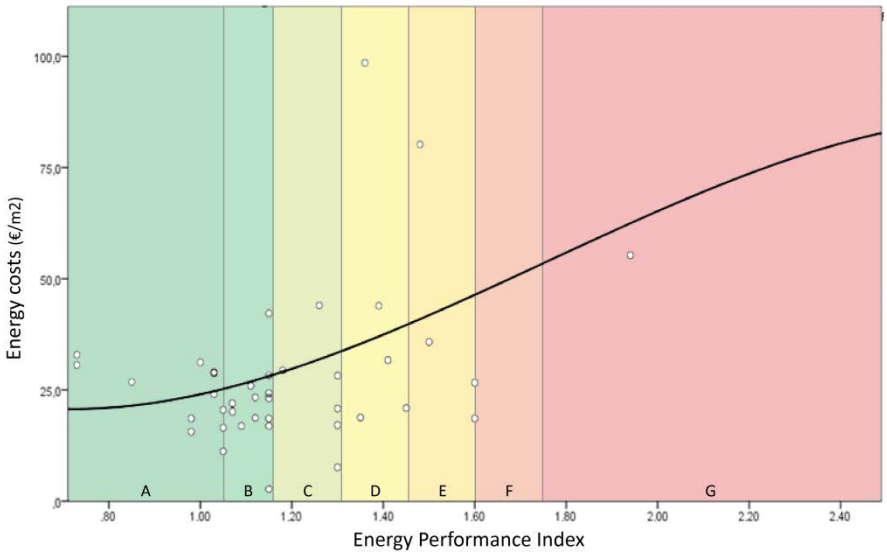


Figure 2; Energy costs versus the energy performance index

Are sustainable certification systems helping the commercial real estate market to move forward? Through providing the necessary rules and protocols, they enable the investors to be more connected with their assets. When considering newly constructed office space from an occupiers' perspective, the demand for office space without a sustainable certificate would be virtually non-existent. Also in the current existing office space, sustainable performance plays a more prominent role than ten years ago. It seems that the energy performance certificate is indeed providing the real estate world with some needed transparency. Although theoretically, the calculation framework seems to align with the energy performance index, the actual energy consumption deviates from the regulatory framework. When these consumption figures are being transferred to energy costs it becomes clear that the technical condition, the office space usage and the nature of the occupier are strongly influencing. Currently, it is up to the real estate sector to embrace sustainability and operationalize this principle through their assets. This report provides both the investor and the tenant with some decisive evidence on the financial side of sustainable performance.

Green buildings experience an increasing demand by tenants and owners, it is just part of what good quality means. With so many barriers cleared away for sustainability, and many parts around the globe that are still in its infancy, no doubt that demand for green assets will continue to evolve. To secure long-term operational performance and therefore sustainability practices within organizations or investments, mutual understanding is crucial for sustainable products such as green leases. This can only be accomplished through accurate measurement of operational flows and the use of benchmarking to estimate sustainability.

Introduction

Image:
LEED Platinum; Transamerica building, San Francisco, USA

1. Research introduction

Shown on the news, it is a major topic in documentaries, often labeled on grocery products, and a practical example is the Toyota Prius. Altogether they share the common notion of sustainability, all in their own way. Sustainability is rapidly gaining ground and is expanding across various market sectors. Clothing brands produce their goods through the use of responsible labor. Grocery stores sell bio-diverse and environmentally-friendly produced goods. Consider a new initiative of the sustainable grocery store: Marqt, a place where only biological products are being sold. The society considers the effect of climate change and greenhouse emissions more seriously during recent years as evidence shows concrete results. For companies, sustainability is generally about the complex challenge of self-interest with environmental protection, merging different interests and creating new opportunities (Hal van, 2010).

The context of the real estate sector is drastically changing, as traditional ways of working do not correspond with renewed sustainable interests. The global crisis in 2007 and onwards forced the real estate society to think different and discover new opportunities and challenges. Sustainability should be taken seriously and companies should shift their attention and combine innovative ideas in a Corporate Social Responsibility strategy (CSR). To fully commit to sustainable operation is currently a bridge to far, but the generated benefits could be eminent when considering the sustainable opportunities that lie in front of us. Being socially responsible is often set aside as being too expensive. But is it? When continuing business as usual, indeed sustainability will be expensive. Consider change as facilitator of sustainable success and likewise benefits in image, productivity and investment returns.

Change is often stated in yearly report and CSR initiatives, but are they really embraced? This all sounds quite subjective. Consider Henry Ford back in the ‘20s. He is better known as the inventor of the production line, which is famous for its productivity increase and better financial performance. Sustainability is not a standard answer on constraints, but often the solution is around the corner. Unfortunately it is too bad that most ideas do not leave the drawing table as public support often lacks commitment. Equal as in other sectors, sustainability is a hard notion to conform and commit to.

As this thesis focuses on the real estate aspect related to sustainability, some basic constraints can be identified. Think about the growing supply of office space during recent years, as new developments were being developed in a rapid pace. The economic crisis had its impact on the employment rate across the globe. Demographics show a worrisome figure as the population (not only in the Netherlands) is ageing. This only stipulates the preceding paragraph in which new possibilities have to be identified. This is also evident for the overflowing existing office stock in which the supply often disconnects with current real estate demand. Sustainability in its current extent could be influential to push businesses towards a more environmental-friendly future.

When considering the rationale of the commercial real estate market to move into sustainability, some basic questions could be asked, in the likelihood of: why would real estate professionals invest in sustainable real estate? An emerging topic within the commercial real estate market is the effect of sustainability on performance. While nowadays investors are increasingly interested in the measurement of sustainable performance and benchmarking, as these results provide a solid base line towards the potential acquisition or transformation of an asset in an investment portfolio. Consequently, how to gather these data and quantitative indicators for the objective measurement and benchmarking of sustainable performance? Although several authors stated evidence with regard to sustainable performance, investment styles, and risk/rewards profiles still relatively much knowledge is absent. The diversification potential of real estate funds when investing in sustainable assets could be an option to dissolve risk. Nevertheless investments in sustainability are not the same as being a socially responsible investor. The management of the organization should be involved in the sustainability program to recognize the added value and equal importance of such practice.

The short introduction indicates a lot of potential issues which are related to sustainability and the integration of the concept in the business cycle. The intent of this research is particularly on the incorporation of sustainability into the real estate investment portfolio. Benefits of a sustainable approach are described by several researchers and provide the author with a background and a sneak peek in the general decision-making process and the markets' regard towards sustainability. Still the question remains: Should the degree of sustainability be an asset selection criterion for office buildings within an investment portfolio? And continued, which indicators are influential on the determination of the rent level? This contribution to existing knowledge attempts to investigate current relationships and research further in the field of wealth maximization and sustainable performance as basis for (responsible) asset allocation.

2. Problem

Following chapter addresses a sound definition and provides a solid background on current problems related to the incorporation of sustainability into the real estate investment portfolio. The chapter starts with the introduction of eco-labeling into the investors' environment during recent history. Second, the facing issues related to the objectivity of the valuations of green office buildings. The problem background continues with some remarks about the benchmarking initiatives which have the possibility to assess individual assets and portfolios of real estate investors. Concluding with a paragraph in which the scientific gap will be identified and defined as a research subject in this thesis.

2.1 Problem background

Currently sustainability is a hot issue stretching from energy consumption, carbon emissions and water usage. Nowadays investors, users, developers and constructors explore possibilities to incorporate sustainable principles in their field of work, often through CSR-performance and the pursuance of sustainable initiatives. Although the sector comprehends the broad notion of sustainability, we do not really have detailed knowledge of all elements and opportunities situated within this discipline. As such, sustainable research is popular because of the potential added value of green buildings in the commercial real estate market.

Especially after a boiling summer, the effect of sustainability is revealed. The resource consumption to keep the air conditioning running is part of the whole energy scheme of a building and takes up a major part of the operational costs. Sustainability in real estate can be traced back to the eco-output of a building, specially related to concepts of energy, water and carbon emissions, but also the reachability, and used materials among others. Due to the mess of sustainable principles and the lack of transparency, sustainable certification systems were introduced some while ago. Scores can be obtained per category and through quantitative weighting a total score is obtained. Within bandwidths the total score of the examined building receives a qualification on for instance the BREEAM-certificate from "Pass (+)" to "Outstanding (+++)".

Such certification systems provide companies across the globe the opportunity to assess and evaluate their sustainable performance of their building stock. This is often done in a particular part in the annual report while the company would like to stress their sustainable or CSR-performance, often in combination with the acquisition of responsible property investments (RPI). These certification systems can be used as a basis towards a sustainable performance increase. Adding sustainable features and certifying buildings in a real estate investment portfolio could enhance operating expenses besides ecological emissions and improvement. Companies could also benefit from an increase in CSR-performance (Eichholtz, Kok, & Quigley, 2009b), which focuses more on social and governance values.

Alongside the introduction of sustainable features is the valuation of the green properties. Many problems arose because of the introduction of sustainability in buildings and appraisers did not how to value these features objectively. Nowadays investors employ better valuation standards for sustainable buildings, but still the investors argue about added risk and poor market compliance among others. Different approaches are currently being used to solve for sustainability issues in the valuation process. There are three standards described by Lorenz et al. (2008), which are all extracted from the main sustainable valuation question. How to identify, evaluate and price those new value-influencing factors that have previously not been on the radar of appraiser? Valuers have an ultimate legal responsibility to clients to provide an unchallengeable assessment of the market value of a property, based on market evidence and valuer's own knowledge and understanding of the market and trends (Warren-Myers, 2012). The valuation of sustainable properties to such a degree is an important factor, while retaining RPI-conditions and subsequently contributing to a better CSR-performance.

As said before, investors are currently uncertain of the actual added value of sustainable improvements. Eichholtz et al. (2009a) discussed the financial possibilities of green buildings and stated that it increases value. To be specific: +3% average rent, +16% higher building value. Others such as Pivo and Fisher (2009), Fuerst and McAllister (2011b), and Miller et al (2010) also acknowledge the added value of 'green' buildings, however with different values for the rent and value. Besides quantitative figures, various authors stated the importance and opportunities of the incorporation of sustainability. Certified properties tend to have a rental/risk premium and an improved occupancy rate. In addition to premiums, there is also an increased market value of the property. More and more commercial buildings apply for a sustainable certification, which results in an increasing share of green buildings in the market. Equally as sustainable assessments, green certification also is a broad notion. Besides different labels, the actual content of each certificate is different. There is not much coherence between these different certificates as well. Some focus solely upon the energy consumption of the building, others on the whole operation or lifecycle of a building.

Certification is currently more on a national basis in which national products prevail. In the US, LEED-certification and Energystar are most common in practice. In the Netherlands, BREEAM-certification has a relatively small market share compared to the obliged energy performance certificate. Although not yet common in the Netherlands, BREEAM has been issued approximately 15.000 labels worldwide. These certification systems encourage property owners and investors to measure and reduce their environmental footprints, but also by promoting broader awareness of the contributions of buildings to climate change. Although until recently many certification systems did not focus on performance, this is rapidly changing. 'Many systems fail to provide the kinds of actionable data needed to support decision-making, such as considering the value of achieving standards or the financial returns associated with alternative levels of environmental standards' (Nelson & Frankel, 2012). Achieving these certifications could be expensive and are often forgotten while observing financial implications of sustainable features.

Whereas the sustainable certificates systems could be useful when looking at building performance, a benchmark has the attribute to state a remark about an investment portfolio as a whole. As sustainable features are being implemented throughout more buildings in a portfolio, it is reasonable to assume that it will add value. These rating systems are emerging to comply with market demand. To integrate various sustainable certificates and combine them into a central knowledge point, two benchmarking initiatives have currently some market support in the Netherlands. The first initiative was founded in 2008 and is called the Global Real Estate Sustainable Benchmark (GRESB). The second initiative, the Dutch Green Building Benchmark (DGBB) was founded in late 2012. GRESB generally consists of an extensive survey which measures sustainable features in an investors' portfolio. Not exclusively on their environmental and financial performance, but more on policies and procedures behind their operations. As such companies have the opportunity to measure and benchmark the sustainable performance against their peers.

The DGBBenchmark attempts to assess the energy performance based on the actual consumption of an office building, which ultimately can be compared against the average of the peer group regarding location, energy consumption and operational costs. This insight helps to focus on validating the sustainable performance of buildings and in this way can be used in CSR reports or to prepare of a certification. Therefore both these benchmarks are significant sources of data relating to resources such as energy consumption and water usage among other factors. The relative “greenness“ of real estate investment portfolios is currently often an important tool which is absent at most real estate companies. Differences are evident between these initiatives as GRESB currently attempts to establish an actual connection between green labeling and portfolio management, while the DGBBenchmark tries to focus on the actual performance on asset-level.

The influence of an organization on the performance of portfolios is evident. Since benchmarking creates an ever increasing source of information besides the fact that current economic times force portfolio managers to review their assets, this data could be of great help. Portfolio managers should be more open-minded towards sustainable alternatives. Current portfolio strategies do not take the effect of such buildings into account and is in such a way an important missing piece in the framework of investment portfolios. While GRESB provides the opportunity to improve portfolio performance by the means of sustainable inputs, it lacks the evidence to operationalize the data on asset level. That is where the DGBBenchmark could be off great support, while it is essential to measure the relative degree of energetic and more importantly sustainable asset performance

The identification of a scientific gap regarding current knowledge is though, since the notion of sustainability can be far reaching in the real estate sector. Market parties still are eager to find out about the actual financial returns when investing or leasing green property, which is both a split between the investor criteria and tenant demand. Especially sustainable certification systems or eco-labels provide the investor and the user with an evaluation opportunity of their property. Several researchers have (successfully) tried to quantify rent and risk premiums. To encourage further increase in sustainable performance, several rating systems or benchmarks were developed to comply with market demand. A benchmark provides the opportunity to an investor to gain insight in their sustainable performance asset – or portfolio wise. The operationalization of the data on building level is still an unknown area within the sustainable field. Alongside the operationalization of the data are the consequences on asset level through the impact of sustainable variables. Still, the effects of sustainability are partially unclear, which could make the difference for a profitable operation of an office property. Especially information on asset level is missing related to the current knowledge about sustainable operation of an investment portfolio.

2.2 Problem statement

The problem background provides for an understanding of sustainable principles and current issues which investors' face in the real estate sector. Further on in the thesis more about the current motives of investors to get involved in sustainability. According to the Bauer et al. (2011) institutional investors are struggling to find the appropriate tools to carry out environmental assessments. Benchmarking performance complies with current demand of real estate investors to evaluate their investment portfolios across the world compared to the competition. A benchmark should consist of several variables to determine and structure an objective outcome, which could be influential in this research.

The first wave of high-performing, green buildings arose as a response to demand for energy and resource efficiency. Times have changed, and strengthened by the arrival of green rating tools, the industry now recognizes that green buildings deliver much more than energy efficiency alone (World Green Building Council, 2013). It also understands that green buildings must be viewed through a more holistic approach. Buildings must be examined in the context of their impact on the local and ecological environments.

Currently, the green building movement has developed, shifting the emphasis towards economics. Consequently, the conversation is now geared around how green buildings deliver on economic priorities such as return on investment and risk mitigation and on social priorities such as CSR-performance and employee productivity. Literature also indicates the potential gains of sustainable features and implementations in a real estate portfolio. Could some relatively easy implementable sustainable features make the difference for an office portfolio to add value, thus becoming more profitable towards the investor? An investment portfolio is subject to constant change during its lifetime, so does sustainability provide chances regarding relative attractiveness? Current knowledge of rating systems or benchmarks does not operationalize data on asset level, and does not provide the investor with the importance of sustainable variables, such as detailed information about energy use, locational factors, waste management, carbon emissions, and water use. Especially at asset level it is important to discover which variables are significantly influential on financial performance. While these variables are identified, there is an opportunity to state an outcome about the general financial performance of an investment portfolio as a whole. Consequently related to the preceding explanation the problem statement will be as follows:

Does sustainability influence the financial performance of office buildings in the Netherlands?

Considering that real estate investment portfolios can be upgraded using benchmark data and related literature, the accompanying variables should prove to be significant thus show an impact on financial performance. These variables are intended to shape the backbone of a hedonic pricing model to calculate and rank several assets in the DGBBenchmark. Significant sustainable variables could serve as determining factors later on in the process of evaluating or transforming a real estate portfolio.

But perhaps more importantly, does a rental premium for green buildings translate into a balanced sheet regarding saved energy costs? If a tenant is confronted with a rental premium, will the energy savings make up the difference in price? It could be of great value to identify these two notions and state evidence to which extent investors are compensated for green assets while occupiers have a better indication of their actual savings potential. These outcomes could influence agreements between the investor and occupier, also known as the "split incentive".

2.3 Target groups

Sustainable efforts can be measured on a global scale, but this broad notion is not applicable for this research. This research uses primarily data of several real estate investors, with some data gathered through the facility management providers. Often these investors are familiar with the notion of CSR-performance and some of them use sustainable certification systems. Although their CSR-performance consists of many activities, often they are eager to learn about the actual functioning of sustainable features. Although the focus is on investors, they are not the only involved peer group for this research. The influence of the occupier related to the investors is best considered in the real estate system, which is described by DiPasquale and Wheaton (1992) in the four-quadrant model. When looking at the four quadrant model the focus is both on the occupant and investor market due to the functioning of the real estate market. Consequently this point of view explains that both occupiers and developers are part of the sustainable outcome. The use and existence of the real estate system will later on be described in the theoretical framework.

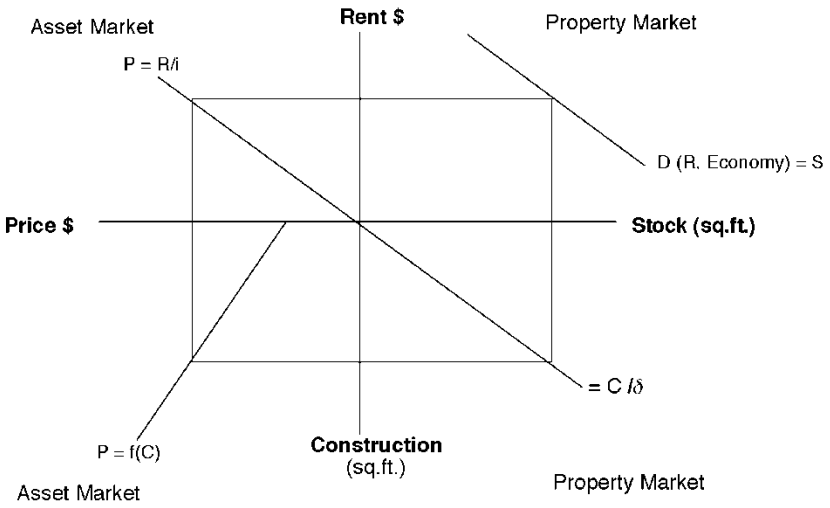


Figure 3; The Four-Quadrant model, DiPasquale and Wheaton (1992)

Circle of blame

During recent years, the relationship between sustainable efforts and impacts versus market value has received a considerable amount of attention. Sustainability should affect market value of a property, but this balance is still missing in direct and unbiased evidence. Blame points to many stakeholders in the industry, but no stakeholder really adopted the principle of sustainability (Cadman, 2000). Various actors in the real estate sector are pointing fingers to each other, and as a consequence the vicious circle of blame was developed. As Cadman elaborated further on the mixed interests of all involved actors, further research identified one more stakeholder in the process. As earlier stated, the valuation practice did not adopt either to the changing market conditions. As sustainability began to gain ground in the commercial real estate sector, actors admitted that there was a need for a change of attitude towards sustainable principles. Lorenz and Hartenberger (2008) created to opposite of the earlier stated circle of blame, while introducing a positive spin to the framework. 'The virtuous circle of blame' tries to demonstrate the added value of sustainability on the cooperation between actors. However the positive spin to the framework explains the potential opportunities for especially occupiers and investors, the main question of financial justification still remains. What does the real estate investor get in return? Subsequently on the other side; does the tenant make up for the rental premium in the energy savings of the office building?

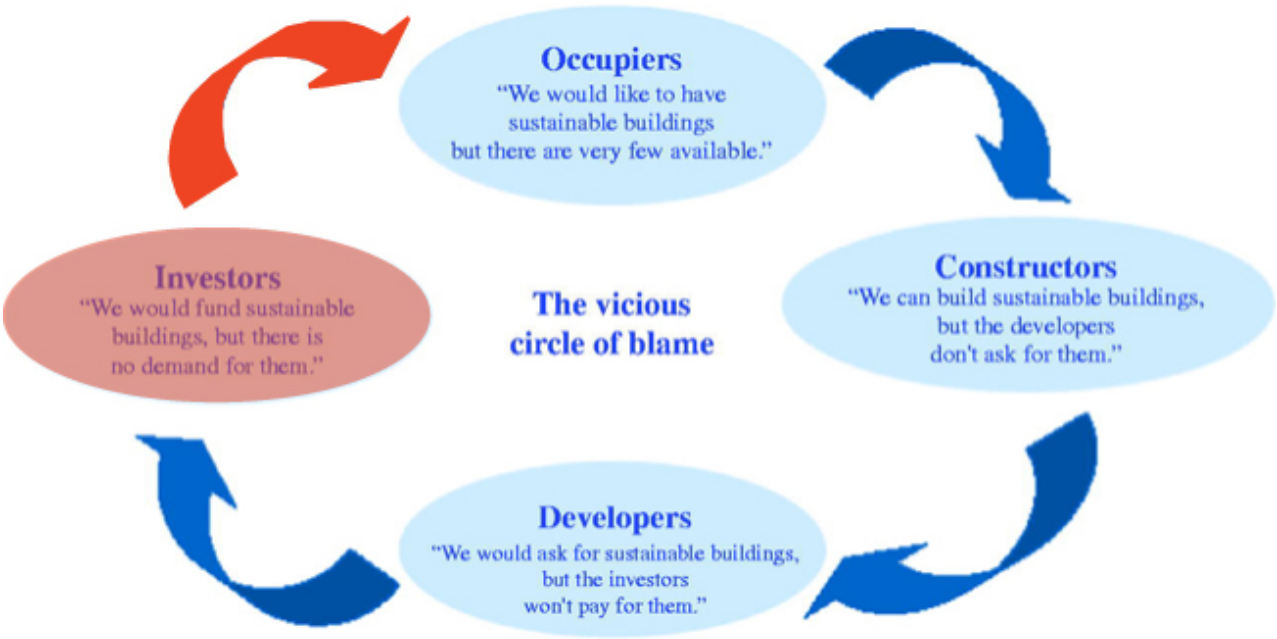


Figure 4; The vicious circle of blame, Cadman (2000)

Since this research would like to focus solely on the impact and effects of sustainability of investors and occupiers, they are to only ones to be illuminated below. The occupiers are willing to invest in a green office building. To be concrete, occupiers are willing to pay an additional rent premium on the lease. Among several reasons why occupiers would like to rent green building, most important arguments are increased operating efficiency, productivity and corporate image. Occupiers seem to be more positive about sustainability, but do not want to pay the full price. Thorough knowledge of the division of costs and benefits is needed while renting out green space. Again, do the actual energy savings make up for the paid rental premium? The actual energy savings are often not available due to the absence of sustainable indicators. Some occupiers just want to comply with current or future regulations while not because of their attitude towards an environmental better performance. It is not the question about the actual demand anymore, but the amount of greenness of a building compared to the rent is a renewed key issue. Going back in the circle of blame framework, the question can be reversed to investors.

Investors need to think about added value to themselves while still providing the desired quality towards the client or occupier. This needs to be done through sustainable measures, but to what extend? Sustainable certification systems are a perfect example for the cohesion between investors and occupiers, while such labels rate properties and in that way provide comprehensive grades. The grade will reflect the greenness of the property and can be translated into the sustainable performance of the involved organization. For investors, it is more the question which benefits result from sustainable improvements and if they will produce the expected rate of return. Still the whole mechanism between the investor and occupier balances on the notion of financial justification. The barrier makes it especially hard for investors to invest in green buildings while some elements of impact are still unknown. Investors are eagerly searching for the most profitable combination of sustainable elements through certification systems or sustainable benchmarks. Therefore a research in the significance of sustainable variables on office buildings could be beneficial.

2.4 Aim and objectives

The general scope is the implementation of best practice, which generates profitable and sustainable solutions for both individual assets as real estate portfolios. Through analyzing and detailed measurement of data, sustainable determinants can be identified. These determinants will form the backbone of a hedonic pricing analysis to quantify the financial performance of offices in the sample set.

The existence of various certification systems and the proofing of real estate portfolios is evident. Although many investors around the world have different views about, for instance CSR performance and financial feasibility of green offices the actual truth about the profitability of certain sustainable features has not been uncovered yet. Generally the objective is to uncover partly *the influence of sustainable features on net rental income and their relation to actual energy savings.* In this research the used data of both literature and benchmarking data will prove to be of great help in the quest to find the most influential (sustainable) determinants.

This research will provide real estate investors with a solid handle regarding sustainability while investing in green assets. The DGBBenchmark provides a source for investors from which they can benchmark their relative energetic performance. This can be used to address a potential tenant, while making a detailed enquiry about the balance of the rental premium and energy savings. To solve the split-incentive, the investor and the tenant can make a well-funded choice on the financial and energetic performance of a specific asset and possibly secure the agreement into a green lease.

When reflecting on the previous assumptions, the quest regarding the added value of sustainable real estate, the circle of blame shows up again. This research is targeted at the investors' supply towards the (potential) occupier. The research will try to quantify assumptions and provide more detailed knowledge on the functioning of sustainability on asset level. The sustainability will be incorporated through the use of Energy Performance Certificates (EPC), which quantifies the relative energetic performance of a building. From an investors' point of view, the current demand for green buildings is clearly there. With the provision of significant variables, the performance of an asset in a real estate portfolio will be the result from the functioning of the underlying sustainable assets. These underlying sustainable assets will be measured on asset level and quantified to state evidence about the whole picture, the national office market. The objective for the occupier is the reflection on actual energy consumption which can be transformed in energy savings related to the sustainable performance. As such, the study will mainly focus on the interaction effects between the surplus of rental income and the projected energy savings.

3. Research questions

Out of the foregoing motivation about the current functioning of sustainability into the real estate market, it is possible to formulate and define research questions. These are related to the problem statement which forms the fundament of this thesis:

Does sustainability influence the financial performance of office buildings in the Netherlands?

On the basis of the preceding main research question it is possible to formulate several sub-research questions. This is important, because there is a need to put boundary conditions on several elements of this research. These sub -questions can also be seen as a rough guide through the graduation project.

1. Should the degree of sustainability be an asset selection criterion for office buildings within an investment portfolio?
2. What are financial benefits of a better energy performance certificate regarding rental income?
3. Does the green premium paid by tenants fade out when comparing the higher rental income with the saved energy costs?

Sub-research questions

1. *The relative degree of sustainability incorporated within investment portfolios in the commercial real estate market*

- How does the commercial real estate market operate and what is the relative position of real estate investors in this respect?
- Why should real estate funds be interested in investing in sustainability?
- What does current evidence regarding sustainable performance stipulate and recommend concerning the added value of real estate?

2. *The change in rental income the office building benefits of a better energy performance certificate.*

- Which model to use when rental income is used to define financial performance on asset level?
- Is there a linear relationship between rental income and the energy performance certificates?
- Do sustainable assets indeed have a higher rental income compared to conventional office buildings?

3. *The balance between energy savings and the rental premium for green offices.*

- What does the energetic trend between actual and theoretical consumption indicate?
- Could the actual energy consumption be related to the energy performance index?
- How are energy savings diffused along the range of energy performance certificates?

3.1 Assumptions

In the following, the author would like to state some assumptions to be able to provide feedback after the research into sustainable drivers. Often people refer to a draft solution to a problem as a hypothesis or assumption, frequently stated as an educated guess. It can also be perceived as a suggested solution based on preliminary evidence presented by the introduction and literature review. The assumptions will be formulated to test alongside the findings of the analysis and model outcomes.

Assumption 1: The leading sustainable variables extracted out of the benchmark and the theoretical framework are indeed providing the real estate investor with useful information regarding its office building portfolio and formulate clear recommendations.

Assumption 2: Sustainable features do add value to offices, which is recognizable in a better financial performance portfolio-wise.

Assumption 3: Only energy use and locational features can predict for the relative higher rental income of offices.

Assumption 4: Besides CSR performance, responsible property investments in sustainable certification systems could be an advantageous approach to reduce risk while still profiting from an equal or higher financial return.

4. General methodology

The selected sustainable variables out of existing literature and benchmarks can be integrated into a hedonic pricing model which defines the significance of the sustainable indicators: energy, transport, facilities and location. These variables will be tested against the dependent variable which forms the background of the results, the rental income. The use of this variable in particular makes it possible to measure and rank the financial performance among the (non-)green buildings in the DGBBenchmark. In this research framework the first step is to identify the relative significance of the sustainable variables related to the rental income. Second is the matching of the evaluated assets in the benchmark and a discussion about the relative importance of sustainability when allocating assets. Third is the sensitive balance between the rental premium and the saved energy costs.

A hedonic pricing model will shed light into the operationalization of the sustainable variables related to office buildings in the data set. If these variables prove to be significant relative to the financial performance, an indication of a higher rent can be estimated. Note that only the relation between energy performance certificates and the rental income will be subject of research. Secondary objectives are related to the observations of actual energy consumption against their theoretical performance and energy performance certificate. This research aims to prove a better sustainable certificate (or score) provides the investors with a better direct return. Secondary objective is to look into the fragile balance between rental premiums and the energy savings. This research will provide the investor of a detailed look into the operation of sustainable assets relative to their inefficient peers. This knowledge could be used to adjust, evaluate and optimize real estate investment portfolios.

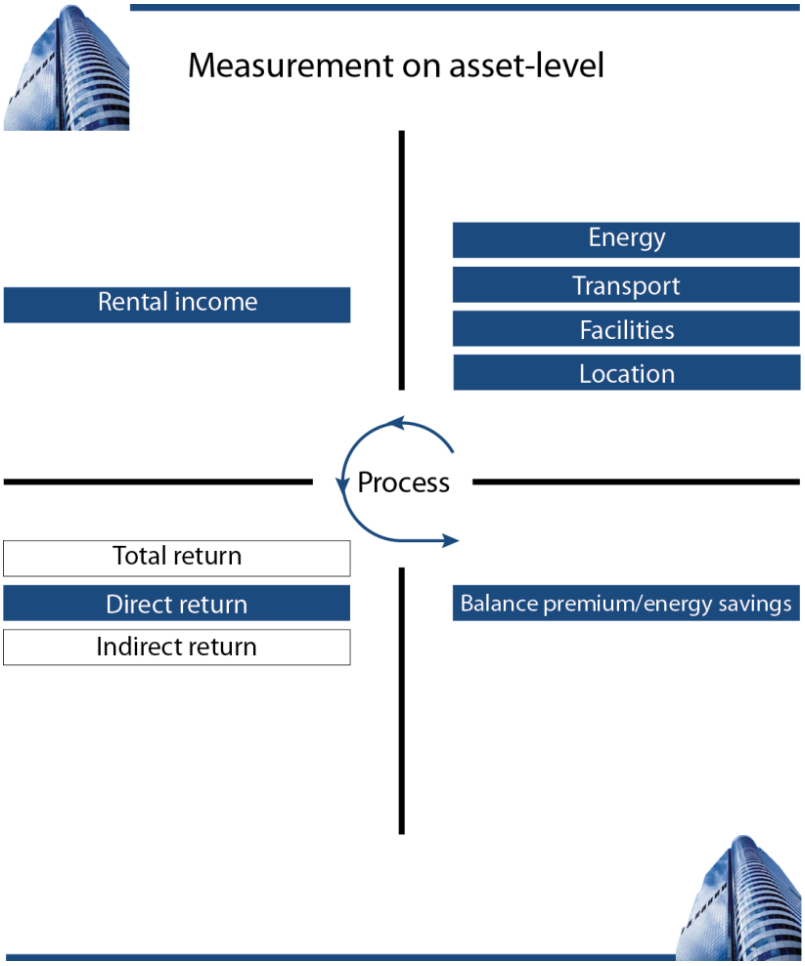


Figure 5; Research process

Former studies already estimated rental premiums through hedonic pricing models. As such the impact of various variables can be explored while at the same time the influence of sustainability can be tested. A good example is the following hedonic pricing model:

$$P_i\,(\text{Score}) = \alpha + (\text{Financials})\beta_1 + (\text{Region})\beta_2 + (\text{Sustainability})\beta_3 + \varepsilon_i$$

where “Financials” include company size (market capitalization), financial performance (return on assets), leverage (LTV total assets), and openness to the capital market (percentage of closely held shares) based on Kok, N., Eichholtz, P., Bauer, R., & Peneda, P. (2010) . There is also a dummy variable for each region (set relative to Amsterdam). Lastly, “Sustainability” is based on the relative financially better position of a green asset. This train of thought is used during the creation of the model of this research.

As such, this evidence was used to construct a statistical model which determines the relation between different sorts of data. The relationship between financial performance and sustainable indicators can be described by a hedonic pricing model. The dependent variable which relates to financial performance is rental income. Independent variables are related to several fields, but can be summarized as market, location, asset and sustainability characteristics. This section provides a very brief summary of the statistical equation and variables. Please take a look at the chapter “Methodology” for more information on statistical models and the variable specification. This equation gives an indication of the hedonic pricing model further defined in the variable specification.

$$\begin{aligned}\text{Rental income} = {} & \beta^0 + \text{Market characteristics}_i\,\beta^1 + \text{Location characteristics}_i\,\beta^2 + \text{Asset} \\ & - \text{specific characteristics}_i\,\beta^3 + \text{Sustainability characteristics}_i\,\beta^4 + \varepsilon_i\end{aligned}$$

Where the factor group Market consists of dummy variables regarding transaction year. Location accounts for the geographic trend on and around each specific case. The variable asset determines the relative asset which reflects size, building year, and occupier information. The variable sustainability includes the energy performance index which estimates the energy label. The variables water and waste are also included into sustainability through usage on m³ and amount of waste in tons. Unfortunately water and waste are not being used in the hedonic pricing model, because they just are not influential (and are not a criterion while acquiring office space). The attentive reader has already noticed that this model is focused on each asset individually. Indeed, this is true as every asset gets “labeled” on their relative sustainable score through the continuous energy performance index.

This general methodology section still has its loose ends, but it is a good starter to revise and enhance the following hedonic pricing models. These preliminary hedonic models give an indication how to solve for statistical problems. As this graduation report proceeds, the attention is to a large extent focused on the methodology section as this forms the key to both answering the research questions, results and subsequent recommendations.

5. Research design

The preliminary phase can be seen as a summary of the first half year of graduating. Although the student is not explicitly conducting research in terms of data gathering and structuring its aims and objectives, the first steps into the demarcation process of the subject have started. Incorporated in the preliminary phase are the P1 and P2 presentations which are basically a status display of progress. As such, the preliminary phase provides the context for further development of the research thesis. During these first steps into the research subject, the first quarter has been used to look further into the opportunities and possibilities of the research project. As earlier stated the notion sustainability is very broad and needs to be reduced into a comprehensive whole. The literature and gained information from the benchmark will be used to configure a set of sustainable variables, which will be used further on in the research. Subjects to be addressed during the preliminary phase are divided into two major parts. First the general research field needs to be defined together with an identification of the scientific gap. Through these two components the research questions can be devised. Second, the literature study which forms the basis for the theoretical framework. This literature review will help to structure the research in terms of knowledge, past experiences and imperfections by other authors.

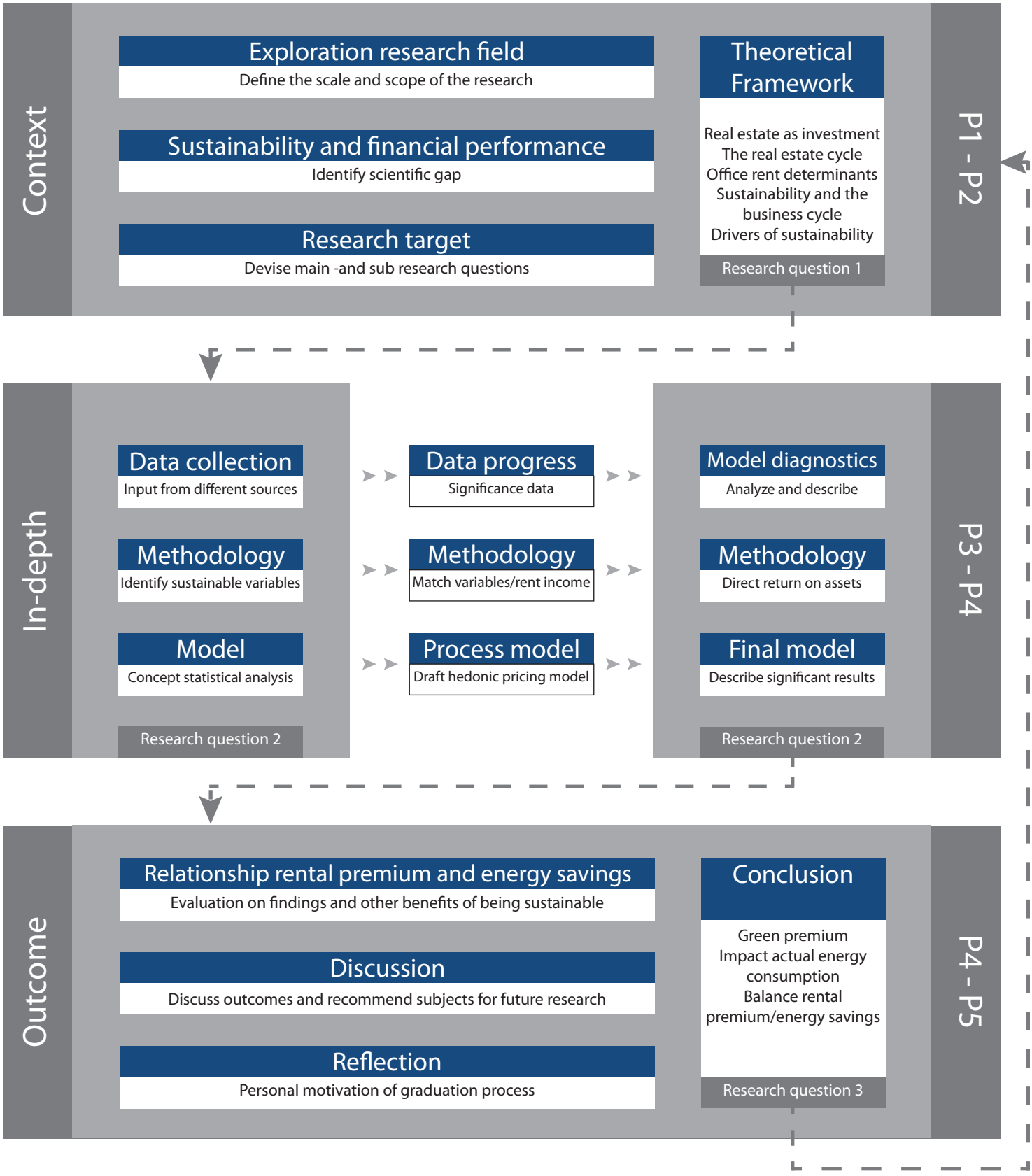
In-depth phase

The main phase of the research consists of the gathering of data through various sources. The main aim of this data is the operationalization through a statistical analysis. As the preliminary phase will describe the sustainable variables to be used in the model, the main phase will process them into quantitative data. First the data is collected from several sources, namely the benchmark of DGBC, DTZ, and Agentschap-NL. This data needs to be structured and converted to be used as an input in the hedonic pricing model. As the sustainable indicators are gathered and identified, the first conceptual analysis can be conducted. The quantitative data will generate an outcome regarding the financial performance of the involved asset. The rental income provides the best perspective on the financial performance. As such, the indicators will provide a significant relationship between sustainability and financial performance. As the results of the hedonic pricing model are being processed, the direct return on sustainable assets will be indicated. Outliers in the research will be identified through model diagnostics and described why their data is not corresponding with the general slope of the sample set. The effects on asset level are visualized and can state possible implications on portfolio level.

Evaluation phase

The evaluation phase starts with the relative correctness of the DGBBenchmark as not all data is of good quality. Consequently, the benchmark will be evaluated on its correctness and usefulness. Second is the matching of energy savings with the calculated rental premium. The energy savings are calculated through standardized formulas and indicate the energy costs per square meter. As such, the key-question can be answered; if the energy savings exceed the rental premium paid by tenants and subsequently to what extent? After the final research element of the report, the discussion of the outcome comes about. The research questions and the accompanying assumptions are being discussed and evaluated on their correctness. General objective is to estimate a relationship between the degree of sustainability and the financial performance and subsequently the balance of the rental premium with the energy savings.

Incorporation of sustainability into the real estate investment portfolio



Theoretical framework

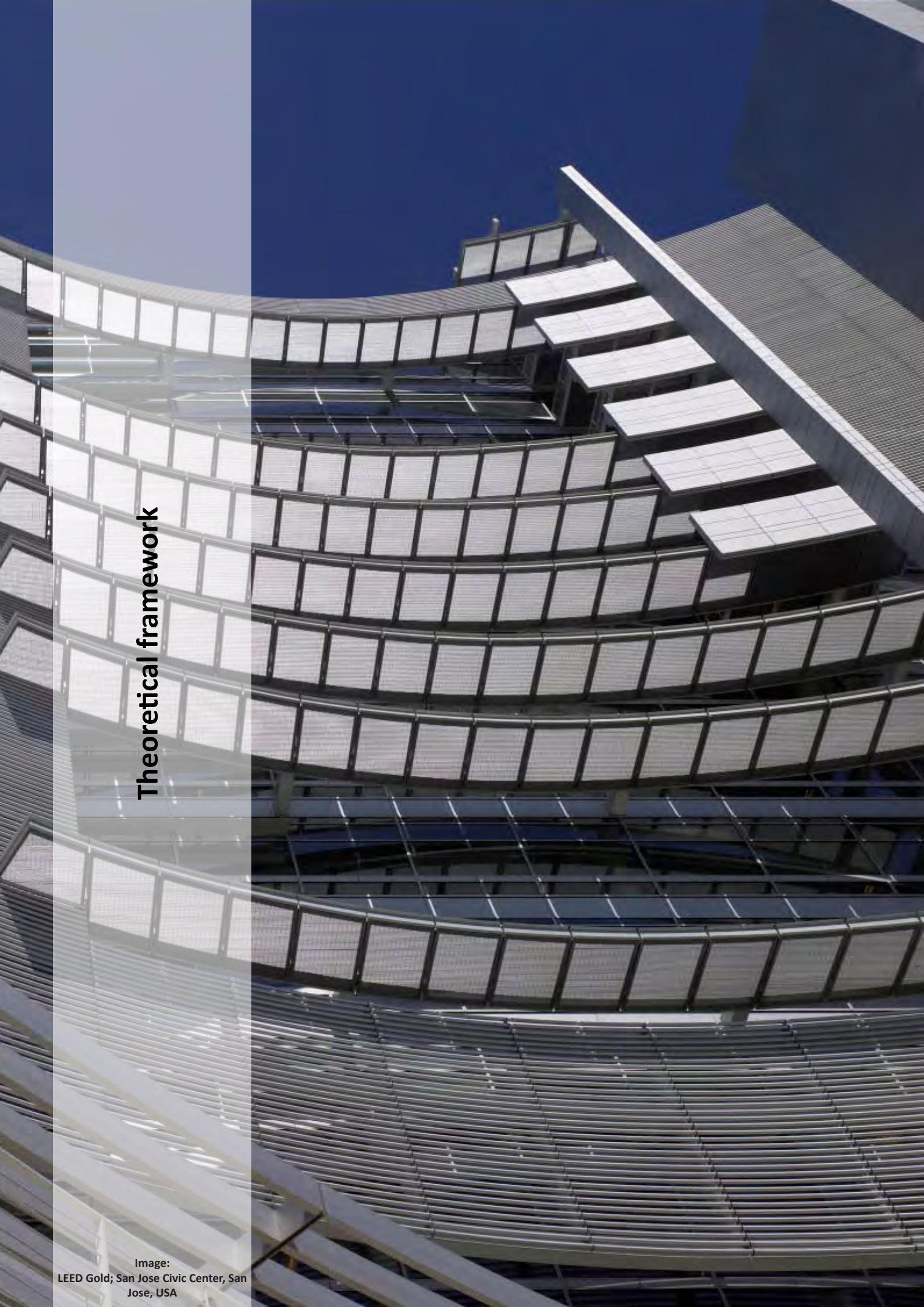


Image:
LEED Gold; San Jose Civic Center, San Jose, USA

6. Theoretical framework

The general focus of the research will be conducted in the field of the investor's real estate market. The added value of sustainability through the use of sustainable features (energy, carbon, transport, water, waste, and wellbeing) will be subject of research. In the theoretical framework several subjects will be discussed as they all contribute partly towards a better sustainable performance. At first a general overview of the investors' market will be provided. What are the relative benefits when investing in real estate and what is the difference between public and private real estate. As the general framework of real estate investments is discussed, the focus will shift towards the current attitude towards sustainability. After a brief summary of findings subtracted from the literature, the general market attitude can be divided into a couple of sub-topics, namely real estate investment vehicles, and the existence of a real estate cycle. The desired goal is the identification and verification of sustainable variables as these are the input for the hedonic pricing model to define net financial performance on asset level. The theoretical framework is connected to the first research question, which is:

> *What is the relative degree of sustainability within investment portfolios across the commercial real estate market?*

In this framework several topics will be addressed, starting from point zero. First the general commercial real estate market is described through a rather summarized perspective. Consequently the role of the investor is explored and described. As the perspective of the investor is defined, the integration of sustainability at company level can be shown. The literature review is continued with the current condition of sustainability investments regarding institutional investors or funds. What does the investor gain when investing in sustainability, improved return, occupancy rate or corporate image? This evidence is concisely concluded while describing the added value of sustainability.

6.1 Introduction to commercial real estate

The definition of the commercial real estate market is very well explained by Geltner and Miller (2007) in their book "Commercial Real Estate, analysis and investments". This reference is used throughout this theoretical framework as a key component. The commercial real estate market consists of two major components which are relevant for analyzing real estate: the **space** market and the **asset** market. The space or usage market is related to the use of real property, which can be seen as the right to use space or the actual property as the land or built space. On the other side of the real estate market is the asset market which represents the ownership of real estate objects. Often the asset market is compared from an economical point of view related to the capital market in which stocks and bonds are traded. Consequently, the real estate asset market must be considered as integrated within a much larger capital market.

The space market is more fundamental of the two in the sense that it determines the cash flows property can generate, and these cash flows underlie any value the property can have. This is based on the underlying notion that within the space market there is an ever changing situation between *demand* and *supply* of real estate. The occupation of an object by a tenant thus decreases supply as the space (in square meters) will be absorbed. In return the owner requires a financial compensation from the tenant to cover the costs of living/working and a premium. This short paragraph elaborates on the basic position of the space market in the much bigger real estate market. Although the space market seems to have great importance for the proper functioning of the real estate market, the asset market is of equal importance because it determines the valuation of property assets, and this in turn governs the flow of financial capital to real estate. Moreover, the asset market is most directly relevant to the analysis of investment in commercial property.

6.2 Real estate as an asset class

Investment - considered as a broad notion - is the act of putting money aside that would otherwise be used for current spending, such as groceries or luxury articles. An investor that invests its capital in an investment opportunity has two objectives to accomplish to guarantee a return on his expenditure. First, the *growth* objective is defined as the value growth of an investment based on a longer time period. Second the *income* objective which indicates that the investor has a short-term and a continuous need to use cash generated by the investment. Consequently an investor has to adopt one of these principles or both. Based on these two fundamental principles from an investor's point of view, investors are eager to maximize their wealth through investments in opportunities.

Real estate investors face in an ever changing market difficulties and typical drawbacks. These constraints are summed up by a wide range of authors, such as (Geltner & Miller, 2007), (Benjamin, Sirmans, & Zietz, 2001 in Gijselaar, 2010) and (Dhar & Goetzmann, 2006 in Meijners, 2012). These constraints of real estate are related to other asset classes in the capital market, which are largely stocks and bonds (and cash).

- Illiquidity
- Transaction costs
- Large unit prices
- High management intensity
- Non-transparent market

Real estate is an illiquid asset, which means when buying or selling an investment it takes quite some time compared to other easily traded asset classes such as stocks and bonds. An office building is thus an illiquid good compared to a stock of the AEX-index. Investors thus face difficulties when acquiring or selling properties in a rapidly shifting market.

At the same time when selling or purchasing real estate, transaction costs are part of the process. Relating to the Dutch housing market, recently transaction costs are lowered from 6% to 2%. This means that 2% of the transaction price is designated for the government. The costs associated with the acquisition of a house are generally way higher since real estate agents, advisors and the notary also charge fees. This means for investors a burden when acquiring or selling a property, which explains why investments in real estate often have such a long-term horizon.

In addition, high unit prices make it difficult for smaller investors to enter the real estate market. An property does not consist of several components that are up for sale. The property is sold to an investors or fund as a whole, which often results in a high unit price.

Management intensity is related to the operational requirements of real estate. Think of an office building and its operational requirements (vacancy, energy etc.). All these components make real estate an intensive investment related to stocks and bonds which can be managed relatively easy.

A concluding constraint is the rather opaque real estate market in which investors can face difficult problems when not adequately prepared. For stocks and bonds there is a continuous index that informs about current conditions. In real estate information is often held back by investors, brokers, tenants and so on.

So why should you invest in real estate? The foregoing constraints presents real estate in quite a bad light, but what are the advantages of real estate compared to the other assets classes (stocks, bonds, and cash)?

- Diversification potential
- Relatively high returns
- Hedging against inflation
- Long-term growth benefit
- Stable and predictable cash flows

The first argument for investing in real estate is because of its diversification potential, and therefore the opportunity to decrease the portfolio risk. Unlike other assets, real estate and real estate diversification pays off at the very time when the benefits are most needed, that is, when consumption growth opportunities are low (Chun, Sa-Aadu, & Shilling, 2004). When managing an investment portfolio the addition of real estate to stocks and bonds is ideal. Mostly because of the predictability of real estate returns, equivalent with the predictability of the stock market. Thus investors could assign real estate a much more important role in the optimal portfolio. The optimal asset-liability investment policy involves an allocation of between 6-12% to real estate on average (Chun et al., 2004). Other evidence suggests an allocation of 10% to real estate in a mixed-asset portfolio (Brounen & Eichholtz, 2003).

Another advantage of real estate is a relatively high return on a long-term basis. Due to the illiquid nature of real estate a long-term vision is requisite. Thus real estate provides a long-term growth benefit and a short-term continuous predictable cash flow. Due to the influence of these benefits real estate can be scaled between stocks and bonds in the investment universe. Due to the stable cash flows, thus predictable returns, real estate has the attribute to hedge against inflation. Several studies looked at the hedging opportunities of real estate and two main results were found. First the inflation hedge is derived from the actual capital gain from the property instead of the stable cash flow (or income return) (Huang & Hudson-Wilson, 2007). Second, not only the capital gain is an appropriate hedge against inflation, also rent indexation protects the investors against inflation (Baum, 2009).

Investment Concern	Stocks	Real Estate*	Long-Term Bonds**	Cash (T-Bills)
Risk	High	Moderate to Low***	Moderate to Low***	Lowest
Total Return	High	Moderate	Moderate	Lowest
Current Yield	Low	High	Highest	Moderate
Growth	High	Low	None	None****
Inflation Protection	L. R. Good	Good	Bad	Best (if reinvested)

Figure 6; Overview asset classes, Geltner and Miller (2007)

6.3 Real estate investment vehicles

Within real estate there are different types of investment vehicles. Since institutional investors have access to a wide variety of types, this paragraph will try structure these types and divide them up in comprehensive pieces. This typology regards real estate assets or properties as underlying assets in the framework of the investment vehicles direct and indirect real estate.

Direct and indirect real estate

Direct real estate investments are the most traditional way of investing in Real Estate. Basically the acquisition of an asset and generate a stable income through the tenant with an exit return when the asset is sold. Direct real estate is the purest form of investing because of the total control of the investment policy and the feeling with the market. Direct real estate can be compared with the purchase of your own house. The equity is directly invested in the asset without many intermediaries. The constraints of direct real estate are generally the ones cited above, namely the lack of liquidity and the transaction costs connected to the high initial investment. Therefore investors sought for other solutions to invest in real estate, because the risk associated with direct investments is often too high. These events created the introduction of indirect real estate, which has a different focus on real estate investment.

Indirect real estate can be seen as investments in real estate, except for the direct acquisition of real property. Investment in indirect real estate is practice for passive investors. Passive investors are those who do not wish to be deeply or directly involved in the management and operation of the underlying real estate assets. They lack the necessary specialized expertise or the time and resources required by such management, yet the value the risk and return characteristics of commercial real estate equity (Geltner & Miller, 2007). Take for instance a pension fund which is interested to diversify its portfolio. Since most pension funds do not have the expertise or employees to invest directly into real estate, investing in indirect funds could be advantageous. In the table below the basic scheme of the types of investment are shown.

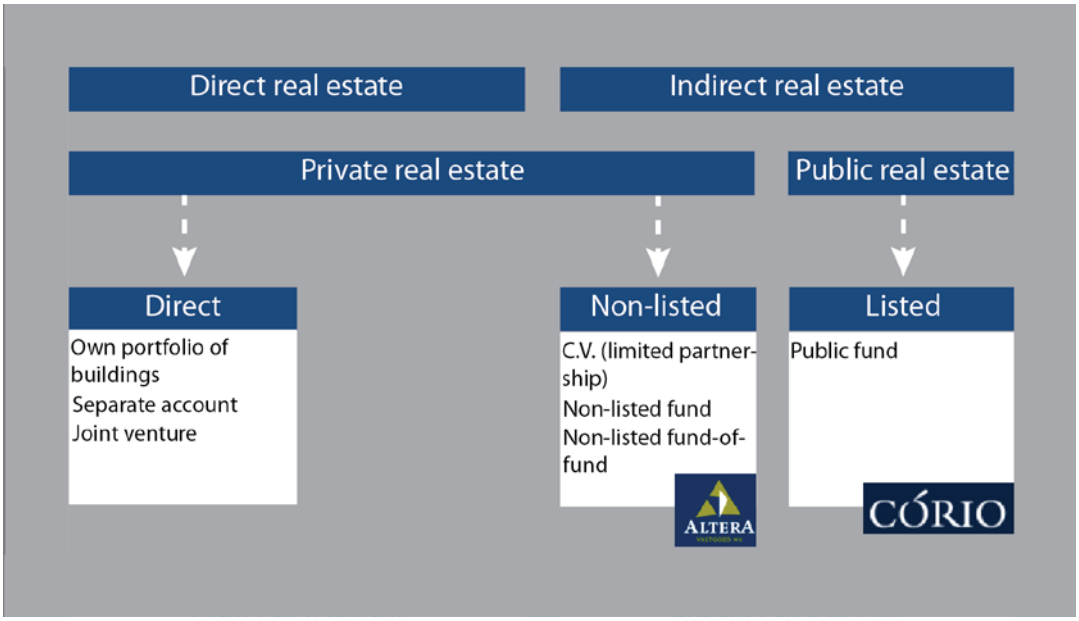


Figure 7; Types of real estate investment

In the following paragraph the differences between listed real estate and non-listed real estate will be discussed. Let's start with listed funds. Listed real estate (US: REIT's) is similar to corporate stock in that it provides investors with an ownership interest in the underlying asset, which is sometimes leveraged. Public real estate trades in shares, enabling small (individual) investors to participate in commercial property investment. Second, these shares are usually publicly traded and so provide the investor with more liquidity than direct real estate investments (Geltner & Miller, 2007).

A withdraw of listed real estate is the correlation with the overall stock market, which makes the returns more volatile (Brounen, Veld 't, & Raitio, 2007). Until now the correlation with the stock market seems to work against real estate, this is actually not true. Due to the transparent nature of the stock market, thus the public real estate market it is easier to measure performance and benchmark portfolios. Due to the volatile nature and the simultaneous added risk, the returns of public real estate could be higher than all other types.

When considering private investment, one has to know that there is no trade in shares or stocks, which is rather different from the public side. A private fund thus has the unique ability to benefit from market inefficiency, thus lower correlation exist between the stock market and the private funds' performance. Besides the inflation hedge (discussed in previous paragraph), a stable return, capital growth and lower risk is often applicable. The risk depends on the particular investment style of the fund. When investing in private non-listed funds, one invests indirect. Investors can benefit from this in multiple ways, namely the absence of transfer tax, lower capital investment requirements, and less local knowledge is required. As funds gather capital from multiple investors, a non-listed fund benefits from the relative scale thus bigger investments form a burden to a lesser extent. Between non-listed funds, investors can opt for different types of funds such as finite life or infinite life funds. Several types of funds are available with varying levels of market risk (depending on the type of real estate assets held by the fund and on the country where such investments are undertaken) (Hoesli & Lekander, 2008). As such, investors can choose between investment styles of several funds. These investments styles represent the risk appetite of a particular investors regarding private indirect real estate. These investment styles are described by INREV(2012a) and shown in the graphic display below. An investment style consists of several notions, but most importantly on the risk/return profile. An investor can choose between different notions such as Core, Core+, Value added or Opportunistic. These labels are related to the preferred return and the amount of risk the investor is willing to take.

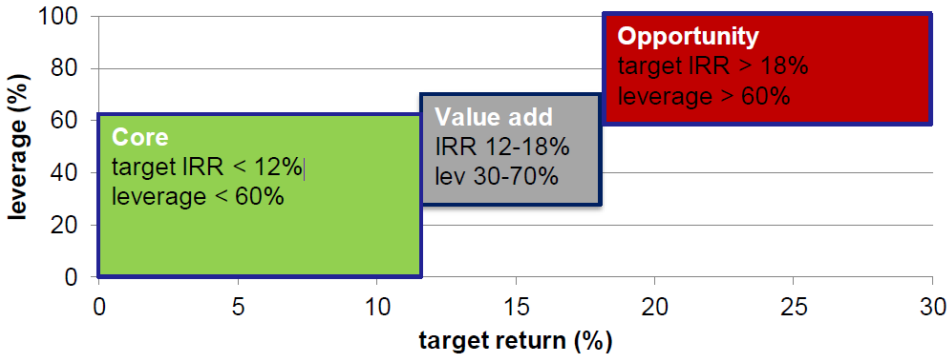
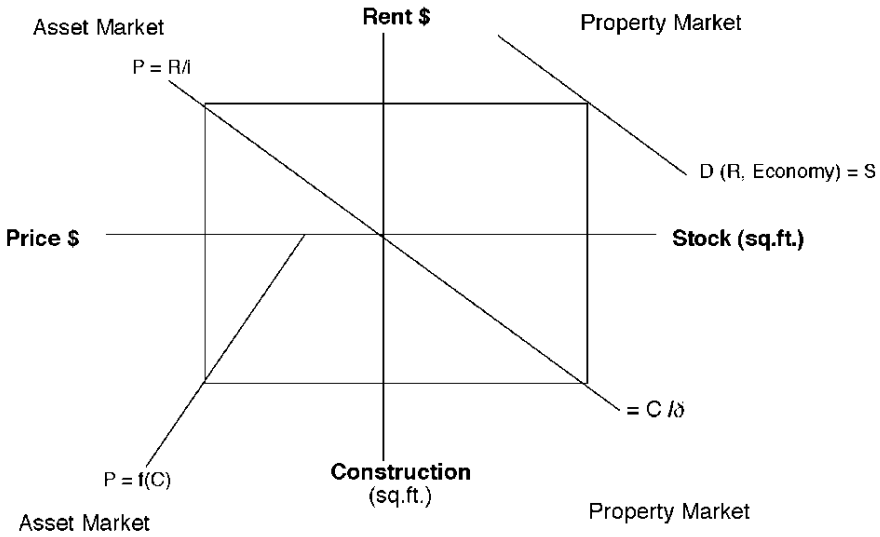


Figure 8; Real estate investment styles, INREV (2012)

6.4 The existence of a real estate cycle

Let's go back to the beginning, in which the cycle of demand and supply are central components of the real estate system. The availability or unavailability of real estate forms the backbone of the space and asset market and creates an equilibrium within the real estate market. The graphic representation of the real estate system just described is useful for performing some basic analyses of the system, and has been developed by DiPasquale & Wheaton (1992). The four-quadrant framework is useful for the description of the long-term equilibrium within the real estate system, allowing the markets sufficient time for the supply of built space to adjust to the demand. The process of external changes to the real estate system, for instance employment growth or capitalization rate disrupt the equilibrium situation, thus the four quadrant framework provides a guide to return to a stable situation.



where:
D = demand for space
R = rent
F(C) = replacement cost of real estate
S = stock of space
i = interest rate
δ = depreciation rate

Figure 1.
The equilibrium of the real estate market

Figure 9; The Four-Quadrant model, Dipasquale and Wheaton (1992)

Several authors wrote about the real estate cycle, both for commercial or residential properties. The four quadrant framework is in this regard a basic tool used for explaining rudimentary knowledge. One set of authors tries to identify a house price cycle through the use of statistical analysis. With the use of a wide set of regression analysis the authors find often macroeconomic determinants of the housing markets (Adams & Füss, 2010), (Beltratti & Morana, 2010), and (Englund & Ioannides, 1997). These determinants can predict a housing price cycle, but evidence is not strong enough to conclude the existence of a real estate cycle of house prices. Other authors tried the same for commercial properties and their macroeconomic determinants (DiPasquale & Wheaton, 1996). See for instance Jackson, Stevenson & Watkins (2008) regarding the "single cross-continental office market". This article surprisingly identifies New York and London consistent with each other, more because of their scale and the same kind of economic base (finance related). Other (recent) research by Srivatsa & Lee (2012) shows that the real estate office markets in Europe are not fully integrated and indicate that diversification across Europe is still a viable investment strategy. These are just some examples that often real estate markets differ from each other and regional aspects prevail in the determination of macroeconomic variables.

In this subsection, explanations have been given regarding the four quadrant model and the general functioning of the real estate system and the integrated (international) real estate markets (or rather lack of it). When the crisis of 2007 emerged, real estate took the fall and simultaneously real estate prices dropped, with office properties as frontrunner. After the Dotcom-bubble, the so called "Wall of money" made everything possible, ranging from extra ordinary transaction prices to the acquisition of farmland to be made into prime property. As the crisis attends, real estate fluctuates around an imaginary "average" value. Kaiser (1997) wrote an interesting article about the existence of the real estate cycle. Key findings included the fact that there are many different property cycles and that the real estate cycle is driven by inflation spikes on a long-term basis. Müller (1999) made an very interesting graphical approach in his article, which is shown below. The figure indicates the general functioning of the market and represents the real estate cycle in a comprehensive way.

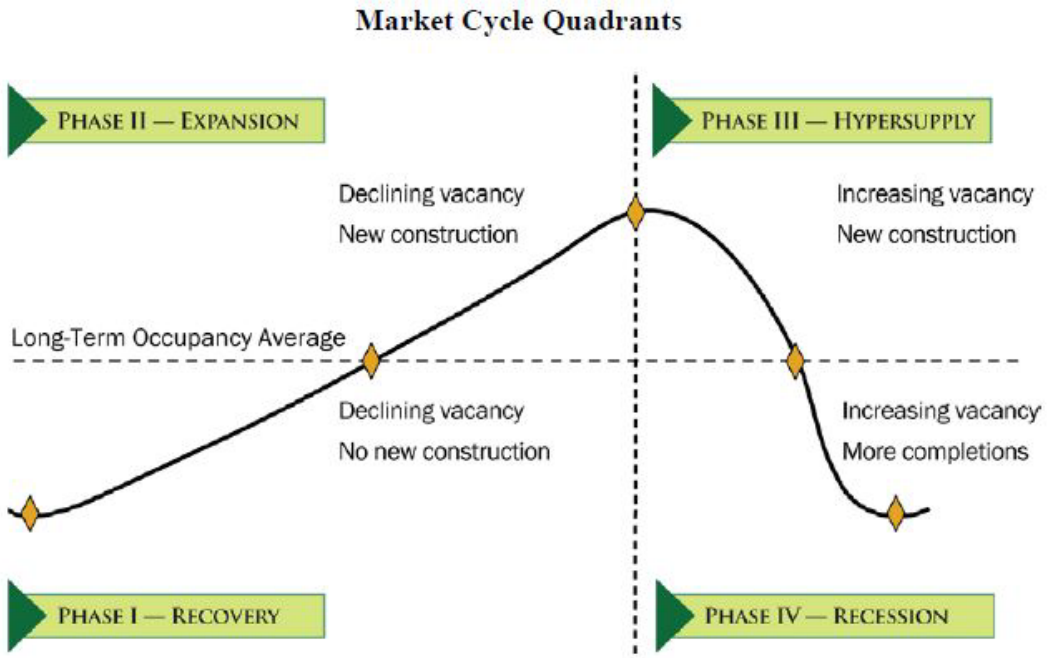


Figure 10; The real estate market cycle, Müller (1999)

The commercial real estate market is very broad with literally millions of different investment products and opportunities. This segment summarized the essential knowledge regarding the real estate system and commercial real estate to continue with investments in sustainability. As the preceding elaborated further on the perspective of an investor, the influence of sustainability on investment decisions can be described further on. Demand and supply form in that point of view an important indicator towards innovation in real estate. As sustainability is becoming more and more integrated in the real estate market, variances between listed and non-listed are still likely, due to their different natures. Sustainability could also be part of an investment strategy or style of a real estate fund in which sustainable features such as certification systems form an important part of the limitation of risk. Lastly, both the real estate system and the real estate cycle form a good indication of current (economic) times. The position of sustainability can be placed in a spectrum of current times; hence it is easier to comprehend opportunities and constraints. Therefore, this theoretical part should be perceived as a short introduction to the work of commercial real estate in which sustainability will be an evolving factor.

6.5 Determinants of office rent

Since this study focuses on office investments this explanatory section is limited to determinants that solely concern office buildings. Since the author will not be the first one to write about offices and the relation with the rental income, a summary of other influential researchers is provided to gain more insight into the functioning of a regression model in the form of hedonic pricing.

Let's start with the hedonic pricing model, how does it work? One of the first formal theoretical frameworks was provided by Rosen (1974) for a given market and a single product with many characteristics. In Rosen's model the interaction of demand and supply produces a market function which relates the vector of office characteristics to the combined price of the asset itself. The hedonic price theory for combined goods assumes that buyers and sellers (supply/demand) maximize their utility. Each seller has a specific demand function that indicates the minimum amount of money he wants to receive for providing the characteristics. This depends on the expected profit, given the cost function and the production level. From these demand and supply functions, equilibrium prices per characteristic follow. This is generally the basic assumption of a hedonic model; the price/rent is related to a set of characteristics ranging from location to asset quality.

Location, physical attributes, access to transport infrastructure, and market conditions have been used in past studies as principal determinants of office space rents (Farooq, Miller, & Haider, 2010). Most of these studies have used transacted rent as the dependent variable in the hedonic analysis. So what can we learn from these previous studies? Below three studies have been discussed more extensively, while thereafter a summary provides the reader with a brief summary of variables mentioned by several authors, these authors are also mentioned in Gijselaar (2010) and Van der Erve (2011).

An early example is provided by Clapp (1980) in which asking rent for offices in the Los Angeles metropolitan area were modeled as a function of land value, quality of space, neighborhood features, pollution levels, distance to the nearest highway intersection, and average commuting time for employees. Important independent variables related to the asking rent include asset size, age, distance by road to the nearest highway, and the number of floors. The sample however is rather limited with only high-rise buildings.

Another attempt to create comprehensive model of the office space market was completed by Rosen (1984). This study suggested that the change in demand and supply resulted in an adjustment of vacancy rates. In response to the change in vacancy rate, the rent changed in a nonlinear fashion. The more rapidly the rent would rise or fall, the further the actual vacancy rate moved away from the normal vacancy rate, whereas the normal vacancy rate is a function of interest rates and expected rent levels. This model was applied to the San Francisco office market, and the inverse relationship between office rents and vacancy rate was confirmed. Although rather accurate this model did not consider the spatial variations and the effect of the quality of office space the transacted rent.

Dunse and Jones (1998) used the office rent at the individual tenant level. This study defined the office rent as a function of the office space quality, location, and contract rights. The influence of quality was captured by age, location of the rented office space within the building, and facilities in –and around the building. The resulting model pointed out age and location of the office space as the principal determinant of rents. Unfortunately, this study could not include the location type or the reachability into the model.

Macro-economy	Location	Asset
GDP growth	Location in country	Age
Inflation	Location type	Asset size
Absorption office space	Location amenities	Number of floors
New construction	Distance to highway	Flexibility
Vacancy rate	Distance to train station	Building quality
Employment rate	Distance to airport	Building amenities
	Distance to other public transport	Tenant situation

Table 1; Determinants of office rent

Macro economy

Macro-economic factors are described by de Wit and van Dijk (2003) in their article; the global determinants of direct office real estate returns. For economic growth, the authors use change in unemployment, inflation and GDP/GMP and for the real estate variables they use capital value, net rent and change in vacancy and office stock in the main office districts. In the conclusion the authors remark that the change in employment and vacancy rate have the strongest effect on direct office real estate returns.

The employment rate has also been described by Mills (1992) which analyzed the building and location determinants for the rent definition and observed facilities near office buildings. Through employment rate Mills was able to state a positive relationship. The outcomes of vacancy rate are in accordance with Rosen (1984), (Glascock, Jahanian, & Sirmans, 1990) and (Wheaton, 1994) which state that the importance of vacancy rate is unquestionable with any rent model and independent of any spatial variation (location variables).

Another notion of the office space market is the absorption rate (read: the rate at which office space is rented/disposed in a specific market during a given time period). Some state that the absorption rate in a specific area is of greater importance compared to (the lagged) vacancy rate. Wheaton (1994) and Sivitanides (1997) have contradicting outcomes, whilst the first author finds the absorption rate to be more significant than vacancy rate, whereas Sivitanides concludes that the vacancy rate is more sensitive in explaining rental changes than the absorption rate.

Location

This notion grasps back to the ancient “location, location, location” as major determinant for office rental prices. One could identify various location variables, consider for instance the distance to a transportation hub. Other location characteristics could be in the range of location type and reachability factors. Note that the influence of the variables below differs per location typology and the national context. However these variables do indicate the importance of the office location within a specific geographical region.

Obviously between cities in the Netherlands there are differences, these are also described by macro-economic factors but can also be isolated through specific dummy variables. More importantly is the actual type of office location, which describes the level of facilities, distances to important points and environmental quality. Important to remember is that there is a clear distinction between the physical assets, the direct surroundings (location type, amenities) and the reachability of the location (distance to important nodes). Often location characteristics form a big part of the determination of rent; see Eichholtz et al. (2010). Various articles describe the influence of the location type while specifying distances to specific cases or locations through Geographic Information Systems (GIS) (Bollinger, Ihlanfeldt, & Bowes, 1998; Öven & Pekdemir, 2006; Sivitanidou, 1995, 1996). Others correct for the spatial variation through isolation of the study region, like (Gunnelin & Söderberg, 2003; Webb & Fisher, 1996).

It appears that the distance to a highway is significant; the rent decreases when the highway is farther away (Clapp, 1980). Opposite outcomes exist as well, Bollinger et al. (1998) claims that noise and congestion effects associated with highway locations can prevail over distance advantages. More recently Ryan (2005) examined the importance of access to light rail transit and highway in the US. Results showed that access to highways is a significant factor in estimating office rents and access to light rail systems is not. The latter outcome is probably due to the nature of the study location, which is the US.

Also the distance to an international airport proves to be influential on office rents and surprisingly indicate two outcomes. Sivitanidou (1996) claims that in LA, the distance to the major airport reveals a negative influence on office rent, while Ozus (2009) finds that offices located around the airport of Istanbul have the lowest rents and highest vacancy. It is expected that the finding of Sivitanidou suits this study better.

The latest addition to quantify reachability is the so called “walkability”. Walkability is the degree to which an area within walking distance of a property encourages walking for recreational or functional purposes (Pivo & Fisher, 2011). If there is a greater variety and supply of facilities, the “walkability” increases and tends to generate a higher rental income.

Asset

Öven and Pekedemir (2006) in Gijselaar (2010) found the following physical building variables to be influential for the rent level in the Istanbul office market. Ranked from highly influential to influential these are the building age, the percentage of unused space in the office, the total floor area, the number of floors and the percentage of common space in the building. A number of authors also report age and asset size as significant (Bollinger et al., 1998; Clapp, 1980; Ozus, 2009; Shilton & Zaccaria, 1994; Sivitanidou, 1995, 1996), while others claim it has either a negligible or no significance (Gat, 1998; Mills, 1992). Although significant, age and the asset size might be subject to different perceptions in different office markets to allow for a general conclusion. Again national context or geographic region is vital to include.

Conclusion

Almost all authors did not focus solely on one determinant which could explain for the office rent situation. The basic principle of a hedonic pricing model is the interaction of several determinants to actually predict the office rent. Consider following statement by Jennen and Brounen (2009); While controlling for the age, location and quality of the object, we find a strong positive effect of being located in dense office areas. We find that the vicinity of other office objects is priced into rent levels, regardless of market conditions. Again three different aspects are merged and one specific effect is investigated. Dependent on the assessment of risk and the preferred type of real estate, investors focus on specific office building which suit their interests. The preceding section showed us that office rent determinants are based on factors which proved to influence the rental income. The results of the determinants can be summarized in roughly three categories, namely market, location and asset characteristics.

6.6 Sustainability

The first part of this extending sustainability section discusses the content of the research related to the social relevance. Sustainability is a well-known issue which currently faces multiple actors in the real estate sector. Before the extensive discussion of current evidence regarding sustainable performance and benchmarking, the author will try to enlighten the reader about the general definition of 'sustainability'.

What is sustainability?

The notion of sustainability emerged in the late 60s in response to concern about environmental degradation. Sustainability can be applied to various disciplines and sectors globally and has been on the agenda of major institutions such as the United Nations or the Organization for Economic Cooperation and Development (OECD) among others. Since the late 60s there has been a lot of change in the view towards the general concept of 'sustainability'. Commonly known among researchers and scientists is the UNCED report (1987) which is named '*Our common future'* and written by the Brundtland-commission. This report contains a definition of sustainable development which has currently a widespread influence: 'Sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs.'

This definition is commonly cited as the general concept of sustainability worldwide. Therefore the social relevance of sustainability is a small piece within sustainable development. According to (Mak & Peacock, 2011) environmental sustainability is in common with social sustainability. Consequently social sustainability is the idea that future generations should have the same or greater access to social resources as the current generation ("inter-generational equity"), while there should also be equal access to social resources within the current generation ("intra-generational equity"). The meaning of this sentence could be traced back to the added value of sustainability on our current business.

The textual explanation of sustainability from Brundlandt and Mak et al. is rather vague. As each person can interpreted sustainability through its own intuition. A more comprehensive graphical approach is stated by Elkington (1998). Elkingtons methodology towards sustainability is the triple bottom line or 3P-approach. Three definitions can be identified: People, planet and profit. These principles form the background for every 'responsible' decision or investment. Translated into practice, these principles focus on preventing pollution, promote sustainable use of resources, contribute to reducing climate change, and protecting the natural environment. As such, the PPP-approach acclaims the strategy of 'reduce, re-use and recycle ", while encouraging the use of environmentally friendly technologies and the use of "renewable energy". Besides the improvement of involved products, process adjustments are also commonly used in practice. Usually a social shared value is introduced to evaluate and reorganize the supply chain. In that matter, not only the 'responsible' business is involved but also indirectly influencing companies along the supply chain. Hence the triple-P approach has as target to improve the process and implement products to reduce environmental impact as much as possible.

Social sustainability is not an innovative topic anymore but a genuine part of a business strategy towards the market. Subsequently different aspects of social sustainability are often considered in Corporate Social Responsibility (CSR). CSR performance is a notion of sustainability in a company, which consists of several fields of interest. The success of a company is not only dependent on the obedience of regulations and laws but also through a wide set of economic, environmental and social issues in ways that benefit the entire community and society globally. An extension on the definition of CSR is the social attitude of the financial operation of the company, also known as Responsible Property Investment (RPI). The RPI component is aimed at the operationalization of social responsibilities through, for instance real estate investments and the extension of loans.

6.7 Responsible investments in real estate

The preceding paragraph elaborated on the principle of socially responsible investing. When considering the impact of RPI on buildings and construction figures, sustainable development of real estate should be part of a companywide strategy. The United Nations Environment Program (UNEP) Sustainable Buildings and Climate Initiative (2009) suggests that buildings are responsible for more than 40 percent of global energy use and one third of global greenhouse gas emissions. It also estimates that buildings are responsible for up to 80 percent of greenhouse gas emissions in our cities and towns. While considering the reduction of greenhouse gas emissions, improvement can easily and cheaply be made in the built environment. In addition to the greenhouse gas emissions, the built environment is also responsible for 30 percent of natural material use and 20 percent of water use on a global scale. It also produces an estimated 30 percent of all solid waste.

Investors are starting to integrate CSR factors alongside traditional measures of financial risk as part of their asset allocation and portfolio risk analysis. The results obtained from such analysis can contribute to specific decisions about whether to acquire or dispose of a property, or identify which properties would benefit from specific RPI interventions to improve their operational efficiency. In addition investors are starting to use RPI criteria to set minimum standards for funds or individual assets they may acquire or hold. Standards can be applied at different levels (across the whole fund or for certain type of properties within the fund, or for assets over certain value) and can be set according to industry benchmarks, certification schemes among others (UNEP, 2012). Investors that have an indirect investment approach wish to integrate RPI and make an assessment of the relative RPI performance of the real estate fund. Until recently it has been challenging for investors to compare the RPI credentials of different funds or property companies, as no complete independent organizations existed to do this. Fortunately some organizations that integrated sustainable performance were founded the past years of which GRESB is one of them.

Global Reporting Initiative

Sustainable certification systems, which includes building and material certification, building energy intensity, water intensity and greenhouse gas emissions for buildings in use, and management and remediation of contaminated land are three issues covered by the Global Reporting Initiative (GRI). This non-profit organization promotes economic sustainability through the provision of standards for sustainable reporting. While providing such standards the Global Reporting Initiative is responsible for increasing transparency and social responsibility (CSR & RPI) in the real estate sector.

According to the GRI organization, the measurement, monitoring and reporting on the sustainability of buildings is an enormous challenge. Therefore a sustainability report is the key communication tool for sustainable performance, and capturing relevant information that can influence company policy, strategy and operations on an ongoing basis. GRI provides investors with key knowledge and ensures correct sustainable reporting in over 4000 companies worldwide.

GRI can be divided up into more subareas of attention, such as financial services, food processing or oil and gas. There are also guidelines within the construction and real estate field which focuses solely on the development, construction and management of buildings. This is called the GRI's Construction and Real Estate Sector Supplement (Global reporting initiative, 2012). The main reason for developing additional guidelines for real estate was to provide an universal language that different companies throughout the world could use to communicate about sustainable performance. This framework of sustainable drivers is very broad and applicable throughout the whole real estate sector with various components. The focus is upon the whole cycle of real estate from construction to demolition, also known as the economic lifecycle of a building. As such this initiative provided various real estate companies with a solid base to act and communicate with each other to increase transparency, thus making sustainability more comprehensive.

6.8 Eco-labeling

Over the last decade, the commercial real estate sector has seen the introduction of a wide range of so called eco-labels. Eco-labeling can be deducted and interpreted as a sustainable certification for properties. These labels follow the trend already explained in the preceding paragraphs while through CSR-performance, socially responsible investing and the global reporting initiative sustainability in general is stimulated. Therefore these labels are a mean to achieve a company's sustainable target. Especially during the introduction of the first eco-labels the differences were quite significant while not every label consequently used all involved (sustainable) factors related to the subject property. Although during current times labeling becomes more and more harmonized, differences between labels are still evident. When considering labeling on an international scale, there are various voluntary eco-labels competing with each other to evolve into market leader. In national real estate markets, there can be a mixture of compulsory and voluntary eco-labels. Foregoing indicated that some eco-labels are obligatory. Indeed, while the measurement of sustainable features is an important factor in reducing emissions. Although not every aspect of eco-labels is integrated into EU regulations, the impact of energy use is. Measurement of energy use in new and existing buildings has become obligatory following the EU Energy Performance of Buildings Directive. The Directive requires that all buildings at construction, sale or rent to have certificates giving information about their energy performance through a rating CO2 emissions.

The direct aim of eco-labels is to provide information to consumers or users about the environmental performance of a product with the indirect aim of influencing their consumption choices, suppliers' production outputs and, as a result, the level of environmentally harmful emissions (Fuerst & McAllister, 2011c). Assuming that sustainable performance is a significant attribute for investors, eco-labeling basically enables them to discriminate between properties according to their performance. Consequently, the demand will increase for properties with a reduced sustainable profile and energy performance, thus providing an economic stimulation to invest in sustainable labeling. The implementation of such an eco -or sustainable label sounds like a wise investment, while the investors benefit from a reduced risk profile and the occupier with a state-of-the-art property which consumes less energy or resources. On the other hand, there is a down-side to the implementation of sustainable labeling, while there are also several reasons why not to invest in environmental performance. Most importantly, investors are still not that eager to invest in sustainable properties or labeling while the available data lacks compared to information regarding other property classes.

Nonetheless, the variety of sustainable certification systems is enormous and not all labels are equally important with regard to the commercial market. Though relatively limited in use, with an estimated number of 15,000 labels worldwide, they are growing quickly and they tend to have more support both within and especially beyond the commercial real estate industry. We can distinguish a couple of major players on the field of labeling, which starts with the internationally used Leadership in Energy and Environmental Design (LEED) and the Building Research Establishment Environmental Assessment Method (BREEAM) rating systems. These two labels are mostly internationally orientated and are being used globally. One major international difference between LEED and BREEAM is that, BREEAM criteria depend on the use of a particular building and include the option of being adapted to suit local circumstances. LEED, on other hand, has a methodology based on homogenous criteria, with less focus on the use of the building. This makes LEED assessments easier and quicker to carry out, especially for mixed-use schemes, although they are not as fine-tuned to individual circumstances. LEED is growing in global popularity and remains the preferred accreditation among US occupiers and investors (Cushman & Wakefield, 2008). Other systems are more nationally based such as the Comprehensive Assessment System for Built Environment Efficiency (CASBEE) in Japan and the National Australian Built Environment Rating System (NABERS) in Australia. While each sustainable certification system has its unique design and point system, and thus weights each category differently, they all consider the same general factors:

- Energy efficiency
- Carbon emissions / pollution
- Water efficiency
- Waste and recycling
- Building materials
- Indoor comfort and air quality and
- Site quality and access to public transit

Only in the Netherlands alone, there are five well-known sustainable certification systems. In the Netherlands, the EPC-label (Energy Performance Certificate) has the biggest market share which is related to the obligatory assessment due to governmental regulations (EPBD). With regard to BREEAM, this certificate is gaining terrain as the assessment is based on a broad set of requirements. Potential tenants have in that opinion "more value for their money". In the table below, a short summary of all different labels has been given which shows the relative broad and extended view of BREEAM and LEED compared to other (older) labels.

	BREEAM	LEED	EPC	Greencalc +	GPR Gebouw
Energy/CO2	19,0%	27,0%	100,0%	65,0%	20,0%
Material	12,5%	20,0%	-	21,0%	20,0%
Water	6,0%	8,0%	-	6,0%	20,0%
Mobility	8,0%	-	-	8,0%	-
Health	15,0%	23,0%	-	-	20,0%
Management	12,0%	-	-	-	-
Waste	7,5%	-	-	-	20,0%
Ecology	10,0%	22,0%	-	-	-
Pollution	10,0%	-	-	-	-
Application	Design & process	Design & process	Design tool	Design tool	Design tool
Quality	Yes, assessment	Yes, assessment	Yes, assessment	No	No
Scope	Broad	Broad	Limited	Limited	Limited
Qualitative	Yes	Yes	Yes	No	Yes
Quantitative	Yes	No	Yes	Yes	No

Two certification systems are explained in the following section, EPC and BREEAM. This paragraph starts with the energy performance certificate which has been introduced by the Dutch government in 1995 to cope with the need to consider energy usage nation-wide. More specifically, the decrease in energy usage has as objective to reduce CO2 emissions. In the course of time it has been expanded to the assessment of the buildings' energy performance in 2008.

The EPBD (Energy Performance of Buildings Directive), first published in 2002, requires all EU countries to enhance their building standards and roll out Energy Performance Certificates (EPCs). EPCs rate buildings according to their energy performance in various categories, including hot water, heating, cooling, fans and lighting, and are required to be made available when a building is constructed, sold or rented out. The landlord or owner has to inform the tenant about the energy consumption of the property. The EPC is mandatory in most European countries for any sale or leasing of buildings, meaning that the EPC should be included in any building advertising. This requirement for publicity allows occupiers and landlords to compare the energy efficiency of buildings against each other at country level. This is an achievement in itself but does not suggest that a more proactive management approach has been implemented to investors' whole asset portfolios (DTZ, 2013).

The values defining the EPC-labels for commercial buildings range from respectively A++ (<0,50) to G (>1,75). The visual translation into a label might give the possibility for owners and tenants to distinguish

oneself from the competition and contribute to a positive image. It seeks to show the energy efficiency of products, which could result in an increased value of the asset when certified with A or B certifications. The energy label for buildings has been obligated by the government since beginning of 2008. In 2009, the EPC has been adjusted to stricter measures from 1.5 to 1.1. This means that it is harder to obtain a relatively high certification (such as A).

When investigating the relationship of rent level compared to the energy certificate, it is important to understand the mathematical method to calculate the EP-Index. Starting from a top down approach with the general formula:

$$Energy\ Performance\ Index = \frac{Q(estimated\ energy\ consumption)}{Q(allowable\ energy\ consumption)} \quad (1)$$

The estimated energy consumption is calculated through several aspects integrated into the building. Most importantly are the following elements: the building shell, the technical building systems and potential "innovative" systems (read: solar systems or district heating). Taking into account systems situated outside the building emphasizes the primary energy approach in the certificate (CENSE, 2010).

$$Energy\ Performance\ Index = \frac{Q(estimated\ energy\ consumption)}{c_1 * A(heated\ surface\ area) + c_2 * A(heating\ loss) + c_3} \quad (2)$$

The EP-Index subsequently can be shown in the equation above, where A(..) stands for a certain floor space area and c are constants. The estimated energy consumption is pretty straight-forward while the allowable energy consumption is based on mainly the building shell and building systems. As such the EPI is a coefficient regarding the relation between the calculated energy rating and the measured energy rating.

Since the research takes some BREEAM data into account, some detailed information about the functioning of this certificate is appropriate. The following acts as a short intermezzo which stipulates the main components of BREEAM and subsequently known bottlenecks. BREEAM is a checklist based sustainability model that is available in various appearances, but most commonly is known for BREEAM-NL, specialized on new building projects and BREEAM-NL In use, specialized on existing buildings. In order to get a BREEAM-NL certification a BREEAM assessor is engaged to assess the product. A temporary assessment can be made early on in the design phase, but the final BREEAM assessment is done after the actual completion of the project. The scoring system of BREEAM is divided into nine categories, each with their respective weight based on credits. Credits can be scored by accomplishing different criteria for one or more points. When these categories are combined into one whole, a total score can be obtained: The BREEAM-score.

The score is divided into the following categories:

1. Management
2. Health and well being
3. Energy
4. Transport
5. Water
6. Materials
7. Waste
8. Land use and ecology
9. Pollution

Figure 11; BREEAM, DGBC.nl

This research has a bigger focus on the certificate of BREEAM In-use as this relates to a bigger extent to the actual sample set of data. BREEAM In-use is especially designed for existing buildings and uses the exact same methodology. In the BREEAM In-use more focus is upon the maintenance and use of the asset and to a lesser extent other categories. The assessment is divided in the same categories, but then again also in three components: Asset, Management and Use. First, asset performance uses the inherent properties of the asset based on its built form, construction and building installations. Second, building performance management which focuses on the operational practice. This comprises of the management of policies, procedures which relate to the operation of the building, the consumption of resources such as water and other materials, and the environmental impact, such as CO2 and waste production. Lastly, the organizational effectiveness regarding the implementation of sustainable decision-making. This requires insight and implementation of policies, procedures and practices, employee distribution, and delivering the output data or parameters.

These three components can be evaluated either separately or as a whole. Within each part, the nine categories of BREEAM are being discussed. On an issued certificate, all three scores are stated separately. It is also possible to assess solely on one category, but mind that the other categories are shown as not completed. So what is the big difference when comparing BREEAM with other sustainability measurement or certification methods? The biggest advantage is that BREEAM is a certification system which is independently tested by third party (the assessor). This allows to a wider and deeper verdict when linking BREEAM to other methods. BREEAM is a broad tool which gathers information of the asset on various categories. This ranges from transport to the surrounding facilities and ends with (environmental) pollution and energy efficient installations. Second thing to remember is the scale of the BREEAM certification as this varies between the asset, the operational management, and the occupier. The extensive process of gathering this data is lengthy, but this can be used to benchmark and evaluate ones asset, portfolio or other construction related activities.

Bottlenecks

There are lessons to be learned according to Stefan van Uffelen, director of the DGBC. Extracted from various interviews are main observations in gathered in this short summary regarding BREEAM. Complaints start with the accreditation of material use during the construction and equally the total life cycle of the building. This category was not of equal importance compared to others during the pilot-BREEAM certificates. Second, the certification process takes some time and is often outsourced, which raises the costs to non-profitable heights. Early adaptors such as Schiphol and OVG paid the price of the BREEAM-pilot projects. These can be seen as early difficulties which BREEAM and the DGBC have to contend with.

Currently, actually in contrast to the view of the commercial real estate market, more and more companies see opportunities and chances for sustainability with respect to new construction or transformation. What kinds of opportunities are currently available? The oversupply of offices enables the occupier to search for more qualitative space. Sustainable offices can provide lower service costs, a higher occupancy rate and yield. BREEAM-In use is rising in the market as demand for certification is escalating. Fund managers are keenly looking for opportunities to upgrade their portfolios. When more empirical evidence regarding the profitability of BREEAM is provided, there will be room for discussion concerning financing construction activities and changes in legislation or government grants to increase sustainable initiatives.

Conclusions

There are evident relationships between the notions of CSR, RPI, GRI and eco-labeling, while scale is the major difference. CSR-performance is part of the general strategy of an organization, while RPI often is the financial part of a company's strategy. Environmental labels are examples of measures that influence the outcomes of sustainable reporting. Although there are several definitions for responsible property investing, these notions are more a general overview of the various choices a professional organization could make. The implications of these kinds of performance measures and initiatives are broad. Not only occupiers of the involved assets, but also investors can benefit from aligning physical real estate to sustainable operation. Currently investors are increasingly integrating sustainable principles within their asset management activities to respond to tenants being increasingly concerned about the environmental performance and operational efficiency of the assets they occupy. As utility prices increase, and labeling of efficient buildings increases, it is likely that this could contribute to reduce rent, decrease vacancy and lead to faster depreciation in less efficient assets due to the absence of tenant demand.

6.9 Sustainability in practice

Currently different organizations, initiatives, and alliances exist in the field of sustainable real estate. The framework of sustainability consists of various actors and stakeholder ranging from end-users to investors and developers. They all share one common need related to objective measurement of sustainable features. Independent organizations that provide the real estate market with useful and measurable information based on objective data. Indeed these organizations exist, but are not widely noticed in the market. In the first paragraph the author will elaborate on well-known existing organizations before introducing sustainable drivers.

Organizations and functions

Throughout the world numerous sustainable certification systems have been developed. These labels are developed under the supervision of national appointed sustainability organizations. The three organizations below are some examples on national scale:

USGBC – United States Green Building Council
BRE – Building Research Establishment (UK)
EPBD – Energy Performance Building Directive (European)
DGBC – Dutch Green Building Council
Agentschap-NL (governmental organization)

Some influential certificates originate from these organizations. Take for instance the USGBC, which initiated the LEED-certification. Corresponding with the situation in the US, BRE initiated the BREEAM certification. On national scale (the Netherlands), BREEAM is gaining a bigger market share due to the DGBC. Another example is the European energy certificate developed by the EPBD, the EPC-energy label is regulated since early 2008, and thus required to use during a transaction. Unfortunately the Lower House rejected a governmental bill that enabled buyers and tenants to go to court if the owner of a building would not provide an EPC- certificate (Rijksoverheid, 2012). Although rejected in November 2012, it is likely the bill will pass during 2013.

These organizations are an example of the relative governmental influence regarding sustainability. Often these initiatives are not market-based and provide a threshold toward the real estate market. Besides the earlier named organizations, investors led initiatives arose during recent years. Two of the most well-known organizations in the Netherlands are the DGBC and the GRESB, which both are industry-led organizations committed to rigorous and independent evaluation of the sustainability performance and assessment of real estate.

The primary objective of the Dutch Green Building Council (DGBC) is to measure sustainability objectively. For this purpose, many initiatives have been undertaken and quite a number of reputable agencies and committees became involved regarding the quality of the organization. The DGBC is a foundation which was founded in 2008 and is partially financed by the real estate market. There are about 400 participants, ranging from suppliers to investors. The budget is 2.2 million annually, of which 50% is compensated by the participants and 50% through service provision.

The DGBC's overarching goal is to advance the sustainability level of the built environment. In practice this leads to four primary goals. The first goal is to allow for the accurate measurement of a buildings' sustainability level. The second goal is to raise the profile of sustainable buildings. The DGBC has already trained some 60 Assessors and more than 300 Experts to certify buildings. The third goal is to expand and share knowledge. Sharing knowledge within the industry is vital to obtaining smooth and rapid progress, and the DGBC organizes numerous conferences and events related to the incorporation of sustainability in

the built environment. The fourth goal is to ensure that sustainable construction becomes common practice and to fully integrate sustainability issues from planning through development and into actual practice. To guarantee sustainable use, it is necessary that occupiers change their habits; consequently the DGBC wants to study how buildings are being used and what actions should be taken to improve on this.

But what is the right to exist of the DGBC actually? The relevance starts with the developed BREEAM labeling systems that are intended to pursuit the degree of sustainability as well as the objective measurement of objects. The certificate BREEAM-NL New Construction is operational since 2009. The certification for existing buildings (In-use) and for Area Development was successfully launched in 2011, and the certificate for infrastructure is coming soon. Moreover the DGBC made a start with a certification for demolition purposes.

When striving to integrate sustainability in the commercial real estate market, BREEAM could be of great help. The DGBC especially uses the BREEAM certification system because of the large role it plays on the international real estate market. It is one of the most important and widely used sustainability labels for assets throughout the world. Not only connection and consistency with the rest of the world are elementary motivations of the DGBC. The BREEAM scheme is also a system that was fairly easy to adjust to the Dutch situation, without compromising international relevance.

The DGBC translated the original English version into Dutch. In April 2008, the council worked out the first adaptation of BREEAM-NL New Construction to the local situation in the Netherlands. Five working groups comprised of retail, residential, office, industrial and regional constituents offered their feedback, and this input was used to form an optimal rating scheme for each building type and region. The next step was to implement what the DGBC had learned. 13 Pilot projects commenced in February 2009. In March 2009 DGBC launched the beta version of BREEAM-NL New Construction. The addition 'NL' makes clear that this is the Dutch version. The beta version was designed to be used for testing. Besides the thirteen official pilots many other organizations and individuals downloaded and tried the beta version. In April and June 2010, the first design-certificates were awarded. In June 2011, the second label was introduced, BREEAM-NL In-Use, followed up by the BREEAM-NL Area Development.

BREEAM-NL is not the only sustainability label focused on buildings that is used in the Netherlands. We know for example, the energy label, the EPC standard, GreenCalc, GPR Building, and LEED. BREEAM-NL is not yet another certification or scheme. The DGBC aims to harmonize the BREEAM requirements with the other systems (which usually only contain a few of the BREEAM criteria). The energy-label and the EPC are required by law and are fully integrated in BREEAM-NL system.
The other initiative is the GRESB, which measures on a different scale and focuses on another user category. GRESB works in tandem with institutional investors and their portfolio managers to identify and implement sustainability best practices in order to enhance and protect shareholder value (GRESB, 2012). The organization has a benchmarking function for a large share of real estate funds around the globe. The basis for the benchmark is an annual survey measuring the environmental and social performance of real estate companies and funds at the portfolio level. The survey is comprised of two parts: Management & Policy (weights about one-third), focusing on environmental policies and reporting of respondents, and Implementation & Measurement (weights about two-thirds), which addresses environmental key determinants, such as energy and water consumption of the real estate portfolio, and the infrastructure needed for superior environmental performance (Bauer et al., 2011). The weight of each dimension thus depends on how it may affect financial performance. The weighting is designed to reflect an overall GRESB score that rewards efforts more than words.

Consequently, the GRESB gathers relevant sustainable data among listed and non-listed funds with as overall target to benchmark the quantitative data and assist institutional investors in their investment decisions. The GRESB provides the investor with an individual scorecard which quantifies the funds'

performance among others in the business. Good performing funds get renowned through the title: “Green star”, and get market exposure due to their good sustainable performance. Bad performers (or “Green starters”) are enabled to discuss their outcomes and encourage them to get involved. Some institutions are even going so far as to incorporate sustainability performance scores into their investment models to better project growth rates and risk levels (Kenney, 2012).

Why is benchmarking sustainability important?

Sustainability is a vague term, and it’s hard to put a number on it. But if you ask the right questions and translate that into a benchmark, it allows the capital market to integrate sustainability into their underwriting, investment decisions, their engagements with investment managers and so on. Once benchmarking is transparent, the sector can really start to move forward. For example, if you can compare office REITs using the same criteria, it becomes clear how active some property managers are in implementing sustainability solutions, where others are not yet fully engaged (Consol, 2012).

Besides the GRESB are more organizations backed by the real estate industry. Although these organizations have a wide set of supporting institutions they often lack the exposure of the GRESB. These organizations often have a better focus on asset-level and provide data on building level. An example is the Green Rating Alliance (GRA). To date the environmental performance of over 4 million m² of European property space in more than 60 cities across 12 countries has already been measured by the GRA. Future prospects state an increase of members which would lift the value of the rated assets to €16 billion covering a surface area of 5 million m2 (Seebus, 2012). Other institutions include the International Sustainability Alliance (ISA), Greenprint, Green Property Alliance (GPA), and Sustainable Buildings and Climate Initiative (SBCI) and so on.

Conclusions

All these organizations, from the USGBC to the GRA all share common goals towards a sustainable future. Either in a managerial way while ignoring sustainability issues will expose a manager to sustainability-related risks or in a financial way to enhance and protect shareholder value. The quantitative data enables organizations to indeed benchmark their performance worldwide but also in their relative peer group based on geographical borders or property type. Often the front runners are announced with high regards related to sustainability. Bad performers on the other hand are not judged, but are informally engaged through the principle: “no naming, no shaming”. Still most initiatives are poorly conceived by the market as the withholding power of almost all the real estate funds is still large. Sharing of data remains quite the same in the real estate sector and most funds are not too eager to communicate sensitive digits. Second most initiatives are not backed by the commercial real estate sector and do not obtain the exposure to actually be successful. Third, asset level initiatives remain sketchy and are either biased or are not being refreshed on a yearly basis. On the other hand, there are practical reasons why real estate funds are interested to join with such initiatives. First is the data collection of sustainable features and the comparison with other real estate funds (benchmarking function). The second argument can be quoted as “join the club”, which means that most funds sense a relative pressure to join since others already joined the benchmark. The third and last argument is about the gathered information, which can be used for CSR-reporting.

6.10 Drivers of sustainability

The current practice distinguishes differences between the degree of sustainability. The relative sustainable performance of an asset or an investment portfolio is based upon drivers that have predicting powers. One could possibly argue that only financial performance matters in case of real estate funds, but these benefits are also dependent on other criteria. Based on research of Nelson & Frankel (2012) there are five crucial drivers that influence the relative sustainable performance or attitude in the real estate market. These are respectively: enhanced operating efficiency, investor criteria, regulatory compliance and incentives, tenant demand, and competitive positioning. These notions will be elaborated further on in this sub-chapter.

The author would like to start with an example of early published evidence regarding sustainable performance. Authors Eichholtz, Kok & Quigley (2010) were among the first the state evidence about the financial well-being of "green" buildings. They used (US-only) data from the Costar group and made clusters of green buildings versus non-green buildings to measure the relative differences. Findings derived from their research show that 'green' is more than just an intangible eco-label. When energy efficient investments are made at the time of construction this could insure against increases in future energy prices and decreases greenhouse gas emission. Reduced operating expenses will save the investor costs. Other benefits from green buildings can be better behavior of employees (less absenteeism and higher productivity), a better image for the company and lower volatility in market value. The last benefit is based upon the preference of tenants who would rather have sustainable buildings. As such, quantitative studies provide the incentive to invest in green buildings, while investors are benefiting from added rent/value premiums and the tenants from increased operating efficiency. Basically if the tenant is *willing-to-pay* the added rent premium, the higher initial investment for investors is justified.

On the table on the next page shows a summary of current existing evidence of various authors, most of it focused on office buildings. Although this table represents not all existing evidence, the author is convinced that this will provide a solid base line to start from. In the following paragraphs, the table will be used to state evidence of the articles relative to the subject discussed.

Author	Property type	Sustainable feature	Observed impact on(%)	Values
Eichholtz, Kok, Quigley (2010)	Office	LEED	Rental price	2,8-3,5%
Eichholtz, P., Kok, N., & Yonder, E. (2012)	Office	LEED	Rental price	3,50%
			Return	7,39-7,92%
		Energystar	Rental price	0,31%
			Return	0,66%
Fuerst & McAllister (2008a, b)	Office	LEED/Energystar	Selling price	31-35%
		LEED/Energystar	Rental price	6-9,5%
Fuerst, F., & McAllister, P. (2009)	Office	LEED	Occupancy rate	8%
		Energystar	Occupancy rate	3%
Fuerst, F., & McAllister, P. (2011)	Office	LEED/Energystar	Selling price	18-25%
			Rental price	3-5%
Kok, N., & Jennen, M. (2012)		EPC A	Rental price	6,50%
		Transport hub	Rental price	13%
Miller, N. (2010)	Office	LEED	Rental price	12,1%
			Selling price	17,7%
		Energystar	Rental price	0,2%
			Selling price	0,0%
Pivo & Fisher (2009)	Office	Energystar/Transit location	NOI	2,7-8,2%
			Occupancy rate	0,2-1,3%
			Market value	6,7-10,6%
			Caprate	(-)0,4-1,5%
Wiley, J.A., Benefield, J.D. and Johnson, K.H. (2008)	Office	LEED/Energystar	Rental price	7-17%
			Occupancy rate	10-18%
Preceding evidence by other graduate-theses				
Erve van der (2011)		EPC A	Rental price	5%
Heineke (2009)	Office	EPC	Rental price	3,7%
Snoei (2008)	Office	Energy cost savings	Energy savings	76%
Visser (2010)		Energy cost savings	Energy savings	32%

Enhanced Operating Efficiency

This variable often is regarded as one of the most influential when related to sustainable performance. Indeed this is partly through, because the relative objective data makes it rather suited to apply quantitative tools. Currently a lot of evidence exists on energy efficiency as part of a rental premium or occupancy rate. An office building which has an enhanced operating efficiency (on asset or portfolio-level) generates an incremental cash flow. This finding is supported by various authors who state the incremental cash flow as a rental premium or willingness-to-pay "extra". Brounen & Kok (2011) state evidence from a residential point of view as their findings relate to transaction prices. Indeed increased energy efficiency pays of in capital gain. But to what extent is this applicable to office properties?

Early evidence by Lützkendorf & Lorenz (2005) reported that the EU energy-efficiency directive is likely to have influence on property values and building design, renovation and investment decisions. This was before the obliged introduction of the EPC-labeling system across the EU. Other graduates at Dutch universities did (relevant) research on the topic of energy efficiency and the significance with rental values, with rental premiums ranging from 3,7% to 5% and energy costs savings of approximately 76% and 32% (Heineke, 2009; Snoei, 2008; Visser, 2010). The author would like to highlight the most recent research by Fleur van der Erve (2011). Her research indicated that the energy efficiency indeed relates to rental levels. In fact, buildings with high energy-efficiency have higher rents than conventional buildings, based on quantitative research. Energy efficient buildings with energy label A results in a 5% rental premium, compared to energy label B. One remarkable indication is related to buildings with extremely low energy efficiency, which seem to have high rents as well. This can be explained due to the relative age and the likely image of such buildings. Outliers in the data, which command higher rents, are often related with (prime) locations. From a qualitative perspective, the tenant can relate sustainability to higher productivity, due to high indoor environment and a positive corporate image. Visser (2010) makes a division between quantitative and quantitative motivations. The energy costs compensation refers to "green leases", which are stimulating to split investment costs for sustainability. The research gives an indication that tenants are willing to pay about 2,5 times a rent premium regarding improved image and an increase of employee productivity compared to energy cost savings.

Other such as Kok, Eichholtz, Bauer & Peneda (2010) see investments in energy efficiency as an indicator to a higher net present value. This holds true especially for building management, lighting, cooling and heating technology, and better insulation. These investments are currently hampered by a lack of information and market awareness, lack of financing, and lack of proper incentives. Such evidence indicate that lower CO2 emissions in the built environment, actually pay back with regard to lower operating costs, improvement in the marketability of properties and, ultimately, are hedged against market and macroeconomic trends that will affect the value of their property portfolio (Kok & Jennen, 2012). Energy efficiency as part of sustainable performance will yield the opportunity for the creation of value and a decrease risks.

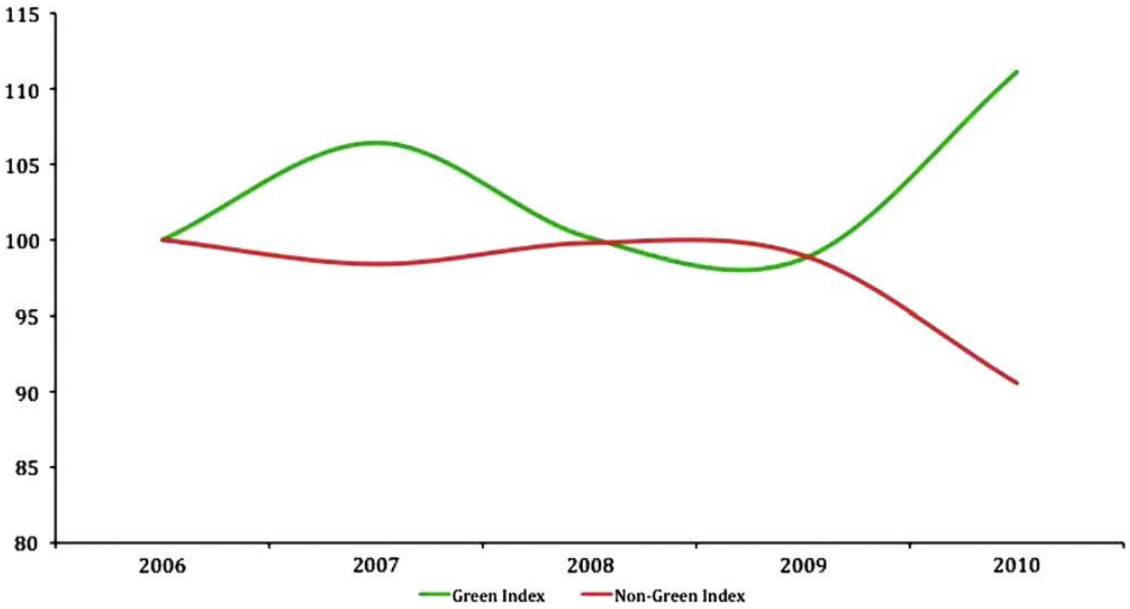


Figure 12; Green/Non-green index, Kok and Jennen (2012)

This index extracted out of the article of Kok & Jennen (2012) is based on the quarterly change (of the Dutch market) in rents for a portfolio of green buildings and a portfolio of non-green buildings. This figure shows that "energy-hogs" are currently facing relatively strong declines in rent, while more efficient office buildings show gradual increase in rental growth. Although the evidence provided by these authors seems ever convincing the commercial real estate market to step into sustainability and even more into energy efficiency, not all authors agree. Consider for instance Fuerst & McAllister (2011c) who found an negative relationship between energy efficiency and pricing in their research related to the impact of energy performance certificates. Firstly it is possible that the information contained in the EPC is not adequately considered by tenants in rental transactions. Second counter argument could be based on the sample size, which was relatively small especially considering that assets were spread across the UK. A final remark is that the data in this study is based upon appraised values rather than transaction prices.

Investor Criteria

With a growing number of investors considering sustainability as an integrated part of the commercial real estate market, how should these investors choose funds and organizations which are among top-rated sustainable performers? Nowadays sustainable certification systems are considered as a good indicator for sustainable performance. The certification is different from energy efficiency as most labels integrate more determinants in the decision-making process towards accreditation.

The table at the beginning of the chapter summarizes important results related to eco-labels and several authors find significant relationships regarding sustainable performance and rental level.
Fuerst & McAllister (2008a, b) state that properties which have a rental premium often have a higher rating. Moreover the higher the sustainable rating, the higher the rent premium, and higher transaction prices. Pivo & Fisher (2009) turn assets results towards portfolio-level and explain when Net Operating Income (NOI) and market values are affected, capitalization rates (cap rate) scale down to approximately 50 basis points related to overall impact on return. A surprisingly contribution to existing knowledge is from Chegut, Eichholtz, & Kok (2012) which looked at the London office market and related green properties (BREEAM-certified) to rental heights and capital gain. The evidence suggest that there is a gentrification effect from green buildings, which expresses in reduced rental prices and value as the supply of green real estate expanded in districts. Each additional green building decreases premiums for a certified building in the rental and transaction market by 1% and 4%, respectively. The authors suggest that the supply and pipeline of real estate forms a potential bias in the results. Most of the green supply was introduced in

2007 and quickly after that. This was during the economic crisis in which London was heavily hit, as employment rate decreased in rapid pace. Consequently the quantitative results suggest otherwise, the authors believe that currently green office properties perform better. To be continued..

Overall, prior quantitative studies show that properties in redevelopment areas commanded higher rents but did not outperform on returns, that energy efficient and green properties had higher rents and values, and that in several instances properties near transit were more valuable and appreciated faster than in other locations. The paper by Pivo & Fischer (2010) states first evidence on the relationship between RPI, market value, and investment returns by comparing the financial performance of RPI and non-RPI office properties. The use of RPI is considered because the authors did not use certification requirement such as LEED. They looked at the overall energy use and the location factor "Transit location". Their findings explain that the RPI status was associated with statistically higher incomes and/or higher values. The existence of rental premiums does not necessarily increase returns for investors because higher incomes lead to higher values which generally offset benefits to returns. The capital gain is often a hard indicator to measure, but it suggests that the market is capitalizing at least some of the CSR-benefits of these types of responsible property investments. Pivo & Fisher close their discussion with the statement:

"Companies can do good and do well, even if they don't do well by doing good"

The statement basically says that in most cases RPI neither harms nor improves total return. Investors still have the same return profile in almost every case, so why not invest in sustainability is the key question?

Again Eichholtz et al. (2012) provide evidence regarding the incorporation of sustainability into the investment portfolio. They suggest that REITs are in the still in an early phase of incorporating elements related to energy efficiency and sustainability into their investment portfolios and have substantial opportunities to enhance operating returns by investing in green-certified buildings or in commercial building retrofits. Sound quantitative results indicate the relative attractiveness of LEED certification with a rental premium of 3,5% and an increased return of around 7,5% in the US real estate market. Given that portfolio greenness is positively related to operating performance and negatively related to risk, these results provide positive outlook for the return on equity and assets of (REIT) investors, and are likely to partially shield returns from the volatility of the business cycle. Another finding to prove the likely less risky situation is that occupancy rates in more efficient buildings are not only higher but more stable. The article provides a solid background to hedge against three fundamental drivers, namely the threat of regulations, energy prices and changing tenant demands.

Already in (2008), Francesco & Levy discussed the potential impacts of sustainability from a property investment perspective. Their attention focuses on the risk profile of sustainable real estate. In particular, the article argues decisions on investment performance, investment products and investment strategies. The figure below shows guidelines when responsible property investments occur.

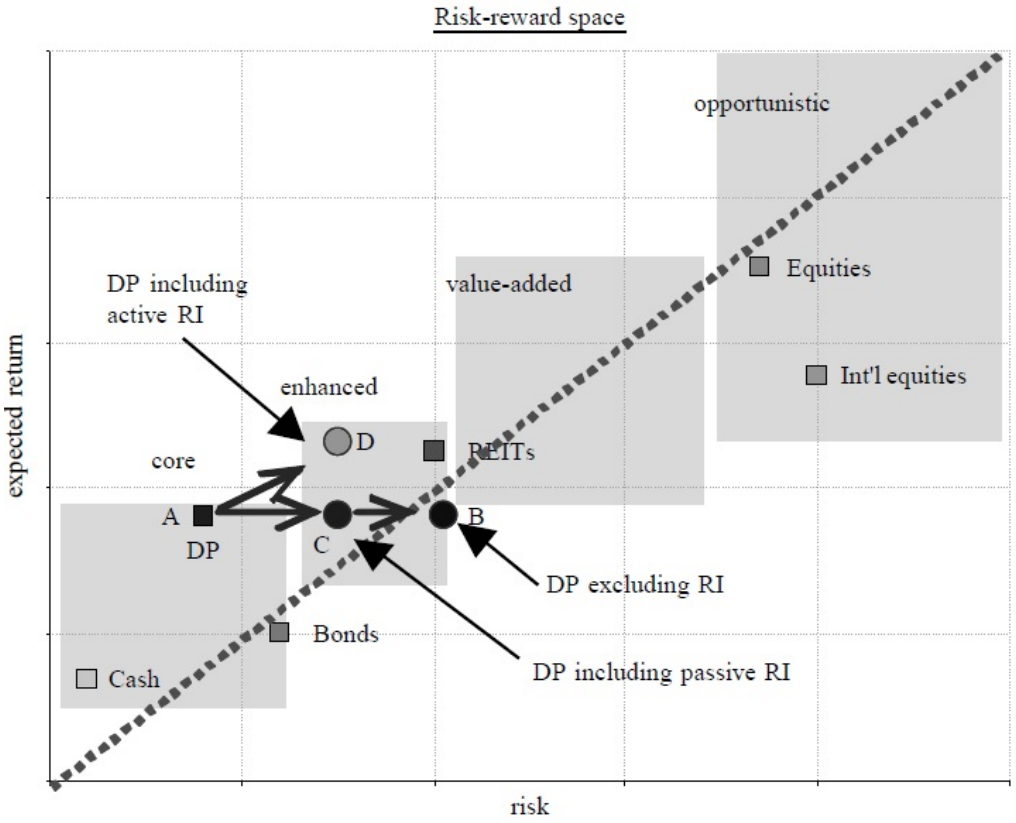


Figure 13; Risk/reward framework, Francesco and Levy (2008)

A property with a core investment strategy that carries no sustainability issues may well sit within the core region, denoted by the A-square. When sustainability has an impact on investment performance, but uncertainty exists as to its impact on return and no action is taken, then the product offering moves from points A to B. When the principles of RPI are introduced, for instance LEED certification, the green building will move to D. Summarizing, a green building is more risky, but due to the influence of certification or other sustainable features the return will be higher. These authors are brought up because of the relative stance of the article. The results indicate a total different attitude towards sustainability than currently exits.

Eichholtz et al (2012) confirms and expands mostly qualitative findings from other authors which looked into risk/return profile and the relative market acceptance. Bügl, Leimgruber, Hüni & Scholz (2009) discussed in their qualitative research the market acceptance of sustainable real estate funds by institutional investors depends on cognitive drivers such as institutional context, and age. The results show that the focus of these actors are on economic aspects of energy and material flows, the life cycle of buildings, and maintenance costs, but less on CSR-criteria. As such, the view of the market on sustainability is dominated by capital gain and risk avoidance. Caijas & Bienert (2011) study identifies the factors affecting the firm's decision-making process to allocate financial resources into CSR-activities and whether these sustainable intentions mitigate the firm's risk profile. Results are two-fold in favor of sustainable performance, as CSR seems to be incorporated more and more among especially public real estate funds. Second, the risk associated with sustainability seems to be incorporated with the stock performance (publicly orientated). Therefore, the authors suggest that real estate funds should be more transparent about their CSR-activities, thus send clear signals to the capital markets.

Regulatory Compliance and Incentives

This subsection is important because of the legislation involved. This should be observed as a potential risk or hazard and needs to be integrated into future plans regarding the selection of assets in an investment portfolio. Governmental policies are often a long-term risk as decisions or new bills are being processed rather slowly. Although this seems quite harmless, real estate funds should be ahead of the legislation or face potential major reinvestments in their portfolio. Government policies regarding sustainability are often related to measurement and the disclosure of carbon emissions, and other (sustainable) metrics for buildings.

Besides introducing environmental bills, governmental departments often outsource research to be informed about the current trends and opportunities regarding energy efficiency, water and waste management among other. As such they demonstrate compliance towards not only investors, end-users, but the whole society. Agentschap-NL (2011b) commissioned a research in the field of offices if transformation is better or more profitable than new construction. Consequently this governmental department keeps up to date with current market circumstances. An example regarding legislation (Agentschap-NL, 2012) are tax-exempt/deduction to stimulate investments in sustainability. The Dutch government has reserved an amount of 151 million to stimulate energy efficiency and sustainable energy in the Netherlands. This amount is not exclusively reserved for the real estate market, but measures on asset level are included such as HVAC, and LED lighting among others. The preceding describes the possible tasks from a regulatory perspective as local governments obliged some sustainable systems either by requiring new projects to meet certain environmental standards, or by providing financial incentives to developers who meet these standards.

The meeting of environmental standards defined by governmental regulations will potentially have significant implications for investors, who may risk decreasing returns profiles from existing assets until for instance the energy performance is improved. A real estate portfolio will seldom consist of a big share of new buildings, meaning investors need to ensure that their existing assets are able to compete against new buildings for potential tenants. While doing this, investors should ensure that they protect their assets against stricter (future) regulations which tend to extend the relative environmental performance. It is expected that governments will extend current regulations and investors will need to understand what the consequences will be. Investors need to consider how the building functions in terms of its own sustainable performance. When such buildings fail to meet the changing requirements of governmental regulations, or seem to perform less favorably when compared to other buildings, then there will be an increased vacancy risk or tenant demand.

Tenant Demand

Sustainability as an investment decision is not only based on the real estate fund wanting to be green and embrace the nature, while being environmentally friendly driven. Without end-users or in office context tenants, there would not be green buildings, environmentally driven investment approaches or green real estate funds. Tenants increasingly consider the total cost of in their location choices, and many seek space with strong sustainability ratings or certifications, in part to reinforce their own environmental image with clients, customers, shareholders and others.

Besides the financial perspective Eichholtz et al. (2009b) also describe the relationship between sustainable real estate and the role of CSR at companies. This article describes that the demand for sustainable real estate is evident and tries to estimate which industries benefit the most from the relative “greenness”. The results indicated that corporations in the oil and banking industries, as well as non-profit organizations, which are among the most prominent green tenants. When considering the actual demand for green space

and not the current occupancy rate, it is documented that firms in mining and construction and organizations in public administration - as well as organizations employing higher levels of human capital - are more likely to lease green office space. Furthermore, the results clearly show that leasing decisions can open up the way towards a better or improved CSR-strategy. As real estate forms a tangible asset, sustainability will push the involved company to a next level in which their desired image eventually will become more likely. Sustainable demand of tenants could be of importance for investors and developers and their competitive positioning. Change in their operation could mean a higher initial expenditure that may be needed for a newly constructed green building, or for the transformation of an existing office building can be regained through energy efficiency, rental heights, and lower risk.

So on what kind of benefits can a potential occupier count on? Often sustainable improvements are shared with other stakeholders in the real estate industry. Consider the added value for a developer and the occupier together. The developer is happy to accommodate the tenant while they both gain exposure through corporate image and “prestige” value. The image produced by the World Green Building Council (2013) shows an overview of possible benefits why to occupy a sustainable asset. Effects related to solely the occupier are productivity and health benefits, which are currently still hard to measure. Through logical thinking, one can indeed suggest that sustainable buildings are technologically more advanced and thus provide a better working environment for the employee.

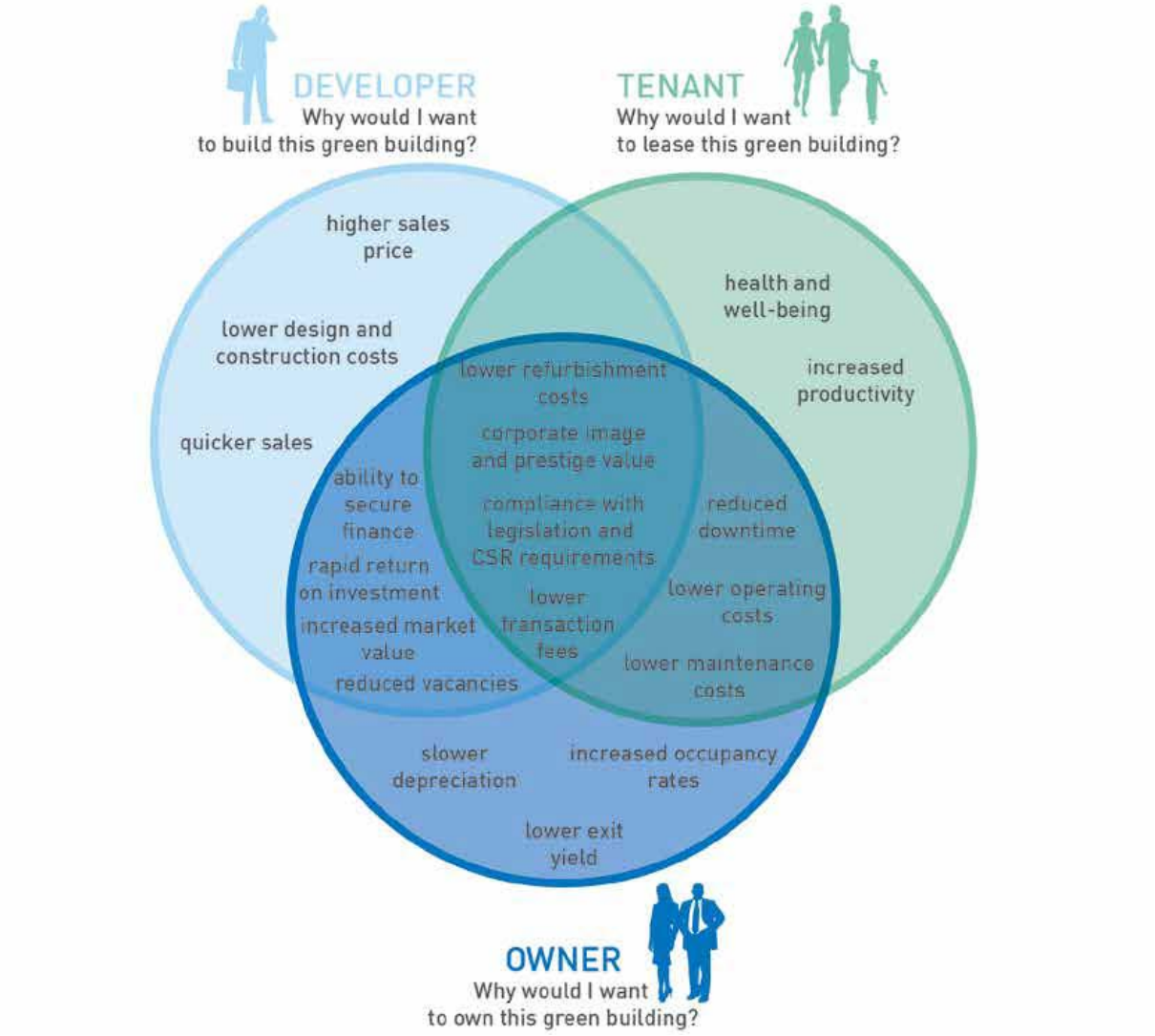


Figure 14; Drivers of sustainability, World Green Building Council (WGBC) (2013)

Competitive Positioning

Competitive advantage over other direct competitors is always a driver in the commercial real estate market. A competitive advantage is partly based on the amount of green building in the investment portfolio, but even more in the actual realized transaction price during sale. Building owners and indirectly investors must be as concerned with the value of their investments upon future resale as they are with current cash flow. These are again the major components of return divided in continuous rental income and capital gain. How to grasp the value of the property? This is where a valuer comes in, when a price has to be estimated.

Lütkendorf & Lorenz (2011) describe the relative role of the sustainability assessment of buildings as a key source of information for several actors in property markets. Since the commercial real estate market embraces current evidence regarding sustainability, often the valuation profession is criticized on their slow adjustment to a rapid changing environment. This indicates a change of mind, also in traditional value systems. Valuers are encouraged to adjust to a more pro-active approach which reflects sustainability, and will result in a competitive advantage. However, more traditionally oriented valuers are dubious about the level of detail of new value systems and their correctness. The struggle between these two sides can be seen in current practice, as a common approach for valuating sustainability features has not yet been approved. Besides the lack of an equal stance, questions arise about the extensiveness of such valuations, which can also be seen as more broad and takes up more time, thus money. When constructing a new approach towards truthful values of buildings one should not focus on the relative “brand value” of a particular label or certificate but on the respective informational content. Another constraint is the availability of sustainable data, as a big share of companies does not have tangible data about their assets. Valuers should focus on the proven relationship between property prices and sustainable credentials. This data should be adjusted and formed into an integral approach consisting of sub-analyses to determine single input estimators. These estimators divide sustainable features up in accessible and coherent data and ready to be used as input for a valuation. These results show that the valuation practice is still adjusting to the notion sustainability, since their profession drives on objective data to estimate market value.

Conclusion

In identifying the impact of sustainability on rents and values, the results of various studies by several authors have identified positive relationships, although by different percentages. The most consistent finding across all described studies was the positive effect of Energy Star and LEED certification on rents and values. Although one could comment that the rent and value premiums for LEED and Energy Star may be a result of a bull market, which is indicative of short-term demand in an under-supplied market. Across almost all studies, location was identified as the major predictor affecting value, but there is truthful evidence to suggest there are relationships between sustainability, rents, and values. However, this does not necessarily assume that the asset is going to automatically generate higher investment returns, and yet again the assessment is highly dependent on market dynamics. When returning to the main question of responsible property investments, if the benefits of sustainability lead to higher returns. One could confidently argue that positive externalities and higher returns are indeed expected. Assuming the rationality of investors, the fact that numerous stakeholders undertake the necessary costs and risks to implement sustainability into commercial real estate, indicates one or two outcomes. Either sustainability in real estate is anticipated to be a self-fulfilling prophecy given its high intrinsic value; or it does indeed yield higher returns, which directly justify the investment.

One should not forget the actual implementation or even the decision to invest or allocate to sustainability. In the beginning it is more a management decision to implement or think about sustainable implementation. For sustainability to achieve results, it requires the commitment of senior management and dedicated individuals with fund teams (INREV, 2012b). That is what people often forget, sustainability needs to be embraced by the organization otherwise there will not be any activity towards sustainable principles. Income and value evidence provides partly an answer to the question of an improved return profile. Risk is a better indicator regarding sustainability; consider an office building with a better green performance. The associated risk regarding vacancy and satisfaction is way lower compared to regular development. As such the landlord has the opportunity to engage with the tenant about green leases, energy use etc. Sustainability is not just about hard facts, but increases the mutual communication. Often in green buildings this understanding creates a better connection between the operational management (read: facility manager) and the upper management (read: allocation manager). These facts are translated into practice as the author identifies a quickly changed environment in 2008. Back 2008 the value of sustainability was in the return element, although with an increased risk profile. Currently green buildings account for a more core investment style as occupancy rate and income remain higher and more stable. So, indeed sustainability is integrated into the business cycle and gains exposure through magazines, the internet, and newspapers among others. Overall, companies are known with the notions CSR, RPI and certification systems. New evidence regarding the relationship between the degree of sustainability or sustainable features and financial performance on asset –or fund level is embraced. Still a lot of progress is to be gained in the nearby future through more extensive reporting of sustainability through for instance, benchmarking. A benchmark such as the one devised by the GRESB was successfully received by the commercial sector. Opportunities lie in front of us to fill the gap between commercial demand and current information supply. In this research the author is trying to find the key to objective performance measurement and the creation of an independent green benchmark.

6.11 Conceptual model

In this conceptual model, key notions of the literature review are combined in an overview for both the investor and occupier. The tables have been divided into three scale levels in which these actors face their decisions. Aim is to identify important drivers for investors to actually incorporate sustainability into their portfolio. The key question for the investor is why to invest in sustainability, while the occupier faces the question if he is willing to pay a rental premium for occupying the asset.

Should the degree of sustainability be an asset selection criterion for office buildings?



Drivers	Asset-level	Portfolio-level	Macro-level
Operating efficiency	Reduced operating costs		Hedge against energy pricing
Investor criteria	Capital gain	Risk mitigation	CSR-policy
	Rent premium	Capital preservation	
	Higher or stable occupancy rate	Marketability	
Regulatory compliance		Hedge against regulations	Dependent on institutional context
Tenant demand	Productivity	Hedge against changing tenant demand	Corporate image
	Eco-labels or ratings	Willingness-to-pay	
Competitive positioning		Location/Transit oriented	Age
		Availability of sustainable data	Level of human capital in the firm

Table 2; Sustainable determinants investor-wise

The table above provides a clear picture which indicates two outcomes, also discussed into the concluding section of the theoretical framework. On one hand the actual quantitative figures which indicate the added value of sustainable real estate in terms of risk and return profile. Several authors describe that real estate portfolios with a higher fraction of efficient, green properties, had significantly lower market betas, which means lower exposure to market risk. Moreover, occupancy rates in more efficient buildings are not only higher but more stable, they are less volatile. This just stipulates the quote of Pivo & Fisher in which sustainable assets do not necessarily perform better, but at least performs the same as conventional assets. The second outcome has a more qualitative approach as this includes a side with more “soft edges”. Sustainability is not just about hard facts, but increases the mutual communication. Issues such as productivity, corporate image and the willingness-to-pay come to mind when exploring the qualitative side.

So basically if the tenant is *willing-to-pay* the added rent premium, the higher initial investment for investors is justified. But to what extent is the occupier willing to pay this rental premium and what drivers are taken into account when such a decision-making process occurs? The drivers of the occupier are more related on asset level and direct surroundings as the tenant is solely interested in a specific office. The table below gives us a handle into the process of the tenant.

.

Why should an occupier be willing to pay a rental premium for a sustainable asset?

Organizational	Technical	Financial
Increased occupant health and productivity	Enhanced building quality	Less need for office space through New ways of working
Increased corporate image	Thermal comfort and air quality	Mitigation of future regulatory impact
Aesthetically pleasing	Reduced downtime	Lower service costs
Compliance with CSR requirements	Personal control over attributes	
Retention and attraction of employees		

Table 3; Sustainable determinants tenant-wise

Again, the outcomes are two-folded as financial benefits are of equal importance compared to organizational performance. Although different, the majority of arguments are in accordance with the investor-side. Again service costs and the hedge against future legislation are of great importance. For the tenant, the sustainable view is also reflected on operational performance, focusing on employee health and productivity. Despite (early) evidence of its impact, improved indoor environmental quality has not been a priority in construction planning and execution, and resistance remains to incorporating it into financial decision-making. Strange, since it is not unknown that a labor force provides the best returns when operating under optimal conditions. One could state that the major financial savings could be of productivity and health which comes under the general term: employee satisfaction. When returning back to tenant demand into sustainable offices, people should remember that the operation of such an asset is not a “piece of cake”. In order to achieve their predicted performance, better performing green buildings need to be backed up by robust commissioning, effective management, and collaboration between owners and occupiers (WGBC, 2013).

While hypothesizing and think about the hazards of regulations, energy prices and changing qualitative demands, we arrive to the conclusion that more efficient buildings have the ability to provide a hedge against all three factors. Most importantly to notice is that changing tenant preferences and investor risk management may translate into risk of obsolescence for inefficient offices. Through accurate reporting and benchmarking, the capital market has the opportunity to integrate sustainability into their underwriting, investment decisions, their engagements with investment managers and so on.

Methodology

Image:
BREEAM Excellent; Extraverde, The Hague, NL

7. Methodology

This section of the graduation report highlights the methods and data used to conduct the statistical analysis of this research. Elaborations and justifications are provided for the choices that have been made according to the methods and data that were collected and utilized. Subsequently this graduation project uses a regression analysis as foundation to answer the stated research questions. The models that are being used have a quantitative nature and most of them are empirically orientated. As such an introduction has been developed to enlighten the reader on the actual functioning of these (statistical) techniques. The introduction forms the source for the selection and collection of the data needed for the dependent variable and the determinants as they will originate from preceding explanation. The methodology section will conclude with an extended summary of the included variables and their influence on process and decision-making elements.

7.1 Data collection

This section will focus upon the definition of variables and the source of the gathered information. Consequently this is the starting point of the research. First the author discusses the sources of which the data originates from. Second, the statistical background will provide knowledge towards the elaboration of both the dependent and explanatory variables. Since the nature of this research relies upon quantitative analysis, data is the key to success. Moreover, this data should not only be available but also reliable. To push the research forward, the data should at least consist of 100 buildings with decent quality to state significant results. With this notion in the back of the mind the search for data began. That is where the DGBC came in; luckily they are currently developing a benchmark which gathers sustainable data of individual assets. As such the first and most important part of the graduation project was set to go.

The DGBBenchmark consists of various office buildings through the Netherlands. The database is dependent on the data of market parties. The DGBC is from its origin a market-based initiative, thus some companies were eager to share sustainable data for future purposes. The benchmark consists of data from various real estate professionals such as Bouwinvest, Bouwfonds, CBRE Global Investors, Mayfield, and NSI among others. The gathered information is based on the actual consumption of the asset, namely energy, gas and other resource consumption. The benchmark also has been enriched by the newest Agentschap-NL database which consists of various commercial properties certified by the EPC-label. To meet the requirements of the research, several elements of the office building should be present. This includes address details (zip-code, street, and number), total energy consumption, energy label (EPC) and preferably occupancy rate during the measurement period. Most of the assessments were conducted during the year 2011. Some of the results differentiate, and are measured during 2009, 2010 and 2012.

Logically, the next step in the process is the collection financial data regarding office properties. The second set of data originates from the financial archives of DTZ, Vastgoedmarkt, VTIS/STRABO among others and a big share is provided by Philip Koppels from the TU Delft. The financial data will only be used for the definition of the dependent variable. This study has a strong focus on financial data, which is backed by sustainable predictors extracted out of the DGBBenchmark. The outcome of the cross-section of both databases marks the start of the analysis of this graduation project. To conduct this research successfully, both sides of the medallion should objectively be screened.

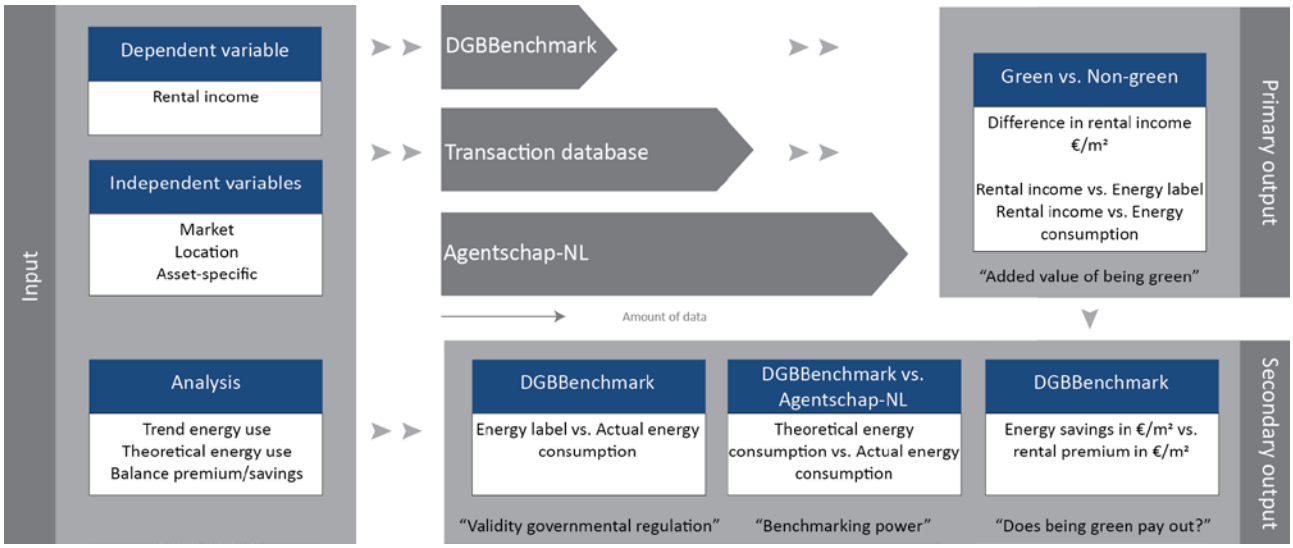


Figure 15; Use of data

So what kind of output does the author expect from the gathered data? In the table above there is a division into three stages, respectively input, data, and output. The input is related to the secondary variables delivered by sources that are not mainly focused on sustainability. Most importantly are the boxes related to the independent and dependent variable(s). These are directly connected to two sources, namely the DGBBenchmark and the transaction data. The Agentschap-NL functions as a support source to assist when the energy performance index or energy-label is absent or has a strange value. All together the aim is to conduct the study to investigate the relation between the rental level and the relative degree of sustainability, based on EPC-certification.

Second in line are the relations between the three data sources. It starts off with the analysis about the energetic trend, theoretical energy use documented by the Agentschap-NL database and the year of construction. With these notions in the back of mind, one could search for relations between the different databases. The three "layers" of data sources provide a good comparison opportunity. Therefore below the boxes some quotes have been added. On a preliminary basis the author assumes that for instance the actual energy consumption of an office is not in accordance with the energy label provided by a governmental department. Benchmarking power traces back to the relative uniqueness of the range of data that is included in the DGBBenchmark. Actual energy consumption provides material not only to compare between assets in a portfolio but it could also be subject of discussion between the owner and tenant. Some special attention is on the relationship of actual energy consumption and energy performance certificate. Since the structure of the actual energy can be decomposed into electricity, gas and district heating consumption, the energy costs can be calculated. The analysis of the results subsequently can tell us about the balance between the rental premium paid by the tenant and the energy costs saved through a higher energy performance certificate.

So the gathered information regarding the rental premium and the energy costs are combined to answer the question of financial performance: "Does being green pay out?" Of course this is not based purely on the balance between energy savings and the extra rent being paid to the owner, but more factors play a (minor) role in the decision to be more sustainable.

7.2 Determinants in regression analysis

As the first part draws upon the notion of financial data and the explanatory variables have other origins, this short section elaborates on the overlap between these variables. Let's start with the concept of a building's value, which has a different meaning for various actors in the real estate industry. The most common definition of asset value is market value, which is the estimated price at which a building probably will transact in the market place between a willing buyer and a willing seller. In turn, for investment-grade buildings this is linked to the rental/capital figure that building occupiers are willing to pay for owning or leasing a building. For offices, the value of a building is linked to a building's location, prestige, lease terms, operating expenses and resulting working environment among others. Other factors include the availability of other green buildings in the area and the viability of future refurbishment. Developers and owners define value as the potential market value of their property, which is in turn influenced by the attractiveness of the property to potential occupiers. Having read this, we can conclude that there is a relation between the often mentioned financials and the location/building characteristics.

Dependent variable: Rental income

The aim of this study is to identify the influence of sustainability on the financial performance of office buildings in the Netherlands. As such, a closer look on the financials is necessary to state useful evidence on this subject. Like the theoretical framework indicated, investing in real estate has several reasons. Besides David Geltner, Susan Hudson-Wilson described in her (2005) article why to be interested in real estate. This article draws upon an intensive research undertaken by Hudson-Wilson and co-authors and as such is credible enough to be used as empirical evidence. These primary considerations are in correspondence with the ones given in the literature study, namely:

1. To reduce the overall risk by combining several asset classes, commonly known as diversification.
2. To achieve an absolute return competitive with other asset classes.
3. Real estate is known for its capacity to be an inflation hedge.
4. Real estate plays a major role in common day-to-day life, and as such needs to be incorporated into ones investment portfolio.
5. Strong cash flow possibilities, which can be considered as a constant direct return or income from rents.

When we get back on track towards the quantification of the financials, which variable is suitable to serve as reliable and truthful source for the regression analysis? From the above considerations, some arguments can already be deleted as it is unable to convert them to useful data. Consequently arguments 1, 3 and 4 can be deleted as dependent variable as risk, inflation hedge and investment universe are either non-quantifiable or not suited to serve as truthful indicator. The dependent variable has to be found in the return component of real estate. When selecting between types of return, three components can be distinguished: total return, direct return (read: income), and indirect return (read: capital gain). Based on evidence provided by IPD time series of 2011, 2010, 2009 and 2008, a statement can be made which return profile to choose. Below are both the indices for total, direct and indirect return extracted from the IPD databank, additionally indices regarding inflation are extracted from the CBS-database(2013). This database contains information about 85% of the total market share of real estate in that particular category.

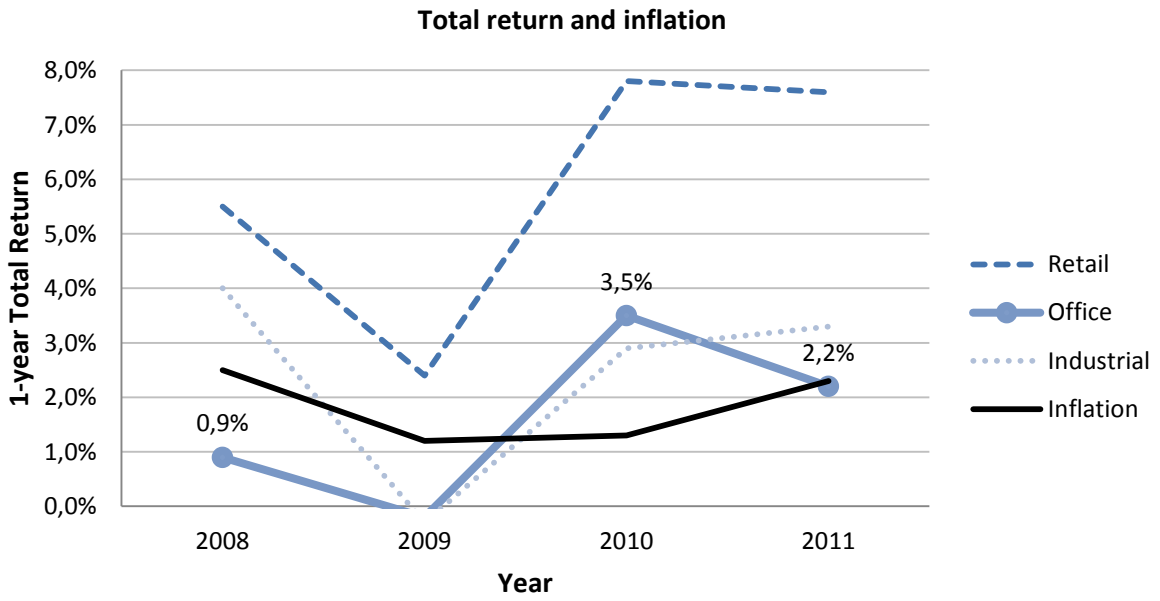


Figure 16; Total return and inflation, IPD & CBS (2013)

All graphical displays (above and below) show an indication of return series, not only from offices, but also residential and retail to show some contrast. When looking at the total return series, one immediately detects the under-performance of several categories of real estate last years. The fact that real estate is an inflation hedge is currently not accurate anymore. When focusing on solely offices, we see that in the four year time-frame, three years were under inflation. Basically, the total return (on investment) is equal to the sum of the direct (income) return and the indirect return (capital gain). The income return is expressed as a percentage of capital applied over a certain period, whereas the capital gain is calculated as the change in capital value, minus any capital expenditure incurred, expressed as a percentage of applied capital over a certain period. So what is the cause of these low values when splitting total return in direct and indirect return?

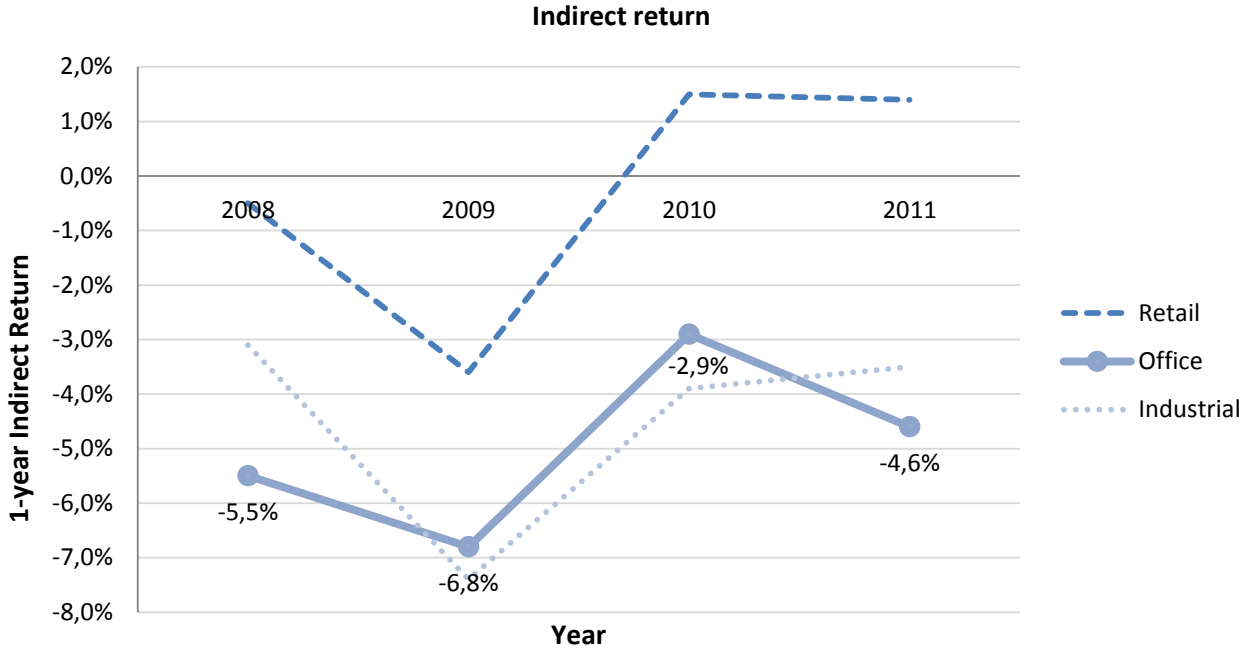


Figure 17; Indirect return, IPD (2013)

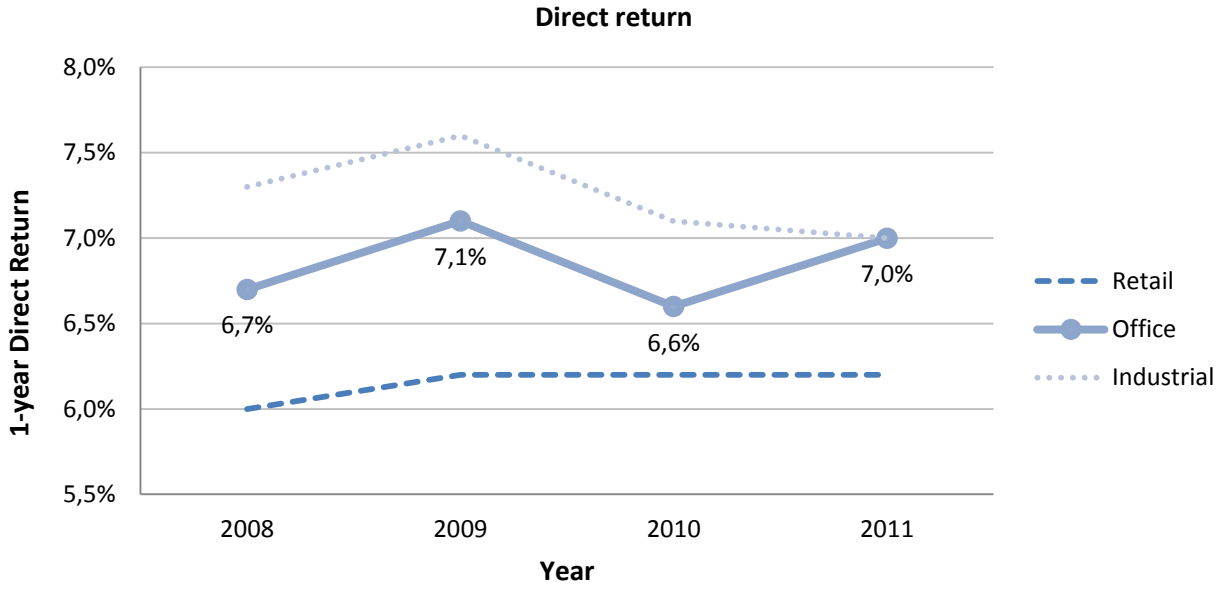


Figure 18; Direct return, IPD (2013)

The two graphs above clearly show a fragmented picture, current economic times result in a negative capital gain regarding almost all property classes. These graphs show that especially the indirect component is volatile and thus is not suited to use in the regression analysis, since it influences the total return greatly. A better measure is the direct return component, which remains rather constant. Besides this evidence one could think also of practical issues of other measures than direct return. Capital gain is based on the market value of a property, often determined by either transaction price or valuation. As this is rather subjective and dependent on market circumstances, direct return is in this perspective a better way to act a dependent variable. Secondly, it should be noted that valuation often does not provide an accurate market value, as smoothing and lagging effects are evident in current valuation business. As reasoned, direct return provides the author the necessary tool to successfully conduct the analysis, put a small adjustment has to be made. Briefly explained; the rent level (=income) is equal to the direct return, but direct return is indicated as percentage of capital value. That is why the rental income will be used in this research, because the value component is left out of consideration. When looking from another angle at the question, why to choose rental income as dependent variable, one could confidently argue that the rental income is an accurate reflection of market circumstances, since this is the particular rent that is transacted in the real estate market between owner and user.
To support the need for financial data, a combination of databases is used (as described in 'data collection'). The database entails several separate sources of information in the range of transaction characteristics such as: rent price per square meter, address details, and gross building surface. This information is matched with the DGBBenchmark.

> "This study by Van der Werf & Huibers (2013) shows that the direct component of the return on a real estate investment has a very attractive risk-return ratio. For a risk-averse investor, this is a product which can protect against unexpected value increase a very interesting development."(Vastgoedmarkt, 2013)

Composition of rental income

The reasons why to choose rental income above capital gain are clear when reflecting on above-mentioned explanation. So what does the author exactly mean when talking about "rental income"? The table 5 gives a short summary through different types of rental income which could be considered for analysis. Since the data is originating from a national real estate firm (DTZ), the data is not detailed enough to state more than the potential gross income. This is because several factors remain unknown, such as vacancy rates and operational expenses among others. Often office buildings are multi-tenant orientated which means that if a transaction occurs; there will be a take-up of office space of for instance 25%. In this case, due to terminology, potential gross income is not correct. A more suitable term is "gross transacted rental price".

Calculation of cash flows from property rents
Potential gross income
- Vacancy allowance
Effective gross income
- Operational expenses
Net operating income
- Debt service
Before-tax cash flow
- Taxes from operations
After-tax cash flow

Table 5; Calculation of cash flows

Variable name	Label	Values	Unit	Measure	No of categories	Source
TRANS_RENT	Transacted rent per m²/LFA		€/m²	Scale		DTZ

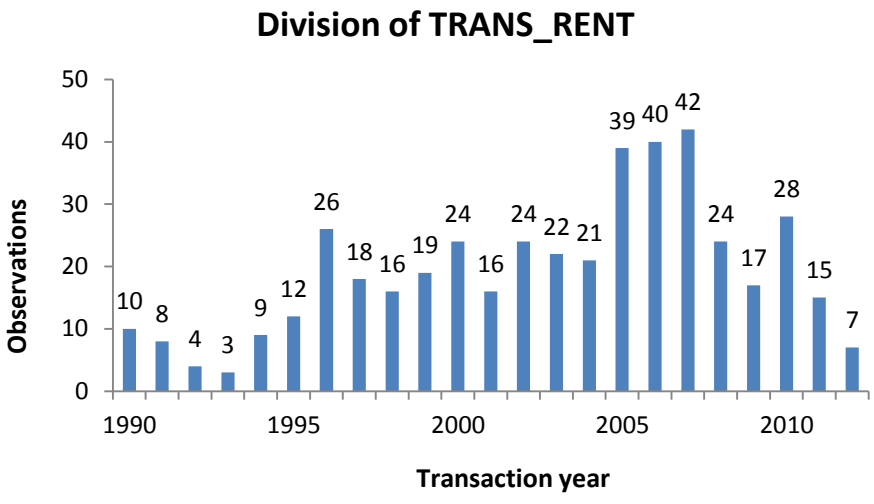
Table 4; Dependent variable for data set

The rental income is defined as the rent per square meter lettable floor area (LFA). So how is this rent transacted in the national system? This is the actual rent which is transacted to an owner of the asset. This sum does not include any service costs, such as the use of resources (electricity, gas and water) or taxes, costs, levies and contributions according to the Raad voor Onroerende Zaken (2003). Note that the transacted rent per square meter can considerably different than asking rent. Another interesting notion is to account the growth of rental level through times. Most of the rental contracts define rental growth as the indexation of the rent. To be specific: the rent is adjusted to the national consumer price index (also known as CPI), published by the Central Bureau of Statistics (CBS).

The tables below give an indication of the sample size; approximately around 25% of the transactions are dated before the year 2000. All others (after the year 2000) are closer to current times, thus more valuable to use. There are 444 transactions observed, which could mean that all offices are covered. Unfortunately this is not the case, although 70% of the cases are covered by transaction data from various sources (which covers 186 assets). Note that the timespan of the sample set is relatively large, which could influence the validity of the statistical model.

Year	n	%
1990-1999	125	28,2%
2000-2004	107	52,3%
2005-2009	162	88,7%
2010-2012	50	100,0%
Total	444	

Table 6; Division of transacted rent



Independent variables

This section provides a description of the explanatory or independent variables, the division between different categories and criteria for the preparation of the statistical analysis. The total number of variables that might predict the level of rental income is quite large, especially with the current dataset. Subsequently there has to be a pre-selection based on the assumption that the height of the rental income is not only dependent on locational characteristics, but also on other categories. The standard of the selection framework was defined by the predictive power of the involved variables and the prospect of the required information to be found.

The introduction and the theoretical framework already gave a sneak peak in the grouping of the explanatory variables to be used in the subsequent statistical analysis. The use of groups simplifies the model into a graspable whole, and thus the effects of each specific group can be identified. Preceding paragraph already stated the importance of macro-economic predictors. This group states something about the national economy as a whole and forms the background for regional developments. When we zoom in towards the actual asset, location characteristics form the second layer in the analysis. Location characteristics should be seen as the type of location including surrounding facilities and the reachability regarding means of transportation (read section 6.5: office rent determinants). The last two categories focus on the asset and provide more detailed information. First, the asset-specific characteristics focus on physical features of the office building, such as age, size and occupancy rate. Most important is the last category, which is also the focus of this research: sustainability characteristics. This group includes variables which focus on the operational (sustainable) performance of the asset.

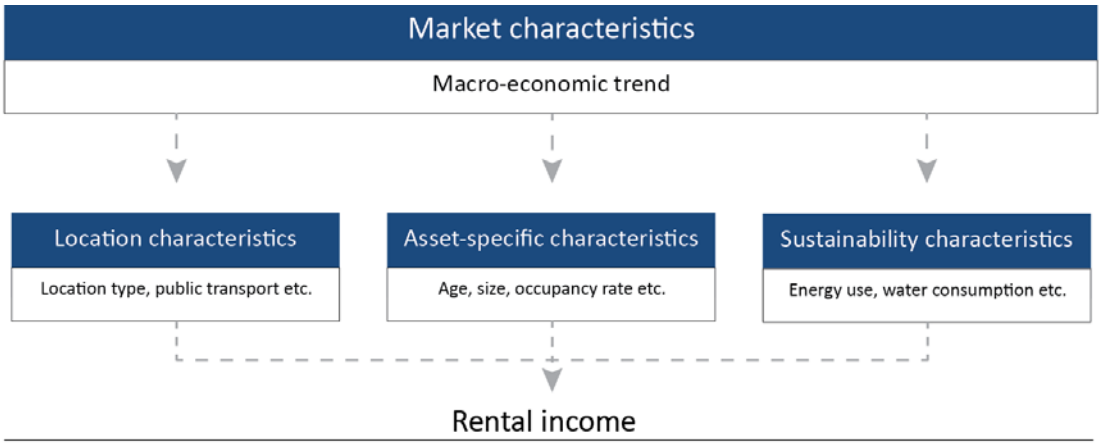


Figure 19; Model specification

The expectation supported by hypotheses stated that the level of rental income of offices can be predicted by factors which are distributed over all four groups plus a certain residual (ε_i). The preceding provided a rudimentary description the intended research set-up and can be written down in a statistical form:

$$\text{Rental income} = \beta^0 + \text{Market characteristics}_i\, \beta^1 + \text{Location characteristics}_i\, \beta^2 + \text{Asset} - \text{specific characteristics}_i\, \beta^3 + \text{Sustainability characteristics}_i\, \beta^4 + \varepsilon_i \quad (4)$$

Where i = 1,…, *n* and *n* is the number of office buildings presented in the dataset intended for this study. Following on the amount of cases are the explanatory variables starting with β_0 (constant), β_1 (macro-economic trends), β_2 (location quality), β_3 (asset-specific information), and β_4 (sustainable performance) which are the (yet) unknown parameters. Again ε_i is the final term; it represents the unexplained part of the model, due to missing characteristics, wrong model specification, and errors in characteristics. The following sections will emphasize the scheme of the above-described process and provide a detailed description of the used independent variables according to factor group.

Market characteristics

This group describes national economic trends and characteristics for the office market. This data consists of historical information ranging back to 2012 to accurately measure recent developments. The major advantage is of the modeling of the economic trend through dummy variables (more on that later on).The simulation of the economic trend covers all the offices which are subject of research.

Variable name	Label	Values	Unit	Measure	No of categories	Source
TRANS_YEAR	Transaction year x	TRANS_1990		Nominal	23	DTZ/VGM
		until				
		TRANS_2012				

Table 7; Independent variables for the group Market Characteristics

From a hierarchical perspective, this would be the first layer of data before proceeding to a next layer. Obviously the rental income in the year 1990 has a totally different value compared to recent years.

Location characteristics

This group zooms in on each particular case and considers the quality of the surroundings regarding facilities, transportation and the situation in the urban grid or basically "the geographical trend". Questions could start from the location of the asset within the Netherlands to the actual "type" of location. Is it a desolate office park or a lively transportation hub? What is the proximity to for instance a subway station? These are major considerations for both the availability of office buildings but most importantly the profitability of an asset. Consequently this group uses completely different data when comparing with the market characteristics group. Focus is on the added value of the office location, since this aspect is well known among real estate professionals.

Variable name	Label	Values	Unit	Measure	No of categories	Source
LOC_NL	Location type	1= Major Three Randstad		Nominal	5	Author
		2 = Inner Randstad				
		3 = Peripheral Randstad				
		4 = Hinterland				
		5 = Amsterdam				
LOC_CITY	Location city	1= Office park		Nominal	3	Author
		2 = CBD				
		3 = Other				
POP_CITY	Population city			Scale		CBS
PUBL_TRAIN	Proximity to train station		m	Scale		ARCGIS
PROX_HIGH	Proximity to highway		m	Scale		ARCGIS
PROX_SCHIP	Proximity to Schiphol		m	Scale		ARCGIS

Table 8; Independent variable for the group Location Characteristics

The location characteristics are built on two layers, namely the location of the asset in the urban grid in the Netherlands and the location within the city borders. The location in the Netherlands (*LOC_TYP*) is defined by five categories, predefined which makes the division of data less difficult. The city Amsterdam has its own dummy, because of the different market characteristics compared to other cities in the Netherlands. The second layer is the situation of the asset in within the city (*LOC_CITY*) and is also divided in three categories to ease the categorization. These three categories are a simplification of several office location typologies first described by Rudolf Bak (2003) and further defined in 2007 by the ROZ/IPD in their list of

definitions regarding the real estate index. This means that CBD is in accordance with “centrum”, Office park is in accordance with “kantoorlocatie” and Other incorporates “woonwijk” and “bedrijventerrein en overig”. Additionally the location type variable contains also the relative level of facilities in the area as the categories all say something about the general state of the location regarding attractiveness, of which is greatly influential by the level of facilities.

Mono-functional offices and office concentrations at industrial sites are considered in the so-called “Office park” locations. These locations are from user-perspective thought of as real business locations. The location characteristics are uniform buildings with the same charisma and good accessibility by car, including good parking. Accessibility by public transport is not necessarily good, but often a smaller train station or connections with subway or bus are close. The offices on this location are relatively young, with many of them developed over the past 20-30 years.

The Central Business District (CBD) is to be seen as an office location which is close to or is part of the city center. Characteristics are expressed as multifunctional, liveliness and often good access by public transport. The accessibility by car can be considered as poor, especially in the larger urban centers there is a big chance of congestion and parking solutions are scarce and costly. The characteristics of buildings in central locations vary greatly. Near or around a central train station there is a concentration of large office buildings, often with a few large users. Towards the city center buildings are more diverse and smaller in scale. Space is limited for new construction and office buildings tend to have a monumental character or have been renovated.

Other locations contain diffused office concentrations. This variable is very diverse and offices can be spread out in residential areas or located on the outskirts of a city. The type of buildings is varied, the office villas, transformed homes in residential areas or separate offices in the outskirts of town. The objects are not necessarily easily accessible by car or public transport. The same counts for surrounding amenities, these are very dependent on the particular location.

The last variable is the number of residents living in a particular city, which is represented in the variable *POP_CITY*. This variable functions as a representation of the size of a city, thus will be used as sort of a gradation system and an indication of the size of the local economy.

Second topic of location characteristics is the use of transportation. Most likely will employees have to commute from their home to work using either public transport, car or by cycling. Several factors account for the attractiveness of an office location, but the reachability plays a major role in this process. Following on this assumption is the division of these transportation means in variables, in this case four. There is only one category of public transport, namely *PUBL_TRAIN* which accounts for the use of either the train or subway. Another variable that will prove to influence rental levels is the respective distance to a major airport. In the Netherlands only one airport applies to this criterion: Schiphol international airport. This will be included in the variable: PROX_SCHIP. The last variable is related to commuting per car, which is stated as the relative distance to the nearest highway exit (*PROX_HIGH*). When an office is more easily accessible the value of the property will likely rise, due to decreased time to reach the building or reduced energy costs. The gathering of this data will be done through the use of a spatial tool (ArcGIS) that automatically calculate the proximity information on basis of the relative location (through zip-code and X-Y coordinates).

Asset-specific characteristics

The asset specifics provide a detailed background about the particular office building. As such the asset is well-documented and will increase the probability of the statistical analysis and the test results.

Variable name	Label	Values	Unit	Measure	No of categories	Source
TRANS_SIZE	Transaction size	m² absorbed	m^2	Scale		DTZ/VGM
TRANS_S	Transaction size (%)	% of GFA	%	Scale		Author
AGE	Building period	1 = <1969	year	Nominal	4	DGBC
		2 = 1970-1989				
		3 = 1990-1999				
		4 = >2000				
EFF_AGE	Effective age	Corrects for renovation		Scale		DGBC
AGE_NEW	Age during transaction	2012-EFF_AGE		Scale		DGBC
ASSET_SIZE	Asset size	1 = <2499	m^2	Nominal	4	DGBC
		2 = 2500-4999				
		3 = 5000-9999				
		4 = 10000-14999				
		5= >15000				
USE_INT	Use intensity	1 = > 30 m² GFA		Nominal	3	DGBC
		2 = 20 m² till 30 m² GFA				
		3 = < 20 m² GFA				
OCCU_RAT	Occupancy rate	1 = 0% -25%	%	Nominal	4	DGBC
		2 = 25% - 50%				
		3 = 50% - 75%				
		4 = 75% - 100%				
OPEN	Opening hours	1 = 5 days, 12 hours a day		Nominal	4	DGBC
		2 = 5 days, 16 hours a day				
		3 = 6 days, 16 hours a day				
		4 = 7 days, 24 hours a day				

Table 9; Independent variables for the group Asset-specific Characteristics

TRANS_SIZE and *TRANS_S* relates to the relative size of the transaction. When a transaction has occurred, consider for instance an office building of 5000 m² which has been leased by only one tenant. The rental income is more accurate than ten smaller transactions by respectively ten tenants. Often stated is that the rental price increases when the transacted square meter size is relatively small. Another potential benefit of the transaction size is that it becomes possible to argue if the property is a single or multi-tenant asset, which can be used as dummy variable to check if there are major differences.

Next concerning asset-specific characteristics are the building features. This group focuses on the condition and the occupier(s) of the office building. It is important to obtain a good reflection of the asset itself because this is one of the main topics in this graduation research. The table incorporates "technical" details which are combined in two variables: *AGE* and *ASSET_SIZE*. *AGE* describes the age of an office building according to its building period. This variable is arranged by year, because the year of construction is reasonably important when relating it to energy use. Buildings constructed before 1990 did not really take energy use into account and are often considered as extreme "energy devours". While *EFF_AGE* corrects for a potential renovation that renews an asset's technical lifetime, *AGE_NEW* subsequently corrects the variable to a continuous one (scale variable in SPSS). Substantial large maintenance and renovations

significantly extend the technical lifetime of an office; consequently the *AGE_*NEW is calculated as the period between renovation and today. Another building element to consider is the size of the building. Different rent expectations exist for the spatial dimensions of an office building. Smaller assets often obtain a higher rental income and throughout the increase of square meters this effect fades out.

The resulting information in the table relates to the occupier and current user condition of the office. It is extremely important to know the occupiers' situation when comparing data with regard to energy consumption. Obviously the energy consumption will be lower when the asset has a vacancy rate of 50% compared with an office that is fully let. The following variables enable the author to confidently enquire the energy use data, because of the possible corrections regarding use intensity (*USE_INT*), occupancy rate (*OCCU_RATE*) and to a lesser extent opening hours (*OPEN*). One could definitely argue the influence of vacancy rate on the rent and energy situation of an office. The other two factors use intensity and opening hours are important as well. The addition of these two variables is based on research of Jones Lang Lasalle into the service costs of office buildings (OSCAR) (2012). They state that there are two reasons why sustainable buildings are not necessarily more energy-efficient. The first is the introduction of the New Ways of Working, which increases the use intensity (and possibly opening hours) of the office building. Second argument is that these sustainable buildings are not being used as "sustainable".

Sustainability characteristics

This group is the topic of discussion the graduation thesis: sustainable performance. One should remember that the used data has a unique character as this data is directly read from the actual consumption meters. That is where the added value of this research rests upon. In the table below the gathered data is shown.

Variable name	Label	Values	Unit	Measure	No of categories	Source
ENERGY	Actual energy consumption		GJ/m^2	Scale		DGBC
ENERGY_THEORY	Theoretical energy consumption		GJ/m^2	Scale		Agentschap-NL
E_INDEX	Energy performance index		0-4	Scale		Agentschap-NL
E_LABEL	Energy category	1 = A++	A-G	Nominal	9	DGBC
		until				Agentschap-NL
		9 = G				
WATER	Water withdrawal by source		m^3	Scale		DGBC
WASTE	Amount of waste		Tons	Scale		DGBC

Table 10; Independent variables for the group Sustainability Characteristics

The most notable variable of this group is *ENERGY* which is defined as primary Giga-Joule per square meter gross floor space. This is the outcome of an equation starting with the combining of the electricity use, gas consumption and other resource use. Other resource use is in this case the so called "district heating" (NL: stadsverwarming). These three energy indicators are gathered, converted in primary GJ and finally divided by the gross floor space (GFA). Note: primary energy consumption is calculated as energy use from the "source", based on fossil fuel consumption. In this case only electricity has to be converted in kWh and thus a return factor has been included (=0,39). This can be seen as the energy generation and transportation loss. The same calculation has been used for the variable *ENERGY_THEORY*, but the theoretical energy consumption only estimates the intrinsic energy use. That is, solely the effect of building performance. The difference between the actual –and theoretical energy consumption is to a large extent the influence of the tenant that houses in the office building.

Following on energy consumption is the certification which indicates the theoretical energy performance of the asset. One of the targets of this study is to identify if energy labels match with the actual energy consumption. Although *E_INDEX* and *E_LABEL* seem different, in fact they are similar because they both indicate the energy performance. The different between the two is shown in the figure. The energy label ranges from A++ till G, indicating a "green" property compared to a relative high energy consuming building. The EPI (energy performance index) is a score to obtain a certification. As such the EPI sounds like a more objective thus useful variable, but in practice, it is only the grade of certification that counts. The energy performance index remains valid in the statistical analysis due to further research. This is because of the following reason; investors are often eager to enhance their energy label by means of least effort. This means that the EPI-score often is in the higher regions of the scale; in this fashion the transfer to, for instance C to D certification is easily made because of a very small difference. The certificates will be used to highlight and show results, while the Energy Performance Index will be used as independent continuous variable.

Figure 20; Relationship energy performance index and certification

The other two variables make the sustainable part complete. Sustainable performance can be measured through combining the variables energy, water and waste. The added value of measures as water consumption in m^3 (*WATER*) and the amount of waste in tons (*WASTE*) is still unknown. However these figures, are measures for only one time-period (for example: 2010) and thus cannot be used in the statistical model. However, the following data analysis will indicate if there is a sign of a relationship.

Concluding statement

All these variables will account for better portfolio proofing through the use of sustainable variables (among others). The complete description of data provides a rather clear indication how these variables are being assessed and how the weights are being distributed along the factor groups. Still the focus remains on the sustainable data because of its relevance to the research and the relative uniqueness of the energy consumption data. It is clear by now that the influence of energy, water and waste flows is rather difficult while we do not know the data throughout the years. That is why the research starts with the added value of an energy-certificate. The actual consumption of resources is subject of analysis when the first output has been produced. Note that this is a preliminary selection; at this point it is not possible to select the best matching variables. Evidently these explanatory variables are related to the subject, which is the rental income. As this study proceeds to the results, a further selection regarding variables will automatically be made on the basis of variable significance.

7.3 Data analysis

Basically this research has two layers of research consisting of the primary and secondary output. The first aim of the study is to find a relation between the energy performance index (EPI) and the transacted rent expressed in rent per square meter. This part mainly focuses on the accuracy of the governmental certification system. The secondary output provides the opportunity to objectively critique the calculated rental premium compared to energy savings. Focus of the secondary output is to compare the actual energy consumption against both the theoretical energy consumption and energy performance index. Additionally, the energy costs of the actual energy use will be displayed against the rental premium paid for energy-efficient properties. The intention is to answer the successive research question mentioned below:

What are financial benefits of a better energy performance certificate regarding rental income?

Does the improved financial performance of more efficient certified properties equal the saved energy costs? It is likely that the rental premium and saving energy costs fade out into a balance of zero.

Descriptive statistics

Descriptive statistics give an overview of the type of data and the spread of data. The dataset is constructed while using a model structure to build up the model. First transaction variables are added and subsequently other explanatory variables. In this paragraph the author starts with the analysis of the whole dataset and the dependent variable.

As previously mentioned the data springs mainly from the DGBBenchmark (asset-wise) and DTZ (transaction-wise) and is enriched with data from Agentschap-NL and other transaction databases such as VTIS/STRABO. The data consists of 265 unique assets which have been merged with transaction data. Only 79 assets could not be combined with transaction data. That leaves 186 assets (=70%) as subject of analysis. During time period 1990-2012, 444 transactions occurred regarding these 186 unique assets.

In the boxplot below an overview is provided for the rental levels of all cases involved. The graph indicates a rather large bandwidth with in some years a rather big range of rental income. One should keep in mind that rental income can be very diverse. Several factors could explain for sudden shocks, for instance macro-economic factors such as unemployment and vacancy rate described by (De Wit & Van Dijk, 2003) and more importantly micro-economic factors. When discussing micro-economic factors, we should include location, type of location and reachability among others. As we can see in the boxplot, there can be two types of outliers in this study; systematic outliers (see: years 2003 and 2007) and incidental outliers such as the stars in 2002. The first type of outlier could be corrected with a dummy variable in the regression, whereas the second type of outlier needs to have some special attention. When the regression analysis is conducted and the outliers is still there, we should take a look at the data provided and actually find out why this “extreme” value has occurred.

Table 11; Division of transactions during the period 1990-2012

TRANS_YEAR		
Year	**Frequency**	**Percent**
1990	10	1,9
1991	8	1,5
1992	4	0,8
1993	3	0,6
1994	9	1,7
1995	12	2,3
1996	26	5
1997	18	3,4
1998	16	3,1
1999	19	3,6
2000	24	4,6
2001	16	3,1
2002	24	4,6
2003	22	4,2
2004	21	4
2005	39	7,5
2006	40	7,6
2007	42	8
2008	24	4,6
2009	17	3,3
2010	28	5,4
2011	15	2,9
2012	7	1,3
Total	444	84,9
Missing	79	15,1

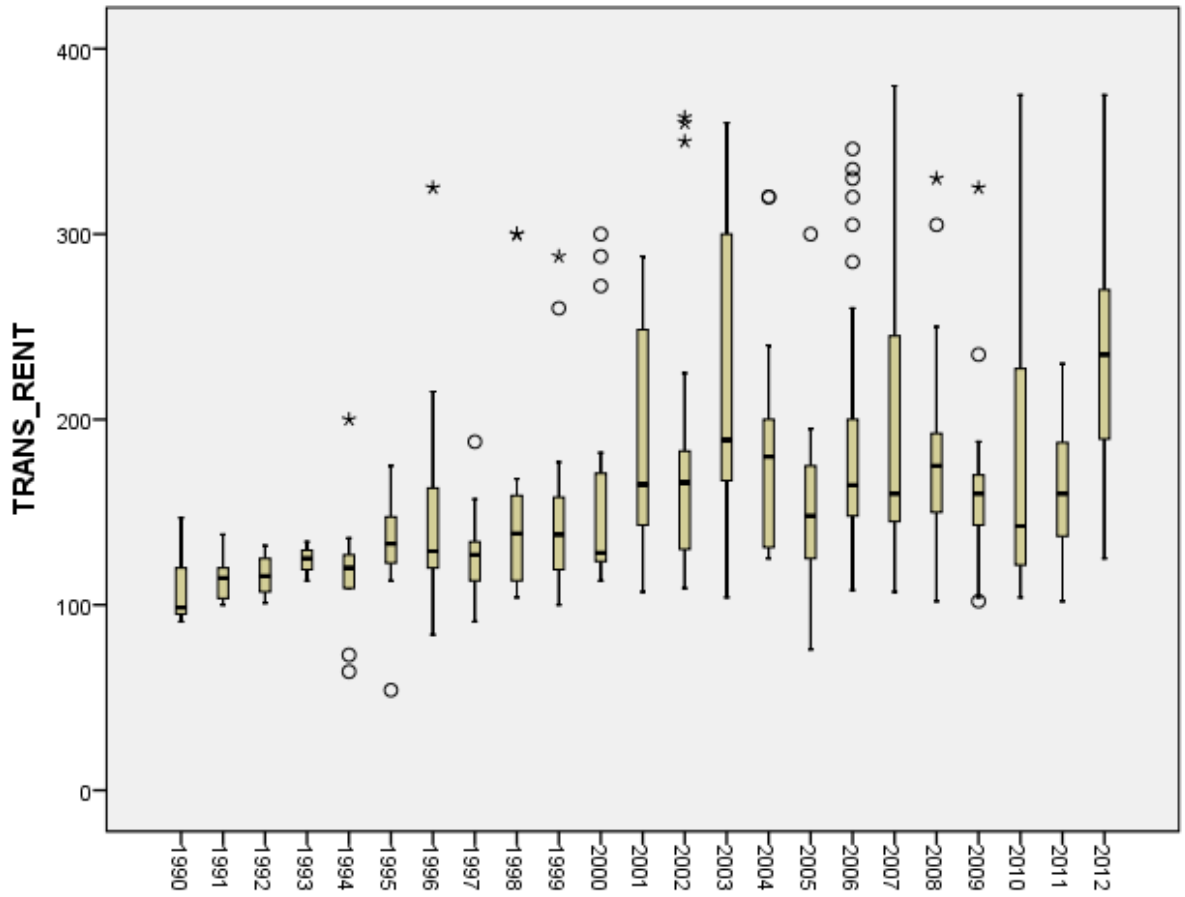


Figure 22; Scatterplot of relation between transacted rent and transaction year

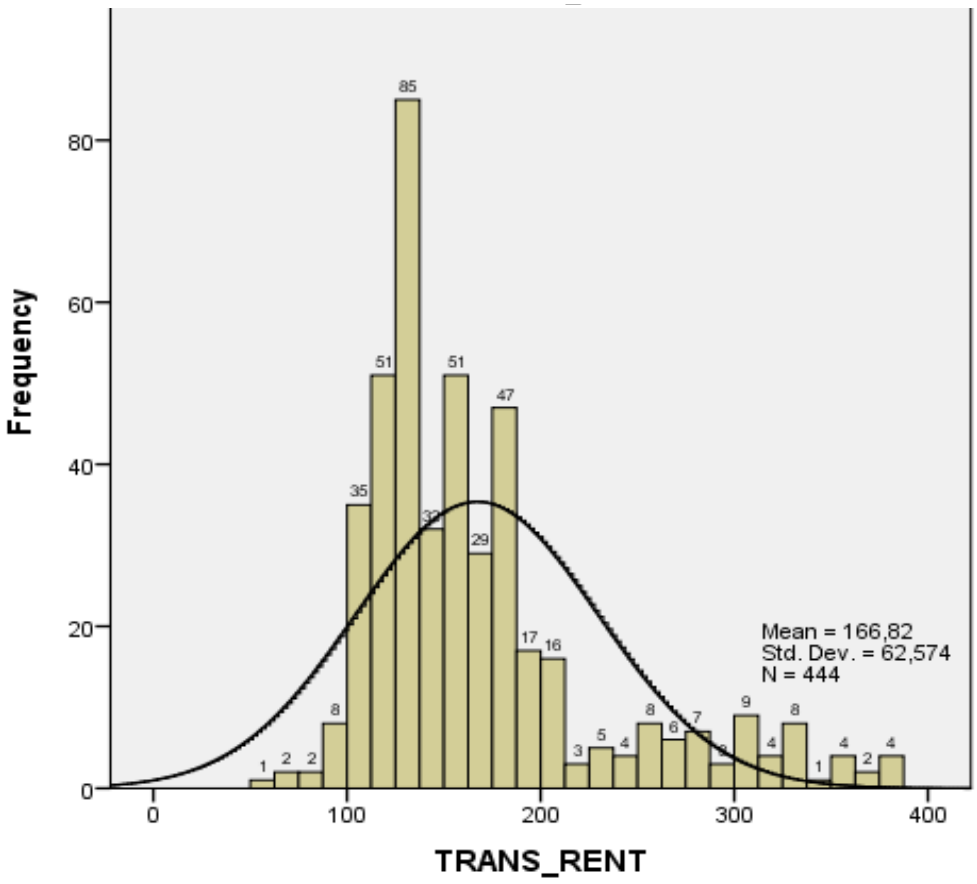
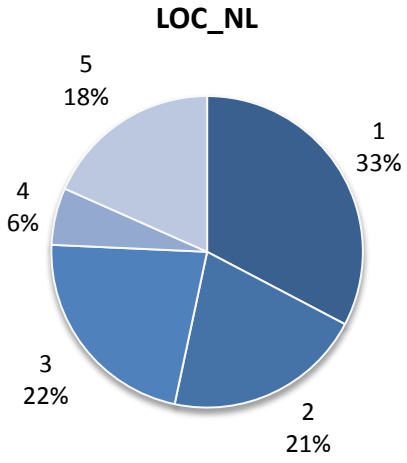
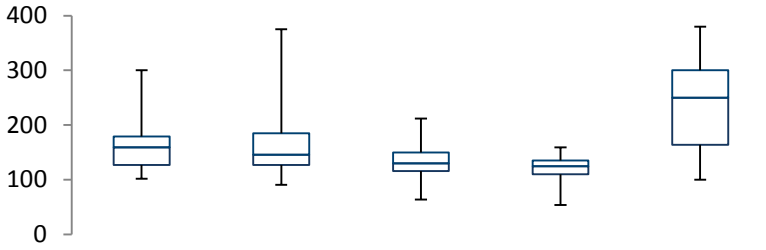


Figure 21; Histogram of the normal distribution of transacted rent

Micro-economic variables

Investors in real estate, typically through a process of naïve diversification, have constructed diversified portfolios, although in many cases more effective strategies could be adopted (Eichholtz, Hoesli, MacGregor, & Nanthakumaran, 1995). This article describes some early evidence of property types and how to diversify across regions. Although this research only focuses on offices, the background of diversification could be a major predictor for rental income. As discussed in the definition of the independent variables, the Netherlands is divided in 5 different regions, respectively The Major Three, Inner Randstad, Outer Randstad, Hinterland and Amsterdam. It is plausible that a different rental pattern is expected among these different categories. It is rather difficult to stipulate which locations and their subsequent types do indeed account for a higher income, although for Amsterdam and the Major Three an increase is expected. The following pie chart and table describe the regional diversification of the variable *LOC_NL* against the rental income *TRANS_RENT*.





LOC_NL	1	2	3	4	5
N	159	79	95	23	88
Average	155,4	170,8	131,8	122,8	233,2
SD	32,07	71,36	25,75	21,2	78,23
Min	102	91	64	54	100
q1	127	127	116	110	164
Median	159	146	130	125	250
q3	179	185	150	135	300
Max	300	375	212	159	380

Table 12; Overview of independent variable Location in the Netherlands

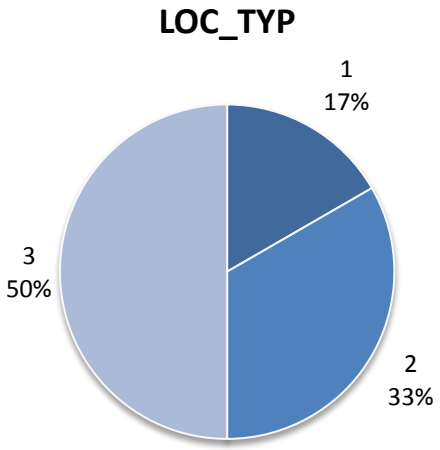
When looking at the division of data and the boxplots we notice two interesting features. One would reasonably expect that LOC_TYP "1" (Major Three Randstad) has a higher rental income than LOC_TYP "2"(Inner Randstad). Second is the major range of rental incomes in the city of Amsterdam (LOC_TYP "5").

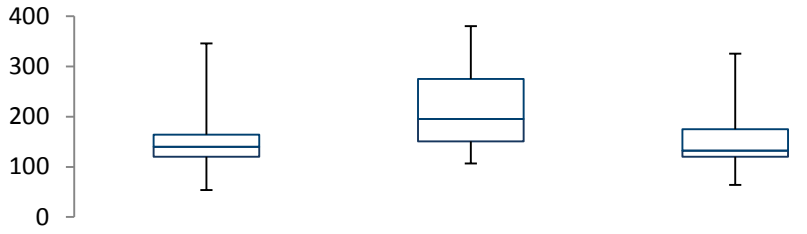
A possible explanation regarding the higher rental income of geographical location is the presence of Schiphol in the dataset. Fortunately, the variable *PROX_SCHIP* adjusts for the relative influence of assets with close proximity of Schiphol International Airport. The major range of rental income in the city of Amsterdam is hard to explain. The variable is already recorded into the dataset as dummy variable to adjust its relative influence. Because of the great variety of office space across the capital, the existence of small sub-markets is present. A wide range of premium office space with high rental income will obviously collide with outdated desolate office parks.

Nevertheless the analysis of the income series gives no significant difference between the return series of the five mentioned categories. This might be caused by the influence of the other dependent variables, which have the ability to characterize these objects similarly well or even better. Note that it is also possible that the dataset might be suffering from a relatively small number of cases or the existence of biased data.

Location type

Like the relative position of the asset in the Netherlands, the type of location is crucial for the determination of rent. Consider for instance an office building with no facilities like a train station or a comfortable place to lunch. It is most likely that a potential tenant is not interested to rent office space at that particular spot. That is why the location features should be included into the model. *LOC_TYP* has been introduced with three categories, respectively Office park (1), Central Business District (2) and Other (3) which have been crossed with *TRANS_RENT*.



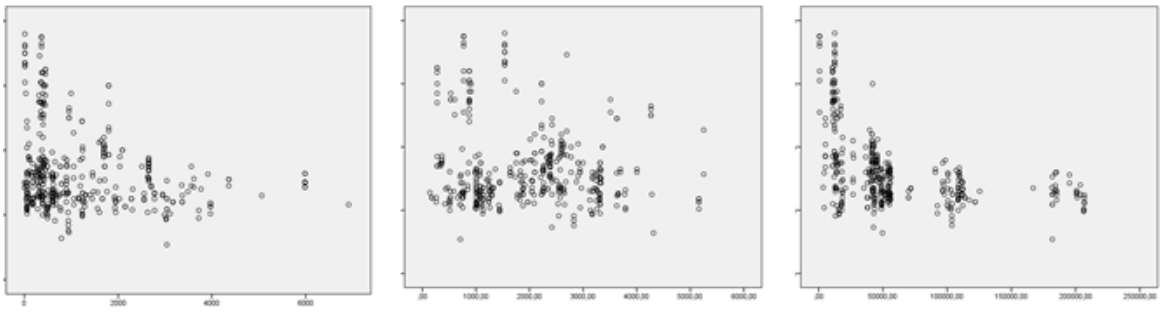


LOC_TYP	1	2	3
N	219	122	103
Average	144,8	215,4	156,2
SD	32,53	77,85	59,73
Min	54	107	64
q1	120	151	120
Median	140	195	132
q3	164	275	175
Max	346	380	325

Table 13; Overview of independent variable Location type

Not surprisingly the CBD has the highest average and median compared to the other two categories. However the range of data is pretty large, this is likely caused by the different natures of the involved CBD's. The difference between office park and other is rather small; this is likely because of the spread of data across the Netherlands. The category "other" is a mixture of several types of offices, which could explain the relative bigger range and difference between median and average.

Figure 23; Scatterplots related to the independent variables of Reachability

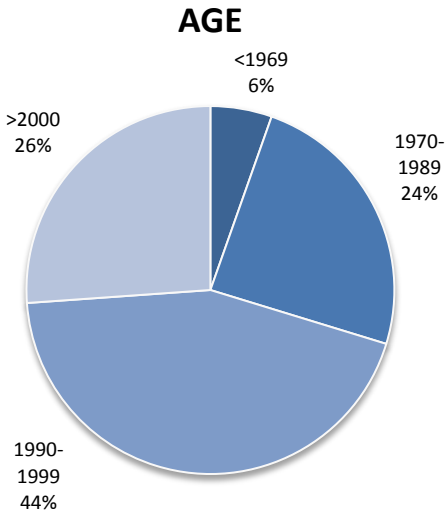


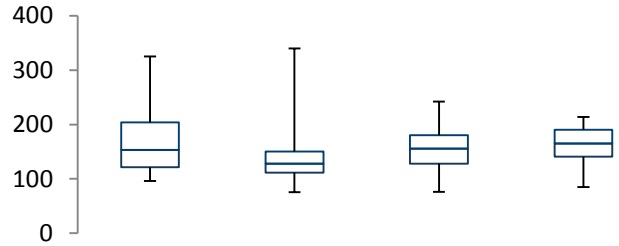
PUBL_TRAIN *PROX_HIGH* *PROX_SCHIP*

The scatterplots above represent the reachability of the respective location per case. So far there does not seem to be a significant or visible relation of variable *PROX_HIGH*. However some cases seem to indicate a higher rent when the distance is closer. This could change when rental levels are indexed according to transaction year. The other two variables, *PUBL_TRAIN* and *PROX_SCHIP* seem to be related with rental income. There is a clear indication of a higher rent when an asset is situated closer to a public transport station or Schiphol.

Asset-specific; building period

The effect of construction year should influence rental income with some logic thoughts. Consider for instance an office from early 80's, although nicely situated along the highway, the asset is characterized by a concrete desert as façade. There is no way that a tenant is willing-to-pay more for such a building than a relative modern building constructed only ten years ago. Additionally the effect of the higher operating costs regarding older assets could negatively influence the rental income. However some caution is perhaps in order, since some building years or construction typologies are subject of relatively high demand. Consider monuments with a G-label and high operating costs, but these objects are definitely quite popular. *AGE* has been shown in relation to *TRANS_RENT*.





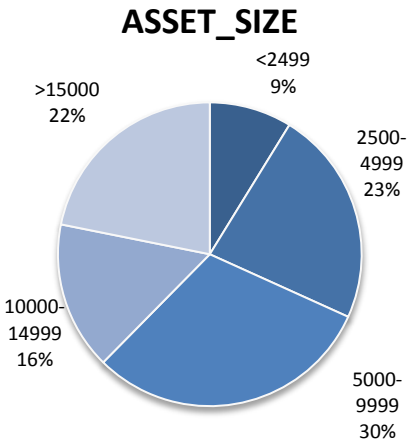
Building period	<1969	1970-1989	1990-1999	>2000
N	24	108	196	116
Average	161,8	152,9	172,0	172,0
SD	58,26	75,24	64,43	42,88
Min	54	64	95	108
q1	121,25	111,5	128	140,75
Median	153,5	128	155,5	165
q3	203,75	150	180	190
Max	275	380	375	346

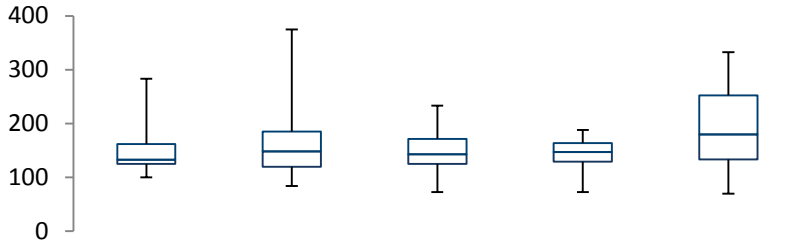
Table 14; Overview of independent variable Building period

There is a clear indication of differences between all four categories. Not surprisingly the category "1970-1989" has the lowest average and median. The high values can probably explained through the transaction year, think of transactions from 1990 to 1995 when these buildings where more technologically advanced. The older buildings (<1969) show a higher rental level, due to the fact that a monumental image correlates with a higher transacted rent. The difference between the two modern categories is absent when looking at averages, although the median shows indeed a difference. Note that the transacted rent is based on the building year of the building, which means that for example a 1995 building can be renovated according to current standards and thus probably obtain a higher rent. This is a loose guess considering many factors that could influence the rental difference.

Asset size

Scale advantages are mainly the cause of lower service costs in larger office buildings. Large objects obtain these advantages through installations, cleaning services, waste management and ICT (Jones Lang Lasalle, 2012). Consequently this signifies that a higher rent could be expected in large buildings due to scale advantages. For smaller buildings rental level inevitably should be lower according to this theory. Basically there should be some sort of linear relationship regarding rental income and the size of an object. Like previous examples, *ASSET_SIZE* is shown against rental income *TRANS_RENT*.





ASSET_SIZE	<2499	2500-4999	5000-9999	10000-14999	>15000
N	39	102	136	70	97
Average	154,5	164,5	154,1	151,9	202,8
SD	58,28	58,66	48,34	36,07	84,34
Min	64	73	76	91	54
q1	125	120	125	129	133,5
Median	133	148	143	147	180
q3	162	185	171,5	164	252,5
Max	305	320	346	285	380

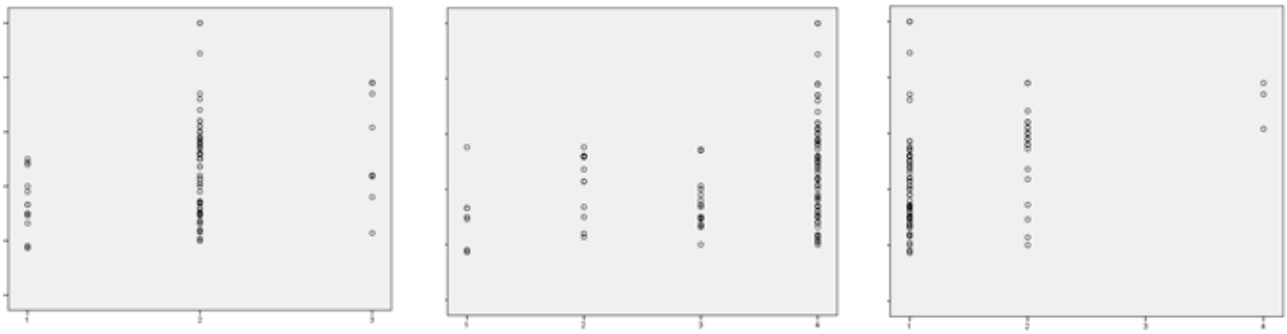
Table 15; Overview of independent variable Asset size

The theory that smaller buildings have a lower rental income proves to be plausible. The lowest category accounts for the lowest rental heights, while the biggest category indeed has both the highest average and median. Surprisingly the other three categories are in line with each other, however due to the spread of data one should be cautious to define premature conclusions. Both categories “2500-4999” and “>15000” account for higher rental incomes. However this is accompanied with a relative high spread of data, which simultaneously reduces the significance.

Asset-related characteristics; user intensity, occupancy rate and opening hours

It is a pity that the availability of this data is relatively low, due to the complex nature of gathering. These specific asset related characteristics have the qualities to improve the data analysis and subsequently the statistical analysis. So why is it important to identify this specific data regarding the use of the object? These variables form the backbone of operational aspects and are subsequently related to operational costs. These operational costs can be traced back to the actual energy output of an object. Just to clarify; the building has an intrinsic energy use, but theories state that actually the tenant is influencing the “sustainability” of an office. Although the gathered dataset is not complete, the data will be used in the analysis and perhaps discuss preliminary evidence of tenants’ influence.

Figure 24; Scatterplots related to the independent variables of Office usage



USE_INT *OCCU_RAT* *OPEN*

These scatterplots give a suggestion about the range and spread of the dataset relative to *TRANS_RENT*. Roughly 25% of the dataset is covered by these three categories and one should not forget that these figures are from the years 2010, 2011, 2012. So to what extent are these figures useful? Essentially it is rather difficult to incorporate occupancy rate (*OCCU_RAT*) into the regression model, the other two are likely to remain constant thus perhaps useful. However this data could corresponds to a larger extent with the actual energy consumption. Considering this fact, it will be likely that user intensity, occupancy rate and opening hours better predict rental income and actual energy consumption.

Sustainability

Energy Performance Certificates have the biggest market share in the Dutch market compared to other international certification schemes such as BREEAM and to a lesser extent LEED. This is caused due to their mandatory nature enforced by the national government. It is important to note that the EPC has been designed to rate the energy performance of a building only; it does not assess the overall sustainability of a building (DTZ, 2013). The concluding comments of the theoretical framework remark that sustainable assets do not necessarily perform better, but at least perform the same as conventional assets. Preliminary evidence should indicate a higher value of “greener” properties.

In regression model, the energy performance will be used as explanatory variable instead of actual energy consumption, why? A measured EP-Index presents a summary of the overall energy use per unit of useful floor area of a building based on the delivered and exported energy and accounting for energy generated in the building. The total weighted energy can be compared with to rank the building against its peers at national level from A to G. Unlike the EP-Index, the actual energy consumption captures the energy use also by non-building related items, such as office equipment and electrics. When an occupier chooses to obtain office space at an office building for example in Rotterdam, he does not know the actual energy consumption and the related energy (and other service) costs. On the other hand, he does know the energy label obtained by the asset in recent history. That is the main reason why actual energy consumption will be used to question the results found by the statistical model. Although the Energy Performance Index is theoretically right about the general consumption profile of the asset, the tenant will (in most cases) determine the actual energy use of an office.

But what is actually in the dataset used in this research? To state something about the significance of data and the reflection of the sample set to the general market situation a pie-chart could indicate the relative division of data. The two pie-charts below indicate the division in percentages. When taking a closer look, we distinguish in the DGBBenchmark that more efficient buildings prevail when comparing to the peer group (Agentschap-NL database).

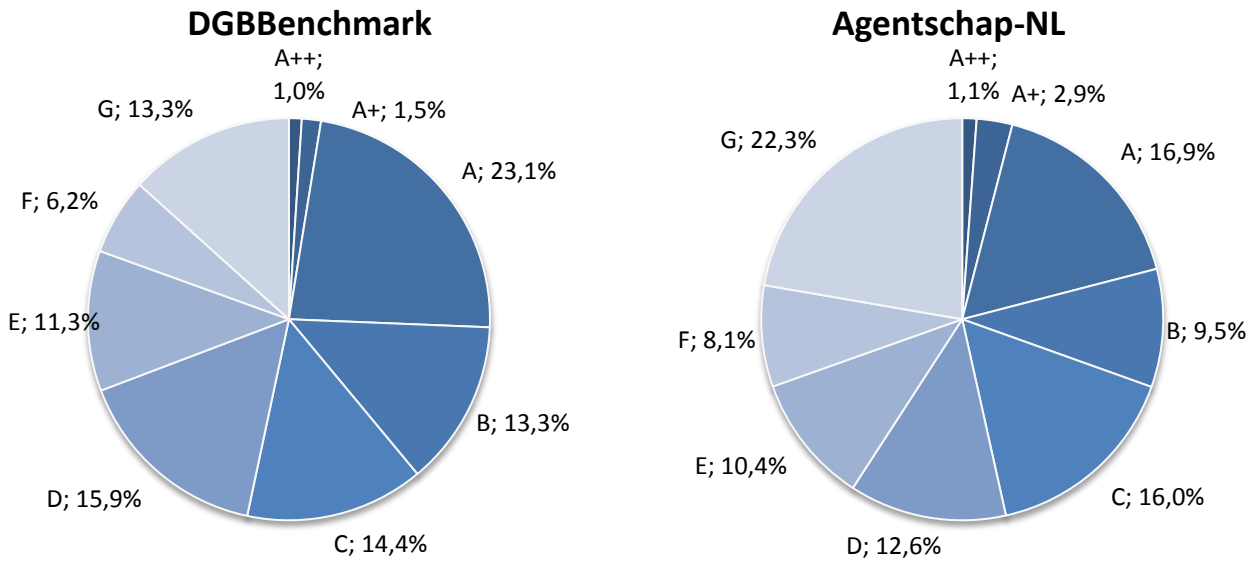
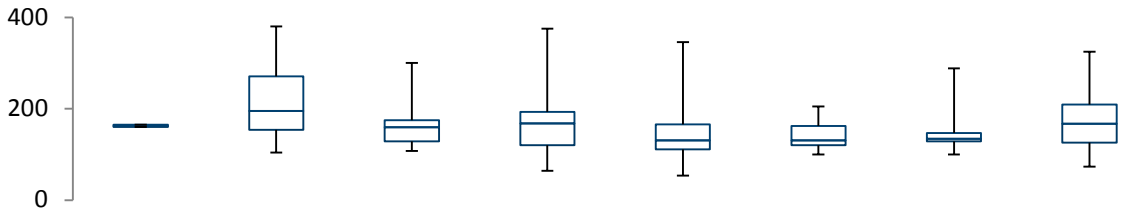


Figure 25; Relationship of the DGBBenchmark compared to average Dutch office stock

The division is not totally due to the amount of modern assets in the benchmark. Although the DGBBenchmark has a considerably high amount of recent office properties, this is not deviating from the peer group. We could confidentially argue that the assets in the DGBBenchmark are better performers relative to their peers.

Next, we take a look at the financials while connecting the dependent variable *TRANS_RENT* with *E_INDEX*. Considering current evidence regarding the added value of green properties directs us to some preliminary statements. That is; greener assets should obtain some sort of rental premium (read: A-label has a higher rental income compared to E-label). There is an opportunity to check for these assumptions while observing the table and boxplot below. Mind again that these observations stretch along a long time horizon which could influence the significance of data.



EPC	A+	A	B	C	D	E	F	G
N	2	90	42	55	48	68	23	44
Average	162,5	216,5	168,5	184,0	142,1	140,0	142,1	176,4
SD	3,54	72,73	50,73	81,95	45,48	25,35	38,28	67,93
Min	160	104	108	64	54	100	100	73
q1	160	153,75	128,5	120	111,5	120	129	125,75
Median	162,5	195	159,5	168	131	131	134	167,5
q3	165	270,5	175	193	165,5	162,25	147	209
Max	165	380	300	375	346	205	288	325

Table 16; Overview of energy performance certificates

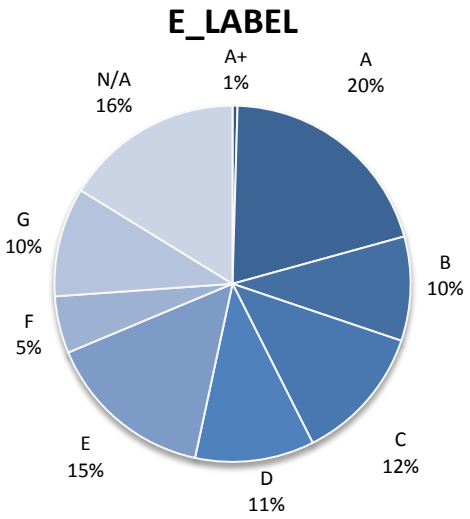


Figure 26; Division energy labels in data set

Unfortunately the A++/A+ categories are not very common and thus the sample size is really small. Luckily the "A" category is widely available and can thus be used to state significant evidence. The "A", "C" and "G" categories suffer from a wide range of data, probably explainable through two factors. The first one is time of transaction; older transactions are in this summary not indexed. Second and more important, it is easier for small office buildings to obtain a higher energy certificate. Fact is, due to their high heating loss surface which directly decreases the Energy Performance Index makes smaller offices more "green", for more technical info read; (Ham van den, 2004). Approximately 85% of the transactions are covered by Energy Performance certificates, which make it possible to investigate the effects of energy labeling regarding the financial performance. Let's see if there is a sign of some preliminary evidence when plotting the *TRANS_RENT* against *E_LABEL*. Note that the rental income in this case is not indexed, thus results could be misleading.

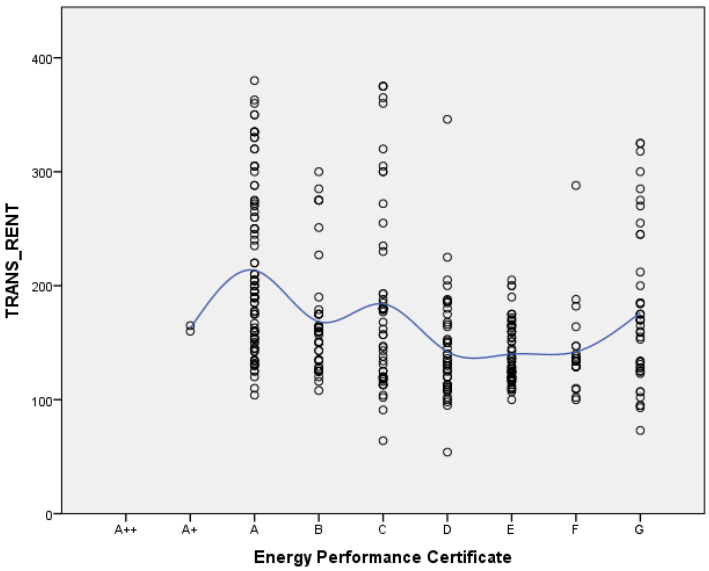


Figure 27; Scatterplot of transacted rent and energy labels

The scatterplot above together with a curved line through averages shows a promising picture. Indeed "A" certified properties obtain a higher average rent, while worse performing properties score less well. Again two notions are unusual and needs some deeper explanation. First, why do the C-rated properties score a higher average compared to "B" properties? The better performance of C could perhaps be explained through governmental influence. The government decided some while ago that they only would rent office space with a C-label or higher. This movement struck across the market and some organizations took over the same criteria. Further research is needed to see what has caused this shift. Second is the relative higher rent of G-rated properties. This was also identified by Fleur van der Erve (2011) in her graduation thesis. Often G-rated objects are monumental properties which have a stately façade or are located directly in the middle of a city enjoying nearby (public) facilities.

Besides the added value of energy performance certificates, BREEAM In-Use certifications are also incorporated into the dataset. Regrettably only 11 objects in the database are BREEAM In-Use certified and for only five of them rental transactions could be matched. In the scatterplot to the side a first glance at the relative position is shown. So far no added value is expected from BREEAM In-Use certification. Yet again, this is probably due to the year of transaction, but perhaps there is just no higher rental income of these particular certified properties.

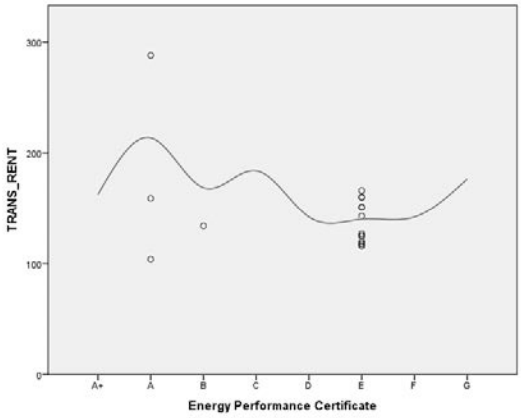
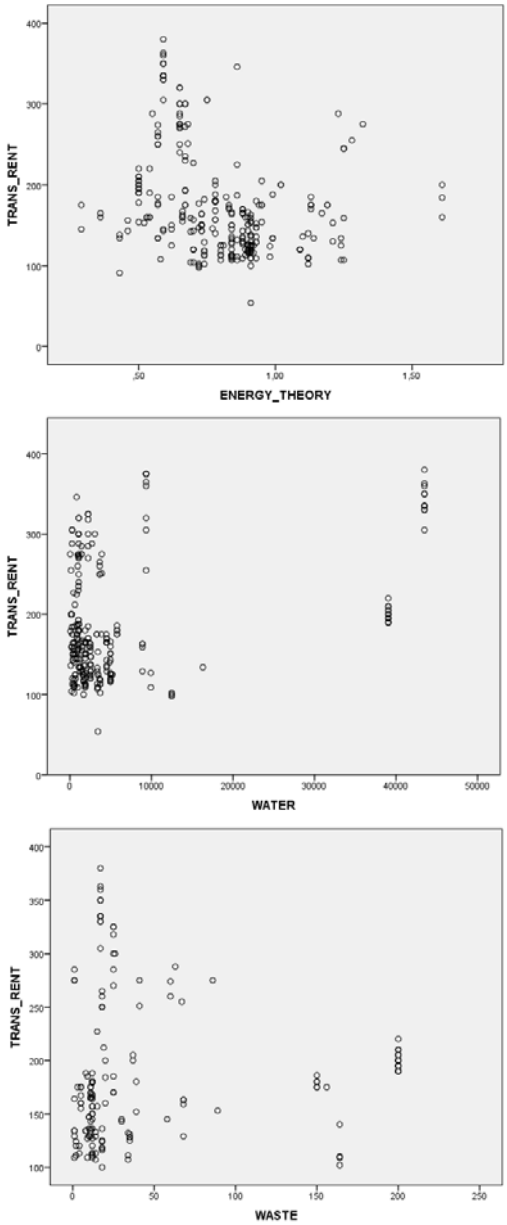


Figure 28; Scatterplot of BREEAM In-Use assets

Other sustainability variables



The first scatterplot shows the spread of data regarding the theoretical energy consumption calculated for the energy performance index (EPI). The general formula has been described in the theoretical section to enlighten the reader on the framework of calculation. This scatterplot is partially comparable with the *E_LABEL* scatterplot, as higher rents are to a larger extent present at smaller theoretical energy use values. Because this theoretical value interferes with the energy performance index, this variable is removed from the final statistical model.

This scatterplot only admits cases which report water use. Although hardly recognizable, none of the cases report a water use of zero. Until now, no clear sign of a relation can be identified in this chart.

Comparable with the scatterplot before, WASTE does not show a relevant pattern. There seem to be a giant spread of data between 0 and 50 tons of waste disposals.

For both *WASTE* and *WATER* a remark has to be made. Although incorporated into the analysis, these variables will probably not make a significant change in rental value. Practical advantages are more in the field of asset management and a better grip on operational performance. While collecting and controlling for these streams, a whole new kind of service can be offered to a potential tenant. These tenants are increasingly interested in reducing service costs; often this is only possible through adequate measurement of operational streams through the object.

Figure 29; Scatterplots of other sustainable variables

Conclusion data analysis

The data analysis gives a preliminary insight of the relative height of *TRANS_RENT* versus the explanatory variables. During this analysis, a lot of assumptions were observed and preliminary evidence was in most cases promising (see: energy labeling vs. rental income). The biggest disadvantage of this short inquiry is the fact that the rental values are not adjusted to their respective transaction year (which is mentioned several times). For this reason the evidence should be taken “with a grain of salt” as further research most definitely clarifies the quest for the added value of “green” properties. The same accounts for operational data, such as *WATER* and *WASTE* as this is measures in 2010, 2011 or 2012. These are just some remarks regarding the sample set of data. Additionally, these results are so called “two-dimensional” and do not go into detail about the joint value of for instance; location, type and EPC-class. In the next section correlation coefficients give us a better indication about the significance and influence on the determination of rental income.

7.4 Correlations

This section has a deeper focus on the relationship between the dependent variable: rental income and the independent variables ranging from micro-economic trends to sustainability. An important difference compared to the preceding section is the transformation of the variable *TRANS_RENT* to *LN_RENT*, in line with (Kok & Jennen, 2012) while the logarithmic transformation facilitates an easy interpretation of the coefficients. The results of the analysis can therefore be interpreted as percentage change in rental price by an increase or decrease in the price determining factor with one unit (so-called price effects). Next, we check whether the continuous and categorical variables are correlated with rental income.

In this following graph an overview of the two sets of correlation coefficients are given. These are divided up in all categories: Transaction, Location, asset and sustainability. The correlations coefficients are computed and put next to their relative variable. The correlation coefficients are accompanied with their significance and number of observations. The significance value tells us that the probability of getting a correlation coefficient this big in the sample set if the null hypothesis were true (meaning there was no relationship between these variables) is very low (close to zero in fact) (Field, 2005). Hence, we can gain confidence that there is a genuine relationship between the particular independent variable and the dependent variable *LN_RENT*.

Continuous

Categories	LN_RENT	Sig	N
TRANS_YEAR	0,359	0,000	444
POP_CITY	0,398	0,000	444
PUBL_TRAIN	-0,202	0,000	444
PROX_HIGH	-0,101	0,034	444
PROX_SCHIP	-0,474	0,000	444
TRANS_S%	0,028	0,555	444
AGE	-0,023	0,630	444
EFF_AGE	0,109	0,021	444
AGE_NEW	-0,109	0,021	444
ASSET_SIZE	0,434	0,000	444
E_INDEX	-0,289	0,000	372
ENERGY_THEORY	-0,288	0,000	2281
WATER	-0,370	0,000	263
WASTE	-0,061	0,443	163

Categorical

Categories	LN_RENT	Sig	N
LOC_NL	0,278	0,000	444
LOC_TYP	0,137	0,004	444
OCCU_RAT	0,283	0,002	118
USE_INT	0,349	0,000	99
OPEN	0,386	0,000	102

Table 17; Correlations of the independent variables with the logarithmic transacted rent

Transaction

The *TRANS*_YEAR variable is not surprisingly correlated with the rental income. Like earlier mentioned, the transaction year, will be corrected to simulate national economic trend during years 1990-2012. Consequently, there will be 23 dummy variables, which are indexed to the average rent of 1990 (will be used as relative “zero” in the regression model). Through this method, it is possible to interpret coefficients in the hedonic pricing model as percentage price change (Weterings, A. et al., 2009).

Location

Locational factors prove to be correlated, whilst divided into three categories; location in the Netherlands, type of location and reachability of the location. Let's start with location on national scale while identifying that there is a pretty high positive correlation which is in line with theory. It is evident that assets located in the Randstad area obtain a higher rent than in the hinterland. At the location type section no surprises as the "central business district" will prevail above the other two categories. Also the amount of residents (*POP_CITY)* proves to be correlated with the rental income. Not a shocking discovery, because bigger cities tend to have a larger economy and generally have a higher office space turnover rate. Lastly, reachability factors show also a clear image. The vicinity of a train station seems to be negatively correlated, which is no strange indication. Noticeable is the proximity to Schiphol, which is highly correlated and is in line with earlier thoughts (to correct for the effect of Schiphol on rental heights).

Asset

TRANS_S does not seem to have any relation with rental income. This could be because the difference between multi and single tenant offices is rather small. *AGE* is defined into three categories and shows a small indication of decreasing rental heights when age increases (besides that *AGE* proves to be insignificant). Fortunately the transformed variables *EFF_AGE* and *AGE_NEW* have better predicting power. The *EFF_AGE* has a positive relation because it has not been changed to "2012-age", which is done in the *AGE_NEW* variable. Although the use of effective age is probably more accurate, this variable is not precise enough according to the Agentschap-NL database which does not correct for renovation. *ASSET_SIZE* has also a pretty high correlation coefficient, which indicates there is a positive relationship when the asset becomes larger. This is not according to earlier thoughts. It is most likely that this variable has a logarithmic relationship with the rental income to correct for this effect. Other aspects like use intensity, occupancy rate and opening hours do show a relationship, which will be further investigated for *USE_INT* and *OPEN*. Occupancy rate is bound to a specific year, so is excluded from the statistical model.

Sustainability

Regarding the energy performance of the objects in the data set some interesting evidence can be found. It is interesting to see that *E_INDEX* is positively correlated. This is according to preliminary assumptions. *ENERGY_THEORY* has almost the same value as energy performance; this is due to the fact that both variables are hugely interrelated since the theoretical energy consumption is part of the EPI-calculation. We will see the theoretical energy consumption back in the analysis of the results, when it will be used while putting it against actual energy consumption. The other sustainability variables (water, waste) are bound to a specific year and are not comparable with continuous variables which stretch several years. These two variables are not assimilated into the hedonic pricing model.

Conclusion correlation analysis

There are some strong correlations between parameters that indicate a strong relationship with the transacted rental income; nonetheless we should test these relations not only by comparing one-on-one but on a more integrated way. At least an important flaw is solved when comparing to the raw data analysis; the macro-economic trend is modeled while using dummy variables through time. The hedonic pricing analysis will help to investigate the relations between the research goal(s) and assumptions.

7.5 Procedure

This section will highlight different phases in the process towards the statistical model through a step-by-step analysis. The road to a significant model that should have predicting power was intensive but educational. The final statistical model describes the effects of the previous mentioned independent variables on the rental income and has been constructed through three phases. The first phase started with the preliminary phase in which the variables are being tested and examined on their relative usefulness or significance. Essentially the results of the first phase are being used to fuel the second phase, which is the selection phase. The selection phase takes account for the elimination of variables from the statistical equation. Finally after thorough analysis of the significance of several variables, a final statistical model can be specified.

Model building

The large number of independent variables makes the model complex; especially because the variables can be distinguished in roughly five categories. This is just a quick summary based on previous section, but enlightens the reader on basic assumptions.

Macroeconomics; there should be a correction for the economic circumstances during the timeframe of research. This is done through the use of dummies for every transaction year. Furthermore it gives an indication about the amount and size of transactions, in such way about building quality and local market circumstances regarding absorption of office space.

Location characteristics based on geographical trend; these variables are selected on location type and proximity to local, national and international facilities. Additionally the population of a specific city or town has been added to support the level of facilities. Obviously, smaller cities have less facilities and are often less accessible.

Asset-specific; these are variables which relate to the asset quality and are hugely interrelated with the term “value”. It implies spatial dimensions, specific construction period and occupier information which form the basis of the general perception of “building quality”

Sustainability; these variables are related to the sustainable performance of an office, also topic of research regarding their influence on rental income. It is important to isolate these features in a separate group to assess and evaluate their influence, both relative to location and building characteristics.

In the first stage of the analysis a general survey was produced in which descriptive statistics describe means, standard deviations and confidence intervals for all variables. An exploration of the distribution of the variable values resulted in several adjustments, as some variables were unequally divided which potentially undermines the prediction power of such variables. Therefore these variables have been recoded to match with the dependent variable *LN_RENT*.

7.6 Using statistics - Linear and multiple regression analysis

In this section some basic statistical theory is explained using quite some background provided by Andy Field (2005). Statistical analysis is done in order to show the validity of using certain correlations. Subsequently, the essence of regression analysis is a way of predicting some kind of outcome from one or more explanatory variables. When using one explanatory variable it is named a simple regression, if more variables are used and thus the complexity is increased to predict an outcome it is named a multiple regression. In a regression model the outcome is indicated as the dependent variable because the outcome is determined by explanatory variables. Consequently the explanatory variables are assumed to predict the outcome independently of each other and so they are called independent variables.

Let's start at the beginning. Consider a simple linear regression analysis, which is an approach to model the relationship between a dependent variable and one explanatory variable. This is done while using a scatter plot (which contains an X –and Y-axis). In this scatter plot, a line is plotted using the Least Squares method. The Least Squares Method is a mathematical method which seeks a straight line to be fitted through a number of points to minimize the sum of the squares of the distances from the points to this line of best fit. This is done by utilizing the residual, a term for the distance between the Least Squares line and the points in the scatter plot. When we translate this theory to plain English, one can basically state that the outcome of the scatterplot produces predicted values (on the "predicted straight line) and residual values (actual values).

Let's converse this theoretical knowledge into a practical example. Suppose that there is a relation between the rental level, building size, age and the location of an office building. In this case the rental level is the dependent variable and the size, age and location are the independent variables as this determines the rental level. This easy estimation can be described as:

$$Outcome_i = Model + error \quad (1)$$

$$Y_i = Ax + b \quad (2)$$

Basically this statistical equation assumes that a (constant) model plus some kind of error (which is a residual) has the attribute to predict the outcome. In this case the author uses a linear model, thus a straight line will be plotted. The straight line estimates the general trend of a dataset at best and subsequently can be formulated as:

$$Y_i = \beta^0 + Building\ size_i\, \beta^1 + Age_i\, \beta^2 + Location_i\, \beta^3 + \varepsilon_i \quad (3)$$

Where i = 1,…, *n* and *n* is the number of office buildings present in the sample set. Y_i is the rental level of an office and β_0 (constant), β_1 (building size), β_2 (age), and β_3 (location) are the unknown parameters. The final term ε_i is the error term; it represents the unexplained part of the model, due to missing characteristics, wrong model specification, and errors in characteristics. This was an example of a multiple regression analysis. The parameters found for an optimal fit using the Least Squares Method represent the simplified relation between the dependent and independent variables. The relation is dependent however on the accuracy of the line plotted. For this purpose, several significance parameters can be used.

Significance parameters

The significance of a line and the goodness of fit is commonly expressed in one of the following parameters which form the output of the statistical analysis:

- Mean (μ)
- Standard deviation or SD (σ)
- R^2
- Significance and P-value
- Autocorrelation

The mean (μ) is the average of all points in the data set. The standard deviation (σ) is a measure for the variability of the points in the data. It can be stated as the square root of the variance, which is the mean of the squares minus the square of the mean. The higher the standard deviation, the more diverse and spread out the data is. Note that due to the fact that the standard deviation works with a squared value, points relatively far away can be weighed too heavy. The residuals of the model can be used to give an estimation of the goodness of fit in the model. This estimation is called the coefficient of determination or R^2 (r-squared).

The significance of the model obtained is an important indicator to determine if the model produces sufficient and valid output. Often the significance is given as a P-value. In order to grasp the concept of the P-value further explanation would be quite useful. Consider a linear regression model in which the predicted values are not placed directly on the regression line (which is the case in almost all cases). The significance of the line is the probability that a predicted value has a good chance to fit to the regression line, taking into account the SD of the sample set.

The last parameter in which is of interest in the regression analysis is the extent to which consecutive observations correlate with each other. This autocorrelation occurs frequently when independent variables are a display of time or overlap with each other on spatial dimensions. Autocorrelation tends to influence the accuracy of the model in an adverse way. In order to determine whether autocorrelation is present, a statistic called the Durbin-Watson statistic can be used. The Durbin-Watson statistic varies between 0 and 4. As a rough rule of thumb, values above 2 indicate that there is probably no meaningful correlation between the independent variables and the dependent variable. Values substantially less than 2 indicate there is evidence of positive serial correlation, if Durbin–Watson is less than 1.0, there may be cause for alarm. Small values of d indicate successive error terms are, on average, close in value to one another, or positively correlated. If $d > 2$, successive error terms are, on average, much different in value from one another, i.e., negatively correlated.

Cross-validation of the model

So how do we know that the statistical model derived from the dataset represents the whole population? Cross-validation is the assessment of accuracy of the model, thus states how well the model predicts the outcome. Previous section showed us the R^2, or the coefficient of determination, which indicates the predictive power of the model. A better measure is the adjusted R^2 which indicates the loss of predictive power or shrinkage. Whereas R^2 tells us how much of the variance in Y_i is accounted for by the regression model, the adjusted value tells us how much variance in Y_i would be accounted for if the model had been derived from the population from which the sample was taken (Field, 2005). This all sounds a bit sketchy, but one should always report the R-squared and the adjusted value because of their accurate indication of predicting power.

Unstandardized and standardized coefficients

In statistics a distinction is made between unstandardized and standardized coefficients used in regression analysis. These factors indicate that if β is raised by one, the dependent target variable Y_i is raised by a factor "A". But what if the scale of a particular independent variable is different than the scale of the dependent variable? There is a high probability of a really low unstandardized coefficient A of, in the range of for instance 0.002. Actually this is true, but it misguides the reader of the relative influence of various independent variables. To correct for this default, the standardized coefficients are created. The purpose of a standardized coefficient is to give insight into the importance of the independent variables with respect to each other and the dependent variable. Standardized coefficients reflect the amount of change in the dependent variable Y_i, when the response of for instance independent variable β_1 changes by one SD and all other independent variables remain constant. So if β_1 increases by 1 SD, the dependent variable Y_i increases by the standardized coefficient times the SD of Y_i, while the other (independent) variables stay constant.

Dummy variables, why?

Regression analysis is used with numerical variables. Results only have a valid interpretation if it makes sense to assume that having a value of "2" on some variable is does indeed mean having twice as much of something as a 1, and having a 50 means 50 times as much as 1. However, in this study there is a need to work with categorical variables in which the different values have no real numerical relationship with each other (ordinal measure). Examples include variables for object location in the Netherlands and the location type. If you have the variable associated with a specific type of location with possible responses including Office park, Central Business District or other, it obviously doesn't make sense to assign values of 1 - 3 and interpret that as meaning that Office park is somehow three times as special affiliated as the "other" location. The solution is to use dummy variables - variables with only two values, zero and one. It does make sense to create a variable called "*LOC_CBD*" and interpret it as meaning that someone assigned a 1 on this variable which relates to a location in a CBD, while others with an 0 are situated somewhere else.

Predicted values and residual analysis

Any data set can be described through several lines show the general trend of the data or scatterplot and so we need a way to decide which of many possible lines to choose. This means that there is a need for a line that best describes the trend within the dataset. The basis is very easy; consider for instance a sample population of men that lose their hair when they get older. Normally one would expect that the trend-line follows a trend with in the beginning (age:21) not that many men lose their hair. As the age increases we suspect that a growing amount of men will lose their hair. This example provides an assumption which is rather easy to visualize. You do not need to be a genius to realize that this method is rather subjective and so offers no assurance that the model is the best one that could have been chosen. Instead, we use a regression analysis to establish the line that best describes the data collected. This line provides us with the *predicted values* of man losing their hair at a certain age.

In statistics, a residual refers to the amount of variability in a dependent variable that is "left over" after accounting for the variability explained by the independent variables in the regression analysis. When you include independent variables (or predictors) in a regression, you are making a guess (or prediction) that they are associated with the dependent variable; a residual is a numeric value for how much is "wrong" with that prediction. So again, when relating to the earlier example with men losing their hair, the *residual value* indicates the difference between the trend-line (predicted value) and the actual age that a certain individual loses their hair. The lower the residual, the more accurate the predictions in your regression are, indicating your independent variables are related to the dependent variable. So basically the residual is the

mistake that the line makes in predicting the value of Y (or the dependent variable). Keep in mind that each case in the sample set will have own residual scores. This is because a regression model provides a "predicted value" for every case, which is estimated from the values of the independent variables of the regression. Each residual score is the difference between their predicted score (determined by the values of the IV's) and the actual observed score of your dependent variable relating to the individual case. This can be shown through the following equation:

$$Residual\ (E) = Y(actual) - \hat{Y}(predicted) \qquad (1)$$

A residual score can be used for many things, such as estimating accuracy of your model and checking assumptions. This method is used in the process towards the final model in which the energy performance index is added to the regression. The difference or the mean of the different residuals defines the standard error of the model. The difference between the positive and negative residuals is called the variance. In other words, residual variance helps us to confirm how well the regression line that is constructed fits the actual dataset; the smaller the variance, the more accurate the predictions are.

Model diagnostics

The statistical model needs to be checked at some point in time. The final hedonic pricing model will be used to gather the model diagnostics. To answer the question of whether the model fits the observed data, or if it is influenced by a small number of cases, we need to look for outliers and influential cases.

Outliers can be identified through the studentized residuals (SRESID in SPSS) and some issues can be summarized into three facts based on Field (2005). Studentized residuals with an absolute value greater than 3 need further investigation because in an average sample case a value this high is unlikely to happen by chance. Furthermore if more than 1% of our sample cases have studentized residuals with an absolute value greater than 2.5 there is evidence that the level of error within our model is unacceptable. Basically this means that the model is a fairly poor fit of the sample data. Lastly, if more than 5% of cases have studentized residuals with an absolute value greater than 2 then there is also evidence that the model is a poor representation of the actual data.

What are studentized residuals and why use them? A studentized residual is the unstandardized residual divided by an estimate of its standard deviation that varies point by point. These residuals have the same properties as the standardized residuals but usually provide a more precise estimate of the error variance of a specific case (Field, 2005). Studentized residuals are less distorted by the OLS fitting algorithm and are closer to theoretical notion of errors. They can be directly compared at different regions of the fit line, hence are better in the assessment of the model. Further no explicit reason can be found in the book of Andy Field or an enquiry on the web.

Besides testing for outliers by looking at the error (through SRESID in the model), it is also possible to look at whether certain cases overlap due to inexplicable influence over the parameters of the model. This type of analysis can help to determine whether the statistical model is stable across the sample, or biased by a few influential cases. Again, this process will uncover outliers that need some explaining.

To draw conclusions about a sample in a hedonic pricing model, several assumptions must be true according to Berry (1993) in Field (2005):

- Variable types; only variables with a quantitative nature either nominal or continuous.
- Non-zero variance; there has to be some variation in value.
- No perfect multicollinearity; the independent variables should not correlate to a large extent.
- Homoscedasticity; at each level of the independent variables, the variance of the residual terms

should be constant, which is homoscedasticity. If the variances are unequal, this is a sign of heteroscedasticity.
- Independent errors; the residual terms should be uncorrelated, through the Durbin-Watson test (see autocorrelation).
- Normally distributed errors; the sample set needs to be normally distributed, otherwise the results are not really representative.

Some additional explanation is needed for the terms homo/heteroscedasticity, because of the important impact on the data. The term that indicates a constant variance through time is called homoscedasticity. On the other side we have heteroscedasticity which indicates the absence of a constant variability. The presence of heteroscedasticity can invalidate statistical tests of significance that assume that the modeling errors are uncorrelated and normally distributed and that their variances do not vary with the effects being modeled. Basically when conducting a regression analysis using heteroscedastic data will still provide an unbiased estimate for the relationship between the predictor (independent) variable and the outcome, but standard errors and therefore inferences obtained from data analysis are suspect.

So basically when something is wrong or strange, the effects are in most cases immediately noticeable through the normal distribution, heteroscedasticity and multi-collinearity. The model diagnostics will be put into practice after the final statistical model to investigate if there are violations in the current sample. This short introduction provides the reader with some basic knowledge into regression models as this report will advance from a preliminary state to a final significant model. As such the hedonic pricing model investigates the relationship of the Energy Performance Index (*E_INDEX*).

Hedonic pricing in short

The principle of the hedonic pricing model has already been described in the theoretical framework through the work of Rosen (1974). Again; the basic assumption of a hedonic model is that the price/rent is related to a set of characteristics ranging from location to asset quality. The hedonic weights assigned to each variable are equivalent to the characteristic's overall contribution to the rental price. The hedonic pricing model is in essence comparable with multiple regression modeling. Subsequent paragraphs will focus on the construction of the statistical model to see if the energy performance index influences the financial performance. Before entering the energy index, the rents of the involved offices will be compared using certain characteristics. Evidently there is a wide range of differences between the assets in the sample set and combined these characteristics form the rental income of each individual property. While correcting for other factors that have the ability to affect the rental price, the effects of these sustainability characteristics will be determined. Hence, it is assumed that the effects on rents reflect the willingness-to-pay of potential occupiers for these sustainability characteristics. This willingness-to-pay can be translated into added value for the investors.

Model composition

In the composition phase, independent variables are analyzed to which extent they contribute to the determination of rental income. Every step in the process is then analyzed on the relative influence and significance of the explanatory variables. Following the composition of the model, the variables are tested through a confidence interval of 75%, which is equal to a p-value of 0,250. Variables tend to change slightly during the process towards the final model. At the final stage of the model, the *E_INDEX* will be added and by then the model is ready to be discussed. Again the equation below indicates the used hedonic pricing model to investigate the relationship of rental income with the energy performance index:

$$\text{Rental income} = \beta^0 + \text{Market characteristics}_i\, \beta^1 + \text{Location characteristics}_i\, \beta^2 + \text{Asset} - \text{specific characteristics}_i\, \beta^3 + \text{Sustainability characteristics}_i\, \beta^4 + \varepsilon_i$$

Transaction variables

The first step towards a solid regression model is the addition of time-dummies. This could be used as a base model to compare the more advanced models and see in if these regression models explain more variance (R^2). For more information regarding the standard regression, the results are given in the subsequent summary table:

Model 1	R Square	Adj R square	SS	df	MS	F	Sig.
Regression	**0,232**	**0,192**	11,207	22	0,509	5,772	0,000
Residual			37,153	421	0,088		
Total			48,360	443			

Model 1	B	Std. Error	Beta	t	Sig	Partial	Part
(Constant)	4,661	0,094		49,615	0,000		
YEAR1991	0,072	0,141	0,029	0,513	0,608	0,025	0,022
YEAR1992	0,088	0,176	0,025	0,501	0,616	0,024	0,021
YEAR1993	0,157	0,196	0,039	0,803	0,423	0,039	0,034
YEAR1994	0,064	0,136	0,027	0,468	0,640	0,023	0,020
YEAR1995	0,185	0,127	0,091	1,452	0,147	0,071	0,062
YEAR1996	0,252	0,111	0,180	2,283	0,023	0,111	0,098
YEAR1997	0,176	0,117	0,105	1,505	0,133	0,073	0,064
YEAR1998	0,327	0,120	0,185	2,731	0,007	0,132	0,117
YEAR1999	0,300	0,116	0,184	2,582	0,010	0,125	0,110
YEAR2000	0,348	0,112	0,238	3,110	0,002	0,150	0,133
YEAR2001	0,516	0,120	0,291	4,310	0,000	0,206	0,184
YEAR2002	0,488	0,112	0,335	4,369	0,000	0,208	0,187
YEAR2003	0,660	0,113	0,434	5,829	0,000	0,273	0,249
YEAR2004	0,498	0,114	0,321	4,366	0,000	0,208	0,187
YEAR2005	0,331	0,105	0,284	3,144	0,002	0,151	0,134
YEAR2006	0,514	0,105	0,446	4,898	0,000	0,232	0,209
YEAR2007	0,550	0,105	0,488	5,263	0,000	0,248	0,225
YEAR2008	0,482	0,112	0,330	4,308	0,000	0,205	0,184
YEAR2009	0,415	0,118	0,242	3,508	0,000	0,169	0,150
YEAR2010	0,417	0,109	0,307	3,809	0,000	0,183	0,163
YEAR2011	0,412	0,121	0,225	3,394	0,001	0,163	0,145
YEAR2012	0,753	0,146	0,284	5,144	0,000	0,243	0,220

Table 18; Hedonic pricing model with market characteristics

The economic trend during 1990-2012 is shown in the graph below. The dummy of 1990 is removed to prevent multicollinearity or the so called “dummy trap” (linking variables and the creation of biased data). Only 0.192 (adjusted R-Square) is explained in the variance, which is quite low. Since none of the specific locational and object features are added, this is not strange. The aim is to include parameters that will decrease this number and to increase the adjusted R-Square. The following step is to check which variables can be added to improve the model.

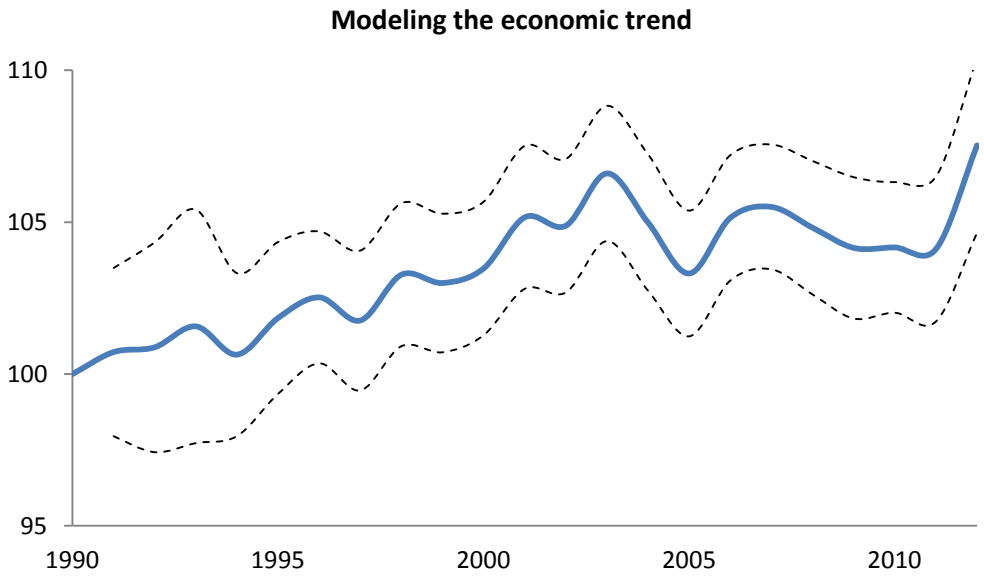


Figure 30; Modeling the economic trend through dummy variables

Location variables

The next stage is to include locational features to correct for the relative location in the Netherlands. Categories of this kind include: the location in NL including the amount of residents and the location type reflecting the level of facilities and location within a city. After the model has been fitted with the locational variables, subsequently the reachability variables are added. This set-up is chosen because it is important to align the location variables in their right form. Also a new column had been added: C/N, which accounts for the nature of the variable, namely continuous or nominal (read: dummy).

Model 2	R Square	Adj R square	SS	df	MS	F	Sig.
Regression	**0,602**	**0,573**	29,115	30	0,970	20,740	0,000
Residual			19,232	411	0,047		
Total			48,347	441			

Model 2	C/N	B	Std. Error	Beta	t	Sig	Partial	Part
(Constant)		4,591	0,209		21,946	0,000		
POP_CITY; Number of residents	C	-0,005	0,013	-0,017	-0,418	0,676	-0,021	-0,013
LOC_NL; Location Utrecht	N	0,156	0,065	0,140	2,405	0,017	0,118	0,075
LOC_NL; Location Randstad area	N	0,071	0,052	0,102	1,379	0,169	0,068	0,043
LOC_NL; Location Amsterdam	N	0,338	0,062	0,408	5,473	0,000	0,261	0,170
LOC_TYP; Central Business District	N	0,249	0,027	0,336	9,203	0,000	0,413	0,286
PUBL_TRAIN; Train Station within 500m	N	0,050	0,024	0,076	2,118	0,035	0,104	0,066
PROX_HIGH; Distance to highway exit	C	-0,008	0,017	-0,017	-0,478	0,633	-0,024	-0,015
PROX_SCHIP; Schiphol within 50 km	N	0,133	0,027	0,196	5,023	0,000	0,240	0,156

Table 19; Hedonic pricing model including location characteristics

POP_CITY
At first sight, the amount of residents in a city is not influential, with a value of nearly zero. Also when the relation is changed into a logarithmic relationship, the recoded variable *LN_POP_CITY* still is not significant. Perhaps other variables describe the local office market characteristics better. When more independent variables are being added, this variable becomes even more redundant and therefore is deleted from the equation.

LOC_NL
The ordinal category *LOC_NL* was originally divided into five categories. After the first analyses it became clear that some categories were influencing each other. That is why the author chooses to split the location up in 3 categories. The location "hinterland" serves as reference while Randstad area, Utrecht and Amsterdam are included into the analysis. Currently, the Randstad area is not really significant, but it will be maintained throughout the analysis.

LOC_TYP
Only *LOC_CBD* reacted in an influential way in the regression model. The other two categories (office park and other) both serve as reference while the CBD indicates a higher rental income in economic hotspots. Additionally the location type indicates the level of facilities in which the central business district obviously scores better.

PUBL_TRAIN
The distance to either a train or subway station is combined in a dummy variable, which makes a difference between the reachability of a specific office. The dummy variable states that the object is situated within a 500 meter range of a transportation hub. Although significant, the influence is not really high.

PROX_HIGH
At first dummy categories for the proximity to a highway exit did not have any effect on the rental income. The logarithmic highway variable fortunately displays another relationship. Although barely significant, this variable remains included until new evidence states otherwise.

PROX_SCHIP
The distance to Schiphol airport is indeed a major predictor, as we saw back in the data and correlation analysis. Obviously this variable can explain for the higher rent for both the Schiphol Boulevard and the South Axis. Because this is the major reason to include this variable, a dummy has been defined. *PROX_SCHIP_50KM* only explains for the objects with a 50 kilometer range.

Asset variables

The asset variables contain object-related characteristics and are supposed to be influential. Successful buildings should combine both locational and asset qualities to obtain the highest rent. In the next section, all gathered characteristics are included into the model. Some unique features have been collected which are use intensity and opening hours. Obviously these are related to energetic performance, but is there also a relation with rental price? The following table gives an overview of the added variables.

Model 3	R Square	Adj R square	SS	df	MS	F	Sig.
Regression	**0,659**	**0,631**	31,884	34	0,938	23,183	0,000
Residual			16,463	407	0,040		
Total			48,347	441			

Model 3	C/N	B	Std. Error	Beta	t	Sig	Partial	Part
(Constant)		4,837	0,188		25,690	0,000		
LOC_NL; Location Randstad area		0,321	0,055	0,387	5,862	0,000	0,279	0,170
LOC_NL; Location Utrecht	N	0,163	0,060	0,146	2,708	0,007	0,133	0,078
LOC_NL; Location Amsterdam	N	0,067	0,048	0,097	1,404	0,161	0,069	0,041
LOC_TYP; Central Business District	N	0,248	0,026	0,335	9,361	0,000	0,421	0,271
PUBL_TRAIN; Train Station within 500m	N	0,028	0,022	0,042	1,256	0,210	0,062	0,036
PROX_HIGH; Distance to highway exit	C	-0,016	0,016	-0,033	-0,952	0,342	-0,047	-0,028
PROX_SCHIP; Schiphol within 50 km	N	0,120	0,025	0,176	4,797	0,000	0,231	0,139
AGE_NEW; Effective age	C	-0,106	0,016	-0,238	-6,769	0,000	-0,318	-0,196
Asset size	C	0,022	0,011	0,067	1,969	0,050	0,097	0,057
Opening hours; 7 days, 24 hours	N	0,341	0,122	0,085	2,790	0,006	0,137	0,081
User intensity 20-30m2 GFA per fte	N	-0,052	0,029	-0,059	-1,794	0,074	-0,089	-0,052
User intensity >30m2 GFA per fte	N	-0,203	0,059	-0,111	-3,444	0,001	-0,168	-0,100

Table 20; Hedonic pricing model including location and asset characteristics

TRANS_S

The percentage of transaction size was added to adjust for the relative size when a transaction occurred. The background of this logic is the following; it is obvious that smaller transactions account for a relative higher rent, since that will only take up part of the building. Although highly correlated, the regression analysis indicated otherwise. This variable is excluded from the analysis.

AGE

The variable *AGE* has been recoded several times to obtain the best fit. First the building year of a specific object has been transformed to effective age (*EFF_AGE*) which is the adjustment for a potential renovation. So if an asset has been renovated or transformed in let's say 2009, the *EFF_AGE* considers this as "building year". To obtain a more accurate continuous scale, *AGE_NEW* was introduced. This is just a simple transformation from 2012 on, which follows the equation: *AGE_NEW = 2012-EFF_AGE*. The year 2012 has been used as starting point because the gathered data does not exceed this specific year. The last correction is for the decreasing rent which is faster from the beginning and evens out through time. This implies there is a logarithmic relationship, which subsequently forms the final variable: *LN_AGE_NEW*.

ASSET_SIZE
Also the size of an object is significantly related to the rental income, although to a less extent. There seems to be a logarithmic relation between the predictor and dependent variable. This is actually not strange, when size increase, rents will rise to a certain level when it fades out. As such the asset size has a logarithmic relationship defined by the variable *LN_ASSET_SIZE*.

OPEN
Also the opening hours of a building are surprisingly significant and influential. This accounts solely for the variable OPEN_7d24h which indicates a 24/7 office building. All other categories did not have any influence on the determination of rental income.

USE_INT
Surprisingly, the user intensity of an object is significant in the hedonic pricing model. All categories ranging from >30 square meter until <20 square meter per fte (full-time equivalent) do change the rental income. One variable user intensity category has been excluded to be used as constant (<20m2 GFA) while *USE_A* (>30m2 GFA) and *USE_B* (20-30m2 GFA) are included into the model. Both variables indicate that when an office space is designed for a more intensive use, the rental income will be higher.

Results

Image:
BREEAM Outstanding; The Cooperative group HQ, Manchester, UK

8. Results

This chapter combines the base model with the subject of research, sustainability. Following on the data analysis and the pre-selection phase, factual descriptions of the findings will be discussed and the attention will shift to the added value of sustainability and the balance of gains versus costs. At the end of the chapter some conclusions and remarks will be added to reflect on the statistical evidence provided through the hedonic pricing model and the subsequent analysis of energy performance and consumption.

The addition of *sustainability; E_INDEX*

The model is perfected through the process that has been described above. The final hedonic pricing model that is used to add the energy performance index has been appended in the table below (Adj. R-squared of 0,68). When taking a first glance at the coefficient of energy performance, one can immediately notice that it is both influential and relatively significant. Fortunately this is in line with the pre-stated assumption. For more info, read the text below.

Model 4	R Square	Adj R square	SS	df	MS	F	Sig.
Regression	**0,709**	**0,679**	30,685	35	0,877	23,288	0,000
Residual			12,574	334	0,038		
Total			43,258	369			

Model 4	C/N	B	Std. Error	Beta	t	Sig	Partial	Part
(Constant)		4,978	0,209		23,835	0,000		
LOC_NL; Location Amsterdam	N	0,432	0,078	0,503	5,558	0,000	0,291	0,164
LOC_NL; Location Utrecht	N	0,230	0,082	0,215	2,788	0,006	0,151	0,082
LOC_NL; Location Randstad area	N	0,134	0,073	0,186	1,847	0,066	0,101	0,054
LOC_TYP; Central Business District	N	0,221	0,028	0,301	7,940	0,000	0,398	0,234
PUBL_TRAIN; Train Station within 500m	N	0,026	0,024	0,038	1,082	0,280	0,059	0,032
PROX_HIGH; Distance to highway exit	C	-0,049	0,019	-0,095	-2,527	0,012	-0,137	-0,075
PROX_SCHIP; Schiphol within 50 km	N	0,124	0,027	0,172	4,648	0,000	0,246	0,137
AGE_NEW; effective age	C	-0,083	0,018	-0,189	-4,575	0,000	-0,243	-0,135
Asset size	C	0,023	0,012	0,067	1,900	0,058	0,103	0,056
Opening hours; 7 days, 24 hours	N	0,303	0,119	0,079	2,534	0,012	0,137	0,075
User intensity 20-30m2 GFA per fte	N	-0,049	0,030	-0,056	-1,618	0,107	-0,088	-0,048
User intensity >30m2 GFA per fte	N	-0,189	0,060	-0,109	-3,164	0,002	-0,171	-0,093
Energy Performance Index	**C**	**-0,095**	**0,049**	**-0,074**	**-1,933**	**0,054**	**-0,105**	**-0,057**

Table 21; Final hedonic pricing model

E_INDEX

For the influence of energy performance, all possible relationships have been researched. The variable *LN_E_INDEX* proved to have both the highest significance and influence. To obtain the rental premium, one must first transform the logarithmic energy performance index back to a linear relation through an exponential function. The data analysis that has been conducted earlier on provided us with a sneak peek into the relationship. The logarithmic function implies that indeed the A-certified properties have a substantial higher rent compared to the other categories and the rent flattens out when the energy performance index increases.

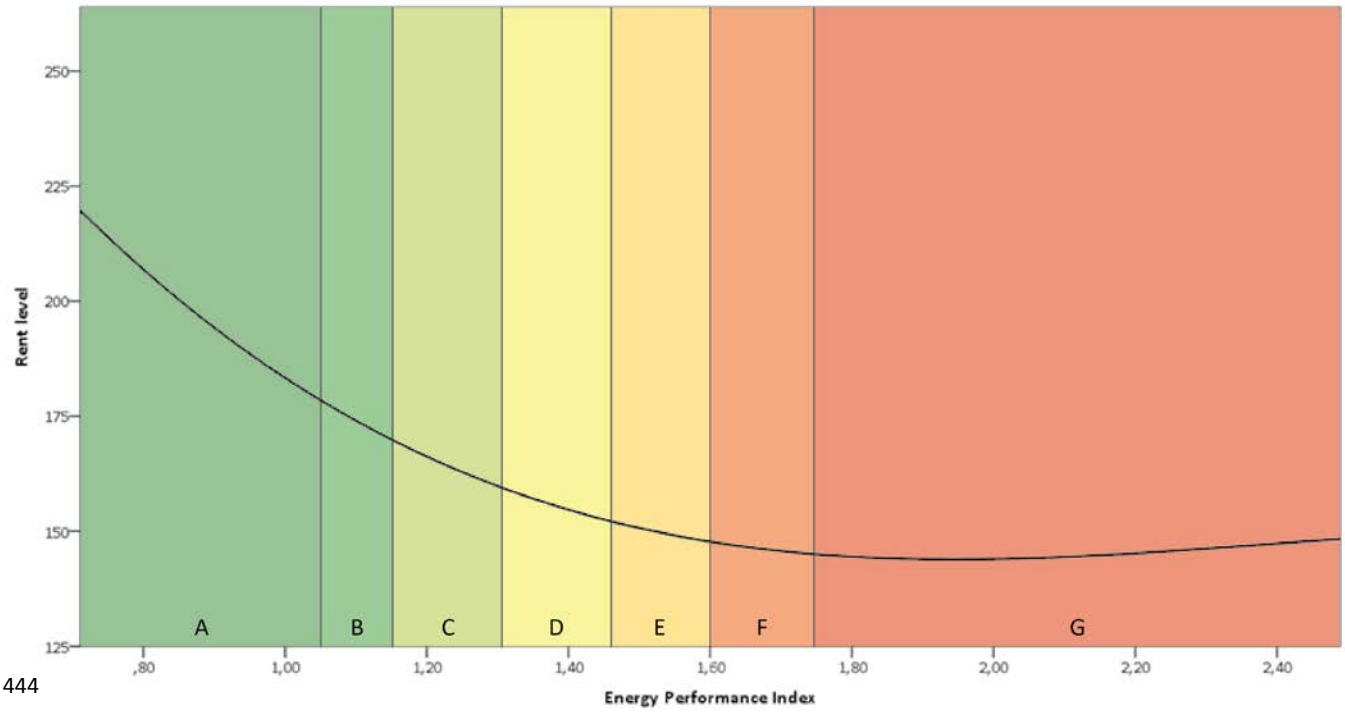
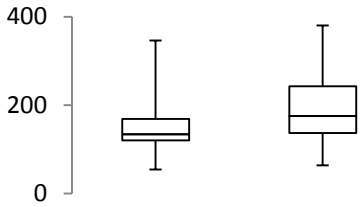


Figure 31; Rental income versus Energy Performance Index

The relationship between rent and energy performance indicates the following relationship through the function “fit line” in SPSS. The predicted line that has been plotted is in accordance with the graduation research of Fleur van der Erve written in 2011. Although some minor differences can be observed. This is the gradual decrease of rent through while the energy performance index rises. In this case, G-certified properties obtain indeed the lowest rent, however some properties with an extremely high EPI-rate are responsible for the slight increase at the scores from 2.40 on. There is a relatively high increase in rental income when the asset has a better EPI-score. The respective rental premiums will be shown at the end of the section when the rental premiums are calculated and compared with respective energy costs. The rental premiums will be estimated through a simple trick in SPSS to obtain “out-of-sample” predicted values. Look for more details at the sample case at the end of the chapter.

GREEN/NON-GREEN index

The difference between green rated and non-green rated is also worthwhile to look into. When talking about green/non-green, a clear distinction between certificates has to be made. In this case certificates in the range of A++ until C are considered "green", certificates that have a higher energy performance index are considered to be "non-green". The boxplot to the side indicates the difference in values between green and non-green assets. Note that these are descriptive statistics.



Index	Non-green	Green
N	183	189
Average	150	194
SD	47,63	73,22
Min	54	64
q1	120	136,5
Median	134	175
q3	169	242,5
Max	346	380

Table 22; Overview Green/Non-Green assets

When the dummy variables *GREEN_NONGREEN* has been added to the hedonic pricing model instead of *E_INDEX* we can look deeper into the actual gains of going green. In the table on the bottom of the page we can clearly distinguish a rental premium of 0,107, which accounts for a rental increase of approximately 11%. This effect is higher comparing this with earlier evidence of Kok & Jennen (2012) which estimate a "green premium" of 6,5%. In the graduation report of van der Erve (2011), there was no clear sign of a green premium. This result indicates that indeed green certificates obtain a higher rent compared to others. Note that the data went back in time until 1990 and the amount of transactions were rather small (372) to state a totally trustworthy outcome.

Green/Non-Green	R Square	Adj R square	SS	df	MS	F	Sig.
Regression	**0,676**	**0,648**	32,679	35	0,934	24,193	0,000
Residual			15,669	406	0,039		
Total			48,347	441			

Green/Non-Green	C/N	B	Std. Error	Beta	t	Sig	Partial	Part
(Constant)		4,903	0,184		26,578	0,000		
LOC_NL; Location Amsterdam	N	0,301	0,054	0,364	5,618	0,000	0,269	0,159
LOC_NL; Location Utrecht	N	0,150	0,059	0,135	2,550	0,011	0,126	0,072
LOC_NL; Location Randstad area	N	0,053	0,047	0,076	1,128	0,260	0,056	0,032
LOC_TYP; Central Business District	N	0,242	0,026	0,327	9,336	0,000	0,420	0,264
PUBL_TRAIN; Train Station within 500m	N	0,036	0,022	0,054	1,653	0,099	0,082	0,047
PROX_HIGH; Distance to highway exit	C	-0,030	0,016	-0,062	-1,830	0,068	-0,090	-0,052
PROX_SCHIP; Schiphol within 50 km	N	0,102	0,025	0,150	4,105	0,000	0,200	0,116
AGE_NEW; effective age	C	-0,079	0,016	-0,179	-4,869	0,000	-0,235	-0,138
Asset size	C	0,014	0,011	0,042	1,257	0,210	0,062	0,036
Opening hours; 7 days, 24 hours	N	0,305	0,120	0,076	2,545	0,011	0,125	0,072
User intensity 20-30m2 GFA per fte	N	-0,175	0,058	-0,096	-3,031	0,003	-0,149	-0,086
User intensity >30m2 GFA per fte	N	-0,063	0,029	-0,071	-2,213	0,027	-0,109	-0,063
GREEN/NONGREEN	**N**	**0,107**	**0,024**	**0,160**	**4,537**	**0,000**	**0,220**	**0,128**

Table 23; Hedonic pricing model with premium for green properties

Confidence limits

The graph below indicates the confidence interval of the regression analysis. The fitted line is accompanied by two gray lines which indicate the 95% confidence intervals. Data that is not within these two lines can be considered as an outlier, since it is bigger as 2 SD's. Just like the plot of the rent versus the EPI-score above, this graph does not incorporate the EPI-range from zero to 0.7, because of the low reliability of the sample set. The same accounts for ranges above EPI-value of 2.0. Only occasionally a scatter appears after the EPI of 2.40.

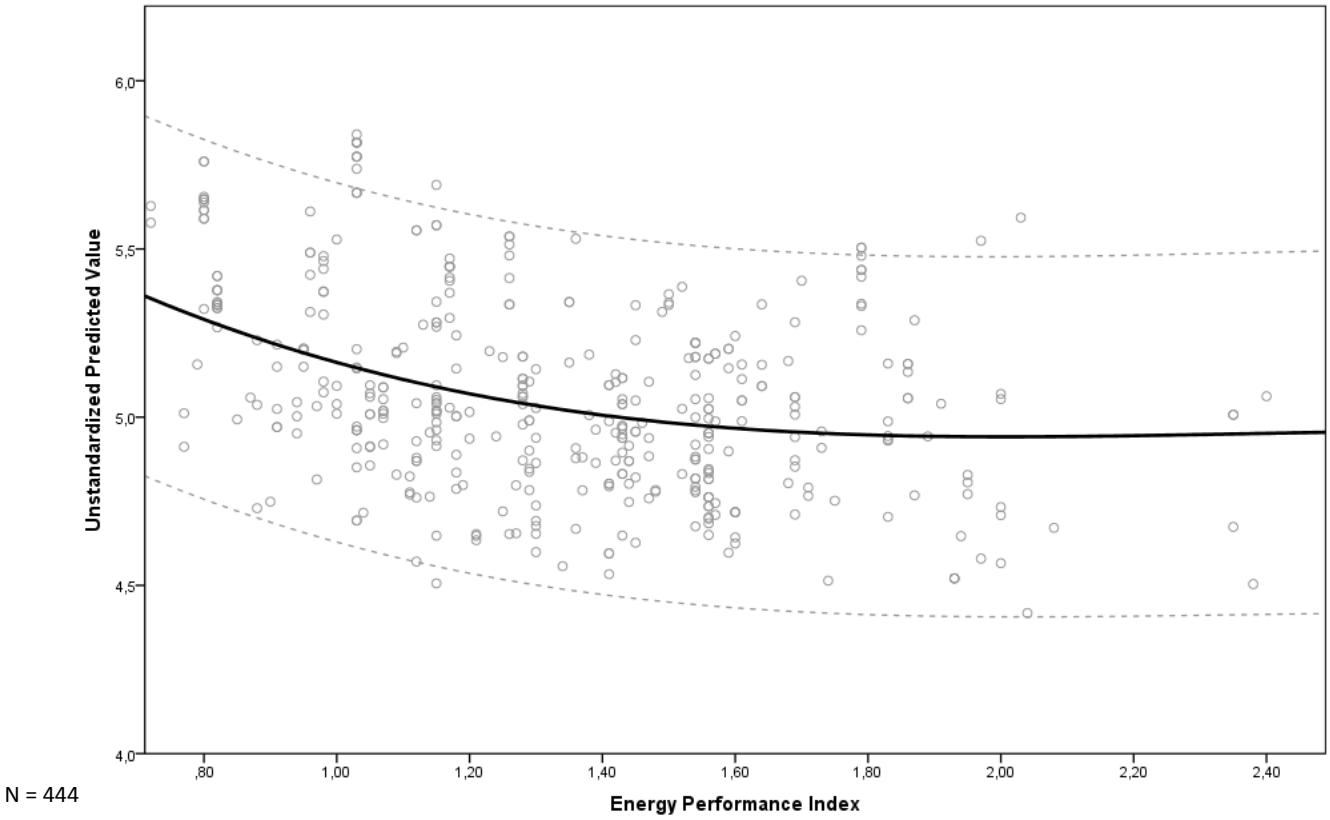


Figure 32; Confidence limits rental income vs. Energy Performance Index

Category	N	Range	Minimum	Maximum	Mean	SD
Energy Performance Index	424	3,150	0,500	3,650	1,347	0,381

Scatters from EPI 2.0 are often dominated with canal-houses with a high energy performance index. The outline of the confidence limits shows us a clear indication of the reliability of the dataset. A remark has to be made about the correctness of data; due to the long time span of 22 years (1990-2012) some bias is present. This is clearly reflected into the dataset, as the confidence limits are rather big. Although we could argue about the correctness and significance of the model, the results will not change much. There is clear evidence that there is a rental premium for "greener" certified properties.

Second after the evaluation of the confidence limits is the hedonic pricing model. How well does the statistical model fit the data? This assumption testing is based on the notion of assessing the validity of the regression model. Already in the section "Using statistics", the procedures have been described in bullet-points to assess the model. There are a couple of "straightforward" assumptions that on the one hand already have been identified, or can be observed in a split-second. These are measures such as the type of

variable, the absence of non-zero variance and the so called interdependence of variables (relates to the source of the involved cases). This section is about the assumptions that are harder to tackle, so the need for some detailed information is evident. Basically there are two ways to assess the accuracy of the model in the sample. The first is related to the residuals statistics, while the studentized residuals (or z-scores) indicate outliers in the sample set. Also included in the residuals statistics is the testing for multicollinearity, heteroscedasticity and normality of errors. The second part is about the influential cases which are selected through the Cook's distance. The Cook's distance identifies cases that have an impact on the model.

Outliers

Any case, for which the absolute value of the standardized residual (SRESID) is 3 or more, is likely to be an outlier. The outliers can be shown in the SPSS output through selecting the option "casewise diagnostics" when conducting the regression analysis. In this case, the author selected a minimum of 2 SRESID as criterion to be shown in the casewise diagnostics. Cases that exceed the SRESID of 3 are shown in an underlined bold font (total of 4 cases). Other criteria for outliers are that only 1% of the data should differ 2,5 SRESID and 5% should not exceed 2 SRESID. Ten cases differ more than 2,5 SRESID (including the 3 SRESID cases), which is a percentage of 2,25%. The last category of 2 SRESID contains 20 cases which accounts for 4,5% and thus is within confidence limits. This evidence shows us that the model is not a poor representation of the actual situation. The outliers which differ 3 or more than 2,5 SRESID will be analyzed into more detail.

Case Number	Stud. Residual	LN_RENT	Pred. Value	Residual
27	2,29	5,42	4,99	0,43
28	**3,97**	**5,85**	**5,10**	**0,75**
38	-2,09	4,67	5,05	-0,38
57	**-3,30**	**4,70**	**5,31**	**-0,61**
78	2,82	5,78	5,26	0,53
193	-2,68	4,64	5,14	-0,50
209	**-3,13**	**3,99**	**4,53**	**-0,54**
223	-2,72	4,16	4,65	-0,49
235	2,68	5,42	4,93	0,50
247	-2,74	4,64	5,14	-0,50
372	-2,29	4,67	5,11	-0,43
376	-2,19	4,62	5,03	-0,41
385	2,23	5,89	5,47	0,41
386	2,39	5,90	5,45	0,45
387	2,90	5,93	5,41	0,51
388	2,54	5,93	5,45	0,48
389	**3,38**	**5,93**	**5,30**	**0,63**
429	2,29	5,70	5,27	0,43
462	-2,10	4,90	5,28	-0,38
507	**3,47**	**5,30**	**4,67**	**0,62**

Table 24; Casewise diagnostics sample set

Case Number	PandID	Observations	City	TRANS_YEAR	Label	TRANS_RENT	Std. Residual	LN_RENT	Pred. Value
28	20	3	Amstelveen	2006	D	346	**3,970**	5,846	5,095
57	35	1	Amsterdam	2010	E	110	**-3,304**	4,700	5,313
78	43	9	Amsterdam	1996	G	325	2,823	5,784	5,258
193	104	5	Gouda	2003	C	104	-2,681	4,644	5,144
209	111	6	Groningen	1995	D	54	**-3,126**	3,989	4,533
235	125	2	Hilversum	2001	B	227	2,68	5,42	4,93
247	135	2	Hoofddorp	2002	A	104	-2,743	4,644	5,145
387	192	8	Schiphol	2012	C	375	2,639	5,927	5,415
389	192	8	Schiphol	2010	C	375	**3,256**	5,927	5,295
507	253	3	Zeist	1994	G	200	**3,218**	5,298	4,674

Table 25; Outliers of the sample set

The table above shows an overview of the evident outliers. The cases that hovered around 2,5 SE have not been included, only the ones that were far above 2,5 SE. The overview consists of 10 cases and there are 9 assets involved in the outlier analysis (one asset appears twice). Due to confidentiality agreements, the precise location of the assets cannot be shown, but the next paragraph will try to explain why the case is deviating to quite an extent.

Case 28 has a standardized residual of 3,871 which is really high and almost statistically impossible. When looking at other transactions, the rental income of 346(!) seems way too high. The other two observations, with one of them transacted in the same year, shows a rental income of 187. This is a difference of 250 €/m2! Although the data has been checked for potential bias, this is the transacted rent according to the financial database.

Case 57 is limited to only one transaction; the recent transaction history is thus unknown. The rental income of 110 is too low compared to the immediate surroundings. Other office properties acquire a significant higher rental income. Considering the location in Amsterdam, the property should be able to perform better. One remark has to be made considering the occupancy rate, which is between 25-50% in 2011. This indicates that before the transaction occurred, the building was performing even worse. The lower rental income could arise from the present vacancy rate and/or economic times.

Case 78 is located in Amsterdam in a very prominent business district. It is likely to assume that the rental income is a bit overrated. A more important fact is that the energy label (G-certified) of this asset does not seem influential for the determination of rental income. There is a big chance that the building is technically outdated, but the location makes up for the all other factors.

Case 193 is located on the outskirts of town near the highway. Since this building has a relative good sustainable score of C together with a relative easy accessibility, the rental income is low. This is maybe due to the total absence of facilities because the asset is situated on location type “office park” and the local office space market (perhaps a high vacancy rate). Furthermore, the asset was built in 1985, which is often a sign of mono-functional use and technical obsolescence.

Case 209 is situated in Groningen and one can immediately see that the rental income is way too low. Actually, the 54 €/m2 is the lowest recorded value in the sample set. Although transacted in 1995, the rent is too low to be added in the model. This is a good example when using transaction variables that stretch back to the early nineties.

Case 235 is situated on an office park in Hilversum a rather rural community, but easily reachable from both Amsterdam and Utrecht. Noticeably is the rather high rental income transacted in 2001. The high rental income could be due to the location of the asset between two major Dutch cities and the relative small office space market in Hilversum. Additionally, Hilversum is the “capital” of a few broadcasting networks, situated on the other side of town. The independent variables thus were not able to correct for these factors.

Case 247 is indicated as an outlier because of the lower rental income than predicted by the hedonic pricing model. This is probably due to the time of transaction, this was back in 2002. The asset was newly constructed in 1998 and subsequently renovated in 2010 and afterwards obtained an energy performance certificate of B. At an earlier stage the building was probably not really sustainable, which could explain for the lower price. Besides sustainable performance is Hoofddorp a notorious area of structural vacancy, the competition is substantial. This means that there is an office space oversupply which brings about a lower rental income.

Case 387 and 389 are transacted in the same building located at Schiphol international airport. Although a specific dummy variable has been included into the model to correct for the influence of the South-Axis and Schiphol, still these transactions differ quite a lot. Both transactions indicate a rental income of 375 €/m2, which is just above the average rent in the area. Due to the fact that the building is divided into two parts with respective A –and D certificates, the energy performance index indicates that the energy label as a whole is C. Most likely, just like case 78, the location of the office is of greater importance than the sustainable performance.

The last case is number 509 and located in Zeist. It was transacted in 1994 with a rental income of 200 €/m2 and is G-certified. The preceding sentence already indicated a couple of potential hazards of bias. First the time of transactions is almost 20 years ago. Second, Zeist is not included into the variables of location in the Netherlands and used as base category with a very low average rental value. Third, the asset is G-certified and still obtains a pretty high rental income. In this case, the reasons why the ZRES is above 3 are various. The synergy of all these sources produced most likely this value.

All outliers are characterized by a considerable difference between transaction rent and the predicted rent in the statistical model. This (residual) gap implies that the assets could not be explained through current model. Several factors could explain for the difference, consider for instance the unknown incentives in rental income, or the classification of the locational characteristics is too broad. The biggest drawback of this model is the long timespan of transaction years (1990-2012). Although the economic trend has been modeled through dummy variables, it is likely that not all values are accurate. So hard quantitative data on rental premiums could be biased, but one thing is sure: greener properties do indeed obtain a higher rent (based on the confidence bound of 95%).

Multicollinearity

Multicollinearity exists when there is a strong correlation between two or more independent variables in the hedonic pricing model. Perfect collinearity exists when at least one independent variable is a perfect linear combination of the others. Typical examples of perfect multicollinearity are when the researcher makes a mistake, for instance: including the same variable twice or forgetting to omit a default category for a series of dummy variables (dummy trap). If there is perfect collinearity between the independent variables it becomes impossible to obtain unique estimates of the regression coefficients because there are an infinite number of combinations of coefficients that would work equally well. Multicollinearity can be checked through two simple measures, either tolerance or VIF, just select “collinearity diagnostics” when preparing the analysis. In this case, the author looked at the VIF when should be less than 10. This is in all cases true, so no multicollinearity exists in the sample set.

Homo/Heteroscedasticity

The term that indicates a constant variance through time is called homoscedasticity. On the other side we have heteroscedasticity which indicates the absence of a constant variability. The explanation of homo/heteroscedasticity has been added into the “Using statistics” section for more information. Errors may increase as the value of an independent variable increases. Consider a model in which the amount of tenants is the independent variable and the average rental income is the dependent variable. When the amount of tenants is low, the variation of rental incomes will be small. But as the amount of tenants increases, it is likely that the variation between the rental levels will grow due to incentives and the demand/supply equilibrium. The greater variability caused by more tenants, could result in heteroscedasticity.

So specifically, it refers to the distribution of numbers for one variable in relation to the distribution of numbers for another variable. Homoscedasticity refers to a spread that is very even and regular no matter which section of the chart you look at. Heteroscedasticity refers to a spread that is uneven and irregular. So, how to observe homo/heteroscedasticity? Like mentioned, when homoscedasticity occurs, the variance should be equal throughout the sample set. The graph to the side shows the variance of the sample set of the used hedonic pricing model. The fitted line shows a constant pattern originating from zero. This is a sign that the set is homoscedastic, thus the data provides us with an accurate reflection of the national situation.

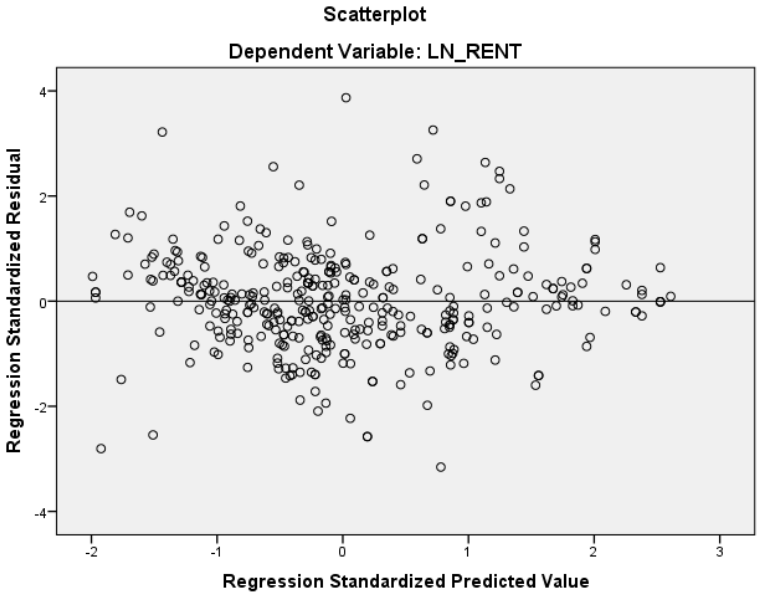


Figure 33; Scatterplot to investigate constant variance

Normality of errors

A statistical model that is not normally distributed can compromise the calculation of estimates and the calculation of confidence intervals. There are two ways in which a distribution can deviate compared to a normal distribution, namely the lack of symmetry (skewness) and the "pointiness (kurtosis). Skewness stands for a deviation compared to the regular normally distributed bell-shaped curve. Kurtosis refers to the degree to which scores cluster at the ends of the distribution and how pointy a distribution is. The latter two principles are shown in the normal distribution and the P-P plot.

The P-P plot (probability-probability) shows the cumulative probability of a variable against the cumulative probability of a particular normal distribution. What this means is that the data are ranked and sorted. Then for each rank the corresponding SRESID-score is calculated. This is the expected value that the score should have in a normal distribution. As the plots below show us, there is an indication of kurtosis as the normal distribution is a bit "pointy". Although not really influential, we should keep in the back of the mind that a share of the variance is being explained by extreme values, for instance the preceding outliers in the last paragraph.

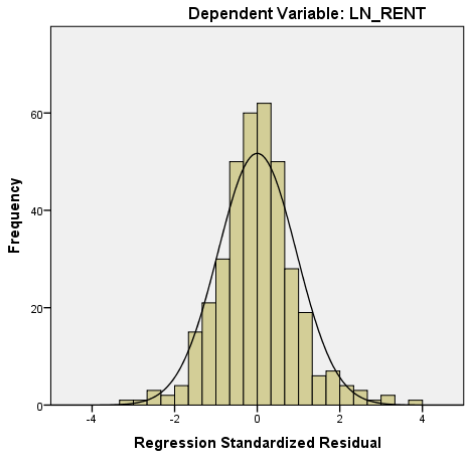


Figure 35; Histogram of sample set

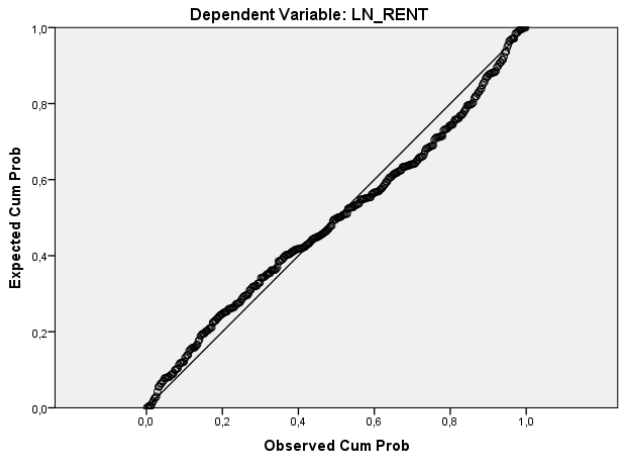


Figure 34; P-P plot of sample set

Influential cases

Second after the outliers and residual diagnostics are the influential cases which could distort the data. So why are residuals not enough? Consider a fitted line which fits the outlier perfectly, while the actual pattern of all other data points shows another pattern or trend. As such, one outlier has the unique characteristic to distort the general trend throughout the data. An influential case could be so different that it has a massive influence on the fitted line which is used to visualize the general trend of the data.

An influential case is spotted while using the Cook's distance, which is a measure of the overall influence of a case on the statistical model. If a point is a significant outlier on Y, but its Cook's distance is < 1, there is no real need to delete that point since it does not have a large effect on the regression analysis. However, one should still be interested in studying such points further to understand why they did not fit the model (Stevens, 2002).

Anyway, the next logical step is to investigate the influence of the outliers on the model. It is important to check if the outlying data points do not influence the model to a big extent, otherwise the fitted trend line would not correspond with the actual trend of the data. As such, the outliers of preceding section will be used to identify if there is any disturbance (the cases that deviated more than 3 SRESID still have an underlined and bold font). The table shows us a positive picture, as all cook's distances are well under the boundary of 1. This means that the outliers do not influence the model to an extent that changes the general trend. Additionally the Cook's distance has been calculated for all other cases, but none showed a disturbing sign.

Case Number	Cook's Distance
27	0,0120
28	**0,0228**
38	0,0194
57	**0,0288**
78	0,0191
193	0,0166
209	**0,0655**
223	0,0298
235	0,0190
247	0,0277
372	0,0078
376	0,0132
385	0,0129
386	0,0085
387	0,0494
388	0,0096
389	**0,0238**
429	0,0106
462	0,0158
507	**0,0540**

Table 26; Cook's distance outliers

8.1 Analysis of the energy performance model

This section is about the secondary output of this graduation research. To aim is to provide critique on the correctness of the statistical model. This sounds rather strange, but how honest is an energy performance certificate precisely? Like previously mentioned, the Energy Performance Index is *theoretically* right about the general consumption profile of the asset, the tenant will (in most cases) determine the actual energy consumption of an office. When an occupier chooses to obtain office space, he does not know the actual energy consumption and the related energy (and other service) costs. So are these two notions actual and theoretical energy consumption comparable? It is expected that the range of data is rather big, but note that the focus of this section is on the observed trend. The following section should enlighten the reader with some detailed information which can be summarized as follows:

Does the green premium paid by tenants fade out when comparing the higher rental income with the saved energy costs?

Focus of this section is to compare the actual energy consumption against both the theoretical energy consumption and energy performance index. Additionally, the energy costs of the actual energy use will be displayed against the rental premium paid for energy-efficient properties.

Data selection

First a small analysis has been conducted to filter extreme outliers from the DGBBenchmark. The subjects are assets that diverge with a factor 4 of known ratios. These known ratios are based upon on large scale consumers for both electricity and gas consumption. These are based on the "Energieprijzen Utiliteitsbouw versie 2011" published on the Agentschap-NL website, see (Agentschap-NL, 2011a). The prices of energy are divided into three categories, namely the raw energy price, the transportation costs and the energy taxes collected by the government. For the calculation of energy pricing several sources have been used to create a framework in which it is able to make a comparison. The delivery prices of electricity are defined on the basis of the "Endex-plus" method, energy service companies (Nuon, Essent and Eneco) provide transport costs and the ministry of finances delivers energy tax. The gas prices are being calculated through the formula provided by the "Gasunie", while transport and the energy taxes prices are supplied by the same sources. The Agentschap-NL price data has two key-objectives. The first one is already mentioned, while it is important to correct for the extreme outliers. When an asset has an energy consumption of four times the average, it is obvious that there is some bias in the sample. The second objective is to provide a baseline for the assessment of the database. The same source has been used to gather energy prices, so that there is no distinction within the data set. Noticeably is the division of the assets in two categories with regard to pricing: objects smaller (<) than 10.000 square meters and object above (>) 10.000 square meters. Note that the gas consumption is "indexed" for the respective year of measurement through the so called Degree Days (NL: graaddagen) to gain an accurate display of data.

Theory versus actual

In the following section the relationship between theoretical energy consumption (*ENERGY_THEORY*) and actual energy consumption (*ENERGY*) will be subject of research (reported in GJ/m2). Once again, theoretical energy consumption is used to calculate the energy performance certificate and therefore is highly interrelated with the variable *E_INDEX*. The theoretical energy consumption is based on the intrinsic energy use of solely the object. The actual energy consumption defers from this definition with only one element. The influence of the office user: the tenant. The actual energy consumption is in this way;

$$ENERGY = ENERGY_{THEORY} + TENANT_{CONSUMPTION} + \varepsilon_i \quad (1)$$

This is an important notion to remember when this chapter proceeds. It is expected that the actual energy consumption is higher than theoretically defined. Yet again, to what extent differs actual from theory? In an ideal situation should the actual energy consumption run close to parallel with the theoretical line. This means that when the energy performance index increases at a steady pace, the theoretical and actual energy consumption should raise parallel to each other with the same slope. The graph below shows an image about the relationship between actual (blue line) and theory (green line) against the energy performance index.

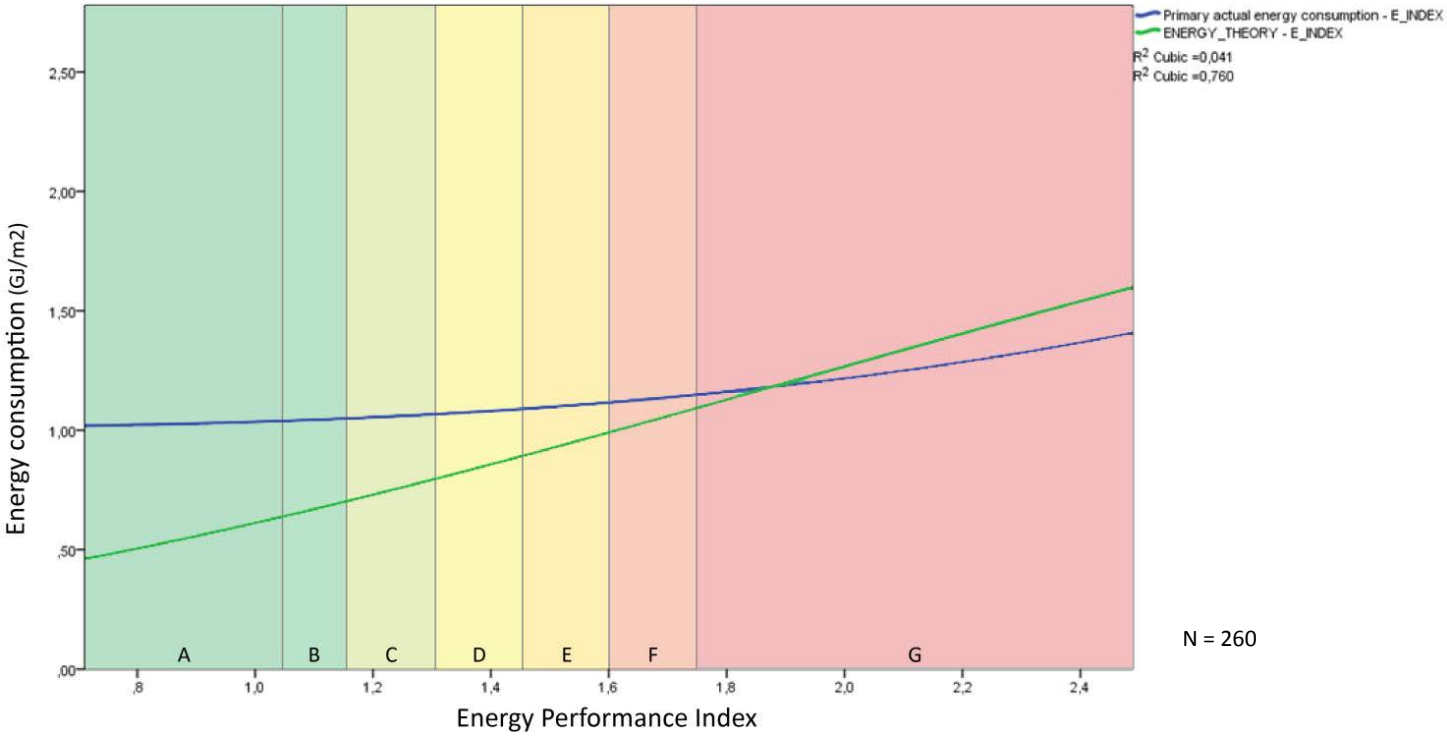


Figure 36; Relationship actual and theoretical energy consumption

An immediate response is evident when considering the spread of the data regarding actual energy consumption. Therefore it is rather hard to actually fit a line which indicates a relationship (R^2 = 0,041). On the other hand, this indicates an important preliminary finding; the energy consumption does not follow a specific path within a close range. This could mean that an A-certified object performs just as a more regular D-rated asset, which puts the relative "greenness" to the test. Although we also can state that when the asset is rated "green" the amount of tenant's influence grows (see bent in plot). When looking at the theoretical energy consumption (R^2 = 0,760), this follows a nearly linear line, which is not surprising. So what is the relationship of both these variables with the energy performance index? It can simply be concluded that there is not much of a relation between the actual energy consumption and the energy performance index (and not in the least with rental income), just like we expected looking back at the first scatterplot.

When an observation has been made of the characteristics per energy certificate, it becomes possible to reflect on the current situation (see descriptives in appendix). Clearly the actual energy consumption does not follow a specific trend as all values hover around a joint average. Yet again, the theoretical energy consumption does not show a worrisome picture while the means and medians are gradually increasing towards F and G-certifications. Especially for G-rated properties it is not strange that the values differ a lot. Since this category is infinite from EPI-score 1,75, the energy use will still rise. When looking at the gradual trend in the actual energy at shows a diverse picture. Inferior rated object actually performs almost as well or even better than A-certified properties. This could be explained through adding the occupancy rate. It is obvious that G-rated properties have a higher chance to have a lower vacancy rate compared to A-rated objects. This line purely shows the current relationship.

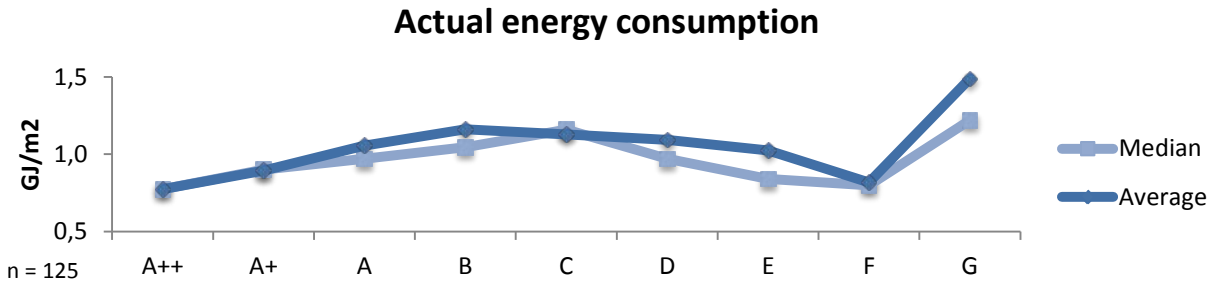


Figure 37; Median and average of actual energy consumption

This pattern is probably due to the fact that the involved buildings are not really comparable with each other. Although this is the recorded energy consumption from different assets, the kind of use differs among them. The comparability of the data could increase while filtering on elements, such as the occupancy rate. So does the occupancy rate of an asset have influence on the energy consumption? The table below shows an interesting picture of the division between energy certificates, occupancy rates and their relative influence on energy consumption.

When looking at the occupancy rate categories ranging from 0% to 100% (which indicates a fully occupied office building), the results vary quite a lot. Although the sample set has been filtered to only 74 cases, there is a notion of a pattern in the set. This is obvious, but when the occupancy rate rises, the energy consumption rises as well. That is one of the main reasons why general (unfiltered) energy consumption data is rather unreliable. More detailed info is shown in the table to the side in which the boxplots show a big range between data. Suppose the data is filtered only on 75-100%, the comparability rises because the energy consumption probably will follow the same trend.

While considering the division of energy certificates between different categories, a clear distinction is necessary to objectively report energy consumption. Otherwise an F-certified asset in the 25-50% category can be compared with a particular asset out of the 75-100% category (see figure in appendix). Through this view, the F-certified property consumes the same amount (or less) of energy compared with an A-certified asset in the 75-100% category. Like expected, G-rated properties dominate the top of the energy consumption, while “greener” assets populate the lower regions. Noticeably is the presence of a C and D-rated asset in the lower regions of the highest occupancy rate. This means that regulated energy performance certificates not really indicate who is a better performer on basis of certification systems.

Occupancy rate	0-25%	25-50%	50-75%	75-100%
N	4	4	15	51
Average	0,813	0,698	0,908	1,381
SD	0,527	0,417	0,587	0,949
Min	0,400	0,430	0,360	0,300
q1	0,400	0,450	0,500	0,820
Median	0,675	0,520	0,720	1,100
q3	1,363	1,123	1,000	1,580
Max	1,500	1,320	2,310	4,900
Lower bound	0,000	0,034	0,583	1,114
Upper bound	1,650	1,361	1,233	1,647

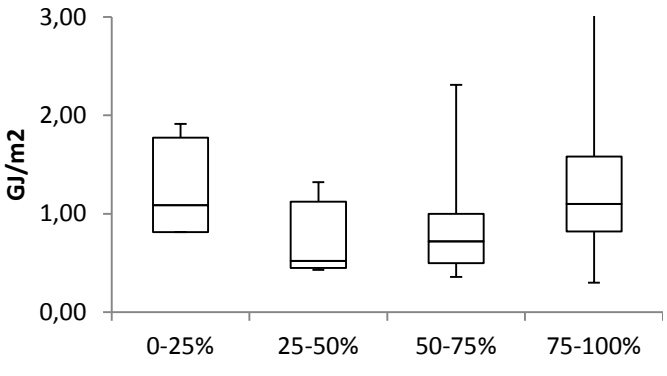
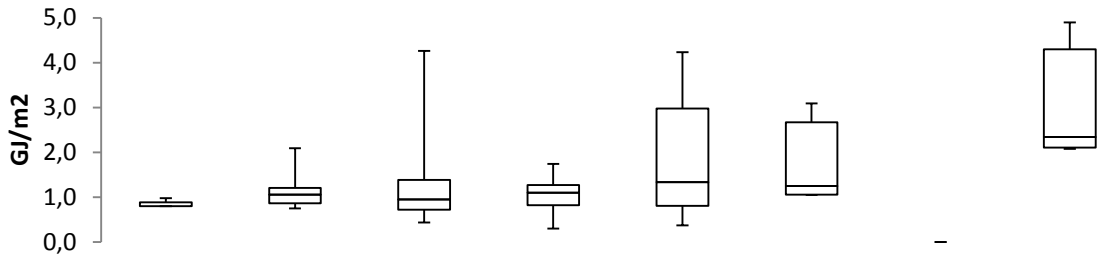


Table 27; Overview occupancy rate and actual energy consumption

In the appendix the age is put against actual energy consumption and the energy label. Interesting to see that during recent years (since 2002) no building has been realized with an EPC-certificate below C (read: D until G). Additionally and more important; it seems that the actual energy consumption is funnel-shaped which indicates a better predictability. Furthermore it is also a fact that the demand for energy inefficient properties just isn't there. Obviously the energy consumption has gone down since the 60's, but this decreasing trend is an important notion. Perhaps in the nearby future, it becomes easier to predict and benchmark energy consumption. This means that for the investor, added value is into better management of operational streams, while (potential) tenants are more service orientated and therefore have a better indication of the actual performance of the underlying asset.

Filter on occupancy rate 75-100%



Actual energy use	A+	A	B	C	D	E	F	G
N	2	13	14	7	5	4	0	4
Average	0,890	1,163	1,230	1,064	1,784	1,660	-	2,915
SD	0,127	0,435	0,945	0,438	1,455	0,968		1,334
Min	0,800	0,750	0,440	0,300	0,370	1,050	-	2,080
q1	0,800	0,865	0,725	0,820	0,810	1,058	-	2,110
Median	0,890	1,060	0,950	1,100	1,340	1,250		2,340
q3	0,890	1,210	1,385	1,270	2,980	2,673	-	4,295
Max	0,980	2,090	4,260	1,740	4,230	3,090	-	4,900

Table 28; Overview of actual energy consumption in the group occupancy rate: 75-100%

The preceding table shows us the descriptive values of the group "occupancy rate: 75-100%". As seen in the table the confidence intervals between q1 and q3 decrease when more observations occur. The boxplots also stipulate the fact that the ranges can be relatively big and as such have as potential hazard some bias.

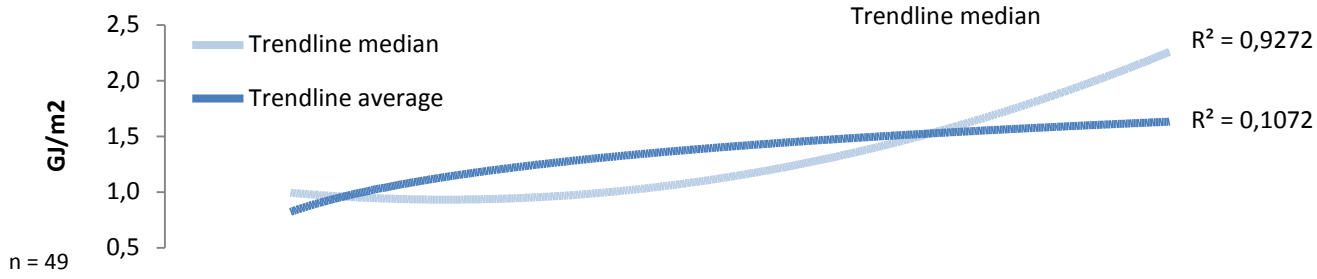


Figure 38; Trend line actual energy consumption and energy labels

When plotting the trend lines of the preceding table next to each other, it indicates that the median (R^2 = 0,9272) has a higher predicting power compared to the average. The average is a bit distorted due to the fact that the minimum and extreme values deviate quite a bit. As such, the median is a better measure to indicate actual energy consumption between the different certificates.

So what exactly did the influence of vacancy rate tell us? Indeed inferior performing properties tend to have a higher energy consumption. Evidently when the energy consumption data is corrected for occupancy rate, there will be more truthful and accurate evidence of actual energy consumption. Still the values tend to have a rather big range due to the diverse nature of usage. Other factors such as user intensity and the opening hours will increase or decrease energy consumption. The scatterplot below gives us an indication of this correction, the blue line represent actual energy consumption, while the green line indicates theoretical use:

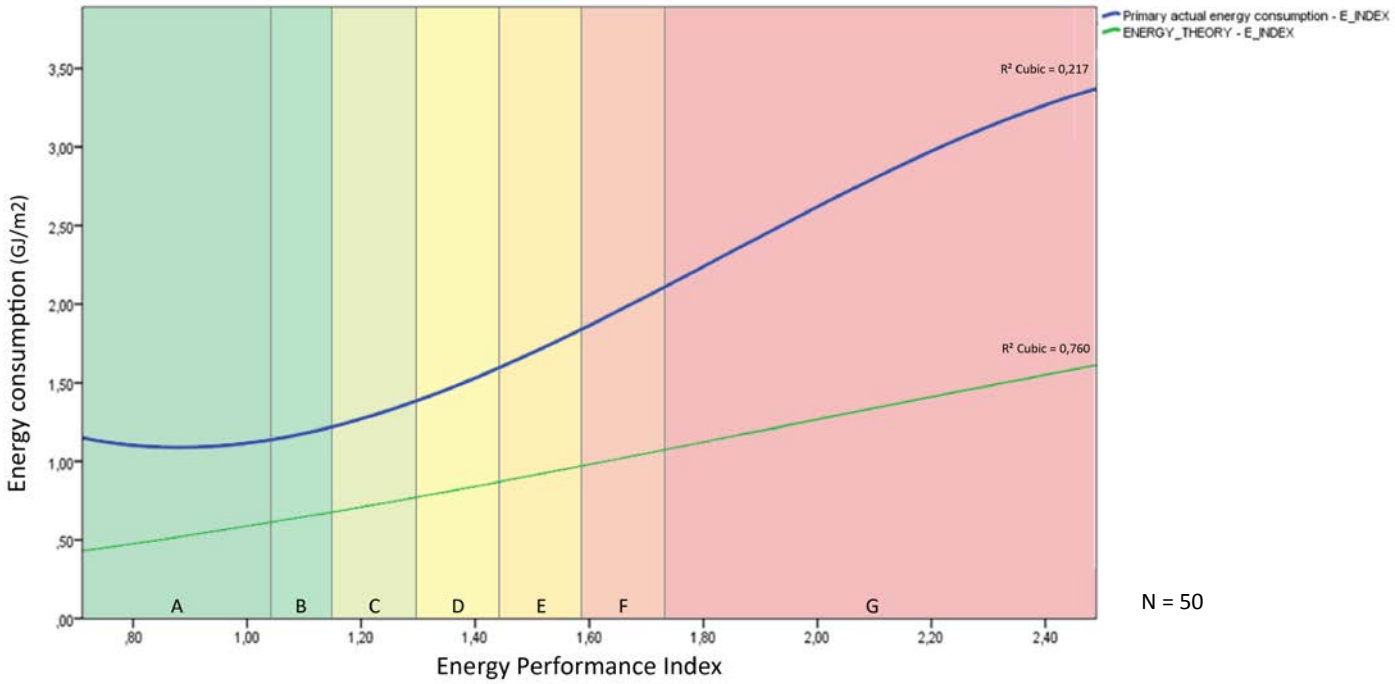


Figure 39; Actual energy consumption filtered by occupancy rate: 75-100%

Actually the findings are very interesting; this indicates that indeed greener buildings consume less energy. A first assumption was that when the energy performance index decreases the influence of the tenant on energy consumption became higher. This fact stipulates that this is not true. The green line indicates the theoretical energy consumption based on the performance of the asset itself. The blue line (with a R^2 of 0,217) indicates the actual energy consumption among different categories. Consider the difference with the preceding plot between actual and theoretical energy consumption. At the beginning of the section, actual energy consumption had an R-squared of 0,041, while the current R-squared indicates 0,217 (which is an increase of factor 5!). Note that there are not that many cases left in this equation (50 to be exact).

Additionally some extra features besides the occupancy rate have been investigated, namely the influence of use intensity and the opening hours of the objects. Unfortunately, the sample size of opening hours was of such small nature, that it became impossible to state significant evidence. On the other hand, some evidence about user intensity has been found. When looking at the categories 20-30m2 and >20m2 (for an overview see appendix), there is an indication of a gradual increase. This data will not be used further on in this chapter, due to the uncertain nature. Possibly in the future, when more data is available, the influence of user intensity could be tested.

Energy savings

In this section the energy saving are being discusses supported by the ratios of the sources described at the beginning of the chapter (see: "data selection"). First the relationship between energy consumption and costs has been shown which includes a fit line. Both theoretical and actual energy consumption have been plotted against the energy costs expressed in €/m2 for the whole sample set which includes both <10.000m2 and >10.000m2 assets. The assets below 10.000 square meters are shown through a **solid** line, while the assets above 10.000 square meters are shown through a **dotted** line. The following plot shows that there is a genuine relationship between the energy costs and the actual energy consumption (kind of obvious, R^2 both around 1).

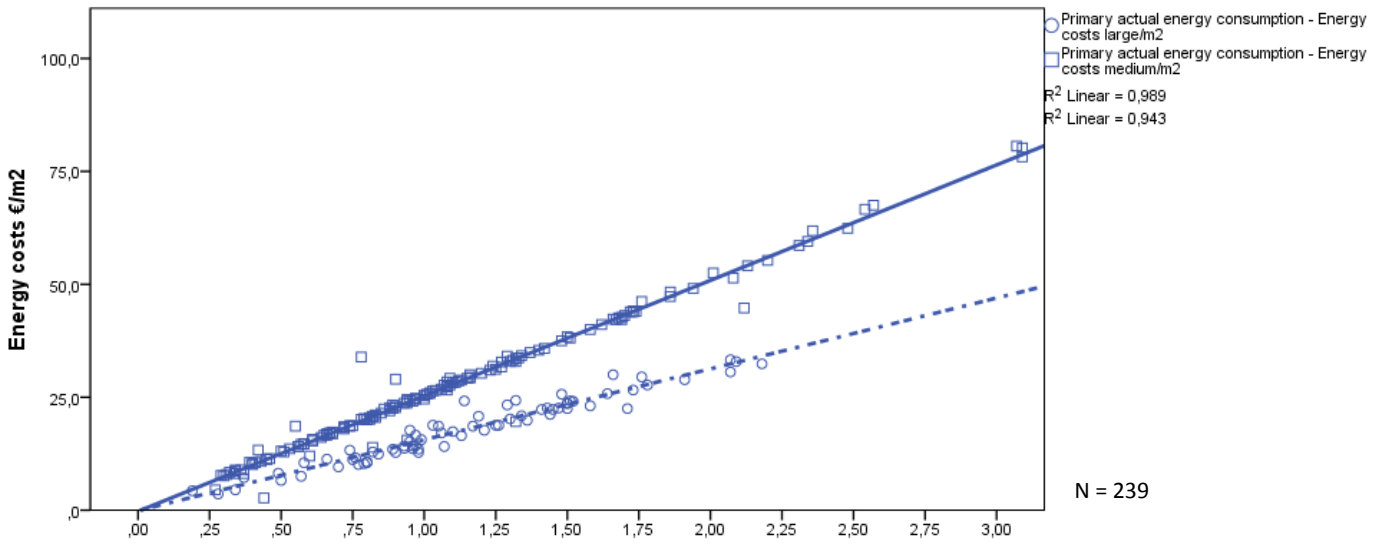


Figure 40; Plot energy costs versus actual energy consumption

The other plot which uses the theoretical energy consumption shows an interesting picture, as the actual energy costs do not show a coherent pattern for both categories (R^2 <10.000 = 0,226 and R^2 >10.000 = 0.234). For instance, it is remarkable that the energy costs will decrease as the theoretical consumption gets bigger; this is of course not a right image of the existing relationship indicated at the preceding plot.

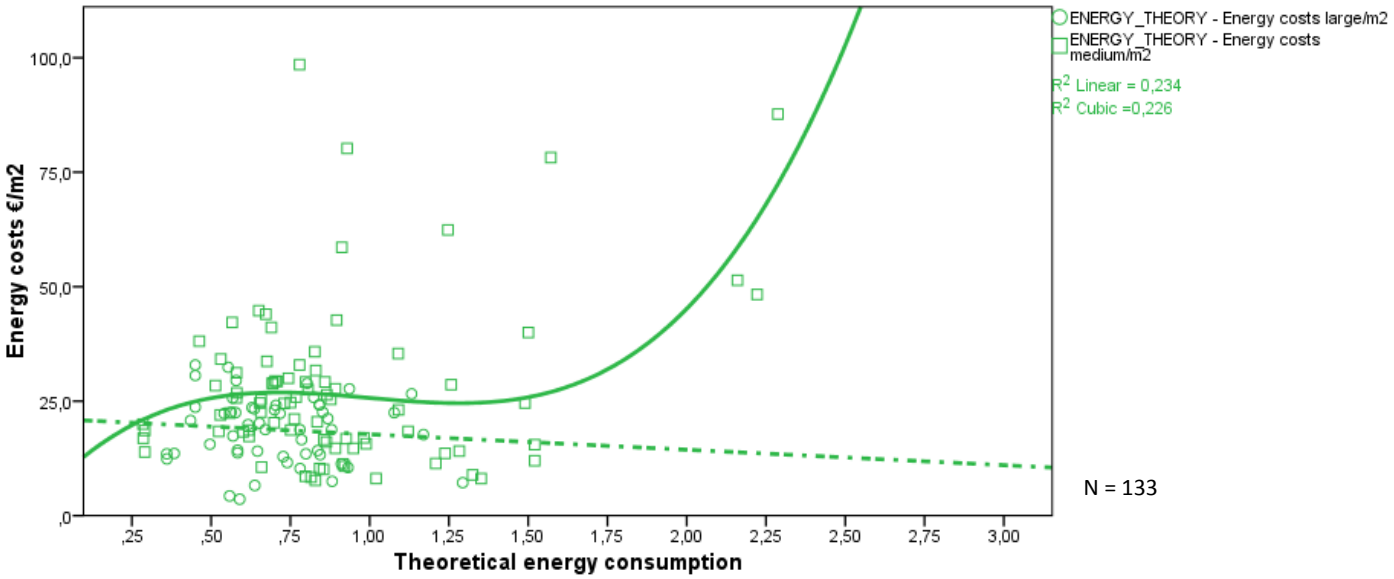


Figure 41; Plot energy costs versus theoretical energy consumption

So what happens when only the fully occupied properties are shown? Note that there are only 47 observations when the data is filtered on occupancy rate: 75-100%. The first remark is that the difference between the energy costs and the actual energy consumption is present. One should pay attention to the technical condition of the asset and identify how the energy is consumed. In the graph below, an indication is shown of the fully occupied assets of both categories “<10.000m2” and “>10.000m2”.

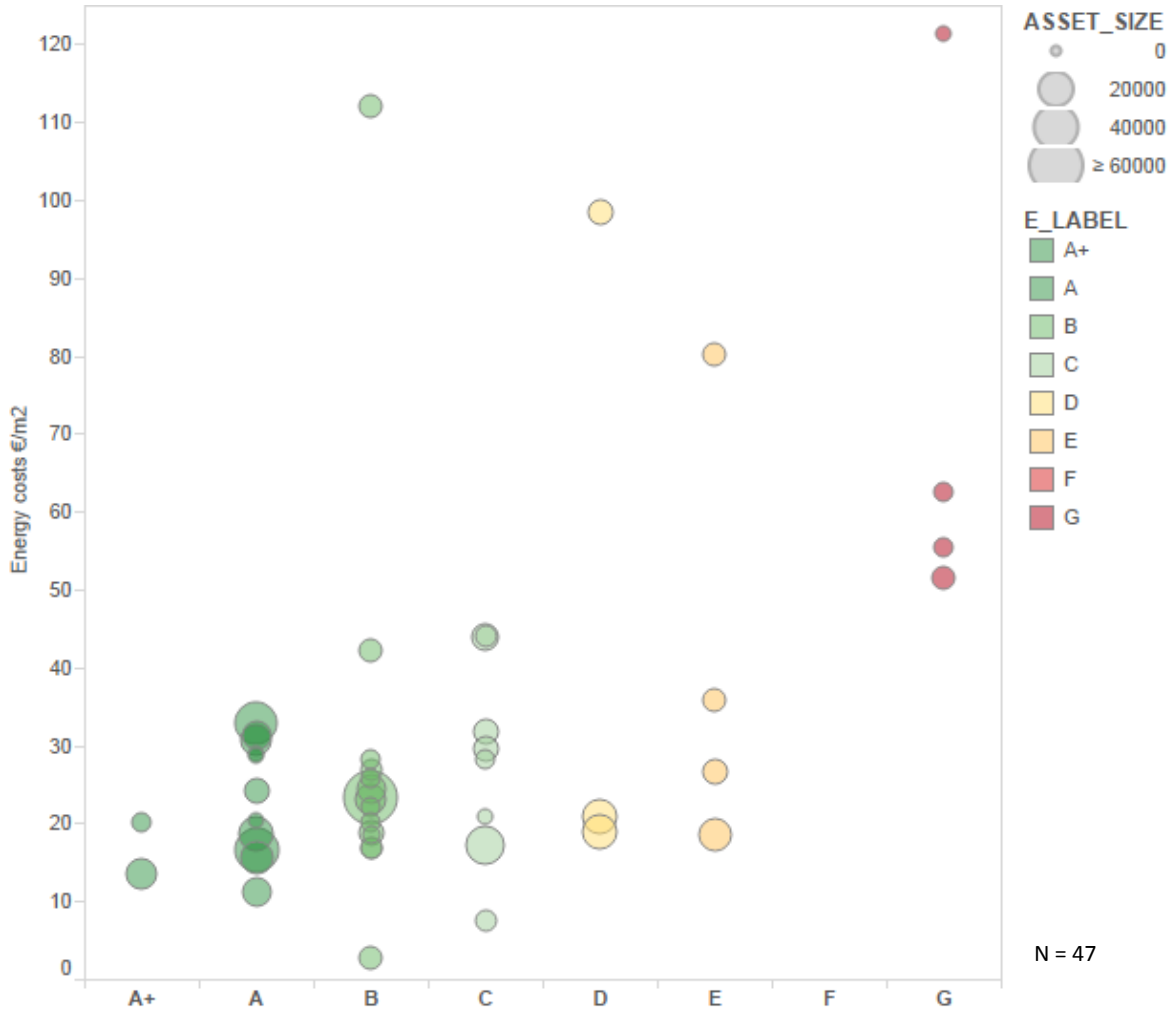
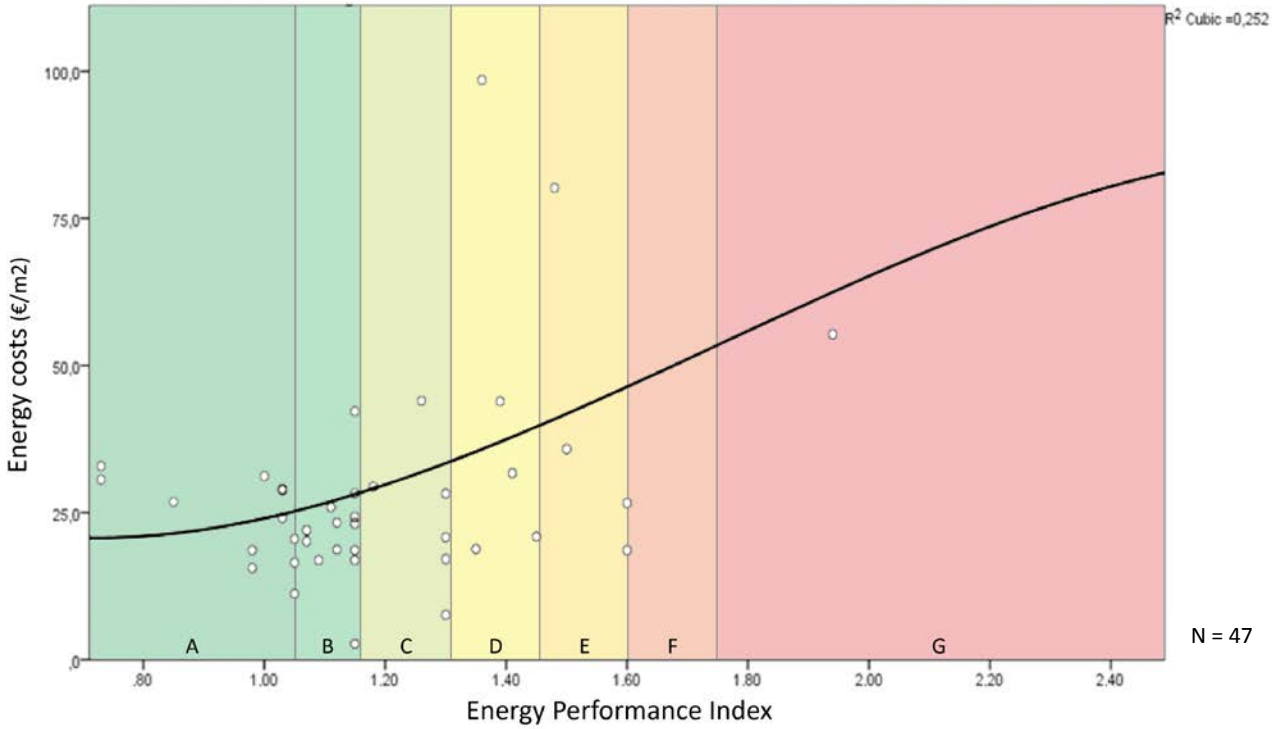


Figure 42; Energy costs and energy labels

Indeed greener assets tend to consume less energy compared to higher rated certificates. Although the results could also be interpreted that due to the range, a clear distinction is absent. An important notion is the fact that the usage of an office is a crucial element in the determination of energy consumption. Consider the outlier at the B-certificate with an energy bill of approximately 110 €/m2, how did this come into being? Two examples could explain for the deviating factors. The first related to the usage of light throughout working hours. Consider a legal firm which rents office space in a B-rated office, but does not use automated light switches. The general manager considers it as extremely important that all rooms are adequately lit throughout the whole day. As such, the energy bill will obviously rise. Another example is the usage of a different day –and night temperature. Some office buildings switch off their installations throughout the night to save energy, while nobody is around during that time of day. Approximately an hour before the office opens again, the installations switch on again, and the room temperature returns back to normal.

Filter energy savings on occupancy rate 75-100%

The first plot shows the remaining assets after filtering for the occupancy rate group: 75-100%. The plot fits the current relationship between the energy performance index and the energy bill. Again, similarly with the energy consumption, the relationship between the energy performance index and the energy costs has improved (R^2 = 0,252). Although the relation is rather tough to predict, it indicates that greener assets have lower energy costs per square meter.



Energy costs	A+	A	B	C	D	E	F	G
N	2	12	14	7	4	4	0	4
Average	16,8	23,8	28,2	25,5	45,5	40,3	-	72,6
SD	4,6	7,1	25,5	11,7	37,1	27,5	-	32,7
Min	13,5	11,2	2,7	7,6	18,8	18,6	-	51,4
q1	13,5	17,0	18,2	17,1	19,3	20,6		51,4
Median	16,8	25,5	22,6	28,2	71,2	31,2	-	58,9
q3	16,8	30,2	26,5	31,7	84,9	69,1		106,5
Max	20,0	32,9	112,0	44,0	98,5	80,2	-	121,2

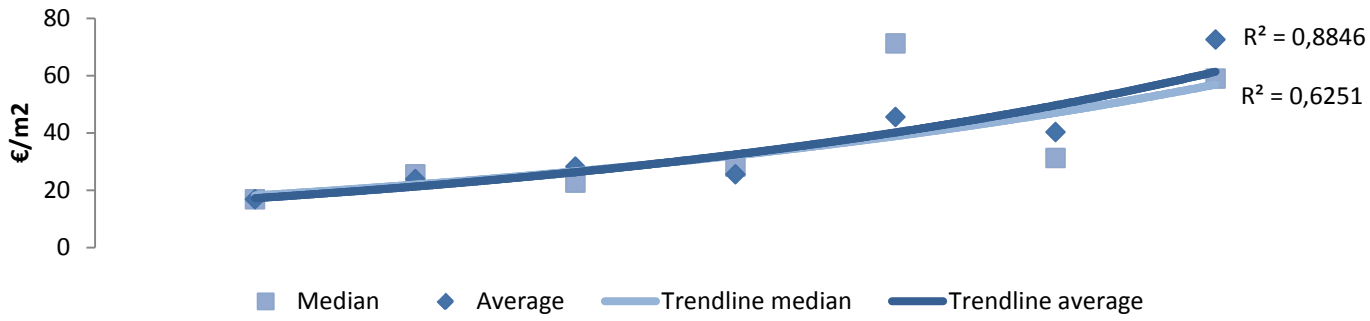


Figure 43; Energy costs and energy performance certificates in detail

The last graph indicates the relationship between the average and median and the value to which the variance can be explained. The trend line of the median has a R-squared of 0,6251, which indicates a genuine relationship, but not completely solid. The trend line of the average indicate a R-squared of 0,8846 which predicts a more trustworthy relationship. The variance at the end of the line is probably produced because of the absence of F-certifications in the sample set. The most important conclusion is that while the energy performance increases, the energy costs that you will likely to pay will rise not linearly but exponentially.

When plotting a division on an ordinal scale (see appendix) in which an interpolation line accounts for the averages between the difference certificates, the relationship between the energy labels becomes clearer. It shows that the green assets ranging from A-label to C-label indeed do have a lower energy bill, but differences between all categories are evident. From a perspective of green/non-green premium, we do see a shift of approximately 10 €/m2 when converting to inefficient properties (D-G). From this evidence we can conclude that energy savings save approximately 65-70% of costs when comparing the A certificate with the G certificate. Note that these results can be biased due to the low amount of cases in the sample set (47 assets).

We observed that the energy savings between the different certificates could be worthwhile to think about. Consider the major change between the projected energy savings shown in preceding tables and plots. Although the evidence is not enough to show a reliable relationship along different energy labels, there is a clear sign of a gradual decrease of energy costs. Next section will clarify the relationship of the rental premium versus

8.2 Analysis of rental premium and projected energy savings

To assess the balance between the predicted rent and the energy savings both the information sources should be combined into a comprehensive case. This is done through the use of a specific case in the dataset which will be described through the developed hedonic pricing model and the projected energy savings. Through connecting both these research outcomes in an example case, the results will be easier to interpret. Note that the rental prices and the projected energy costs are based on the authors' results and could not reflect the actual situation due to unknown parameters and bias in the sample set. More importantly, it is about the balance between the rental premium and projected energy savings and if the extra rent can be expected to reimburse through energy savings.

The office building is located just on the outer half in the center of Rotterdam. Its close proximity to both the general shopping areas (such as "de koopgoot" and "de lijnbaan") and public transport (metro and train) make it a relatively attractive building because the close walking distance. Although the highway access is not within 5 minutes travel time by car, the office provides parking spots underneath the building. The accessibility by car is relatively good for a center location. This is all underlined by the Google Walk Score (which indicates walkability) and rates the asset with a high score of 90. The office has been constructed in the early nineties and therefore looks quite outdated and not conform modern times. Back in the days, sustainability was not considered as important and as such the building obtains an energy performance index of 1,56 which translates into an E-certification. When looking at preliminary evidence the theoretical consumption is way lower compared to the actual energy consumption.

Building details	Description	
Age	1991	
Asset size GFA	9000	
Asset size LFA	8402	
Google walk score	90	
Location in the NL	Randstad area	
Location type	Central Business District	
Public transport	303	m

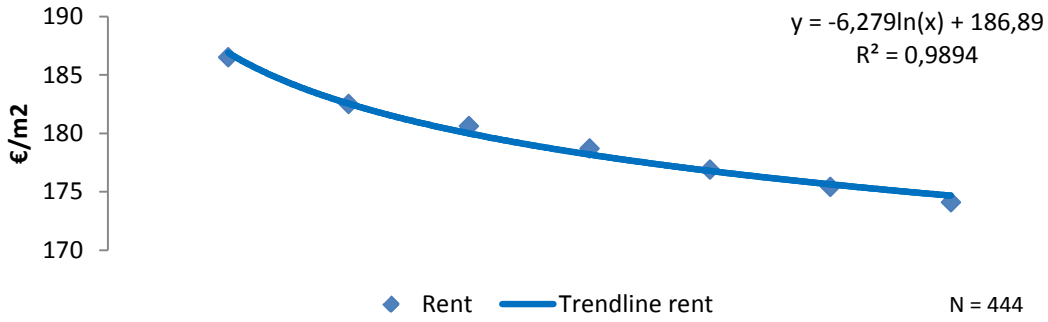
Technical details	Data	Unit
EP-index	**1,56**	
Energy certificate	E	
Electricity usage	1130169	kWh
Gas usage	4660	m^3
Water usage	4970	m^3
Actual energy cons.	1,69	GJ/m^2
Theoretical energy cons.	0,90	GJ/m^2
Projected *service* costs	37,5	€/m²

Table 29; Overview of sample case

The hedonic pricing model is based on several characteristics to explain for the rental price. For more info on the functioning of these models, read the theoretical framework and the "using statistics" section. In short; the transacted rental price is based on the characteristics like location, location type and the level of facilities among others. Like the final model showed, the effect of sustainability is clearly present but to a small extent compared to the included variables. As such this particular building in Rotterdam relies on its location and quality and to a lesser degree on sustainable certification. Currently the asset is blessed with a meager E-certification which is not really sustainable. The model indicated that the when the energy performance index decreases (and the certification gets better), the rental price should obtain a premium per label. So what kind of premiums could we expect between the range of certificates?

This can be done through using one particular case and create the so called "out-of-sample" predicted values based on an online source (UCLA: Statistical Consulting Group, 2013). In this case it is useful to obtain predicted values for this particular case which are not used in the statistical model. In SPSS, the dependent variable is set to be missing for this particular case. As such, the predicted values are generated but the case is not admitted to the final model. The goal is to generate different predicted values for changing EP-indexes. This office building will be copied in the SPSS dataset, the transacted rent will be deleted and the EP-index will be changed in every case for each energy label. As an example, case 1 will

have an EPI of 1,00 which accounts for an A-label, case 2 has an EPI of 1,10 which accounts for a B-label and so on. When running the regression analysis, the save command is used to save the predicted values to the current dataset. As such the cases are not admitted to the model (and cause bias), but the asset obtain different rental prices while the energy certificates are changing.



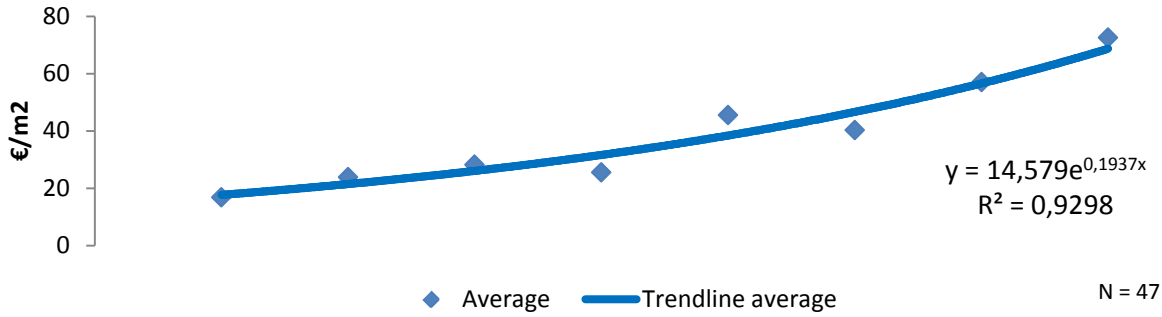
Certificate	A	B	C	D	E	F	G
Predicted	186,5	182,5	180,6	178,7	176,9	175,4	174,1
Trend line	186,9	182,5	180,0	178,2	176,8	175,6	174,7
%	107,0%	104,5%	103,0%	102,0%	101,2%	100,6%	100,0%
Premium	2,4%	1,4%	1,0%	0,8%	0,7%	0,6%	

Table 30; Rental premium for sample case

So how does the asset perform when the energy label gets upgraded to a greener certificate? The model estimates that that the current rental price of the assets should be 175€/m². Due to the uncertain nature of the model, this rental value should be taken with a grain of salt. What matters is the gradual increase of rent when the sustainable performance increases.

Especially A-certified properties do really well in this model. Between the A and G certificate is a gradual rental premium of 7.0%. The steps between all other categories are more stable at a rate of approximately 1.0%. Noticeably is the steep rise of slope from B-certificate to the A-certificate, the premium has almost been doubled (2.4%) with regard to the normal slope. The influence of the energy certificates is remarkable and indeed properties tend to obtain a higher premium when a better label is obtained.

So what about the actual energy savings when assets are more "sustainable" through greener certifications? This data is based on the sample set of 47 assets which are filtered on occupancy rate and therefore can be regarded as "equals". The average trend of energy cost versus certification has been plotted in the figure below.



Energy costs	A+	A	B	C	D	E	F	G
Predicted	16,8	23,8	28,2	25,5	45,5	40,3	57,0	72,6
Trend line	17,7	21,5	26,1	31,6	38,4	46,6	56,6	68,7
%	26%	31%	38%	46%	56%	68%	82%	100%

Table 31; Energy savings for sample case

Since we currently know both the rental premium and the projected energy costs, the two outcomes are set against each other to look at the balance. Does the rental premium make up for the energy savings, or does the tenant simply pays too much? The table below indicates the certification, the energy costs and the rental premium. The results are being compared with previous academics that did similar research in the field of sustainability and willingness-to-pay. The first two authors (Visser, 2010, Snoei, 2008) suggested that tenants were not willing to pay extra to a full extent. Snoei (2008) suggested that the willingness-to-pay by tenants is about **76%** of the energy costs savings while a higher rent is asked. Basically, the investor needs to make the investment to obtain an A-certified property, while the tenant receives the benefit, in the shape of lower energy costs (also known as "split incentive"). Visser (2010) found that tenants are only willing-to-pay 32% of their energy savings back to the investor in a rent premium. Question is: Do these assumptions hold when comparing the rental premium versus the projected energy costs? The columns with preceding authors are besides the columns of respectively energy costs and rent/premium. Both assumptions hold as the premiums are consequently lower than 32% of the energy savings which indicates that green assets are proving to be more energy efficient while the energy savings are significantly bigger than the rental premium. Additionally a lower rental premium has been reported compared to earlier work by van der Erve (2011). Although the data has a big confidence interval and should be taken with reservation, this evidence shows that it is profitable to rent more sustainable and be more profitable.

Certificate	Energy costs	Visser: 32% (2010)	Snoei: 76% (2008)	Rent	Premium	Van der Erve (2011)
A	€ 21,5	€ 15,1	€ 35,9	€ 186,9	**€ 12,2**	€ 16,0
B	€ 26,1	€ 13,6	€ 32,4	€ 182,5	**€ 7,9**	€ 6,4
C	€ 31,6	€ 11,8	€ 28,1	€ 180,0	**€ 5,3**	€ 3,1
D	€ 38,4	€ 9,7	€ 23,0	€ 178,2	**€ 3,5**	€ 0,4
E	€ 46,6	€ 7,1	€ 16,8	€ 176,8	**€ 2,1**	€ 0,2
F	€ 56,6	€ 3,9	€ 9,2	€ 175,6	**€ 1,0**	€ -
G	€ 68,7	€ -	€ -	€ 174,7	€ -	

Table 32; Comparing preceding academic evidence

Conclusion results and analysis

The first objective was to find out if the green premium that is paid by tenants fade out when comparing the rental premium with the saved energy costs. This can be directly translated into the existing framework of the energy performance certificate. Indeed there seems to be a rental premium for better performing (read: “greener”) assets. This is based upon the notion provided by a hedonic pricing model which combines several influential aspects of which the energy performance index is one. Besides the other variables like location type or the reachability, the relative sustainable performance does matter. Could these variables predict future implications of sustainable measures in an investment portfolio? We could definitely argue that an upgrade from a G-certificate to an A-certificate pays off into a rental premium regardless of potential investment costs associated with renovation. The rental premium that is estimated for the change from a G-certificate to an A-certificate is 7.0%. The difference of green (A-C) versus non-green (D-G) is estimated to be 10.7%. Again, the model is not completely trustworthy due to the diverse nature of transaction years and model estimation. More importantly, could an investor tell the potential tenant that the energy savings outweigh the higher rent?

Yes, these energy savings exceed the rental premium. To actually report on a percentage grade is maybe a bit premature regarding the sample set of 47 office buildings. That is why the energy savings have been compared with the rental premium. What can be observed is that indeed the savings are higher than the rental premium that is paid by the tenant. In this report two academic reports have been used as preceding evidence (Visser, 2010, Snoei, 2008) on the percentage of energy savings that the tenant is willing to pay extra.

These outcomes are positive for both the investor and the occupier, since the balance between savings and premiums is pretty delicate. The investor indeed does obtain a rental premium on greener properties while the tenant saves energy costs while he is situated into a green asset. Regarding these two notions, the key-issue described as the split-incentive can be discussed and mutual communication should ensure sustainable operation of the property. Since this graduation does not address the initial costs to obtain a higher certificate, this is a requisite to take along while it is unclear if the rental premium is enough to cover the initial investment for the potential upgrade of the asset.

It seems that the energy performance certificate indeed is providing the real estate world with some needed transparency. Although theoretically, the calculation framework seems to align with the energy performance index, the actual energy consumption deviates from the regulatory framework. When these consumption figures are being transferred to energy costs it becomes clear that the technical condition, the office space usage and the nature of the occupier are strongly influencing.

Discussion

Image:
BREEAM Outstanding; Treglown court, Cardiff, UK

9. Discussion

This discussion takes us from the knowledge gained in the theoretical framework, to the methodology section and finally arrives at the results. During the process of writing this thesis and the preceding research it became clear that the incorporation of sustainability into the real estate investment portfolio is harder than it seems. A lot of remarks can be made on various fields of knowledge ranging from pure financially orientated investment decisions to qualitative productivity benefits. The general outline of this report can is formulated into the main research question which acts as guideline through the thesis:

Does sustainability influence the financial performance of office buildings in the Netherlands?

In order to look into the effects of sustainability, several aspects should be mentioned to arrive at a conclusion. Fundamental to the research is the question if sustainability is integrated into the business cycle of institutional investors. Additionally the author investigates if the degree of sustainability indeed is an asset selection criterion. When the rationale of the investor and occupier are described regarding sustainability, the study proceeds into more specific questions. Additionally in the following paragraphs, the stated assumptions are integrated into the discussion. Think of sustainable variables that influence financial performance and how to align them to gather results? And successive, what are the exact financial benefits of such sustainable variables?

The theoretical framework provided a clear picture which indicates two preliminary outcomes. The first outcome is related to the added value of sustainable real estate in terms of risk and return profile. Several authors describe that real estate portfolios with a higher fraction of efficient, green properties, had significantly lower market betas thus lower exposure to market risk. Moreover, occupancy rates in more efficient buildings are not only higher and less volatile. This just stipulates the quote of Pivo & Fisher in which sustainable assets does not necessarily perform better, but at least performs the same as conventional assets. The second outcome has a more qualitative approach as this includes a side with more “soft edges”. Sustainability is not just about hard facts, but increases the mutual communication. Issues such as productivity, corporate image and the willingness-to-pay come to mind when exploring the qualitative side. While hypothesizing and move in the direction of hazards regarding regulations, energy pricing and changing qualitative demands, the theoretical framework arrives to the conclusion that more efficient buildings have the ability to provide a hedge against all three factors (regulation, energy and demand). Through accurate reporting and benchmarking, the capital market has the opportunity to integrate sustainability into their investment decisions, their engagements with investment managers and so on.

The hedonic pricing model estimated that a range of independent variables had influence on the rental income of specific properties, which included more categories than only energy use and locational features as earlier assumed. Also asset-related and operational variables, such as effective age, user intensity and asset size did show a pattern in the results. Still it remains rather difficult to estimate the correct rental price through the selected explanatory variables, the low amount of transactions and the time-frame of these transactions (1990-2012). The diverse nature of the office user and characteristics of the location, reachability, type and asset makes it difficult to extract the right rental premium which reflects sustainable performance.

When looking back at some assumptions stated at the beginning of the report, some are indeed true, while others remain sketchy. First we can conclude that the sustainable variables extracted from several sources such as the DGBBenchmark prove to be significant. However some variables show a weak response in the regression analysis while others are over-performing. Regardless of other features like the position in the urban grid or the level of facilities, sustainability ought to be incorporated into the business cycle, regarding the disposal, renovation and maintenance of the asset.

Already during the data analysis, preliminary evidence seemed in most cases promising. The biggest disadvantage of this short inquiry is the fact that the rental values are not adjusted to their respective transaction year. For this reason the preliminary evidence of the data analysis should be taken "with a grain of salt" as further research most definitely clarifies the quest for the added value of "green" properties. Additionally, the first results are so called "two-dimensional" and did not go into detail about the joint value of location, type and EPC-class. When the first evidence was converted into a hedonic pricing analysis some variables became (surprisingly) redundant. So what kinds of premiums are expected between the ranges of certificates? Especially A-certified properties are better financial performers according to the model. Between the A and B certificate is a gradual rental premium of 2.4%. The rental premium between G-rated and an A-rated property is around 7.0%. These figures are based on the sample case shown in the preceding section. As such, this evidence proves there are higher cash flow opportunities when a specific object has a better energy certificate.

When considering the influence of energy costs present-day, not much evidence has been reported on the balance between the rental premium and the likely energy savings. This report shows that the energy savings exceed the rental premium to a considerate amount. Note that to actually report a percentage grade is rather tough regarding the small sample. Consequently the results have been gathered from two sources, respectively the rental premium and the projected energy costs which have been merged into a sample case. Indeed, the energy savings tend to be higher than the rental premium that is paid by the tenant. Two preceding academic reports have been used as evidence (Visser, 2010, Snoei, 2008) to test whether the tenant is willing to pay the additional rent (considering the projected energy savings). The results imply that indeed green assets consume less energy compared to their inefficient peers and the rental premium can be stated as a (small) percentage of these savings. Both investors and occupiers could benefit from this approach through mutual communication and (financial) instruments such as a green lease. As such the gathering of data that reflect actual energy consumption can open the way for such agreements and the incorporation of sustainability in the real estate sector.

Sustainability from an operational perspective is the biggest gain on a short term perspective. The degree of sustainability does add value to offices, so irreversibly this will influence a portfolio. The choice for acquiring a sustainable asset could be of a total different nature, namely the risk-profile. As such opportunistic investors will not benefit from an extremely sustainable asset, but do benefit from a sustainable approach! If the operational manager has a better idea of information streams like energy, water and waste the asset manager has the opportunity to market the property better. The added value is in the service component towards the potential occupier.

This service component can be provided through a green lease in which the two parties, the investor and the occupier make agreements on performance which are beneficial for both parties. Currently more and more green leases are rolled out as part of CSR-strategies. An article wrote by Seebus (2013) indicates the practical advantage of such an agreement. A green lease helps to improve the sustainable performance of the rented space by securing critical commitments. Additionally both the occupier and the investor are enabled through financial incentives while adopting green measures. These commitments and financial impulses improve the operational information flow which can be used to benchmark and evaluate on agreed objectives.

A recent article shows that also on national scale some action is taken: "Energy consumption tenant and landlord can be lowered down" (Wiegerinck, 2013). The split-incentive is solved through the so called "Duolabel kantoren" in which the investor and the tenant make an arrangement on the costs and benefits of a sustainable upgrade. The involved parties even claim that they can reduce energy consumption with 10% without additional investments (based on a recent pilot). Of course this is a green lease operating with another name. A final example of the gradual increase of green leases is shown by the IVG research department (Beyerle, Haux, & Voss, 2013). Through a recent survey they indicate that green leases seem to

be becoming increasingly important: while only about 17% of the companies that participated in the survey had already concluded green leases in their operation. Also, separate from the survey, however, the websites of individual European property companies feature up to 900 green leases brokered (Beyerle et al., 2013).

Since individual assets are subject of research, the implications on portfolio-level are unfortunately rather vague. Note that individual green office buildings do add value through both direct and indirect returns, but the effect of multiple "green" offices could be suffering from a "neighborhood competition" as the supply of green-rated assets increases. It could be that these newly build or renovated sustainable offices "over-satisfy" demand and possibly not realize the same rental heights as compared to early adopters. Although this fact makes the future green office stock challenged, it does not take away the increased employee productivity -and absence and the likelihood of less volatility in (a higher) occupancy rate.

Are sustainable certification systems helping the commercial real estate market to move forward? Yes, they do. Through providing the necessary rules and protocols (GRI CRESS), they enable the investors to be more connected with their assets. From a demand perspective, no occupier would acquire a newly constructed commercial office space without certificate. Also in the current existing office space sustainable performance plays a more prominent role than ten years ago. This report focused upon the difference between the EPC-certificates as obliged labeling system in the Netherlands. Others such as BREEAM (In-use), LEED, DGNB and HQE gain ground throughout Europe and will most likely benefit from an improved financial return (as other evidence stipulates).

It seems that the energy performance certificate among others indeed is providing the real estate sector with some needed transparency. Although theoretically, the calculation framework seems to align with the energy performance index, the actual energy consumption deviates from the regulatory framework. When these consumption figures are being transferred to energy costs it becomes clear that the technical condition, the office space usage and the nature of the occupier are strongly influencing.

9.1 Recommendations for further research

Although some aspects of sustainability and offices has been covered, still a lot research needs to be conducted before the majority and laggards are convinced that sustainability could be more than the boy scout who is only interested to save the ordinary house sparrow from leaving the outskirts of town. Also in this report it has been shown that sustainability could be a profitable tool to conduct business. Unknown spots are countless as sustainability is a rather broad notion. Let's start with the more financial and quantitative side before indicating some interesting qualitative subjects.

Benchmarking and the rating of sustainability

A product, which is gradually becoming established into the real estate market are sustainable real estate (investment) funds. This new type of fund invests in sustainable properties, which are distinguished by high levels of energy and resource-efficiency and more BREEAM rated categories (greenhouse gas, waste etc.). These special funds have only been offered by around one tenth of the companies to date (Beyerle et al., 2013). They all have one thing in common: attractive prospective returns. The differences between such funds are evident, so how to test for the relative sustainability of a fund or a "sustainable company"? Recently in the US they introduced the so called sustainability ratings for real estate investments (Hirsch, 2013). The product, the sustainability index is a share index that highlights companies that are managed in a way which respects the environment and the society and not simply grasping for immediate profits. Examples of sustainability indexes are: FTSE4Good, Ethibel Sustainability Index (ESI) and Dow Jones Sustainability Indexes (DJSI). Being registered on a sustainability index will reward companies with increased respect and legitimacy and more practically by granting them access to the increasing number of socially and environmentally conscious investors. In Europe or on a smaller scale, in the Netherlands, no such initiative has been developed. All these different products are wandering around without a comprehensive index or tool to structure the supply of these products. The index could structure funds/companies from a financial side, or more on their CSR-efforts.

Green finance

Sustainable real estate investments are currently a hot topic, but an even more interesting topic is the position of the major banks, which currently are not so eager to finance new construction or renovation projects. Back in the golden days from 2003 until the financial crisis, the wall of money was prominently present and bankers were ever eager to dispose their financial resources for your dream office, shopping mall and even your own residence. Due to strict Bazel three regulations, banks closed the door not only for opportunistic investors but also for regular starters like you and me. It seems like the added value of sustainability has been proven enough to correct for this effect. Shouldn't there be a discount for more energy-efficient properties? Nowadays only Triodos bank has integrated sustainability in their operational practice. The first meager evidence is summarized in a very recent report: Financing tools for a green building stock (Kok & Eichholtz, 2013). This report came into existence through the group: Market Financiers Group of the Dutch Green Building Council and GRESB, which aim is to make sustainability an implied condition in (debt-) financing real estate developments. The report shows some first evidence on how other countries deal with sustainability and some very interesting examples are provided.

Cost to be sustainable

We generally do know about the financial gains of sustainable offices, but what are the costs associated with being sustainable? What are the preferences of both the investor and the occupier? Considering the outcome of this research, some room for negotiation is created. What if an investor is willing to invest in a G-certified property and turn it into a more sustainable asset? Should he choose for an additional certification through LEED or BREEAM In-use? The setup of such research could have the same structure as

this one; compare the investment costs or lifecycle costs against recent evidence of willingness to pay and the actual energy savings. There are currently tools that assess the investment costs of such sustainable upgrades, one of them is the LEAF-tool developed by the Brink group. If investment costs are integrated into a comprehensive whole together with the rental premiums and projected energy savings, the business case would be very interesting.

Productivity and employee absence

The financial perspective of sustainable objects has been covered by quite a lot of authors, while the actual technical details are missing. This subject could be booming when you are able to prove that sustainable assets have a lower employee absence and a higher productivity. Any business owner can tell you that employee salaries and expenses make up the majority of operational costs associated with leasing an office. While approximately 85% of total workplace costs are spent on salaries and benefits only 10% is spent on rent and less than 1% on energy costs. Research suggests that by making even small improvements to factors such as productivity, health and wellbeing, businesses can experience greater financial benefit than they would from more efficient resource use in building operations (World Green Building Council, 2013).

Quest for new KPI

This research went into depth into the energy performance certificates which are estimated through a standardized calculation. This calculation provides an output, namely the theoretical energy consumption and as we now know, this energy consumption profile does not correspond with the actual energy consumption. Due to the varied nature of office space usage, there is currently no real key performance indicator which can project or estimate the actual energy consumption. Features as user intensity, occupancy rate and opening hours are useful, but do not cover the whole “load”. Perhaps a more truthful predictor could be in the range of FTE per square meter?

Reflection

Image:
LEED GOLD; Schmidt Hammer Lassen Architects, Warsaw, Poland

10. Reflection

Fortunately I had the opportunity to encounter my graduation subject some time ago. As I was reading in a magazine, my eye fell on an article about the financial benefits of sustainability and the sustainable certificates LEED and Energystar. This came in handy when I attended the first lectures about choosing a graduation theme and the layout of this research. Since I did prepare myself on a basic scale, I was able to make choices faster and more effective. As such my research advanced in a rapid pace. Besides the assistance from my graduation mentor, I challenged myself to reading a lot of literature about the added value of sustainability. Although these articles were rather economical (not all!), understanding them became easier as I attended my free electives at the University of Amsterdam at Real Estate Finance. Consequently, the research methodology and framework was the outcome of an eventful half year at either the university in Delft or Amsterdam.

As such I started the second half year with a lot of refreshing ideas and initiatives and started working on my final report which in the end contributes something to the existing body of knowledge about the incorporation of sustainability into the real estate investment portfolio.

The concept of the research was rather vague when I started looking for an internship, since the nature of the data could be steering towards another objective. The DGBC provided me with an interesting set of data which enabled me both to investigate into the relationship between pricing and EPC and the balance between energy savings. The first one or two months were really to obtain and structure the data to gain an insight into the possibilities, which is quite time-intensive. Nonetheless I managed to gather a comprehensive sample set, which proved to be significant and useful during the research.

Yes, I have made things hard on myself while being determined to conduct a quantitative analysis that forced me to find two appropriate datasets, financially and technically. Despite the cautions from my mentors regarding the feasibility of my graduation I remained positive and eager to finish the research within the given time limits.

Some suggestions to other graduates are perhaps handy. From a university perspective, be prepared when you are meeting your mentors, make an agenda or write something down. This will enable you to ask structured questions and get the best results from the moments you meet your instructors. Another thing relates to the actual report. Be sure to keep writing. Research is fun, but putting text on paper is not. Try to describe your findings immediately in keywords. Look for an internship rather quick, they can help you while also help to steer your research. This really comes in handy when you want to discover something new. Lastly, try to meet professionals “in the field” who can help you structure your research, gain new ideas and most importantly discuss and criticize you on your main topic.

My experience of the graduation track during the past year was intensive, it was quite a ride. I consider the knowledge and experience I gained as a person really valuable. Hopefully some people are encouraged when they read this short reflection on the process and have the same personal experience.

Definitions and abbreviations

CBS
Centraal Bureau voor Statistiek - Central Office for Statistical Data in the Netherlands

Closed-end fund
A closed-end(ed) fund is a collective investment scheme with a limited number of shares.

Core fund
A core fund holding is bought with the express purpose of being held for a (very) long time, and is often of high quality with a stable performance record.

Correlation coefficient
Statistical measure of the correlation strength between two variables or datasets. The coefficient varies between -1 and +1 with -1 indicating a purely negative correlation (one set of data is the exact negative proportion of the other set) and +1 indicating a purely positive correlation. The weaker the relationship is between the two sets of data, the closer the coefficient will be to zero.

CSR - Corporate Social Responsibility
Corporate initiative to assess and take responsibility for the company's effects on the environment and impact on social welfare. This generally applies to efforts that go beyond what may be required by regulations or environmental protection groups.

Dependent/Independent variable
In an experiment, the independent variable is the variable that is varied or manipulated by the researcher, and the dependent variable is the response that is measured. An independent variable is the presumed cause, whereas the dependent variable is the presumed effect.

Direct Real Estate
Investors invest directly when more than 50% of the shares of the asset are owned.

Direct return; rental income
A percentage value for the total return that is created by an operation’s income from property, a fund or an account. In case of real estate this is rental income.

Diversification
The division of investment funds among a variety of securities with different risk, reward, and correlation statistics.

Eco-labeling
The provision of information to consumers about the environmental performance of a product (LEED, BREEAM, EPC, Energystar etc.) with the indirect aim of influencing their consumption choices, suppliers’ production outputs and, as a result, the level of environmentally harmful emissions.

Financial performance
A subjective measure of how well a firm can use assets from its primary mode of business and generate revenues. Regarding the real estate industry; the direct -and indirect return profile.

GFA (BVO)
Gross Floor Area – The floor area measures from the insides of the walls including transportation and installation areas

Hedge
In finance, a hedge is a position established in one market in an attempt to offset exposure to price fluctuations in some opposite position in another market with the goal of minimizing one's exposure to unwanted risk.

Hedonic regression model
In economics, hedonic regression, also hedonic demand theory is a revealed preference method of estimating demand or value. It decomposes the item being researched into its constituent characteristics, and obtains estimates of the contributory value of each characteristic.

Indirect Real Estate
Investing in real estate without actually investing in the asset. Indirect investment can be done in many ways and varieties, including securities, funds, or private equity. Most investors interested in indirect investment would do so through a company or advisor who has experience in this type of investing (a so called portfolio manager).

Indirect return; market value
The increase in an asset's market price, also called capital appreciation or gain.

INREV
International Association for investors in non-listed Real Estate funds – Association for nonlisted European Real Estate Professionals

IPD
International Property Database; performance indices for institutional investors

IVBN
Belangenbehartigingsorganisatie voor institutionele beleggers in Nederlands vastgoed – Organization that attends to the interests of Dutch institutional investors in real estate

Lagging
A valuation error caused by valuers using 'old' comparables that fail to mirror market conditions, at the time of valuation.

Listed-fund
Listed real estate is similar to corporate stock in that it provides investors with an ownership interest in the underlying asset, which is sometimes leveraged. Public real estate trades in shares, enabling small (individual) investors to participate in commercial property investment. Second, these shares are usually publicly traded and so provide the investor with more liquidity than direct real estate investments.

Open-end fund
An open-end(ed) fund is a collective investment scheme, which can issue and redeem shares at any time. An investor will generally purchase shares in the fund directly from the fund itself rather than from the existing shareholders. It contrasts with a closed-end fund, which typically issues all the shares it will issue at the outset, with such shares usually being tradeable between investors thereafter.

P-value
The p-value is a measure for the significance of a regression variable. As part of the regression output, it represents the probability that the regression coefficient for the variable in question is actually 0 (insignificant in a regression model). Ideally, the p-value is to be as close to 0 as possible to ensure

coefficient/variable significance. As part of a t-test, the p-value is the probability that the null hypothesis is true; the null hypothesis is usually rejected if the p-value is lower than 0.05 (less than 5% chance the null hypothesis is true).

Real Estate Investment Trust; REIT
A company that purchases and manages real estate and/or real estate loans. Some REIT's specialize in purchasing long-term mortgages while others actually buy real estate. Income earned by a trust is generally passed through and taxed to the stockholders rather than to the REIT.

Rental premium
A rent above the level which a property could reasonably be expected to command in the market on normal terms. Such rents may be justified in instances where the tenant receives a present or future benefit (sustainable improvement) against the normal market.

RPI – Responsible Property Investments
Property investment or management strategies that go beyond compliance with minimum legal requirements in order to address environmental, social, government and most importantly financial goals in the application of capital i.e. the actual investment process.

Smoothing
In the context of appraisal-based property series this is an under-measurement of 'true' variance. Or bias of time series second moments toward zero.

Split-incentive
Split incentives happen when those responsible for paying energy bills are different than those making capital investment decisions. The most common form of split incentives is in leased buildings where tenants pay the energy bills, but landlords (read: investors) pay for upgrades.

Standard deviation
The square root of the variance. A measure of dispersion of a set of data from its mean.

Total return
This is the sum of the income return and the capital growth. Total return is generally considered a better measure of an investment's return than income return alone.

Value-add fund
Value-added or opportunity-style investment funds seek to acquire portfolios of commercial properties with the potential for significant value creation over a shorter-term time horizon. Objectives may include "value-added" opportunities for capital appreciation and income potential in markets with higher volatility, lower barriers to entry and high growth potential for the more risk-tolerant investor.

List of figures

Appendices

The appendices consist of data regarding the hedonic model and the energy savings. The tables and plots below serve an illustrative purpose to support preceding research objectives and outcomes.

Syntax SPSS; final hedonic pricing model

Final model which incorporates the E_INDEX

```
REGRESSION
  /DESCRIPTIVES MEAN STDDEV CORR SIG N
  /MISSING LISTWISE
  /STATISTICS COEFF OUTS CI(95) R ANOVA COLLIN TOL CHANGE ZPP
  /CRITERIA=PIN(.05) POUT(.10)
  /NOORIGIN
  /DEPENDENT LN_RENT
  /METHOD=ENTER LOC_AMS LOC_UTR LOC_RANDSTAD LOC_CBD PUBL_TRAIN_500M LN_PROX_HIGH
PROX_SCHIP_50KM LN_AGE_NEW LN_ASSET_SIZE OPEN_7d24h USE_B USE_A LN_E_INDEX TRANS_1991
TRANS_1992 TRANS_1993 TRANS_1994 TRANS_1995 TRANS_1996 TRANS_1997 TRANS_1998 TRANS_1999
TRANS_2000 TRANS_2001 TRANS_2002 TRANS_2003 TRANS_2004 TRANS_2005 TRANS_2006 TRANS_2007
TRANS_2008 TRANS_2009 TRANS_2010 TRANS_2011 TRANS_2012
  /SCATTERPLOT=(*ZRESID ,*ZPRED)
  /RESIDUALS DURBIN HISTOGRAM(ZRESID) NORMPROB(ZRESID)
  /CASEWISE PLOT(ZRESID) OUTLIERS(2)
 /SAVE PRED ZPRED RESID ZRESID.
```

Residuals Statistics[a]

	Minimum	Maximum	Mean	Std. Deviation	N
Predicted Value	4,5138	5,8404	5,0881	,28837	370
Residual	-,61249	,75104	,00000	,18459	370
Std. Predicted Value	-1,991	2,609	,000	1,000	370
Std. Residual	-3,157	3,871	,000	,951	370

a. Dependent Variable: LN_RENT

Green/Non-green premium

```
REGRESSION
  /DESCRIPTIVES MEAN STDDEV CORR SIG N
  /MISSING LISTWISE
  /STATISTICS COEFF OUTS CI(95) R ANOVA COLLIN TOL CHANGE ZPP
  /CRITERIA=PIN(.05) POUT(.10)
  /NOORIGIN
  /DEPENDENT LN_RENT
  /METHOD=ENTER LOC_AMS LOC_UTR LOC_RANDSTAD LOC_CBD PUBL_TRAIN_500M LN_PROX_HIGH
PROX_SCHIP_50KM LN_AGE_NEW LN_ASSET_SIZE OPEN_7d24h USE_A USE_B E_GREEN_NONGREEN
TRANS_1991 TRANS_1992 TRANS_1993 TRANS_1994 TRANS_1995 TRANS_1996 TRANS_1997 TRANS_1998
TRANS_1999 TRANS_2000 TRANS_2001 TRANS_2002 TRANS_2003 TRANS_2004 TRANS_2005 TRANS_2006
TRANS_2007 TRANS_2008 TRANS_2009 TRANS_2010 TRANS_2011 TRANS_2012
  /SCATTERPLOT=(*ZRESID ,*ZPRED)
  /RESIDUALS DURBIN HISTOGRAM(ZRESID) NORMPROB(ZRESID)
  /CASEWISE PLOT(ZRESID) OUTLIERS(2)
/SAVE PRED ZPRED RESID ZRESID.
```

Simple linear regression on energy consumption

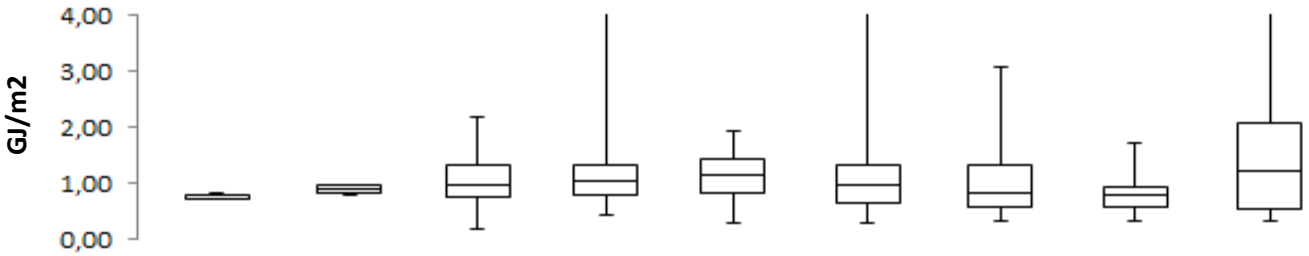
Model ENERGY	R Square	Adj R square	SS	df	MS	F	Sig.
Regression	**0,020**	**0,014**	0,594	1	0,594	3,600	0,059
Residual			29,683	180	0,165		
Total			30,276	181			

Model ENERGY	B	Std. Error	Beta	t	Sig	Partial	Part
(Constant)	1,226	0,062		19,864	0,000		
ENERGY	0,094	0,050	0,140	1,897	0,059	0,140	0,140

Model ENERGY_THEORY	R Square	Adj R square	SS	df	MS	F	Sig.
Regression	**0,739**	**0,737**	18,914	1	18,914	370,136	0,000
Residual			6,694	131	0,051		
Total			25,608	132			

Model ENERGY_THEORY	B	Std. Error	Beta	t	Sig	Partial	Part
(Constant)	0,339	0,055		6,193	0,000		
ENERGY_THEORY	1,200	0,062	0,859	19,239	0,000	0,859	0,859

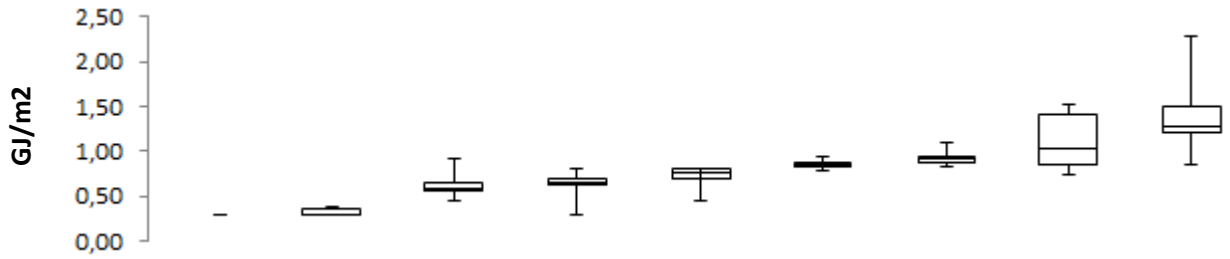
Descriptives energy consumption



Actual energy use	A++	A+	A	B	C	D	E	F	G
N	2	4	52	28	27	31	24	13	24
Average	0,775	0,895	1,055	1,160	1,128	1,093	1,025	0,818	1,489
SD	0,068	0,089	0,460	0,694	0,461	0,734	0,667	0,351	1,131
Min	0,727	0,800	0,190	0,440	0,300	0,290	0,340	0,320	0,340
q1	0,727	0,810	0,750	0,775	0,820	0,650	0,573	0,585	0,538
Median	0,775	0,900	0,970	1,045	1,160	0,970	0,840	0,800	1,220
q3	0,775	0,975	1,318	1,328	1,440	1,340	1,338	0,950	2,063
Max	0,820	0,980	2,180	4,260	1,940	4,230	3,090	1,710	4,900
Lower bound	0,160	0,754	0,927	0,891	0,945	0,824	0,743	0,606	1,011
Upper bound	1,389	1,036	1,183	1,430	1,310	1,362	1,306	1,031	1,966

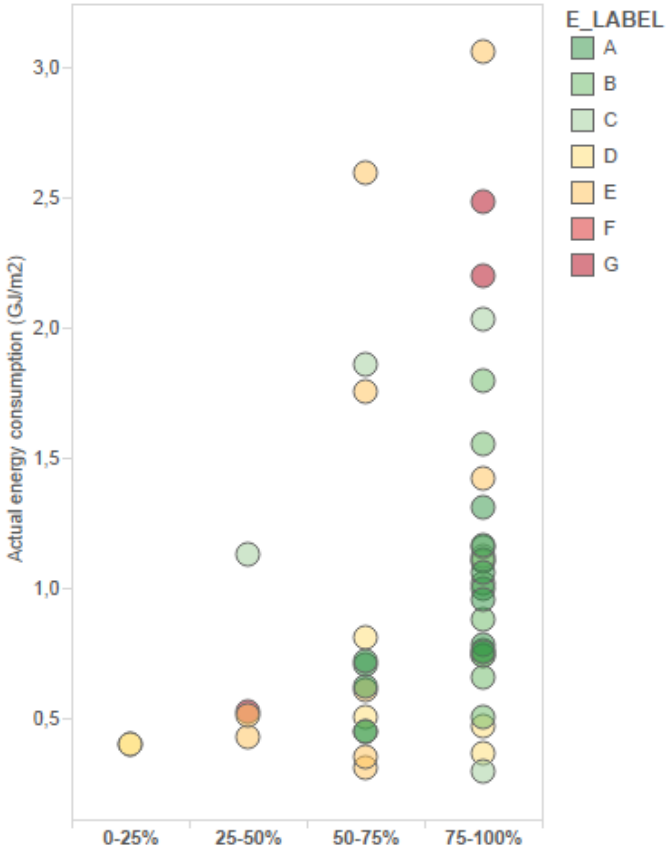
Next table provides us with an overview of the theoretical energy consumption between the energy labels.

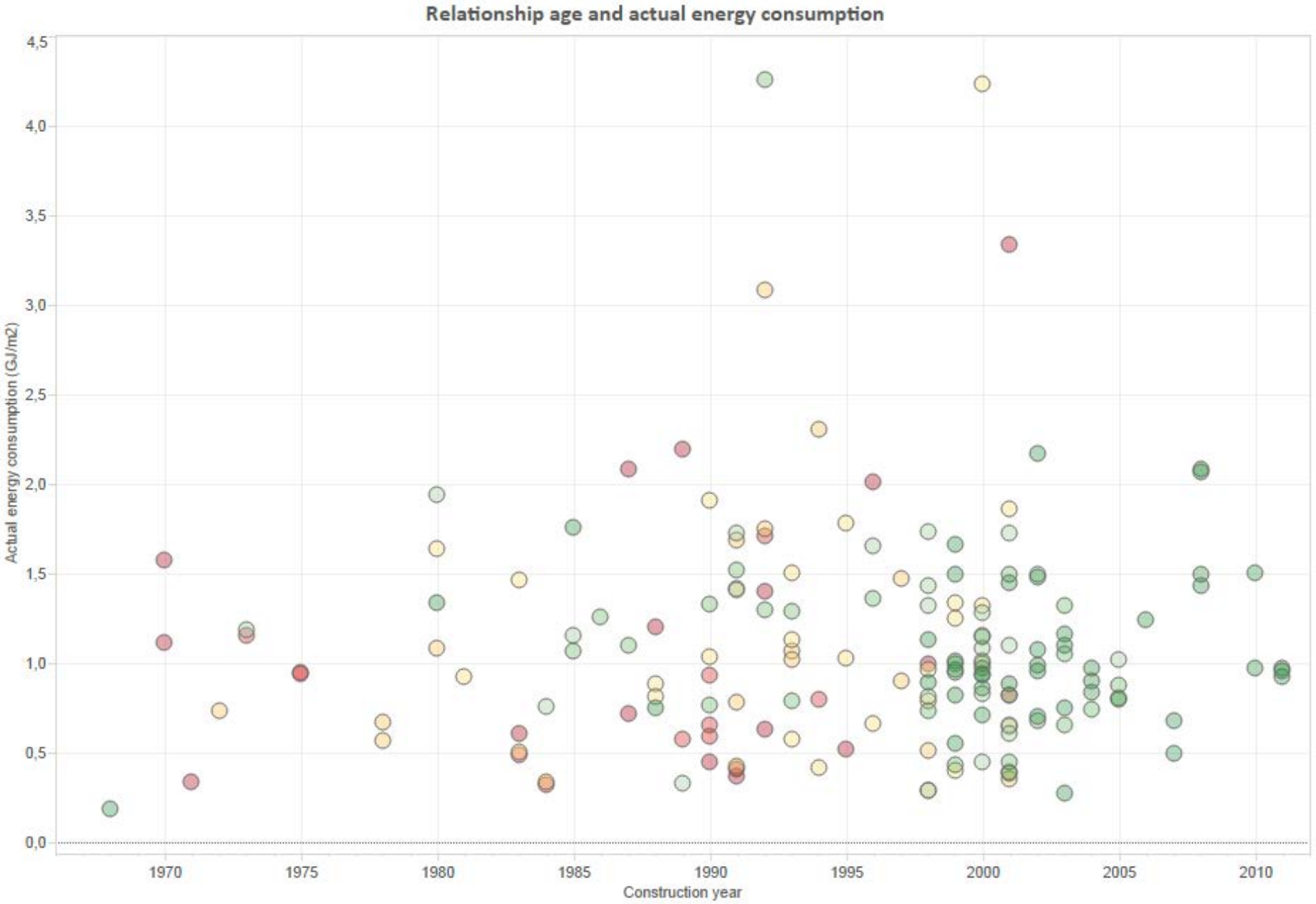
Just like the graph at the beginning of the section showed us, there is a general trend in the data which gradually increases when the energy performance index rises. Again, this is not strange since the theoretical energy consumption is a major part of the energy performance equation.

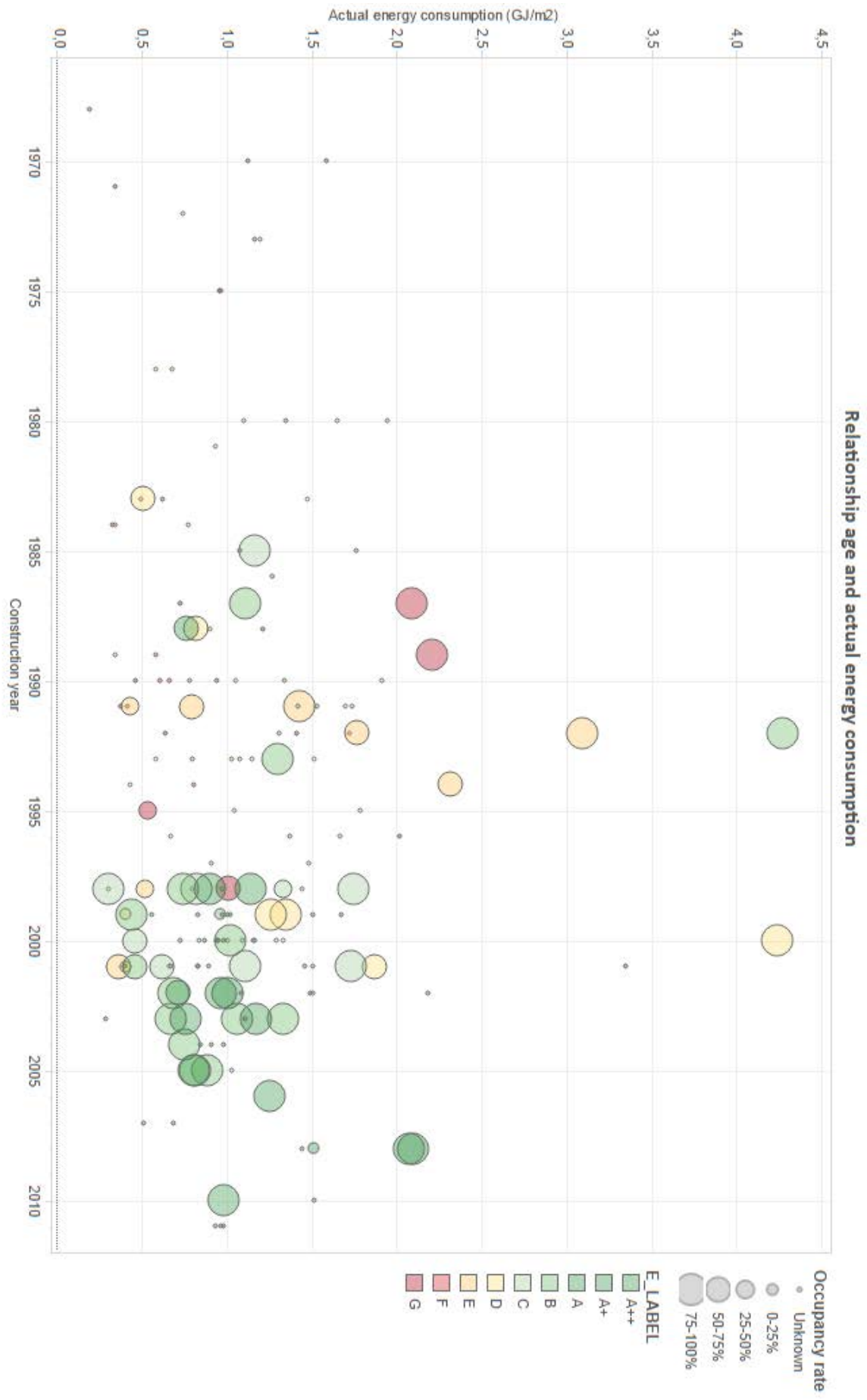


Theoretical energy use	A++	A+	A	B	C	D	E	F	G
N	2	3	36	16	14	22	15	9	16
Average	0,290	0,342	0,601	0,645	0,761	0,846	0,920	1,090	1,389
SD	0,290	0,052	0,085	0,117	0,152	0,042	0,069	0,293	0,386
Min	0,290	0,290	0,460	0,290	0,440	0,780	0,830	0,740	0,860
q1	0,290	0,290	0,558	0,629	0,705	0,824	0,880	0,844	1,209
Median	0,290	0,361	0,581	0,658	0,763	0,842	0,911	1,033	1,283
q3	0,290	0,361	0,650	0,704	0,801	0,865	0,949	1,421	1,501
Max	0,290	0,380	0,920	0,800	0,700	0,940	1,090	1,520	2,290
Lower bound	-	0,215	0,572	0,580	0,669	0,826	0,881	0,845	1,175
Upper bound	-	0,471	0,631	0,710	0,852	0,866	0,958	1,335	1,603

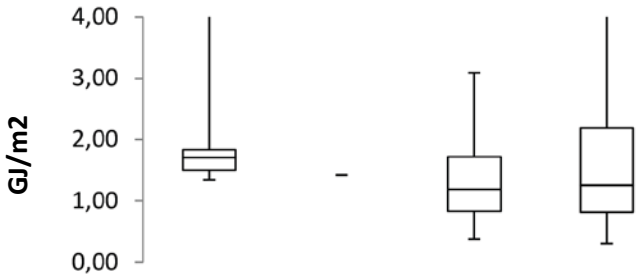
Energy certificates and actual energy consumption




Relationship age and actual energy consumption
Actual energy consumption (GJ/m2)
4,5
4,0
3,5
3,0
2,5
2,0
1,5
1,0
0,5
0,0
1970
1975
1980
1985
1990
1995
2000
2005
2010
Construction year

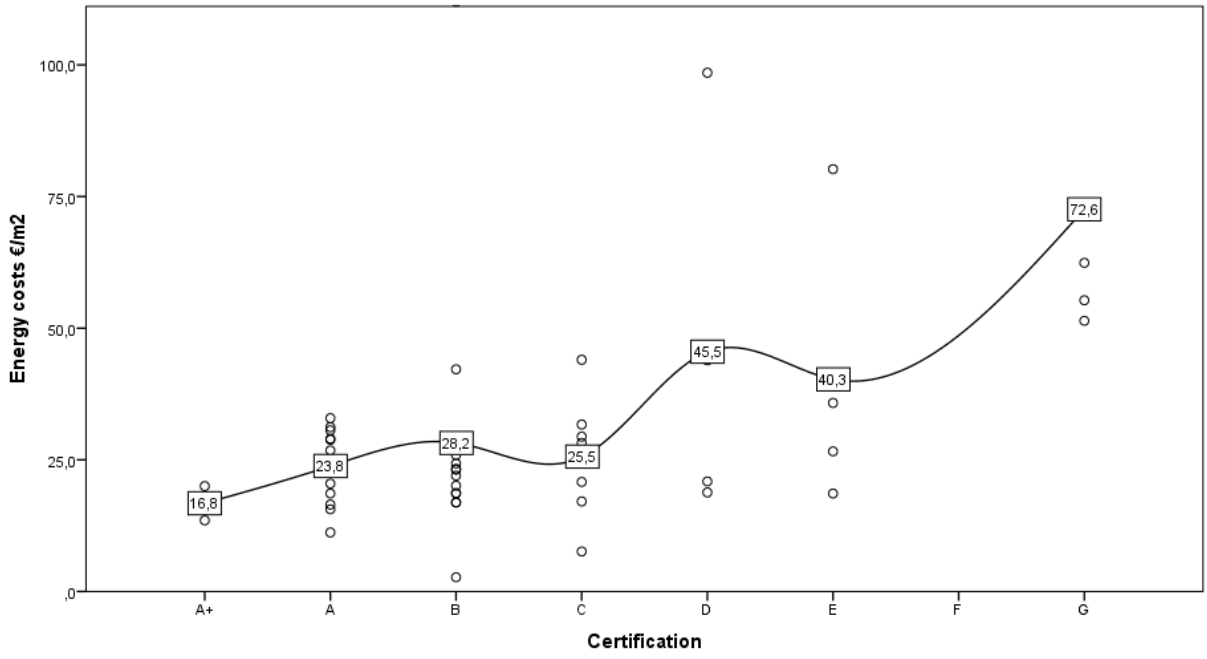

Relationship age and actual energy consumption
Actual energy consumption (GJ/m2)
0,0
0,5
1,0
1,5
2,0
2,5
3,0
3,5
4,0
4,5
Construction year
1970
1975
1980
1985
1990
1995
2000
2005
2010
Occupancy rate
Unknown
0-25%
25-50%
50-75%
75-100%
E_LABEL
A++
A+
A
B
C
D
E
F
G

Actual energy consumption filtered on occupancy rate 75-100% and user intensity



User intensity	0	<30m2	20-30m2	>20m2
N	20	1	20	10
Average	1,345	1,420	1,296	1,618
SD	1,132		0,651	1,148
Min	0,660		0,369	0,300
q1	0,815		0,828	0,815
Median	1,020	1,420	1,190	1,255
q3	1,153		1,720	2,188
Max	4,900		3,090	4,230

Interpolation line through averages of energy costs versus certification



Certificate	n	Average	%	%	Median	%	%
A+	2	16,75	-30%	23%	16,75	-34%	28%
A	12	23,8	-16%	33%	25,5	13%	43%
B	14	28,2	10%	39%	22,6	-20%	38%
C	7	25,5	-44%	35%	28,2	-60%	48%
D	4	45,5	13%	63%	71,2	128%	121%
E	4	40,3		56%	31,2		53%
F	0	-			-		
G	4	72,6		100%	58,9		100%

Overview of costs per certificate

	Data based on trend line				Data based on raw (observation) data			
A	LFA	8402			LFA	8402		
	Rental price	€ 1.570.250			**Rental price**	€ 1.566.973		
	Energy costs	€ 193.293			Energy costs	€ 214.350		
			€ 1.763.543	**€ 195,9**			€ 1.781.323	**€ 197,9**
B	LFA	8402,0			LFA	8402,0		
	Rental price	€ 1.533.682			**Rental price**	€ 1.533.365		
	Energy costs	€ 234.606			Energy costs	€ 253.929		
			€ 1.768.288	**€ 196,5**			€ 1.787.294	**€ 198,6**
C	LFA	8402			LFA	8402		
	Rental price	€ 1.512.291			**Rental price**	€ 1.517.401		
	Energy costs	€ 284.749			Energy costs	€ 284.749		
			€ 1.797.040	**€ 199,7**			€ 1.802.150	**€ 200,2**
D	LFA	8402,0			LFA	8402,0		
	Rental price	€ 1.497.114			**Rental price**	€ 1.501.437		
	Energy costs	€ 345.609			Energy costs	€ 409.725		
			€ 1.842.723	**€ 204,7**			€ 1.911.162	**€ 212,4**
E	LFA	8402			LFA	8402		
	Rental price	€ 1.485.342			**Rental price**	€ 1.486.314		
	Energy costs	€ 419.476			Energy costs	€ 362.700		
			€ 1.904.818	**€ 211,6**			€ 1.849.014	**€ 205,4**
F	LFA	8402,0			LFA	8402,0		
	Rental price	€ 1.475.723			**Rental price**	€ 1.473.711		
	Energy costs	€ 509.132			Energy costs	€ 513.000		
			€ 1.984.855	**€ 220,5**			€ 1.986.711	**€ 220,7**
G	LFA	8402			LFA	8402		
	Rental price	€ 1.467.591			**Rental price**	€ 1.462.788		
	Energy costs	€ 617.949			Energy costs	€ 653.175		
			€ 2.085.541	**€ 231,7**			€ 2.115.963	**€ 235,1**

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