How Green Buildings Mitigate Risk

Master's Thesis

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Executive Summary

Problem Statement

Since its launch in 1998, the Swiss Minergie label for energy-efficient and sustainable buildings is on its road to success. Thereby, Minergie certifies different kinds of constructions and sets new standards in the building industry. Building according to Minergie standards entails extra costs for certification, planning and building materials, which will cost up to 10% more than conventional buildings. However, as the surge of new Minergie certifications points out, there seems to be a significant demand for Minergie buildings on the Swiss real estate market. Moreover, there is academic evidence that the residential real estate market rewards Minergie buildings with higher sales prices and rents compared to conventional counterparts. This difference is also called a green premium and expresses the higher willingness to pay for a green building than for a conventional building exhibiting the same characteristics and location.

The study of Salvi et al. (2008) shows by means of hedonic regression analysis, that there exists a green premium of transaction prices for single-family homes of 7% and for condominiums of 3.5% in the canton of Zurich. Therefore, the premium prices for Minergie at least break even with the up-front additional costs paid of 5 to 10% on average. In a more recent study, Salvi et al. (2010) examines the residential rental market in Switzerland, more specifically in Zurich. The authors again run hedonic regression models and the results reveal a nationwide green premium for net rent of 6.0% and for the canton of Zurich a premium for net rent of 6.2% in the residential real estate sector. As the two leading Swiss studies from above show, research has been mainly focused on the residential sector, whereas little research exists for the commercial sector. This might be mostly explained by the fact that 87% of all definite Minergie certified buildings are single- and multi-family homes. Moreover, data availability for sensitive property information is scarce. Thus, these circumstances led to a research gap on green premia in the commercial sector of Switzerland. Additionally, the existing studies concentrate exclusively on premia on sales prices and rents, whereas risk-mitigating factors as higher occupancies are left out. However, a risk-return conscious investor will need to asses both dimensions in order to take an educated investment decision. Hence, the question arises if and to what extent Minergie-certified commercial office buildings show premia in sales prices and

rents compared to their non-certified counterparts. Moreover, the question remains if and how green buildings affect occupancy rates in the residential as well as commercial market.

Objective

This study aims at complementing the existing literature on green sales- and rent premia in the residential sector with evidence in the commercial real estate sector in Switzerland. Moreover, this master thesis examines a possible occupancy premium in the commercial as well as the residential sector. All three premia on sales, rents and occupancies are analyzed by running hedonic regression models. This allows for the isolation of the ceteris paribus effect of a Minergie certification on prices, rents and occupancies compared to a conventional property in a quality adjusted setting. Furthermore, the empirical results shall be quantitatively as well as qualitatively reasoned from an investor's perspective.

Approach & Theoretical Basis

The master thesis structures itself mainly into three parts. In a first step the theoretical basis of the research topic shall be provided. A brief history of the emergence of green building activities in real estate markets embeds the subject-matter into a broader global context and shows how the Swiss Minergie label entered the green market. Furthermore, the role of green building labels is examined from a theoretical, economic point of view as well as their practical implementations in the form of concrete national and international labels are outlined. Thereby, the object of study, the energy-efficient Swiss Minergie label is discussed in more detail. Especially the different Minergie standards (Minergie, Minergie-P, Minergie-A, -Eco) and their requirements are explained more thoroughly. Moreover, the current literature that esimates the impact of green buildings on a property's risk and return is presented and compared with each other in order to prepare expectations on how green buildings exhibit sales-, rent- and occupancy premia.

The second part of the thesis conducts the empirical analysis regarding sales-, rent- and occupancy premia. Rosen (1974) as well as the empirical approaches of the reviewed papers deliver the theoretical foundations to investigate the empirical data by means of hedonic models. Thereby,

asking data for the years 2009-2016 from the real estate platform homegate.ch is analyzed for the sales- and rent premia. Additionally, further locational and time trend variables are added based on the addresses and the time of availability of listings. After cleaning up the raw data, samples arise consisting of 1'241 listings for sale and 1'609 listings for rent in total. Thereof, 79 and 75, for sale and rent respectively, are certified according to a Minergie standard. These small sample sizes for commercial office buildings do not allow for differentiation between various degrees of certification, e.i. Minergie, Minergie-P, Minergie-A and the supplement -Eco. However, the samples sizes are big enough to make statistically significant statements about Minergie certifications in general. Since the listings on rental properties naturally lack of information on occupancy, the homegate.ch data set is inappropriate to further analyze the occupancy premium. For this purpose, a data set from REIDA (2016) and its operation partner Meta-Sys AG for the years 2014-2015 is investigated. Compared to the homegate.ch listing data, REIDA represents real contractual data and includes information on vacancies of the buildings, which homegate.ch does not. Although, the sample size for commercial real estate is limited when it comes to inferential statistics, the residential sample form REIDA is comprehensive enough to draw statistical conclusions about a potential occupancy premium in the residential real estate sector. As the data from REIDA is based on contracts, there is only information about whether a given space is occupant or vacant. This binomial information on occupancy merely allows for running logit models. However, since logit models are difficult to interpret, single contracts are assigned and aggregated to building levels. The aggregation results in sample sizes of 16 Minergie buildings in the commercial and 37 Minergie buildings in the residential real estate sector. The consolidation of the single contracts on a building level enables the calculation of occupancy rates for Minergie-certified and conventional buildings. Hence, hedonic regression models can be applied to regress building and locational attributes on occupancy rates and to examine whether an occupancy premium exists on the Swiss commercial and residential real estate market.

In the third and last part of the master thesis, the empirical results regarding the sales-, rent- and occupancy premia are reasoned and discussed from an investor's point of view. For this purpose, a cap rates based analysis merges the insights from the different premia in an exemplary contemplation. Moreover, it shall be quantitatively reasoned whether and to what extent energy savings from Minergie buildings pay. A qualitative discussion about possible explanations why there exists a high

willingness to pay for Minergie properties concludes this part.

Results

The data sets for the sales-, rent- and occupancy premia are analyzed with appropriate hedonic regression models. Thereby, the green premia for sales-, rent- and occupancy are successfully isolated in order to undertake a first attempt to close the scientific gap in this field of study.

Results based on the homegate.ch data set reveal, that Minergie certification exhibits a highly significant sales premium of 23.79% per square meter usable area in the listed data. The asking data for rents also shows with 16.75% a highly significant premium for Minergie buildings compared to their conventional counterparts. Overall, it can be stated that these results underpin and confirm the existence of a green premium on sales and rents in the Swiss commercial real estate market. What is more, these insights concur with what earlier studies find regarding sales- and rent premia on the office sector of other developed countries as the U.S.

The results from the contractual data of REIDA can not confirm a statistically significant occupancy premium in the commercial sector, even though the coefficient of the hedonic OLS model indicates the expected sign. The lack of statistical significance can be reasoned by the too small sample size of Minergie buildings in the commercial sample. Nevertheless, the logit model reveals a positive causality between Minergie and occupancy on a 90% level of confidence. The hedonic OLS regression results of the residential sector show an occupancy premium of 2.06%, ceteris paribus. This result is statistically significant even on a 95% confidence level. To conclude, there is evidence that a green premium exists for the commercial and residential sector in Switzerland. However, small sample sizes and limited amount of control variables restrict the significance of the analysis.

In the last part of the thesis a comparative cap rates analysis consolidates the results found for the sales-, rent- and occupancy premia. A lower risk premia for Minergie certified buildings underpins what has already been found in other studies. Moreover, an exemplary calculation reveals that additional money paid for Minergie will only be paid back after 98 years, if only energy-cost savings are taken into consideration. Expressed differently, energy savings can only explain about 22% of a premium paid for a commercial Minergie building in Switzerland. The remaining high

willingness to pay is ascribable to Minergie's superior comfort and enhanced conservation of value.

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List of Abbreviations

BAFU	Bundesamt für Umwelt
BFE	Bundesamt für Energie
BREEAM	Building Research Establishment Environmental Assessment Method
BWO	Bundesamt für Wohnungswesen
CBD	Central Business District
CCRS	Center for Corporate Responsibility and Sustainability
DCF	Discounted Cash Flow
DGNB	Deutsche Gesellschaft für Nachhaltiges Bauen
EnDK	Konferenz kantonaler Energiedirektoren
IRR	Internal Rate of Return
LEED	Leadership in Energy Environmental Design
OLS	Ordinary Least Squares
OVB	Omitted Variable Bias
REIDA	Real Estate Investment Data Association
U.K.	United Kingdom
U.S.A.	United States of America
USGBC	United States Green Building Council
VIF	Variance Inflation Factor
ZKB	Zürcher Kantonalbank

Chapter 1

Introduction

From 2000-2014, buildings consumed an average of 45.5% of the total domestic energy consumption in Switzerland. This total energy consumption for buildings is dominated by the space heating consumption which accounts for the lion's share at 75% (BFE, 2015a). Heating oil on its own has a share of about 16% of the total final energy consumption by energy source in Switzerland for the year 2014 (BFE, 2015b). These and similar statistics in other developed countries demonstrate that sustainability measures are especially effective in the real estate sector, as buildings consume a great share of total energy resources.

Since the launch of the first international green building label BREEAM (Building Research Establishment Environmental Assessment Method) in 1992, sustainable buildings constitute an integral part of the global real estate sector. Also in Switzerland, the green building label Minergie has become well established since its launch in 1998. The fact that awarded Minergie (2015a) certifications have increased tenfold for the last ten years underpins its road to success. Consequently, this raises the question if and to what extent a Minergie certification outperforms a conventional building in terms of sales prices, rents and occupancies in the Swiss real estate market. Existing studies from Salvi et al. (2008) and Salvi et al. (2010) focus on the premia in prices and rents of green buildings in the residential sector. Both studies were conducted at the Center for Corporate Responsibility and Sustainability (CCRS) at the University of Zurich in corporation with Zürcher Kantonalbank (ZKB). The findings of Salvi et al. (2008) show sales price premia of 7% for single-family homes and

3.5% for condominiums based on transaction data of the residential sector in the canton of Zurich. Two years later Salvi et al. (2010) estimate a rental green premium of 6.0% nationwide and a 6.2% green premium on monthly net rents in the residential sector for the canton of Zurich. These studies focused on sales prices and rents in the residential real estate sector. One reason for the focus in residential real estate might be the fact that the biggest share of Minergie certified buildings constitute residential buildings and thus a sufficiently large database on residential buildings is available. Nonetheless, the question remains if similar green premia exist in the commercial real estate sector. In order to answer this question this thesis investigates sales price and rental listing data of office buildings from the real estate platform homegate.ch (2015). Moreover some additional locational and time trend variables are added to hedonic regression models in order to best isolate the effect of a Minergie certification on an office building. Besides complementing the current state of research with the green premia of sales prices and rents in the office sector in Switzerland, this work further aims to investigate a possible occupancy premium for Minergie certified buildings. For this purpose, a data set from REIDA (2016) and its operation partner Meta-Sys AG is investigated. Compared to the homegate.ch data set, REIDA represents real contractual data and additionally includes information on vacancies of the buildings, which homegate.ch does not. A disadvantage of the REIDA database is that its sample size for commercial real estate is limited when it comes to inferential statistics. However, the residential sample from REIDA is comprehensive enough to draw statistical conclusions about a potential occupancy premium in the residential sector.

This work is mainly structured into three parts. In the first part, Chapter 2 briefly outlines the historical emergence of green building activities in real estate markets. Thereafter, Chapter 3 deals with the role of green building labels. In a first step, Chapter 3.1 discusses the role of green building labels from an economic point of view. Thereafter, Chapters 3.2 and 3.3 introduce the Swiss green building label Minergie and its standards. Furthermore, the most recent development of the Minergie label is outlined in the following chapter. Moreover, some of the most important national and international green building labels are presented in Chapter 3.5 and finally compared in a summarizing overview table. Chapter 4 presents the existing literature on green buildings in Switzerland as well as some of the most important worldwide studies that estimate the impact of green buildings on a property's risk and return.

In the second part of this work, empirical data from homegate.ch and REIDA are investigated using appropriate hedonic models (Rosen, 1974). Based on the data set from homegate.ch a sales and rent premium of green office buildings in Switzerland are estimated. From an investors point of view, these two premia can be seen as return-enhancing dimensions. However, as a risk-return conscious investor needs to assess both dimensions, a third possible premium on occupancy rates is evaluated based on the REIDA data set, which includes information on vacancy. This third premium on occupancies extends the investor's risk-return contemplation on how green buildings mitigate risk. The empirical part, outlined in Chapter 5, firstly introduces the theoretical background of the hedonic model. Then, the data set and its variables are defined, described and hypothesised. Furthermore, descriptive statistics shall give the reader a feeling for the data used. In a last part of Chapter 5, the results of the different premia are validated and discussed.

In the third and final part of this work the sales-, rent- and occupancy premia shall be reasoned and discussed from an investors point of view. In the first part a cap rates based analysis is conducted and illustrated with an example, which merges the insights from the different premia in a summarizing contemplation. Thereby, the results from the sales- and rent premia influence the calculated cap rate and its risk premium and thus contribute to how green buildings mitigate risk. In a second step, a quantitative analysis examines an example if and to what extent energy savings from Minergie buildings pay. The last part of this chapter qualitatively discusses possible explanations as to why there exists a high willingness to pay for Minergie buildings.

The thesis concludes with a summary of the findings and how the results contribute to the current research in this field. Moreover, some guidance for further research shall be given.

Chapter 2

Emergence of Green Buildings in Real Estate Markets - A Brief History

In this section, the historical development of green buildings worldwide, and the Swiss green building label Minergie are discussed. In order to understand the green building movement, some historical facts need to be taken into account.

The Club of Rome, a global think tank, started with its publication of "The Limits to Growth" in 1972 a discussion about scarcity and finitude of planet Earth's resources. Moreover, this publication highlighted the need for a worldwide rethinking towards sustainable economic activity (Schelling, 2013). In the same decade, the oil price shocks caused by the oil crisis in the years 1973 and 1979 triggered a new thinking about reliance on oil and sustainability. As a consequence there emerged a new interest in energy efficiency, solar technologies, better insulation for homes and commercial buildings and further forms of sustainable technologies. However, this strong interest did not last long and decreased mainly due to falling energy prices. Only in the early 1990s a renewed interest in sustainable issues reemerged as a result of various incidents such as the Brundtland Report in 1987 and the United Nations Conference on Sustainable Development in 1992, also known as the Rio Conference (Kibert, 2004). These events and the rethinking towards a more sustainable world led to the first green building rating system, the British BREEAM, established in 1992. Only one year later, in 1993 the U.S. Green Building Council (USGBC) was formed in Washington DC, out of which

arose the international green building label LEED (Leadership in Energy & Environmental Design) in 1998 (Kibert, 2004; USGBC, 2015a). In the same year the Swiss Minergie standard for sustainable buildings was established. At about the same time, an interdisciplinary research group at the Swiss Federal Institute of Technology Zurich developed the vision of a 2000-Watt-Society as a long-term goal. It is understood as a holistic approach, which aims at reducing energy demand to a sustainable level by affecting building activity, mobility, spatial planning, consumption etc. (Schelling, 2013). According to Leib und Gut (2009) Minergie used a simple approach to merchandise their label by means of a pull-strategy, lower energy indices through marketing. Moreover, their idea about the Minergie standard was easy to communicate, i.e. Minergie leads to higher comfort and lower energy demand by means of up-front additional costs, which are affordable for the owner. Additionally, it was crucial for the success of the Minergie label that buildings were enabled to be officially certified and that the standard was accepted and applied by public building contractors (Schelling, 2013). All this paved the way for success of the Swiss Minergie label, which represents the state of the art of sustainable green buildings in Switzerland.

Chapter 3

The Role of Green Building Labels

3.1 The Role of Green Building Labels - An Economic Perspective

In the following, some economic implications of green building labels shall be reasoned and discussed according to Meier (2008). Hereby, the term *label* is used synonymously for *certificate* in this master's thesis, which means that a product, or more specifically to this thesis, a building is officially proofed to meet certain requirements (Merriam-Webster, 2016). Therefore, labels signal the presence of certain characteristics of a building and a certificate proves it has met certain minimum requirements. Thus, this idea is also referred to as *signaling* in information economics. Hereby, the supplier of a product, or the owner of a building, produces a signal for the potential buyer or tenant, which conveys the information about the presence of certain buildings characteristics (Frank, 2005). In the case of a green building certificate, information about low energy demand and other sustainability traits are embodied and verified by the corresponding label. Additionally, by means of different degrees of certifications, the producer of the signal is able to differentiate between various levels of energy-efficiency and sustainability of the green building. In general, a green building label is especially valuable if the verification of the buildings' characteristics is associated with great cost or if it is impossible for the potential buyers or tenants to verify the information on their own. This is often the case when information is asymmetrically distributed amongst the parties involved, as is the case in real estate markets. On the one hand, the developer of a real estate project is involved from

the very beginning of the construction of a building and thus owns information about quality and sustainability of the building process and to what extent they were implemented. On the other hand, the interested parties in renting or even buying the building are often only able to consider the construction after it has been finished. Hence, the interested parties are only able to screen the building on the existence of sustainability standards with considerable additional costs. This is the point where a sustainability label acts as a signal, which is sent from a trusted independent third-party institution to facilitate or even enable a transaction. Thereby, as long as the costs for certification are below the ones of the interested parties for proving the sustainability characteristics in hindsight, the existence of a green building label is justified, as it makes the transaction more efficient than without.

Besides the signalling function of an eco-certified building, there might be other positive impacts of a green building label, for example standardization and comparability, as Meier (2008) pronounces in her paper.

Standardization and *Comparability*

As a green building label sets a clearly defined standard on which minimum requirements have to be met, it standardizes the way a green building has to be constructed. In that way the label facilitates and makes the process of planning for a developer and architect more efficient, as the standards precisely determine how sustainability has to be implemented. Moreover, the assessment of a green building also allows for classification into different degrees of "greenness". Therefore, most green building labels grant different grades for different degrees of fulfilment of sustainability. Thus, not only a standardization but also a product differentiation, which allows for comparison between green labels, goes along with certification.

Facilitates Award of Subsidies

Public authorities, financial institutions etc. could make building labels a condition for receiving subsidies, better conditions or other advantages. Without the existence of a building label, the examination whether a project qualifies for subsidies or better conditions is very complicated and causes great costs. Thus, the existence of a certification facilitates such examinations and increases efficiency.

Market Segmentation

As mentioned above, building labels often show tiered levels for example Platinum, Gold, Silver and Certified for the international LEED[1] label. This allows for the emphasis of different degrees of sustainability or highlighting specific aspects of sustainable buildings. Therefore, the real estate market becomes more transparent and its transactions more efficient.

The above reasoning screens the mechanisms of green labels from an economic perspective. But what are their consequences for investors and occupiers of these green buildings? The following section discusses the argumentation of Fuerst and McAllister (2011a) on how green labels influence the value of commercial office buildings by means of various channels. In general, investors and occupiers might profit from subsidies, tax reliefs and reduced regulatory barriers for example. Investors in particular might benefit from increased occupancy rates, lower utility costs[2] and lower depreciation rates. Moreover, they insure against possible future regulatory tightening. From an investors' perspective these benefits should contribute to a lower risk premium. According to Fuerst and McAllister (2011a), often cited benefits for occupiers are improved productivity due to lower employee turnover, absenteeism or increased output. Moreover, they profit from reduced utility costs and reputational benefits. All these advantages have an impact on the valuation of a commercial office building. Its value can be expressed as a discounted sum of all future cash flows or net incomes and is written as follows:

$$V = \sum_{t=0}^{T} \frac{(R_t - C_t)(1+g)^t}{(1+i)^t} \tag{3.1}$$

Hereby, V corresponds to the current capital value. R_t is rental income and C_t are the operating costs and accruals. Thus, $R_t - C_t$ is the Net Operating Income (NOI). Moreover g is a constant growth rate and i is the discount rate or target rate of return, which consists of the risk free rate and a risk premium. Since ownership of a property is unlimited in time t, Equation 3.1 can be written as a perpetuity, where the NOI is divided by the *Cap Rate*:

[1] More on international labels in Chapter 3.5.
[2] If rental contracts are based on gross leases.

$$V = \frac{NOI}{i - g} \Leftrightarrow V = \frac{NOI}{Cap\ Rate} \tag{3.2}$$

As mentioned above, green building labels might affect the variables of this valuation model in various ways. For instance, occupiers should be willing to pay higher rents R_t because labeled buildings improve business performance [3] and enhance reputation. Green buildings might also reduce costs of ownership C_t by lower vacancies and reduced operating costs. Moreover, Fuerst and McAllister (2011a) argue that the risk premium may be lower for sustainable buildings, as the income streams are expected to show less volatility compared to conventional buildings. This reasoning about how the attribute of a green building label might affect the pricing of a property will be reconsidered in Chapter 6. In the course of this, the results found on sales-, rent- and occupancy premia in this study will be holistically implemented in a cap rates based analysis.

3.2 Minergie - The Swiss Green Building Label

In the subsequent sections the characteristics and requirements of the Swiss Minergie label and its different standards are outlined. According to Salvi and Syz (2011), the "Verein Minergie" constitutes the predominant eco-labeling and eco-certifying institution in Switzerland and thus serves as the foundation for scrutinizing the causality between sales price and rent premia as well as vacancy rates of eco-certified office buildings and its conventional counterparts in this work.

"Verein Minergie" is an association supported by the economy, the cantons and the Federal Government of Switzerland. Minergie represents a building standard and its term is understood as a quality label for new and modernized constructions of all types of buildings (Minergie, 2015b). According to Verein Minergie the association promotes efficient use of energy as well as renewables in order to lower environmental pollution. Additionally, Minergie shall enhance quality of living and competitiveness. Moreover, Minergie aims to reduce consumption of non-renewable resources to an environmentally sustainable level (Minergie, 2015c).

Minergie (2015b) lists three main advantages of its building standard on their homepage: superior

[3] Evidence for higher business performance of green buildings is for example found in the paper of Kats et al. (2003).

comfort, higher energy cost savings and enhanced conservation of value. The reasons for a higher thermic comfort in buildings with well insulated and dense outer walls, floors and roofs are warmer inner surfaces of the building envelope, no radiation of cold air as well as avoidance of draft. Additionally, the building is better protected against high temperatures in summer time. Building quality strongly influences the medium to long term value of a property. The study from Salvi et al. (2008) called "Minergie macht sich bezahlt" finds additional value or a green premium for a single-family Minergie house compared to a conventional building ceteris paribus of about 7 %. For a multi-family home the green premium or surplus price amounts to 3.5 %.

The main focus of a Minergie certified building lies in living and working comfort of its dwellers. This convenience is enabled through a valuable building envelope and a systematic ventilation. The specific energy consumption serves as a guide variable in quantifying building quality. This and other requirements (see above) act as benchmarks for classifying buildings into different Minergie standards (Minergie, 2015b). Verein Minergie certifies three different building standards: Minergie, Minergie-P and Minergie-A as well as the supplement -Eco. Among all definitely certified buildings, the Minergie label, the basic certification, is given to 90.5% of all Minergie buildings, and thus constitutes the most important label for comfortable and energy-efficient buildings in Switzerland. Compared to the basic label, the Minergie-P Standard aims to reduce even more energy consumption and currently accounts for 8.4 %. The strictest standard, Minergie-A, only entered the market in 2011 and hence represents not more than 1 % of the whole pie (Minergie, 2015a).[4] Table 3.1 exhibits the standards percentage share in more detail and reveals that the supplement -Eco is stronger represented proportionally the higher the level of certification.

[4] These percentage numbers of the three standards include also the buildings, which are additionally certified with the supplement -Eco.

Table 3.1 – Definitely Certified Minergie Labels

Standard	Percentage Share
Minergie	89.8%
Minergie-ECO	0.9%
Minergie-P	6.9%
Minergie-P-ECO	1.4%
Minergie-A	0.6%
Minergie-A-ECO	0.4%
Total	100.0%

Source: Minergie (2015a)

3.3 Minergie Standards

In the following all three standards and the supplement -Eco are discussed in more detail. Furthermore, it shall be shown which requirements for each standard are compulsory to obtain certification.

3.3.1 Minergie (Low Energy Buildings)

The "basic" Minergie standard constitutes the most important label for comfortable and energy-efficient buildings in Switzerland. Since its market entry in 1996, about 32'500 new buildings were constructed and certified according to this basic standard. The two most important characteristics of the Minergie basic standard are a good insulated building envelope combined with a replacement of ventilated air with a comfort ventilation[5]. Thereby, the building envelope is required to fall below the legal requirements by at least 10% (Minergie, 2015d). The principal aim of the Minergie label is to build high quality constructions, which meet the required standard and to charge for this certification. Prerequisites for certification are: (1) lowering energy demand by at least 25% and fossil energy consumption by at least 50% below the average state of the art; (2) Additional costs for building according to Minergie shouldn't exceed 10% compared to conventional buildings; (3) Built estates have to be at least as disposable as their conventional counterparts (Minergie, 2014).

The Minergie certification (also Minergie-P and Minergie-A) follows a specified structured pro-

[5] The term comfort ventilation is not normatively regulated. It stands for a simple, high quality ventilation system with heat recovery. Comfort ventilation is energy-efficient and satisfies high claims regarding noise, air draft and temperature.

cess: planners (architects or engineers) put in a request at the certification office of Minergie. Included in their request are all necessary calculations according to SIA-Norm 380/1 "Thermische Energie im Hochbau". In a second step, the building is regarded as provisionally certified while construction is ongoing and after completion the building gets definite certification. During and after construction, random samples are taken in order to assure quality of their standards (Minergie, 2015d).

First and foremost, Minergie targets low energy consumption and observance of the specified Minergie energy limit value. This Minergie limit value may not be exceeded so that certification can take place. Thus, for each building a weighted energy index has to be calculated. Minergie (2015e) defines the energy index as a measure of a buildings entire yearly net energy supply, related to the energy reference area (kWh/m^2 a). In other words, the energy demand per square meter of heated living space constitutes an ideal proxy for building quality of an edifice. This index takes different energy sources into account and weights them according to their rate of use and weighting factors. Therefore, a solar installation for example earns a weighting factor of 0 due to its eco-friendliness, whereas fossil energy fuels have a weighting factor of 1. In the end, the weighted energy index of the building has to be lower than the Minergie limit value to meet the requirements of the standard. For newly built residential (single or multi-family) the Minergie limit value amounts to 38 kWh/m^2 a [6] whereas for an administration office the boundary is 40 kWh/m^2 a. The corresponding numbers for modernizing buildings constructed prior to 2000 are 60kWh/m^2 a for residential and 55 kWh/m^2 a for administration buildings (Minergie, 2014). The requirements to get Minergie certified are therefore related to the heating energy demand and the overall energy demand. Although there are various ways to meet these requirements, it is crucial to regard the building as an integral system consisting of building envelope and housing technology, that is: heating, ventilation and water warming. Due to the strict regulations of the Minergie standard, the decision to get certified should be taken on time and well planned. Additionally, one should bear in mind that a certification for an existing building incurs notable additional expenditures, which might only be attainable through a complete renovation (Minergie, 2011).

[6] 38 kWh/m^2 a corresponds to 3.8 liter heating oil per square meter per year (Minergie, 2011).

3.3.2 Minergie-P (Nearly Zero Energy Buildings)

According to Verein Minergie (2015d), Minergie-P standard denotes and qualifies buildings, which seek an even lower energy consumption than the basic Minergie standard. Since its launch in 2003 over 2'300 buildings have been certified according to this stricter standard.

Minergie-P requires an independent building concept which focuses on low energy use. Thereby, passive heat sources like sun exposure shall contribute to the coverage of heat demand. Crucial to Minergie-P constructions is a very well insulated and airtight building envelope in order to trap heat longer inside the building during winter months. Compared with the basic standard, Minergie-P requires a building envelope which falls at least 40% below legal requirements. Additionally, each building is inspected for its airtightness. Moreover, usage of renewable energies is compulsory as well as high efficient home appliances with category A or cooling devices with category A+. The rules of use of Minergie (2013a) prescribe that additional costs for building according to Minergie-P standard shouldn't exceed 15% compared to conventional counterparts.

According to Minergie (2013a), the Minergie limit value for heating, cooling, warm water and ventilation amounts to 30 kWh/m^2 a for residential single and multi-familiy homes, which corresponds to a consumption of three litres of fuel oil per square meter of heated living space a year. The corresponding limit value for the amount of fuel oil for administration buildings is even lower at 2.5 litres.

3.3.3 Minergie-A (Plus-Energy Buildings)

The latest standard of Verein Minergie (2015d) was only launched in 2011 and represents the strictest Minergie standard. The most important prerequisite of this standard is that it requires its energy balance to at least break even. This means that the effort for space heating, water warming, ventilation and if necessary air-conditioning has to be covered entirely by renewable energies in the annual average. Consequently, energy sources such as solar energy, biomass, geothermal heat and heat from the outside air are deployed to reach that ambitious goal.

The main requirement of Verein Minergie (2013b) to get Minergie-A certified therefore constitutes a limit value of 0 kWh/m^2 a year. In order to meet this standard, a typical Minergie-A building

often combines different energy generation systems. For example a geothermal heat pump can be combined with solar cells or another combination could be solar panels and wood heating. As for the Minergie-P standard, Minergie-A also requires energy efficient equipment, e.i. household appliances and lighting. In addition to the higher standards, Minergie-A takes "grey energy" into account. Grey energy of a building is defined as the cumulative energy demand for building and demolition of the construction. It is documented under the assumption of an average building life and measured as the amount of energy per square meter and year (kWh/m^2 a). Considering the lifespan of a building, the grey energy should not exceed 50 kWh/m^2 a to obtain Minergie-A certification (Minergie, 2015d). Another important characteristic of Minergie-A as well as Minergie-P buildings is the air permeability of their building envelope. Therefore, the same specific limit values cannot be exceeded in either standard (Minergie, 2013a,b).

In principal, Minergie-A is based on simliar criteria as the Minergie-P standard, but requires additional and more severe constraints. Therefore, Verein Minergie (2012) mentions that a popular way to get Minergie-A certified could be an upgrade from Minergie-P for example by means of increased use of solar energy. Additionally, further stricter requirements of the Minergie-A standard have to be taken into account to reach the plus-energy certification.

3.3.4 Supplement -Eco

The additional certification -Eco can be gained for all Minergie standards and combines the quality of the standards with healthy and ecological architecture. Until now, 530 buildings were certified Minergie-Eco, 547 Minergie-P-Eco and 140 Minergie-A-Eco. Minergie-Eco categorizes its requirements into six categories. Health aspects are considered in the criteria of (1) light, (2) noise and (3) indoor air. Requirements regarding building ecology fall into categories (4) crude materials (5) fabrication and (6) demolition. Minergie-Eco should be regarded as accompanying the construction process and therefore it is crucial that its requirements are implemented in an early phase of the whole construction process (Minergie, 2015d).

Table 3.2 summarizes and compares the different Minergie standards and their requirements for new buildings.

Table 3.2 – Comparison of Minergie-Standards: Conception for New Residential Buildings

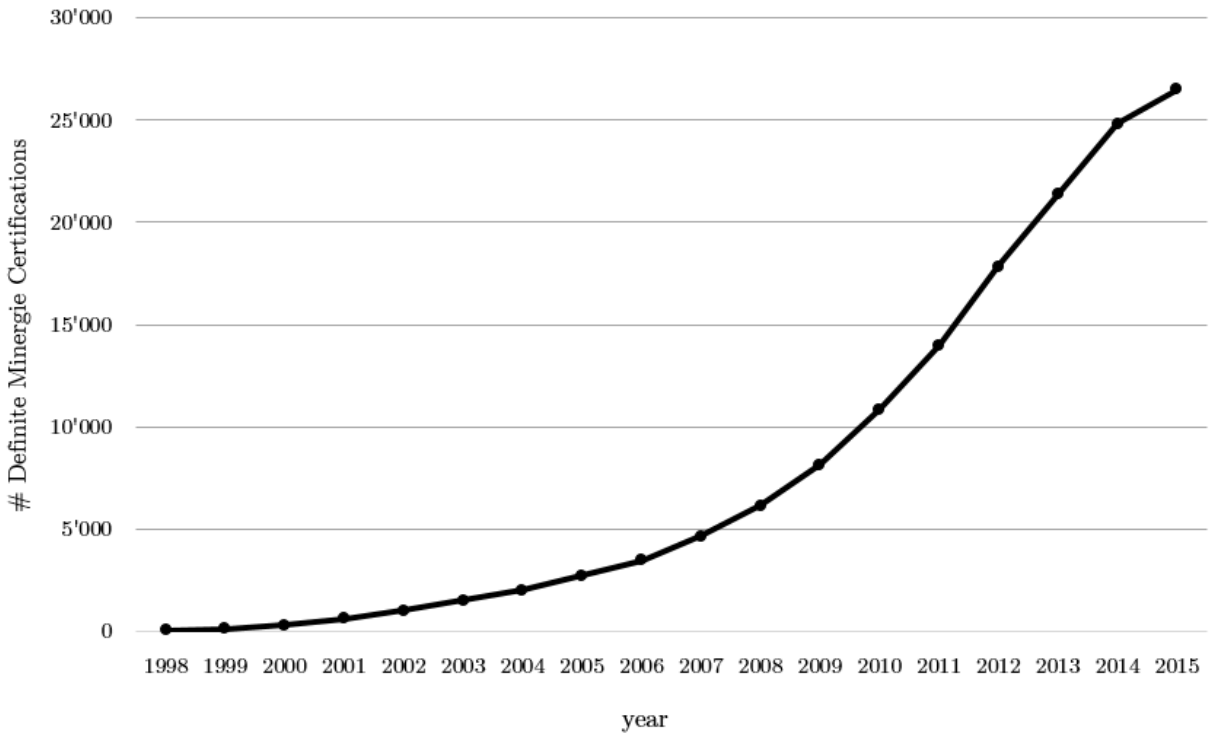
	Minergie	**Minergie-P**	**Minergie-A**
	Low Energy Buildings	*Nearly Zero Energy Buildings*	*Plus-Energy Buildings*
Minergie Limit Value	38 kWh/m^2a 3.8 l heating oil	30 kWh/m^2a 3 l heating oil	0 kWh/m^2a
Primary Requirement (Heating Energy Demand)	10% below legal requirements	40% below legal requirements	10% below legal requirements
Tightness of Building envelope	no requirements	air change below 0.6/h with 50 pascal pressure difference	
Household Electricity	no requirements	best appliances & lighting	best appliances & lighting
Grey Energy	no requirements	no requirements	below 50 kWh/m^2a
Combinable with	-	-Eco Minergie-A	Minergie-P
Additional Costs	max. 10%	max. 15%	no requirements

Source: Minergie (2015d)

3.4 Development of Minergie in Numbers

The Minergie standard has become increasingly successful since its launch in 1998. According to Heinz Tännler (2015), the president of Minergie Schweiz, about one out of every four newly constructed buildings has been Minergie certified since the standards inception. Whereas only 292 buildings were Minergie certified by 2000, definite certifications climbed up to 26'496 as of July 2015 (Minergie, 2015a). At the same time about 10'000 additional Minergie certifications were planned, but not definitely certified due to the fact that the buildings were still under construction. Considering both definite and provisional certifications the numbers sum up to over 36'000 Minergie certifications by mid of 2015. The following graph depicts the yearly development of definite Minergie certifications from its market entry up to date in Switzerland (Minergie, 2015a).

Figure 3.1 – Definite Minergie Certifications



Source: Minergie (2015a)

As Figure 3.1 shows, the amount of Minergie certified buildings has grown in an almost exponential manner over the past 15 years. Only the last two years its annual growth rate decelerated slightly, which is depicted by the little kink at the end of the curve. In general, all kind of buildings, be it residential or commercial buildings, can meet the criteria of Minergie standards. However, according to Salvi and Syz (2011) green building activity is first and foremost popular amongst private homeowners. Thus, the biggest share of green constructions belongs to residential owner-occupier and private owners of residential multi-family buildings. As of July 2015, 87% of all Minergie certified buildings are residential buildings. Thereof, 61% are single-family and 39% are multi-family homes. Out of the 13% of non-residential buildings, administration offices represent the biggest share in this category with 41%. The main focus of this thesis lies in the segments of administration offices, industry and insurance, which amount for only about 6% of the whole Minergie market. Referring to Salvi and Syz (2011) the following table outlines the distribution of Minergie certified buildings by property type in Switzerland.

Table 3.3 – Definitely Certified Minergie Buildings by Property Type

	Number of Minergie Certified Buildings	**Percentage of Total**
Single-family homes	**15'462**	**53%**
Multi-family homes	**10'000**	**34%**
Others, whereof	**3'845**	**13%**
Administration offices	***1'561***	
Schools	*744*	
Sales	*492*	
Restaurant	*243*	
Sport facilities	*218*	
Industry	*201*	
Warehouse	*131*	
Insurance	*110*	
Hospitals	*76*	
Indoor swimming pools	*49*	
Real estate for special purposes	*20*	
Total	**29'307**[7]	**100%**

Source: Own representation based on Salvi and Syz (2011, p. 88) and updated with latest data from www.minergie.ch.

3.5 Overview of National and International Green Building Labels

The number of different sustainability labels has risen to a point where one can speak literally of a "label-jungle" (Wüest & Partner, 2011). Over the past 25 years, many countries and institutions have developed their own rating tools and its corresponding labels. On the one hand, these labels satisfy the specific needs of the countries diverse climatic conditions, national regulations and so forth. On the other hand, such heterogenous rating systems are based on different evaluation criteria, which makes a comparison between them difficult. For internationally active stakeholders like builder-owners and investors it is therefore crucial to know the most important characteristics of the various green building labels in order to make a sophisticated choice among the myriad of labels (Reed et al., 2009). Therefore, the section below shall highlight the most important worldwide green building labels and their features. Moreover, some comparison to the Swiss Minergie label shall be drawn and a summarizing table of the mentioned labels gives an overview of the various green building labels.[8]

[7] Difference between definite 26'496 certified buildings and 29'307 due to several types of properties within a project number.

[8] All information on the international labels are taken directly from their official websites when no other source is specified.

3.5.1 BREEAM

The Building Research Establishment Environmental Assessment Method (BREEAM), constitutes the worlds first sustainability rating system for buildings. Since its launch in 1990 BREEAM (2015) reports 425'000 certified buildings and another two million registered for assessment in over 60 countries worldwide (BREEAM, 2015). These impressive numbers show that BREEAM is the leading international sustainability label for real estate. Although BREEAM is originally rooted in the United Kingdom (U.K.), it can be used to evaluate all types of buildings anywhere around the world. Thereby, standard assessment schemes have been developed for offices, industrial buildings etc. If a project doesn't fall into a standard scheme, "bespoke" critera are used to assess the building individually. BREEAM (2016) assesses a buildings performance based on a wide range of criteria, which include "energy and water use, the internal environment (health and well-being), pollution, transport, materials, waste, ecology and management processes." These performance criteria are assessed and credits are assigned in accordance with their performance. Thereafter the scores are weighted in order to reflect the importance of each category. Finally, the weighted credits are summed up and translated into a rating range from pass, good, very good, excellent and outstanding. The thresholds betweeen the ratings are thereby given in percentage scores of total achievable credits. The BREEAM and Minergie standard therefore both allow for assessment of different building types and categorization into different levels of sustainability. According to a study by RICS (2015) BREEAM accounts for 80% of commercial real estate across Europe. The French label HQE has only an 11% share and the U.S. label LEED and the German label DGNB both have less than a 5% stake in the market. The study reveals that BREEAM is the most preferred sustainability label for new and existing commercial real estate in Europe.

3.5.2 LEED

The Leadership in Energy & Environmental Design (LEED) constitutes a credit based building rating system developed by the US Green Building Council (USGBC), a non-profit organization (Biblow, 2009; Potbhare et al., 2009). Since its establishment in 1998, the same year as the Swiss Minergie label, there have been more than 29'000 certified commercial projects and more than 82'000 certified

LEED for Homes residential units located in over 150 countries and territories as of June 2015 (USGBC, 2015a). LEED can be applied to all building types - commercial, residential and also to entire neighborhood communities. Moreover, LEED incorporates the whole building lifecycle, e.i. design and construction, operations and maintanance, tenant fitout as well as significant retrofit. In order to meet the requirements for different stages in the life-cycle and various building types, LEED offers four main rating systems: *LEED Building Design and Construction*, *LEED for Interior Design and Construction*, *LEED for Building Operations and Maintenance*, and *LEED for Neighborhood Development*. Each of these rating systems is divided into subsections according to the type of building or project.

In general, LEED works as a third-party verification that ensures buildings achieve high performance by evaluating the following key criteria: sustainable site development, water savings, energy efficiency, materials selection and indoor environmental quality. Based on these criteria 100 base points can be achieved. An additional 10 points extra for *Innovation in Design and Regional Priority* sum up to 110 maximum achievable points. Depending on how many points a project earned, it falls into one of four certification levels: Certified (40-49 points), Silver (50-59 points), Gold (60-79 points) and Platinum (80+ points) (USGBC, 2015b).

According to Salvi and Syz (2011) LEED, compared to Minergie, shows a roughly 280 times lower penetration rate in their corresponding domestic markets in the year 2009. This number reveals that there is still huge potential for growth for the LEED label. Although a direct comparison between Minergie and LEED seems to be difficult, some remarkable differences can be accounted for. While Minergie focuses on low energy demand by means of setting concrete technical limit values and emphasizing on comfort of living, USGBC (2015c)'s LEED highlights the financial benefits, cost savings and lower vacancy rates of their certified buildings compared to conventional counterparts. While LEED is able to pronounce their economic advantages through the findings of several academic papers, only a few studies on the green premium of Minergie certified buildings have been conducted so far.

3.5.3 DGNB

The "Deutsche Gesellschaft für Nachhaltiges Bauen" - DGNB (2015a), was established as a non-profit- and non-governmental organization in 2007. Since its launch, DGNB has realized over 1'210 projects whereof more than 500 projects are certified. The label systematically assesses mainly office and administration buildings and also takes lifecycle costs into account. DGNB evaluates six fields of sustainability: process, ecological, economic, socio-cultural, technical and location quality. These topics comprise about 60 criteria which are concerned with sustainable construction (Wüest & Partner, 2011). For each of the six fields a degree of fulfilment is assessed, which is calculated as a combination of evaluation points and their corresponding weightings. The overall project itself is then valued based on the 6 topics according to their importance, which finally leads to a total degree of fulfilment. Depending on this percentage DGNB awards Platin ($\geq$ 80%), Gold ($\geq$ 65%), Silber ($\geq$ 50%) and Bronze ($\geq$ 35%) labels (DGNB, 2015b). DGNB constitutes one of the most comprehensive certification systems worldwide, because it accounts not only for architecture but also for the operating phase of the building (Wüest & Partner, 2011).

3.5.4 Energy Star

Energy Star was founded in 1992 as a joint program of the U.S. Environmental Protection Agency (EPA) and the U.S. Department of Energy which has the objective to promote energy-efficient products in order to reduce greenhouse gas emissions (EnergyStar, 2016a). Since 1995, EPA started certifying homes with the Energy Star label and the total number of certified homes has grown to nearly 1.6 million in 2014. Buildings certified under the Energy Star requirements are at least 15% more efficient than those built to the International Energy Conservation Code (IECC) and include additional energy savings which leads to a total performance advantage of up to 30% compared to typical new homes (EnergyStar, 2016b). As with the Swiss Minergie label, Energy Star is applied more often to residential buildings. Furthermore, Energy Star like Minergie is a national label, which finds application in the domestic U.S. market (Wüest & Partner, 2011). However, from 1999 onwards, the Energy Star label also started certifying commercial buildings (Wiley et al., 2010). As of year-end 2014, more than 25'000 commercial buildings have been certified according to Energy Star. Thereby,

EPA's 1-100 Energy Star score enables energy performance comparison between different kinds of facilities across the U.S. A score of 50 stands for a typical median performance, whereas a score of 75 indicates that your building performs better than 75 percent of all similar benchmark buildings in the U.S. and qualifies for the Energy Star label (EnergyStar, 2016c). Thereby, the energy use must be certified by a professional engineer and the ranking in the top quartile has to be challenged yearly in order to maintain their Energy Star certification (McGrath, 2013). However, there is no cost to apply for certification, but the application has to be verified and stamped by a licensed professional engineer or registered architect, who checks whether the reported property use characteristics (e.g. square footage of the building), energy data and the indoor environment criteria have been met (EnergyStar, 2016d).

Table 3.4 – Comparison of International and the Minergie Label

	International Labels			National Labels	
	BREEAM	LEED	DGNB	Energy Star	Minergie
year established	1990	1998	2007	1992	1998
country of origin	UK	USA	Germany	USA	Switzerland
certified buildings	432'429	111'000	507	1'625'000	36'000
residential real estate (certified)	425'690	82'000	18	1.6 m	31'320
commercial real estate (certified)	6'739	29'000	489	25'000	4'680
certification costs	ca. CHF 7'000	CHF 2'300-24'000	CHF 15'000-41'000	CHF 0.-	CHF 900-20'000
rating scale	PASS ($\geq$ 30%)	Certified (40-49)	Bronze ($\geq$ 35%)	Energy Star certified	Minergie
	GOOD ($\geq$ 45%)	Silver (50-59)	Silber ($\geq$ 50%)	($\geq$ 75/100 score)	Minergie-P
	VERY GOOD ($\geq$ 55%)	Gold (60-79)	Gold ($\geq$ 65%)		Minergie-A
	EXCELLENT ($\geq$ 70%)	Platinum (80+)	Platin ($\geq$ 80%)		Supplement-Eco
	OUTSTANDING ($\geq$ 85%)				
examined criteria	energy & water use	sustainable site development	process-	energy use	building envelope
	internal environment	water savings	ecological-	property use characteristics	ventilation
	pollution	energy efficiency	economic-	indoor environment criteria	Minergie limit value (energy)
	transport	materials selection	socio-cultural-		thermal comfort
	material	indoor environmental quality	technical-		building technology
	waste		location quality		extra costs
	ecology				
	management process				

Source: Own representation based on Salvi et al. (2010, p.11) and updated with latest data of the corresponding websites.

Chapter 4

Existing Literature on Green Buildings

The impacts of green buildings on a property's risk and return have been widely scrutinized in the academic literature in recent years. Most studies focused mainly on three kinds of premia: sales, rent and occupancy. The characteristics of green buildings therefore seem to imply advantages compared to conventional constructions, which are reflected in higher sale prices, higher rents as well as in lower vacancies.

The following section shall provide the reader with an overview of the existing Swiss and international literature regarding a green premium. Moreover, the studies shall give an indication how green buildings might not only mitigate risks but also add value from an investor's point of view. In order to sensitize expectations regarding rent-, sales- and occupancy premia on the Swiss office market, this section shall set the theoretical stage for the upcoming empirical analysis of the master thesis. At the end of the chapter an overview table including the most important findings of the studies discussed below shall conclude this section.

4.1 Swiss Studies

The financial implications of sustainable real estate has been examined in several studies conducted in Switzerland. Especially the Center for Corporate Responsibility and Sustainability (CCRS) at the University of Zurich, which is in charge of the scientific investigation of the topic. Due to the fact

that the predominant Minergie label in Switzerland is mainly specialized in residential real estate[9], most studies have been carried out on the non-commercial sector.

Already in 2008, Salvi et al. published a study wherein they examine a sample consisting of about 9'000 home ownership transactions, which have taken place between 1998 and 2008 in the canton of Zurich. Among those transactions, 250 buildings are Minergie certified. The authors run a hedonic regression model in order to filter out the Minergie premium by holding other building characteristics constant. The results show a green premium of transaction prices for single-family homes of 7% and for condominiums 3.5%. Bearing in mind that Minergie standards prescribe a maximum of 10% additional costs for a new building compared to conventional counterparts, the 7% green premium roughly corresponds to these extra costs. Moreover, the authors explain the smaller green premium for condominiums by the fact that multi-family homes (including several condominiums) are able to reach the energy limit value more cost-effectively than single-family homes. The reason for this is that a detached single-family home has a unfavorable ratio between building envelope and living space. This circumstance leads to higher construction costs and therefore justifies higher transaction price premium for single-family homes.

More recently, Salvi et al. (2010) published a paper in which the CCRS in corporation with Zürcher Kantonalbank (ZKB) conduct a more detailed analysis about rental premia of Minergie certified dwellings in Switzerland. The sample consists of nearly 13'000 newly constructed rental objects, which were offered for first time rental on the internet portal homegate.ch for the period between 2002 and 2009. Amongst this data, 1'173 objects are Minergie certified, which leads to a solid data basis. As in the earlier study from Salvi et al. (2008), the authors conduct a hedonic regression model by controlling for building characteristics such as size, quality, architecture and location. The results reveal a green premium for net rent (i.e. without utilities) of 6.0% throughout Switzerland and for the canton of Zurich a premium for net rent of 6.2% over the whole evaluation period. Thereby, it is worthwhile to note that a clear trend towards convergence between rental yields of Minergie and conventional dwellings exists. While during the years 2002 and 2005 an average gross rent premium of 12.2% was observed, this number had sunk to 5.7% for the period of 2006-2009. The study challenges the thesis that a Minergie certification ceteris paribus leads to a 10% higher

[9] See Table 3.3 for Minergie Certified Buildings by Property Type.

net rent, which would in return compensate for the cost surplus for building according to Minergie standards. Taking the above results into account, the study concludes that the additional costs for building green in Switzerland can not be fully compensated for by correspondingly higher net rents. Another interesting insight from the perspective of tenants is the fact that the additional costs for renting a Minergie certified building greatly exceed the savings from utilities. While the willingness to pay for the rent of a new Minergie dwelling is on average CHF 132 higher than for a conventional counterpart in Switzerland, savings from less utilities amount only to CHF 14 for certified buildings. These numbers show, that on average tenants seem to be willing to pay more for Minergie certified buildings even if they do not get completely compensated for the higher payable rents.

Another important study by Salvi and Syz (2011) examines the drivers of green housing construction in Switzerland. The authors conclude that green building activity in Switzerland is mainly determined by different income levels and cultural affiliation amongst Swiss municipalities. Additionally, the study finds significant but less important results regarding the impact of homeowners' attitude towards environmentalism. Moreover, there is no evidence found that governmental subsidies encourage additional green housing construction in Switzerland.

Current Swiss studies regarding the financial implications of sustainable Minergie buildings show positive and statistically significant premia of up to 10% on transaction prices and offer rents compared to conventional buildings. Thereby, research is limited to the residential real estate sector while the commercial sector is faded out. The reason for this might be that Minergie - as the predominant sustainability standard in Switzerland - is mainly applied in the residential sector and thus there is much more data availability than in the commercial office sector. Moreover, the above presented Swiss studies focus on rental and price premia but do not consider possible occupancy premium of Minergie buildings, which might also be reasoned by the lack of data availability.

4.2 International Studies

During the last few years several international studies have financially assessed and compared green buildings to conventional construction. These studies mostly focus on office buildings, which can be explained by the fact that well-known international labels such as LEED and BREEAM originally

applied to the commercial sector and only recently expanded their scope to residential homes. Further details regarding international labels can be found in Chapter 3.5. It is also striking that most research regarding the comparison of sustainable buildings and their conventional counterparts has been done on ENERGY STAR or LEED certifications in the U.S. market. The reason for this might be that the CoStar[10] database provides detailed information on these labels and thus makes an empirical investigation feasible. Although all of the described U.S. studies share the same CoStar database, variations in the results can be mainly explained by study-specific data selection, i.e. sample size, control variables and timespan of the data. In order to put the Swiss studies as well as the empirical analysis of this work into scientific context, the most important international studies and their results shall be outlined subsequently.

Miller et al. (2008) examine the rent-, sales- and occupancy premia of LEED and Energy Star office buildings in the U.S for the period of 2003-2007. In their hedonic regression model they control for age, location and the time of sale. Their results lead to a sales price premium of 9.94% for LEED and 5.76% for Energy Star buildings. However, the data set did not provide enough data to discriminate between different LEED certification levels in the hedonic model. Nonetheless, the authors were able to make a statement about value addition by the LEED rating in general. The extra costs to become LEED certified (not taking certification fees into account) vary greatly in this survey between different regions. For Silver certification the extra costs amount to between 1.0% and 3.7%, for Gold certification 2.7% to 6.3% and for Platinum certification 7.6% to 10.3%, depending on the various regions. Taking into account that the sales price premium of 9.94% for LEED certified buildings does not differentiate between various certification levels and thus represents an overall average value for LEED, one can assume a net premium for LEED certifications. Miller et al. (2008) also report rent and occupancy premia, but without having controlled for them in a regression. These mere descriptive results show a 9% rental premium for Energy Star buildings and an occupancy premium of 3.7% to 4.2% for Energy Star and LEED respectively. Nevertheless, it is not possible to make a satistically reliable statement with these numbers of rent- and occupancy premia due to a lack of proper inferential statistics.

[10] CoStar is according to Miller et al. (2008) the leading collector of property data and partner of virtually all the leading commercial real estate firms through out the U.S. and U.K. (CoStar, 2016).

Wiley et al. (2010) examined the effect of LEED and Energy Star labeled Class A office buildings on rent, occupancy rate and sale price in the U.S. By means of hedonic regression analysis, they find a rent premium of about 7 to 17% as well as improved occupancies of about 10 to 18% for green buildings. The sales price premium is estimated at $\$30/ft^2$ and $\$130/ft^2$ for Energy Star- and LEED-certified buildings, respectively. According to Fuerst and McAllister (2011a) the study of Wiley et al. (2010) might be limited by the fact that locational effects are not properly accounted for. Even though they identify labeled buildings and their conventional counterparts in the same metropolitan area, differences with respect to location-quality within a metropolitan area could persist. This circumstance could bias results in the way that observed premia may include a locational as well as an eco-labeling premium. Another objection to Wiley et al. (2010) is that they neither state the period of the sample nor the number of Energy Star and LEED labeled buildings. Only the total number of observations for the leasing data (n=7'308) and the sales data (n=1'151) is known. Fuerst and McAllister (2011a) infer from their summary statistics that the sample for LEED and Energy Star was rather small, e.i. 30 and 440 for the rental sample and 12 and 70 for the sales sample, respectively.

Fuerst and McAllister (2011a) investigate in their latest study if LEED and Energy Star offices obtain premia on rents, sale prices and occupancy rates. Their OLS hedonic regression results suggest that office buildings with Energy Star or LEED certifications obtain a rental premium of about 4% and 5% respectively. When a building certifies for both labels, an additive effect leads to a rental premium of about 9%. The sale price premium of Energy Star and LEED certified office buildings amounts to 18% and 25% respectively. Dual certification again leads to an additive effect and its sales price premium is estimated at 28-29%. For the third dimension, the occupancy rates, only a small positive occupancy premium of about 1% for Energy Star labeled buildings is found, whereas no occupancy premium for LEED certified office buildings could be confirmed.

In a further study, Fuerst and McAllister (2011b) investigate the rental and sales price effects of eco-certification (LEED and Energy Star) on office buildings in the U.S. The data used contains about 10'000 observations of transaction prices during a 10 year period from 1999 through 2008. Asking rent observations amount to about 18'500 and are taken from the 4th quarter 2008. In contrast to Miller et al. (2008), this data set was large enough to discriminate between different

LEED certification levels. Their hedonic regression models control for variables such as age, height, number of stories, lot size, location, building quality and submarkets. The regression analysis leads to a rental premium of 5% for LEED and 4% for Energy Star certification. The premium for sales prices amounts to 25% for LEED and 26% for Energy Star certified buildings, where higher levels of certification also achieve a higher premium.

In an earlier study Fuerst and McAllister (2009) scrutinize the effect of eco-labeling on the occupancy rates of commercial office buildings in the U.S. They analyzed a sample consisting of 292 LEED and 1291 Energy Star buildings as well as about 10'000 conventional offices in the control group. By using ordinary least squares (OLS) and quantile regression analysis, they find a significant positive relationship between occupancy rate and eco-labeled buildings. In order to perform the analysis, they simply rewrite the hedonic model so that occupancy rate serves as the dependent variable, on which all other explanatory variables are regressed on. When controlling for differences such as age, number of stories of the property, lot size, location, asking rent, building quality and submarkets, LEED certified offices show 8% higher occupancy rates and Energy Star certified offices 3% higher rates. Nevertheless, the occupancy premium for Energy Star labeled offices is concentrated in some market segments more than in others.

Eichholtz et al. (2010) analyze transaction data from the CoStar data bank for the years 2004 through 2007. In order to evaluate rent and sales premia for LEED and Energy Star certified buildings, they include 8'105 commercial office buildings with rental data and 1'813 buildings which have been sold. 694 buildings were certified in the rent sample and 199 in the sale sample. The authors include many control factors in their regression models, such as age, building size, building quality and more. According to Veld and Vlasveld (2014) their precise control for location clearly distinguishes this paper from others. Eichholtz et al. (2010) modeled 893 (i.e. 694 plus 199) small clusters of nearby office buildings. Thereby, each cluster ranges only 0.2 square miles and contains at least one labeled building and also at a minimum one non-labeled building. On average, every cluster therefore consists of 12 buildings and allows for precise locational effects to be taken into account. Moreover, this study controls for regional differences in office space demand by including the increase in employment in the service sector as well as amenities near the buildings. The study concludes that the transaction premium for a green building is up to 16% and shows high statistical

significance. Nevertheless, when certification is modeled separately for LEED and Energy Star standards, only the latter shows significant results for the sales premium. Similar results are found for office rents. If "greenness" is modeled as a whole, a 3.5% rental premium with high significance is found. Distinguishing between LEED and Energy Star certifications leads to a highly significant 3.3% premium for Energy Star- and an insignificant 5.2% premium for LEED-certified buildings.

The study additionally examines how energy savings may influence the green premium. Amongst all buildings that have been certified as energy efficient, they find a clear inverse relationship between market value and energy use. Their calculations reveal that a 10% reduction in site or source energy use, leads to an increase in market value of 1.1% and 1.2% respectively. These increments would add over and above the average rent and sales premium for a certified building.

Eichholtz et al. (2013) builds on their earlier study (see section above) and contributes to the scientific field of green buildings in the commercial property sector in three ways. First, this study investigates how the green premium was affected by the unstable period of the subprime crisis in the years 2007 to 2009. The results conclude that the economic premium for green buildings sunk slightly during the recent economic downturn, in which the supply of green office space rose substantially in a stagnant market for commercial office space. Rents and occupancy rates of rated buildings are still superior compared to conventional high-quality properties, i.e. relative rents have not changed. Secondly, this study uses a large cross-section of data of office buildings to determine the market rent and asset value premium of more efficient buildings. Thereby, they control rigorously for differences in hedonic characteristics and location by using propensity-score weights. Although the premia for a green rating are slightly smaller relative to those found in their earlier work (Eichholtz et al., 2010), they still show significant coefficients. Applying a much larger set of observables and controlling quite strictly for quality differences they find an overall rental premium for a green rating of 2.5%. Energy Star rating on its own has a 2.1% rent premium and LEED 5.8% respectively. The general sales price premium for a green rating amounts to 13.3%, where LEED on its own has a 11.1% sales price premium and Energy Star 12.9%. Regarding occupancy rates, green buildings show a propensity-score weighted occupancy that is 2.8% higher than their nearby control buildings. In a third step Eichholtz et al. (2013) relate the green premia to the peculiarities of the scoring systems that underlie the certification process. Results show that characteristics of green buildings that are associated with

higher thermal efficiency and sustainability contribute to increases in rents and prices. Moreover, they find that LEED and Energy Star standards take different aspects of sustainability into account while both generate higher returns. In general, the findings imply that investors attribute a lower risk premium for more energy-efficient and sustainable office space and this preference seems to persist in a volatile property market. Moreover, green buildings may serve as a hedge against rising energy prices and also against a shift in future preferences of stakeholders towards more eco-friendly issues.

Chegut et al. (2011) examine the financial performance of BREEAM certified office buildings in the UK during the period of 2000 to 2009. The study finds through hedonic regression analysis a rental and transaction sales price premium of 21% and 26%, respectively. As in most studies, they use a semi-log regression model, which relates the logarithm of office rents per net square meter (or selling prices per net square meter) to the hedonic attributes of the building. Besides building characteristics such as age, size, public transportation accessibility etc. they use various further controlling variables, for example rental contract features (e.g. lease length), days on market and macro-economic conditions (e.g. time dummies). Their rental sample consists of 67 certified and 1'104 control buildings and the sales sample contains 70 certified and 1'953 control buildings. The data used in this study is once again provided by the CoStar database.

Overall, the international studies on the financial implications of green buildings show a broad spectrum of results. Although premia across studies differ strongly, most studies find significantly positive results. In the U.S., green buildings achieve 2% - 9% higher rents compared to non-labeled buildings. The price premium found in the U.S. studies is even larger and amounts to 6% - 26%. From the studies above, Fuerst and McAllister (2009), Fuerst and McAllister (2011a), and Wiley et al. (2010) represent the only papers providing occupancy premia, which have been evaluated by proper statistical methods. The other two studies from Miller et al. (2008) and Eichholtz et al. (2013) only provide rather descriptive results for occupancy. It is remarkable that although most studies share the same data source from CoStar they yield a wide range of results. These differences in results can be explained by varying evaluation periods, sampling and statistical methods. This literature review makes clear that one can expect positive premia regarding rent, sale and occupancy in the residential as well as commercial real estate sector of developed countries. The following table summarizes the most important insights of the presented studies:

Table 4.1 – Literature Overview

Study	Database	Country	Period	Control Buildings	Sample	Rent Premium	Sales Premium	Occupancy Premium
Residential Sector								
Salvi, Horehájová, and Müri (2008)	ZKB, AWEL	Switzerland	1998-2008	9000	250 Minergie			
					Single-family homes		7%	
					Condominiums		3.5%	
Salvi, Horehájová, and Neeser (2010)	homegate.ch	Switzerland	2002-2009	13'000	1'173 Minergie			
					Nationwide	6.0%		
					Canton of Zurich	6.2%		
Office Sector								
Miller, Spivey, and Florence (2008)	CoStar	U.S.A.	2003-2007	> 2'000	643 Energy Star	9%	6%	4%
					LEED		10%	4%
Wiley, Benefield, and Johnson (2010)	CoStar	U.S.A.		1'151 Sales in total	510 Energy Star	7-9%	$\$30/ft^2$	10-11%
				7'308 Rents in total	42 LEED	15-17%	$\$130/ft^2$	16-18%
Fuerst and Mc Allister (2011a)	CoStar	U.S.A.	1999-2009	13'971 Sales in total	2'111 Energy Star	4%	18%	1%
				36'236 Rents in total	313 LEED	5%	25%	-
					264 Energy Star & LEED	9%	28-29%	
Fuerst and Mc Allister (2011b)	CoStar	U.S.A.	1999-2008	15'000	834 Energy Star	4%	26%	
					197 LEED	5%	25%	
Fuerst and Mc Allister (2009)	CoStar	U.S.A.		10'000	1291 Energy Star			3%
					292 LEED			8%
Eichholtz, Kok, and Quigley (2010)	CoStar	U.S.A.	2004-2007	9'025	Energy Star	3%	16%	
					LEED	5%		
Eichholtz, Kok and Quigley (2013)	CoStar	U.S.A.	2007-2009	24107	Energy Star	2%	13%	3%
					LEED	6%	11%	
Chegut, Eichholtz, Kok and Quigley (2011)	CoStar	U.K.	2000-2009	1'104	67 BREEAM	21%		
				1'953	70 BREEAM		26%	

Source: Own representation based on Veld and Vlasveld (2014, p.165)

Chapter 5

Empirical Analysis

In the first section of this chapter the general hedonic model is outlined, which is a statistical method often used to determine the relation between the price or value of a good to its underlying characteristics. Thereafter, the structure of the empirical analysis is divided into the three dimensions of sales-, rent- and occupancy premia in the Swiss office sector. The reason for this division is that each premium is based on a different data set. For the sales and rent premia, data from homegate.ch is analyzed. Therefore they share the same data structure and are thus treated together in Chapter 5.2. The data set for the occupancy premium is provided by REIDA[11], which includes also information on occupancy rates. The occupancy premium is outlined in Chapter 5.3. Each of these three sections about sales-, rent- and occupancy premia consist of the following parts: In a first step the source of data, its preparation and selection as well as the parameters are presented. While explaining the different parameters of the hedonic model, it shall also be reasoned which impact on the sales-, rent- or occupancy premium they may have ex ante. The following section outlines descriptive statistics of the data set and in the last section the choice of the proper specifications for the hedonic regression model and its results are discussed.

[11] Data source: Real Estate Investment Data Association (REIDA, 2016) and its operation partner Meta-Sys AG.

5.1 The Hedonic Model

Office buildings can be seen as heterogeneous goods, which offer a bundle of various characteristics. Therefore, the price or rent for office space is defined as the money paid for the total utility offered by a certain bundle of characteristics. The question on how much a single price-determining characteristic, for example the age of the building, contributes to the total selling price or rent can not be answered based on the overall price of the object alone. Thus, each marginal price of all other attributes (e.g. size, quality, location, etc.) has to be determined, in order to enable the valuation of the influence of a specific characteristic (e.g. Minergie certification) on the price or rent of the building, ceteris paribus. Rosen (1974) with his theory on hedonic prices provides the theoretical foundation for valuing the price-determining characteristics of a building. In his paper, Rosen (1974) derives a price function of differentiated products in market equilibrium, which constitutes the hedonic model. In the hedonic model, the buyer and seller implicitly value all building characteristics, which are bundled in the property. The selling price or rent corresponds to the sum of the quantity of the characteristics, which are weighted by their implicit prices. The general idea of the hedonic model is therefore to break down a good into its components, and then estimate the value of each characteristic by means of multiple regression analysis. The theory of the hedonic approach was discussed broadly and developed further in several academic papers. Moreover, its practical relevance is ubiquitous, inter alia for the determination of green premia in the real estate sector. All of the papers reviewed in Chapter 4 use some form of hedonic approach in order to isolate the effect of green certification. As already described above, the hedonic model establishes a functional relationship between the price of a property p to the characteristics of the building z. Each property z is thereby described by n characteristics $z_1, z_2, ..., z_n$ which leads to the following functional form:

$$p = f(z_1, z_2, ..., z_n) \tag{5.1}$$

.

The characteristics $z_1, z_2, ..., z_n$ are for example usable area in square meters, age of the building, or centrality to the closest city center. Applying the functional relationship of Equation 5.1 to a sample consisting of different buildings allows for a multiple regression analysis. In the regression

model, the buildings' characteristics z_i are weighted by their implicit hedonic prices p_i, which leads to a weighted sum, the property price. Thereby, the implicit hedonic prices p_i, which are equal to the regression coefficients β_i are estimated by using the corresponding "quantities" of the building characteristics z_i as well as the known price p of the building as a whole. The general hedonic regression model therefore takes the following form:

$$p = p_0 + \sum_{i=1}^{n} p_i z_i + \varepsilon \tag{5.2}$$

$\Leftrightarrow$

$$p = \beta_0 + \sum_{i=1}^{n} \beta_i z_i + \varepsilon \tag{5.3}$$

Another important aspect for hedonic regression analysis constitutes the choice of a proper functional form. Most studies reviewed (Chegut et al., 2011; Eichholtz et al., 2010, 2013; Fuerst and McAllister, 2011a,b; Miller et al., 2008) take the price or rent per square foot or meter as their dependent variable, instead of the price or rent only. That way, one of the most decisive criteria for an office space buyer or tenant, i.e. usable area, is directly incorporated in the price or rent, instead of being one of several building characteristics. Moreover, the functional form of the multiple regression model has to be determined. It can be selected between a linear, semi logarithmic and a double logarithmic model. Also with respect to this question, the academic world concurs with the choice of a semi logarithmic hedonic model, where the price or rent per square meter is transformed logarithmically and the independent building characteristics stay linear. In practice, it is common to transform dependent variables such as prices or wages with a natural logarithm. These variables, which can not take on values below zero, often evoke problems of heteroscedasticity, which can be resolved by using a log-lin model. Moreover, the log-lin model offers advantages when it comes to interpretation of the regression coefficients (eso, 2015). A one-unit increase in z_i of Equation 5.4 leads, approximately, to a $100\beta_i\%$ change in $\ln(p/m^2)$. The exact calculation is simply derived by reversing the natural logarithm by Euler's number and subtracting by 1: $e^{\beta_i} - 1$ (Hill et al., 2008).

Therefore, the equations for the semi logarithmic regressions for the sales (5.4) and the rent (5.5) model in this study are written as follows:

$$\ln(p/m^2) = \beta_0 + \sum_{i=1}^{n} \beta_i z_i + \varepsilon \tag{5.4}$$

$$\ln(net\ rent/m^2) = \beta_0 + \sum_{i=1}^{n} \beta_i z_i + \varepsilon \tag{5.5}$$

The hedonic model for occupancy follows the same reasoning as for the sales and rent models. The Equation 5.6 is simply derived by rearranging the rent model (5.5) so that the occupancy rate serves as the dependent variable on which all other attributes of the building are regressed on. In this way occupancy can be understood as an indicator, which reveals the ability of a building to serve the markets needs. Therefore, occupancy is determined by the characteristics a building possesses for a given rent. However, a natural vacancy rate in rental markets exists for several reasons for example search costs, short-run supply inelasticity, etc. Thus, besides building characteristics, occupancy levels for a specific building also depend on market-specific characteristics as well as rent setting of the building owner (Wiley et al., 2010).

$$OR = \beta_0 + \sum_{i=1}^{n} \beta_i z_i + \varepsilon \tag{5.6}$$

As Wiley et al. (2010, p. 234) states: "If the market is not saturated with green buildings, then available space may rent in a segmented market characterized by excess demand." If this holds true, green buildings might not only demand higher rents but also achieve higher occupancies than conventional buildings. Assuming an investor considers the price of a building by discounting its expected future cash flows, a green building with lower operating expenses should sell at a premium price simply because of the expected cost savings. When the same building is also able to boast higher rents and lower vacancies, the pricing premium will be even higher.

In order to isolate the effect of building green, multiple regression analysis is performed. The method of Ordinary Least Squares (OLS) as well as the underlying data set entail some statistical problems and biases, which shall be explained in the following section.

The data set of homegate.ch represents asking data from real estate listings in Switzerland and can therefore deviate from effective prices or rents paid. This study is aware of the fact that its

asking data might vary from real transaction data because of not realized transactions for example. It is further possible that other motives than selling or leasing are the reason for putting a listing on homegate.ch. Getting a market benchmark for a building price or rent could also constitute a reason for putting a listing on the internet. However, the homegate data is used in order to realize the analysis of the green premium for office buildings in Switzerland. Moreover, Lehner et al. (2011) find in their study that asking prices and transaction prices yield similar results for the Singaporean residential real-estate market.

For the analysis of the occupancy premium, a data set from REIDA is examined. The provided data set of REIDA constitutes, in contrast to the data base of homegate.ch, real contractual rent data. However, some of the parameters in the data have been falsified in order to comply with data protection.

In general, a hedonic regression model should capture as many price-, rent- and occupancy determining factors possible, in order to best isolate the effect of a Minergie certification. Thus, there is a risk of leaving out important characteristics of an office building in the model. This leads to an omitted-variable bias (OVB) problem (Hill et al., 2008). According to the literature review, all studies include at least some building characteristics such as size, age, quality and locational attributes. As the data for this study is taken from the real estate platform homegate.ch as well as REIDA, the data sets are as complete as its entries of listings and contracts allow it to be. The sample for regression analysis is selected as to include the most important and complete variables possible. Although, the listings of the homegate.ch data set are extended further with some locational variables, the OVB problem might persist, as the valuation of real estate property represents a complex matter. As already mentioned above, hedonic regression analysis often evokes problems with heteroscedasticity, i.e. error terms having different amounts of variation across observations (Stine and Foster, 2013). In order to detect changing variances, the residual plots of the respective models are displayed and checked if their appearance is fan-shaped. Additionally, a Breusch-Pagan test is performed to test for heteroscedasticity. As the Breusch-Pagan test indicates the presence of heteroscedasticity in the homegate.ch as well as the REIDA data, heteroscedasticity-consistent standard errors are used in the models.[12] Another issue is autocorrelation of the residuals in the hedonic regression model.

[12] The regression analysis is computed by *Wolfram's Mathematica 10*, which incorporates heteroscedasticity-consistent standard errors in its LinearModelFit command.

This is taken into consideration with the Durbin-Watson statistic, which tests for the existence of a first-order autoregressive process. A value close to 0 indicates positive autocorrelation, whereas a value close to 4 indicates negative autocorrelation (Stine and Foster, 2013). As the results of the hedonic regression in Tables 5.7 - 5.10 show, the homegate.ch data appears to be rather positively autocorrelated. However, the REIDA data sets show no autocorrelation with Durbin-Watson test statistics close to 2.[13]

Moreover, the problem of collinearity, i.e. correlation between explanatory variables, shall be addressed. Thereby, the Variance Inflation Factors (VIF) are used to measure the effect of collinearity for each variable. A VIF larger than 10 suggests high redundancy of the variables and that they should be removed from the model. For each variable the corresponding VIF is listed in the regression results and none of the variables show critical values in the homegate.ch data set. However, the categorical variable building period *built1* - *built6* and the numerical variable *age* in the REIDA data set show high VIFs. The reason for these high VIFs is that the six building categories are modeled with a reference category *built6* and indicator (dummy) variables for the other five. This setting inevitably provokes high VIFs for the indicator variables. Nonetheless, the indicator variables show small p-values and thus high significance despite VIFs larger than 10. Furthermore, according to Allison (2012) the overall test that all indicators show coefficients of zero is unaffected by the high VIFs. Moreover, the high VIFs of the indicator variables do not affect anything else in the regression.

5.2 Sales- and Rent Premium

5.2.1 Data Set

The data set for the sales- and rent premium is principally based on listing data for property to purchase or rent from the real estate internet platform homegate.ch. All structural variables, which embody quality characteristics of the buildings are included in the homegate.ch data set. Additionally, the locational variables *distancekm* and *city* are added manually to the corresponding addresses from the homegate data set. Moreover, to control for time trend effects, the variable *timeindex* is also added manually to the corresponding point in times (years) for the sales- and rent data set.

[13] Durbin-Watson D test statistic for the REIDA data sets can be seen in Table A3 and A5 in the appendix.

The following table gives an overview of the variables for the green sales- and rent premium for office buildings in Switzerland. The independent variables fall into the above mentioned categories, which are structural, locational and time trend variables. The name used in the models, data source, description and the unit of the variables are summarized in Table 5.1.

Table 5.1 – Description of Variables: Sales- and Rent Model

Name in Models	Data Source	Description	Units
Dependent Variable			
ln(price/m²)	homegate.ch	natural logarithm of offer price per square meter usable area	CHF/m²
ln(net rent/m²)	homegate.ch	natural logarithm of offer net rent per square meter usable area	CHF/m²
Structural Variables			
view	homegate.ch	dummy variable (D), 1=object has view	D
elevator	homegate.ch	D, 1=object has elevator	D
parking	homegate.ch	D, 1=object has parking lot	D
garage	homegate.ch	D, 1=object has garage place	D
wheelchair	homegate.ch	D, 1=object has wheelchair access	D
age	homegate.ch	age or time since last renovation on object (whichever occurred more recently)	years
builtnew	homegate.ch	D, 1=object has been built in this year	D
builtold	homegate.ch	D, 1=object has at least 50 years	D
minergie	homegate.ch	D, 1=object has been certified by minergie	D
Locational Variables			
distancePT	homegate.ch	distance to next public transport connection in meter	m
distancekm	homegate.ch & Bing Maps	distance to nearest of 5 biggest cities (Zurich, Geneva, Basel, Lausanne, Bern) in km	km
city	homegate.ch & statista (2016)	D, 1=object is located in one of the 10 biggest cities in CH	D
Time Trend Variable			
timeindexsales	Wüest & Partner (2016)	real estate price index for office space for the years 2009-2016, base year 2009 = 100	index point
timeindexrent	BWO (2016a)	yearly arithmetic average of the quarterly determined mortgage reference rate	%

Source: Own representation.

5.2.2 Discussion of Variables and Hypotheses

In the following section the different hedonic variables from the table above shall be outlined in more detail. Besides explaining the variables and their derivations, this section also provides an

ex ante contemplation on how the various variables might impact the dependent variable. The considerations build on the literature reviewed as well as on the author's own reflection in order to set up the hypotheses.

Dependent Variable

The regressand in the sales price model constitutes the natural logarithm of total selling price of the homegate.ch listing divided by the usable area[14] in square meters of the object. For the rent model the dependent variable is the monthly net rent divided by the usable area in square meters.

Structural Variables

The structural variables *view*, *elevator*, *parking*, *garage* and *wheelchair* embody quality characteristics of the specific building and reveal the corresponding feature by means of a dummy variable. Although these variables were not explicitly implemented in the studies (except for *parking* in Fuerst and McAllister (2011a)) from the literature review, all of them represent enriching attributes of a building and therefore should be rewarded by a potential buyer or tenant by means of a higher sales price or rent. Hence, it is expected that these five dummies have a positive impact on the sales price as well as the payable rent.

The *age* of the building represents another control variable of the model. Here it is defined as either the time from the year of construction up to date or since the last renovation on the object has taken place - whichever occurred more recently. As potential buyers and tenants in general value newer or just recently renovated buildings higher, it can be expected that higher building ages are associated with lower rents and prices. Evidence for this negative relation is found in several papers of the literature review. It is noteworthy that most papers model the control for age by means of dummy variables for different timespan (e.g. Eichholtz et al. (2013) or Chegut et al. (2011) etc.). Thereby, according to expectations, the timespan coefficients for age tend to decrease with increasing age of the building.

Additional to the *age* variable, the *builtold* and *builtnew* dummy variables complement and refine

[14] In the homegate.ch data set the surface corresponds to the usable area, which is commonly defined as the actual occupied space without including common areas of the property as restrooms, cafeterias, shared hallways etc. However, the contractual data from REIDA uses rentable area, which is the usable area plus a share of the common areas. As the rent payments include the common space, the actual monthly rent is usually calculated based on the rentable area (O'Grady, 2013).

the controls for age. The dummy *builtnew* shows a value of 1, if the object has been built in this year and thus is an indicator for a new construction. The variable *builtold* however, represents a dummy for buildings, which are at least 50 years old. While Chegut et al. (2011) found significant positive coefficients for new or renovated buildings in their rent sample, no comparable variable for *builtold* is found in the literature review. Nonetheless, since buildings with an age of over a half of a century are not expected to offer equivalent technologies and amenities as contemporary buildings, it is hypothesized that *builtold* impacts the sales price and rent negatively.

The variable of interest is the *minergie* dummy. Since all studies reviewed show significant positive coefficients or premia for green buildings, the main hypothesis is that this holds also true for Minergie certified office buildings in Switzerland. Although the studies of Salvi et al. (2008) and Salvi et al. (2010) show such premia for rents and sales prices in the residential sector, there still remains the question of how Minergie certification affects office rents, sales and occupancy on the Swiss market.

Locational Variables

Besides quality characteristics, location constitutes a crucial component for value determination in the real estate market. Within this analysis, local characteristics are modeled by three different variables: The variable *distancekm*[15] measures the distance from the building's address, which is included in the homegate.ch data set, to the nearest center of one of the biggest five Swiss cities in kilometres of road by private transport (car). Thereby, the main railway stations of Zurich, Geneva, Basel, Bern and Lausanne are defined as the city centers. Thus, this variable serves as a measure of centrality for location. The classic monocentric city model theory provides the theoretical explanation on why the equilibrium of real property rents or sales prices per square meter decreases per kilometre of additional distance from the city center (Geltner et al., 2013). According to this simplified model, all residents have to commute to the central business district (CBD), because its the only place were production takes place, and thus they incur transport costs proportional to the distance of the commute. Spatial equilibrium is presumed, i.e. consumers are indifferent between locations and their utility from living in a given location is constant. Then, if their transportation

[15] The data for *distancekm* was calculated by matching the addresses of the buildings with their closest big city nearby. Therefore, distances were calculated with Microsoft's Bing Maps API Distance Calculation.

costs will decrease with higher centrality, their housing costs will rise with increasing proximity to the CBD, due to the attractiveness and scarcity of central locations. Therefore, theory predicts an inverse relation between distance from the city center (*distancekm*) and real estate rents and prices. Thus, as prices and rents are higher for residential real estate near the city center, this must also hold for commercial buildings within a competitive market.

Homegate.ch provides the *distancePT* variable, which measures the distance to the next connection to public transport in meters. The reviewed academic literature finds ambiguous results regarding this variable. According to Eichholtz et al. (2013) public transport access within one quarter-mile has a positive significant impact on rents per square foot. Whereas the same variable has a negative significant sign for sales prices. In general, it can be stated that a better accessibility to public transport should increase the demand for office space. Expressed differently, companies require short connections to public transports in order to facilitate the commute of their employees. Therefore, it is hypothesized that there is an inverse relation between *distancePT* and price or rent. This causality is also supported by the theory of centrality explained above.

Another locational variable, the *city* dummy controls for whether a building is located in one of the ten biggest cities in Switzerland [16], or not. The assignment whether a location is situated within one of the most populous ten cities was based on the corresponding zip codes. Miller et al. (2008) found positive significant coefficients on all their city-dummies in the U.S. for their sales price model. This empirical evidence and also the support from the above explained monocentric city model theory, which also applies to this variable, lead to the hypothesis that the control variable city exhibits a positive relation to rents and sales prices.

As a further locational variable the municipal and cantonal tax rate of the different locations in Switzerland could be of great interest.[17] However, the strongly federalist tax system of Switzerland makes it difficult to impossible to compare between different tax regions within the country. Regardless, a comparison on a cantonal level would make more sense, since the municipalities would share

[16] The ranking for the ten biggest cities of Switzerland was found on the website from statista.com.

[17] The reasoning for a locational tax variable could be as following. As tax rates might differ greatly within regions, people as well as companies in higher tax brackets prefer to be located in low-tax regions. This in turn means that rents and prices in low-tax regions tend to be higher than in high-tax municipals, since wealthy people and companies increase the demand in such preferable regions and thus also might force up rents and prices. According to this, it would be expected that lower tax rates go along with higher rents and prices, and vice versa.

the same cantonal tax laws, which vary greatly amongst cantons. Due to the fact that this study includes locations from various cantons in Switzerland (see Table A1 and Table A2), the tax issue can not be properly accounted for. Thus, due to poor comparability a variable for tax is not taken into account in this study.

Time Trend Variables

As the analyzed data set consists of asking data for the years of 2009 to 2016, the time trend variable *timeindexsale*, which accounts for the price development on the Swiss office market, is implemented in the sales price model. It represents a price index for office space in Switzerland and its base year is defined as 2009 with 100 index points. This time trend variable serves as a control for time effects. It is expected that with rising rents and building prices for the period 2009-2016 (except for 2011) that the rents and prices of this data set increase over time as well. Therefore, it is hypothesized that the coefficient for *timeindexsale* shows a positive sign in the sales model, as in the study of Fuerst and McAllister (2011b). However, the main reason for the inclusion of this variable is to control for time trends. Thus the interpretation of the coefficient is secondary. As the data for the rent model also represents a time series from the years 2009 to 2016, an adequate time trend variable *timeindexrent* is chosen to control for trends over time. In Switzerland, the mortgage reference rate ("Hypothekarischer Referenzzinssatz bei Mietverhältnissen") is used for rent adjustments due to changes in mortgage interest rates (BWO, 2016b). Therefore it can be used to control for rental changes over time. If for example the reference rate theoretically increases by one percent, the landlord is entitled to a rent increase of 12% (four times 3% per quarter percent reference rate increase) (Lachat et al., 2009). Thus, the sign of the *timeindexrent* is expected to be positively related to the dependent variable *net rent*.

To conclude this section, Table 5.2 shows the impacts of the different control variables on sales prices and rents. Thereby, the revised literature and its findings are listed. Additionally, own ex ante expectations on the control variables, which are discussed and reasoned above, are shown in the last column of the table.

Table 5.2 – Expected Signs of Coefficients

	Salvi et al. (2008)	Salvi et al. (2010)	Miller et al. (2008)	Wiley et al. (2010)	Fuerst et al. (2011a)	Fuerst et al. (2011b)	Fuerst et al. (2009)	Eichholtz et al. (2010)	Eichholtz et al. (2013)	Chegut et al. (2011)	**ex ante expectations**
Structural Variables											
view											+ / +
elevator											+ / +
parking					+0/+0						+ / +
garage											+ / +
wheelchair											+ / +
age			- /	- / -	- / -	+ / -		- /	- / -	0 / -	- / -
builtnew										/ +	+ / +
builtold											- / -
minergie											+ / +
Locational Variables											
distancePT									- / +	+0 / -0	- / -
distancekm											- / -
city			+ /								+ / +
Time Trend Variables											
timeindexsale						+ /					+ /
timeindexrent											/ +

+ or -: coefficient sign for Sale / Rent; 0: not significant (according to their study)

Source: Own representation based on literature review.

5.2.3 Admission Criteria

In order to derive a data set as complete as possible and to avoid heavy outliers, several admission criteria are applied to the entire raw data set. A listing on homegate.ch is only admitted to the final data set if it meets all of the criteria outlined in Table 5.3. The criteria for sale and rent differ with respect to selling price or net rent as well as the usable area. The period of available listings is chosen right after the height of the financial crisis in 2009 up to the current date, which also includes offers available from 2016. The further boundary values are determined in a way that tries to leave as much as Minergie certified buildings as possible in the data set.

Table 5.3 – Admission Criteria

Variable	Admission Criteria	
	Sale	**Rent**
price / net rent (monthly)	CHF 100'000 < ... < CHF 7'500'000	CHF 500 < ... < CHF 20'000
usable area	20 m^2 < ... < 7'500 m^2	50m^2 < ... < 1'300 m^2
price or net rent / usable area	2000 CHF/m^2 < ... < 10'000 CHF/m^2	5 CHF/m^2 < ... < 100 CHF/m^2
age (built / renovated)	> 1850	> 1850
available from	2009-2016	2009-2016
all variables	complete data	complete data

Source: Own representation.

5.2.4 Descriptive Statistics

After applying the admission criteria to the raw data set, the following samples for sales and rent data result. The sales data set counts 1'241 buildings in total. Thereof, 79 buildings are Minergie certified. Due to the small sample size it is statistically not advisable to differentiate between various levels of certification. Therefore, this data set and the upcoming analysis distinguishes only between conventional buildings and buildings that have reached any of the Minergie standards. This also applies to the rent data set, which consists of 75 Minergie certified buildings and another 1'534 conventional control buildings. Additionally, Table 5.4 exhibits the counts for dummy-variables included in the final models for sale and rent. In general, these two data sets provide a solid data basis of offer prices and rents to analyze the impact of a Minergie certification.

Table 5.4 – Sample Size for Sale and Rent

	#	*view*	*elevator*	*parking*	*garage*	*wheelchair*	*builtnew*	*builtold*	*minergie*	*city*
Sale										
2009-2016	1'241	89	498	514	359	214	135	24	79	590
Rent										
2009-2016	1'609	321	776	761	554	477	166	11	75	49

Source: Own representation.

The descriptive statistics of the numerical variables for quality characteristics and location are outlined in Table 5.5 and Table 5.6. For each numerical variable of the final data set, the mean,

median and standard deviation are shown. Of particular note in the sale data set is the fact that Minergie buildings are on average much smaller compared with the whole data set. This circumstance explains why the mean total selling price of about CHF 1.1 m is much greater for the sample as a whole than for the Minergie buildings. These relations reverse and stand to reason when comparing prices per square meter of usable area. By doing so, Minergie certified buildings are offered at a 37% (5'053/3'695) premium per square meter of usable area compared with buildings total. Regardless, this number does not allow for conclusions about the premium that we are looking for, as it does not control for any of the other variables. Another interesting fact given by the descriptive data is that Minergie buildings' construction or recent renovation is on average only 2 years old. For the entire data set the average age amounts to 22 years. This difference can be reasoned by the fact that Minergie is still a relatively young label founded only in 1998. Moreover, the distance to public transport is shorter for Minergie houses on average, this probably results from the fact that high-quality standards as Minergie are more likely to be found in more expensive locations with better infrastructure. However, the other variable for centrality *distancekm* and the variable *distancePT* for the rent data contradicts this reasoning at first glance, as they show shorter distances to public transport or city centers for the whole data set compared to the Minergie buildings.

Table 5.5 – Descriptive Statistics Sale

Sale						
	price (CHF)	*surface (m^2)*	*price/surface*	*age (years)*	*distancePT (m)*	*distancekm*
all						
Mean	1'103'233	365	3'695	22	207	33
Median	985'000	250	3'273	5	100	14
Standard Deviation	933'826	394	1'410	36	236	52
minergie						
Mean	551'671	120	5'053	2	148	40
Median	560'000	116	5'092	2	100	13
Standard Deviation	396'537	113	1'388	2	164	62

Source: Own representation.

In general, the rent data shows on average higher net rents for Minergie certified buildings compared to the overall data set. Even with respect to net rent per square meter of usable area,

Minergie certified office space leases at a premium of about 16% (21/18) without controlling for any variables. In contrast to the sales sample, the usable area, measured in square meter, of Minergie-certified buildings is on average larger than the overall sample. As in the sales data, Minergie buildings are on average much younger than conventional buildings in the rental market. Their construction date, or most recent renovation, is on average only 3 years ago, whereas the whole record shows a mean age of 18 years.

Table 5.6 – Descriptive Statistics Rent

Rent						
	net rent (CHF)	*surface (m2)*	*net rent / surface*	*age (years)*	*distancePT (m)*	*distancekm*
all						
Mean	2'480	148	18	18	142	31
Median	1'900	105	17	9	100	13
Standard Deviation	2'182	139	8	24	171	47
minergie						
Mean	3'151	162	21	3	196	36
Median	2'400	115	20	3	100	16
Standard Deviation	2'451	143	7	2	205	56

Source: Own representation.

5.2.5 Hedonic Regression Results

In the following section, the empirical results for the sales and rent premium of Minergie certified vs. conventional office buildings are validated and discussed. Thereby, the results of the different control variables shall be shortly reasoned and compared with the ex ante expectations of their coefficients (see Table 5.2). The main focus is the dummy-variable *minergie*, which signals that a building is generally Minergie certified (without distinguishing between different levels of certification). The meaningfulness and interpretation of the Minergie coefficient is scrutinized in more detail, as it stands for the possible sales or rent premium of a sustainable building. Moreover, its value shall be put in context with the literature reviewed. Besides the variables coefficients, the Tables 5.7 - 5.10 also outline their levels of statistical significance. A coefficient, which is statistical significant at the 90% level is marked by *, at the 95% level marked by **, and at the 99% level by ***. Additionally, the VIFs (as a measure of collinearity) of the different variables are listed in the last column of

the respective tables. Also the coefficient of determination (R^2) as well as the Durbin-Watson test statistic for autocorrelation is listed in each table.

Results Sales Price Premium

From Equation 5.4 we derive the hedonic regression equation with the natural logarithm of the asking price per square meter usable area as the dependent variable. The choice of a semi-logarithmic log-lin model improves the model in terms of heteroscedasticity issues. [18]

$$\begin{aligned}\ln(p/m^2) = \beta_0 + \beta_1 view + \beta_2 elevator + \beta_3 parking + \beta_4 garage + \beta_5 wheelchair \\ + \beta_6 age + \beta_7 builtnew + \beta_8 builtold + \beta_9 minergie + \beta_{10} distancePT \\ + beta_{11} distancekm + \beta_{12} city + \beta_{13} timeindexsale + \varepsilon\end{aligned} \tag{5.7}$$

It can be seen from Table 5.7 that the structural variables *view, elevator, garage, age, builtnew* and *minergie* meet the ex ante expectations about the sign of their coefficients in the sales model. Additionally, all three locational variables *distancePT, distancekm* and *city* show the expected signs. Surprisingly, *parking, wheelchair* as well as *builtold* don't show the expected signs. Although one would expect a positive relation between the enriching characteristics of parking or a wheelchair accessible building, these two variables have statistically significant negative signs. The reasons for that are ambiguous. For example, the placer of the listing does not regard this information as crucial and omits mentioning it. Another possible reason could be the OVB, which produces unexplainable noise in the data. The statistically significant positive coefficient for the dummy of 50 years old buildings could be explained by the fact that very old buildings are often placed in favorable locations and therefore sell for a premium of approximately 18%, holding all other variables constant. This is also confirmed by the data, as the 24 buildings that are 50 years old or older have, on average, a distance of only 23 km to one of the five biggest Swiss city centers. Moreover, about half of these buildings show even a proximity of under 5 km. These distances are clearly below the average of 33 km for the variable *distancekm* of the whole data set and support the hypothesis that buildings aged over 50 are located in more favorable locations. Furthermore, the *timeindexsale* shows a significant

[18] The improved residual plots as well as the enhancement in Breusch-Pagan test are attached in the corresponding *Mathematica* Files on the attached data CD.

negative coefficient, but, as already mentioned, serves primarily as a control for various time effects. Although the other variables show the ex ante expected signs, *elevator, distancekm* and *city* do not reach the 90% confidence level. In a next step, these insignificant variables are taken out from the model in Equation 5.7. which then proceed in a descending manner and starting with the variables that show the highest p-value (*distancekm*).[19] This leads to the final model, which consists only of significant variables and those results are displayed in Table 5.8.

Table 5.7 – Hedonic Regression Results Sale (All Variables Included)

Variable	Coefficient	Standard Error	t-Statistic	P-Value	Sign.	VIF
Intercept	10.8640	0.2265	47.9718	1.06E-283	***	0
view	0.1378	0.0306	4.4985	7.49E-06	***	1.1426
elevator	0.0261	0.0221	1.1837	0.2367		2.1418
parking	-0.2066	0.0198	-10.4308	1.83E-24	***	1.7410
garage	0.1093	0.0230	4.7543	2.23E-06	***	1.9891
wheelchair	-0.0950	0.0245	-3.8807	0.0001	***	1.5654
age	-0.0021	0.0003	-8.3714	1.53E-16	***	1.4892
builtnew	0.2688	0.0270	9.9598	1.59E-22	***	1.2914
builtold	0.1757	0.0576	3.0498	0.0023	***	1.1509
minergie	0.2150	0.0329	6.5393	9.05E-11	***	1.1786
distancePT	-0.0002	0.0000	-4.6785	3.21E-06	***	1.5146
distancekm	-0.0001	0.0001	-0.8076	0.4195		1.0593
city	0.0206	0.0152	1.3534	0.1762		1.0541
timeindexsale	-0.0243	0.0021	-11.6477	8.18E-30	***	1.2038

R^2=0.4225; $Adj.R^2$=0.4164; DurbinWatsonD = 0.3098
Sample Size: 1'241
* Significant at the 90% level, ** Sign. at the 95% level, *** Sign. at the 99% level

Source: Own representation.

The final model consists of 10 variables, which are all statistically significant on a 99% confidence level, and is written as follows:

$$\begin{aligned} \ln(p/m^2) = \beta_0 + \beta_1 view + \beta_2 parking + \beta_3 garage + \beta_4 wheelchair + \beta_5 age \\ + \beta_6 builtnew + \beta_7 builtold + \beta_8 minergie + \beta_9 distancePT + \beta_{10} timeindexsale + \varepsilon \end{aligned} \tag{5.8}$$

The final model shows an adjusted coefficient of determination of 41.6%. Therefore, 41.6% of the total variation in sales price per square meter usable area is explained by the variation in the

[19] Appendices on the data CD exhibit each step towards the final model.

independent variables. This number is in the range of the reviewed literature, which shows R^2 between 24% (Chegut et al., 2011) to 83% (Wiley et al., 2010) for the sale models. The variable of interest, the *minergie*-dummy amounts a coefficient of 0.2134. This approximately corresponds to a 21.34% Minergie sales premium, holding all other variables constant. The exact calculation ($e^{0.2134} - 1$) would even lead to a 23.79% premium for Minergie. This means that on average a Minergie certified building sells for 23.79% more per square meter usable area than their conventional counterparts, ceteris paribus. At first glance, this number seems to be pretty high, but similar results are found in the studies of Fuerst and McAllister (2011a), Fuerst and McAllister (2011b) and Chegut et al. (2011) on the U.S. and U.K. markets. Fuerst and McAllister (2011b) find a sales premium for Energy Star rated buildings of 26% and for LEED rated buildings of 25%. In their more recent study Fuerst and McAllister (2011a) find a smaller sales premium for Energy Star labeled buildings of 18% and for LEED rated buildings they confirm the 25% sales premium. Chegut et al. (2011) find for their BREEAM certified buildings a sales premium of 26%. All three studies above use the same semi-logarithmic model specifications as in this work and their dependent variable also constitutes a price per square foot or meter. Although, these three studies were based on transaction data from CoStar data bank and scrutinized three different labels, the results of this study are entirely in line with their findings. It is noteworthy that the result of the sales premium strongly depends on the parameters chosen. Thereby, this study tries to find a balance between including the most important hedonic characteristics of an office building in Switzerland as well as to reach a sufficiently large database for analysis. After the selection of the variables, the determining of its admission criteria also strongly affects the premium. Several different sensible boundary values for the admission criteria were tested and with all the different data sets a sales price premium persists.

Table 5.8 – Hedonic Regression Results Sale (Significant Variables Only)

Variable	Coefficient	Standard Error	t-Statistic	P-Value	Sign.	VIF
Intercept	10.8254	0.2250	48.1058	6.16E-285	***	0
view	0.1435	0.0303	4.7303	2.50E-06	***	1.1191
parking	-0.1946	0.0176	-11.0620	3.50E-27	***	1.3716
garage	0.1186	0.0220	5.3834	8.75E-08	***	1.8234
wheelchair	-0.0940	0.0244	-3.8513	0.0001	***	1.5535
age	-0.0021	0.0003	-8.3726	1.52E-16	***	1.4874
builtnew	0.2597	0.0263	9.8826	3.25E-22	***	1.2236
builtold	0.1616	0.0559	2.8889	0.0039	***	1.0843
minergie	0.2134	0.0329	6.4933	1.22E-10	***	1.1761
distancePT	-0.0002	3.76E-05	-5.1258	3.44E-07	***	1.4335
timeindexsale	-0.0238	0.0021	-11.5326	2.73E-29	***	1.1799

R^2=0.4205; $Adj.R^2$=0.4158; DurbinWatsonD = 0.2913
Sample Size: 1'241
* Significant at the 90% level, ** Sign. at the 95% level, *** Sign. at the 99% level

Source: Own representation.

Rent Premium

In the following section the results from the hedonic regression of the rental sample are outlined and discussed. The hedonic regression equation is analogous to the sales price model derived from Equation 5.5. Therein, the dependent variable represents the natural logarithm of the asking net rent per square meter usable area. All explanatory variables are the same as in the sales price model, except for the timeindex (see Chapter 5.2.2).

$$\begin{aligned}\ln(net\ rent/m^2) = \beta_0 + \beta_1 view + \beta_2 elevator + \beta_3 parking + \beta_4 garage + \beta_5 wheelchair \\ + \beta_6 age + \beta_7 builtnew + \beta_8 builtold + \beta_9 minergie + \beta_{10} distancePT \\ + beta_{11} distancekm + \beta_{12} city + \beta_{13} timeindexrent + \varepsilon\end{aligned} \tag{5.9}$$

In the general model shown in Table 5.9, which includes all variables, the structural variables *view, elevator, garage, age, builtnew, builtold* and *minergie* show the ex ante expected signs for their coefficients. As in the sales model, the quality characteristics *parking* and *wheelchair* exhibit negative signs, although *wheelchair* does not reach the 90% level of significance. The same ambiguous reasons

as in the sales model can be reasoned for these findings. The signs of the locational variables coefficients *distancePT* and *city* meet the ex ante expectations, whereas the variable *distancekm* shows contrary to expectations a positive, but statistically not significant (P-Value: 0.3423) coefficient. Overall, the variables *wheelchair, age, builtnew, builtold* and *distancekm* do not show statistical significance at a 90% confidence level. Thus, these variables are taken out of the general model in a descending manner, starting with the coefficient with the highest P-Value (*builtold*).[20] In the end, this eventuates in the final model exhibited in Table 5.10, which consists exclusively of statistically significant variables.

Table 5.9 – Hedonic Regression Results Rent (All Variables Included)

Variable	Coefficient	Standard Error	t-Statistic	P-Value	Sign.	VIF
Intercept	2.5120	0.0613	40.9719	2.53E-251	***	0
view	0.0553	0.0266	2.0798	0.0377	**	1.1254
elevator	0.1183	0.0222	5.3405	1.06E-07	***	1.2217
parking	-0.0954	0.0222	-4.2944	1.86E-05	***	1.2263
garage	0.0710	0.0229	3.0918	0.0020	***	1.1855
wheelchair	-0.0264	0.0254	-1.0399	0.2986		1.3453
age	-0.0003	0.0005	-0.6311	0.5281		1.1708
builtnew	0.0390	0.0365	1.0683	0.2855		1.2309
builtold	-0.0614	0.1224	-0.5019	0.6158		1.0143
minergie	0.1508	0.0509	2.9617	0.0031	***	1.1486
distancePT	-0.0003	0.0001	-4.5352	6.18E-06	***	1.0249
distancekm	0.0002	0.0002	0.9498	0.3423		1.0109
city	0.1418	0.0623	2.2772	0.0229	**	1.1414
timeindexrent	0.1200	0.0250	4.8029	1.71E-06	***	1.0781

R^2=0.0843; $Adj.R^2$=0.0768; DurbinWatsonD = 1.4400
Sample Size: 1'609
* Significant at the 90% level, ** Sign. at the 95% level, *** Sign. at the 99% level

Source: Own representation.

[20] Appendices on the data CD exhibit each step towards the final model.

The final rent model consists of eight variables, which all reach at least the 90% level of confidence. The underlying hedonic regression equation writes as follows:

$$\begin{aligned}\ln(net\ rent/m^2) = \beta_0 + \beta_1 view + \beta_2 elevator + \beta_3 parking + \beta_4 garage + \beta_5 minergie \\ + \beta_6 distancePT + beta_7 city + beta_8 timeindexrent + \varepsilon\end{aligned} \tag{5.10}$$

The final rent model shows an adjusted coefficient of determination of 7.8%. Thus, only 7.8% of the total variation in net rent per square meter usable area can be explained by the variation in the explanatory variables. This explanatory power is rather small compared to the literature reviewed, as the coefficients of determination range from 49% (Chegut et al., 2011) to 69% (Eichholtz et al., 2010) in their corresponding rent models.

The coefficient of the dummy variable *minergie* amounts to 0.1549 and shows high significance on a 99% level of confidence. This approximately corresponds to a 15.49% Minergie rent premium, ceteris paribus. The exact computation ($e^{0.1549} - 1$) leads to a 16.75% rent premium for Minergie certified office buildings, holding all other variables constant. This means that a Minergie certified office building rents on average for 16.75% more per square meter usable area than a conventional office building. The literature reviewed shows rent premia in the range of 2% (Eichholtz et al., 2013) to 21% (Chegut et al., 2011) for the office sector, but most of the studies find a value clearly below 10% for the rent premium. Nonetheless, Wiley et al. (2010) find for their LEED sample a similar premium of about 15 to 17%. Moreover, the study of Chegut et al. (2011) shows an even higher rental premium of 21% for BREEAM certified buildings in the U.K. Therefore, putting this result into context with current literature, it shows a rather high rental premium compared with previous findings. It is again worth mentioning that the rent premium is, as in the sales model, very sensible to the admission criteria applied to the data. However, several reasonable admission criteria were tested for the rent model and a positive significant rent premium persists.

Table 5.10 – Hedonic Regression Results Rent (Significant Variables Only)

Variable	Coefficient	Standard Error	t-Statistic	P-Value	Sign.	VIF
Intercept	2.5249	0.0593	42.5491	3.07E-265	***	0
view	0.0510	0.0263	1.9374	0.0529	*	1.1048
elevator	0.1146	0.0214	5.3493	1.01E-07	***	1.1432
parking	-0.1000	0.0212	-4.7210	2.55E-06	***	1.1161
garage	0.0732	0.0227	3.2192	0.0013	***	1.1637
minergie	0.1549	0.0505	3.0658	0.0022	***	1.1325
distancePT	-0.0003	0.0001	-4.5062	7.08E-06	***	1.0226
city	0.1435	0.0620	2.3124	0.0209	**	1.1343
timeindexrent	0.1146	0.0245	4.6822	3.08E-06	***	1.0352

R^2=0.0823; $Adj.R^2$=0.0777; DurbinWatsonD =1.4350
Sample Size: 1'609
* Significant at the 90% level, ** Sign. at the 95% level, *** Sign. at the 99% level

Source: Own representation.

5.3 Occupancy Premium

5.3.1 Model Specification and Data Set

As previously mentioned, the data basis for examining the occupancy premium is provided by REIDA and its operation partner Meta-Sys AG. In contrast to the homegate.ch data set, which represents asking data, this set of data is based on real rental contracts. The enriching additional information of this data is whether a rental object is vacant or occupant. The raw data set, provided by Meta-Sys AG, is on a contract level and therefore includes the information whether a rental unit is vacant or not. This type of information would only allow for a logit model, where the dependent variable is a dummy showing 0 or 1. However, the interpretation of a logit model is much harder than of a linear regression model and thus its result in this study serves mainly to statistically confirm and underpin the findings in the hedonic model. In order to create a hedonic regression model out of these contractual data, all the single contracts of the data set are assigned to their corresponding buildings and their data is pooled and aggregated on a buildings' level. In that way an occupancy rate is computable as the relation between effective rent and target rent and thus delivers the dependent variable for the occupancy regression model. This way, the effect of various building characteristics as

for example Minergie certification etc. on occupancy can be measured and interpreted. In principle, the model for the occupancy premium is simply derived by rearranging the hedonic regression model and defining the occupancy rate as the regressand. This model specification allows the question if and to what extent an occupancy premium for Minergie certified buildings exist to be answered. The formulation of the model specific equations are shown in the regression results. The following table presents all the variables, which are used for the hedonic occupancy model and shows their name in the models and description as well as their units. The dependent variables are described for both the hedonic and the logit model. The explanatory variables are as in the sales- and rent model categorized into structural and locational variables. A time trend variable is omitted, as the provided data from REIDA only includes the years 2014 and 2015. Therefore, time trend effects are assumed to be negligible. All variables displayed in Table 5.11 are taken from the REIDA data set and correspond to the hedonic model. The pooling of the single rental contracts in order to describe the building level is the reason why some variables are the sum (*sumsurrentable*) or average (*avggrossrentmqyear, avgroomscats, avgfloorcats*) of several contracts of the same building.[21] It is noteworthy, that REIDA falsified the variables for rentable area (*surrentable*) and *age* (or building period) in order to comply with data protection. The fact that no information on renovation is given in the export of REIDA could distort results on occupancy. This way, a possible refurbishment towards a higher building quality and standard would signal vacancy although it should be excluded from the analysis. In order to take this into account the categorical variables *built1* - *built6* are modeled in the way that the building periods *built1* - *built5* are compared to the most recent reference period *built6* (UCLA, 2016). Since for the years 2011-2015 *built6* "hidden" renovations are expected, this period is also expected to show lower occupancy rates than the others. "Hidden" renovations could be present in the whole period from 2011-2015 as the falsification of variables amounts to +/- 5 years. Such building operations might lead to an increase in the vacancy rate and thus could bias the effect of the other regression coefficients on occupancy. Additionally, in the immediate time period following renovation, these newly constructed buildings may also take up some time to obtain new tenants, which in return explains higher vacancies. The upcoming analysis examines the commercial as well

[21] For the logit model these variables are not summed up or averaged on a buildings' level, as the data stays on a contractual level. This can be seen in the designation of the variables *surrentable, grossrentmqyear, roomscats* and *floorcats* in the logit model regression results of Table A4 and A6 of the appendix.

as the residential real estate sector. The data set from REIDA consists of about 25'000 commercial and 136'000 residential rental contracts in total. In the commercial data set there are not only offices but also buildings for warehouse, trade, industry and gastronomy included. Therefore, the residential real estate data represents the more powerful data basis, as it consists of "homogenous" residential contracts and also includes a sufficient large number of Minergie certified buildings. More on these numbers in the next section on descriptive statistics.

Table 5.11 – Description of Variables: Occupancy Model

Name in Models	Description	Units
Dependent Variable		
OR (Occupancy Rate)	[effective rent w/ vacancy (CHF)] / [target rent w/o vacancy (CHF)]	%
Occupancy (Logit Model)	1 = occupant; 0 = vacant	D
Structural Variables		
ln(sumsurrentable)	natural logarithm of sum of rentable area from the contracts of the same building (falsified +/- 5% uniform)	m^2
built1 - built6	D, 1=built in corresponding period, where built6 is the base category, which is always 0	D
age	age of the building (falsified +/- 5 years)	Years
ln(avggrossrentmqyear)	natural logarithm of building average of gross rent per square meter per year	CHF/m^2
avgroomscats	building average of the categorical variable for numbers of rooms (1 room to 6 rooms and more)	D 1-6
avgfloorcats	building average of the categorical variable floors (1=basement, 2=ground floor,...5=upstairs or penthouse)	1-5
minergie	D, 1=object has been certified by Minergie	D
Locational Variables		
ratingmicroch	rating for micro location within Switzerland (1=extremely unfavorable,...17=average,...33=extremely favorable)	1-33

Source: Own representation.

5.3.2 Descriptive Statistics

The information on the delivered attributes of the REIDA data set are almost complete and only some of the data points are excluded due to missing data. No further admission criteria are applied to the data in order to retain a sample as big as possible. For the commercial and residential data sets the sample sizes as well as the counts for the dummy-modeled building periods as well as Minergie certifications are listed in the table below.

Table 5.12 – Sample Size for Occupancy

		#	*before 1920*	*1921-1960*	*1961-1980*	*1981-2000*	*2001-2010*	*2011-2015*	*minergie*
Commercial (2014-2015)	Hedonic	2'391	312	666	599	622	155	37	16
	Logit Model	18'081	1'560	6'503	5'043	3'846	1'041	88	125
Residential (2014-2015)	Hedonic	6'851	224	2'039	2'339	1'610	530	109	37
	Logit Model	101'146	1'928	42'585	35'948	16'240	4'049	396	361

Source: Own representation.

The commercial as well as the residential data set are shown on the aggregated hedonic building level as well as the single contract logit level. Noteworthy is the fact that only 16 Minergie certified buildings are included in the commercial data set, which corresponds to 125 contracts. This sample size is unlikely to deliver statistically significant results regarding the occupancy rate. On the other hand, the residential data set seems to have with 37 Minergie certified buildings enough data to examine the effect of Minergie certification on occupancy.

The descriptive statistics of the numerical variables are outlined in Table 5.13 and 5.14. For each of the variables the mean, median and standard deviation are listed.

An important fact is, that the mean occupancy rate for the overall commercial sample (including conventional buildings) is with 94.28% much higher than for the Minergie buildings, which only reach occupancy levels of 83.73% on average. At first glance this might be an indicator for lower occupancy in Minergie certified buildings. However, this mere descriptive statistic does not take any of the other control variables into account and therefore does not allow for drawing any conclusions. Additionally, one should bear in mind that the Minergie sample for commercial buildings can not be a representative sample with only 16 objects. The average age of a Minergie building in the sample is only 7 years whereas the overall sample shows an average building age of 52 years. The other building attributes are in a similar range when comparing the overall data set with the Minergie sample.

Table 5.13 – Descriptive Statistics Occupancy - Commercial

Commercial (hedonic)						
	occupancy rate	*sumsurrentable (m^2)*	*age (years)*	*avggrossrentmqyear*	*avgfloorcats*	*ratingmicroch*
all						
Mean	0.9428	901	52	215	2	22
Median	1.0000	147	48	143	2	23
Standard Deviation	0.1786	2'303	28	272	1	9
minergie						
Mean	0.8373	846	7	215	2	19
Median	1.0000	505	8	269	2	24
Standard Deviation	0.2958	1'949	3	104	1	10

Source: Own representation.

An interesting fact in the residential data set is that as in the commercial data the overall occupancy rate is higher than in the sub-sample of Minergie certified buildings. With 98.16% the occupancy rate of Minergie certified buildings is only slightly lower than in the overall sample, which shows occupancy of even 98.34%. The statistics of the Bundesamt für Wohnungswesen (BWO, 2016c) support this finding for occupancy rates of apartments in Switzerland. They computed a vacancy rate of 1.19% for the 1st June of 2015, which corresponds to an occupancy rate of 98.81%. Again, Minergie certified buildings are on average much younger and also seem to be built with more rentable surface area compared to the overall sample. Moreover, also in this data set, the Minergie certified buildings show higher average gross rents per square meter a year, which might indicate that this data also supports a rental premium for Minergie like in the homegate.ch data set. The further numerical building characteristics do not seem to show remarkable differences between the overall data set and the Minergie sub-sample.

Table 5.14 – Descriptive Statistics Occupancy - Residential

Residential (hedonic)							
	occupancy rate	*sumsurrentable (m^2)*	*age (years)*	*avggrossrentmqyear*	*avgroomscats*	*avgfloorcats*	*ratingmicroch*
all							
Mean	0.9834	1'421	48	250	3	4	25
Median	1.0000	1'144	47	236	3	4	27
Standard Deviation	0.0630	1'223	24	177	1	1	7
minergie							
Mean	0.9816	2'550	8	279	3	4	22
Median	1.0000	2'159	8	269	3	4	25
Standard Deviation	0.0347	1'125	7	49	0.3	0.4	7

Source: Own representation.

5.3.3 Hedonic Regression Results

In the following section, the hedonic regression results for an occupancy premium of commercial and residential Minergie certified vs. conventional buildings are validated and discussed. Furthermore, the results of the hedonic regressions are also underpinned by the findings of the corresponding logit models. The main focus lies in the coefficient Minergie. A positive significant coefficient for this variable would indicate a significant positive relation between a Minergie certification and occupancy. The meaningfulness and interpretation of the Minergie coefficient will be discussed in more detail, as it stands for a possible occupancy premium for sustainable buildings. Additionally, the findings shall be put into context with the current literature. Furthermore, the same measures of statistics are applied and shown as has already been done in the sales- and rent models. The parameter tables include the coefficients as well as their statistical significance marked by stars. Moreover, the corresponding results of the logit models are added to the tables. The extensive versions of each of the tables on its own can be taken from the appendices Table A3 - A6.

Results Occupancy Premium - Commercial

By rewriting the general formula for a hedonic rent model (e.g. Equation 5.5), the following regression equation with the occupancy rate as the dependent variable results:

$$\begin{aligned} OR = \beta_0 + \beta_1 ln(sumsurrentable) + \beta_2 built1 + \beta_3 built2 + \beta_4 built3 + \beta_5 built4 \\ + \beta_6 built5 + \beta_7 built6 + \beta_8 age + \beta_9 ln(avggrossrentmqyear) \\ + \beta_{10} avgfloorcats + \beta 11 minergie + \beta 12 ratingmicroch + \varepsilon \end{aligned} \tag{5.11}$$

The occupancy rate can take on values in the interval of $[0; 1]$ and can therefore be interpreted as a percentage value. The numerical variables *sumsurrentable* and *avggrossrentmqyear* are as in Fuerst and McAllister (2011b) logarithmized. Moreover, the model specification of a categorical building period is implemented according to the paper of Fuerst and McAllister (2011a). An interesting insight of the hedonic OLS regression results of Table 5.15 is that according to expectations, the buildings which have a building period before 2011 show higher occupancy compared to the base period of *built6*. This observation underpins the assumption that there might exist hidden renovations in the base period, which erroneously increase vacancy but could not be accounted for in the data. Another interesting insight delivers the highly significant locational variable *ratingmicroch*. It allows for the interpretation that the more favorable a location for a specific building, the higher is its occupancy rate. Interestingly, the hedonic OLS regression model shows no statistical significance of the Minergie dummy on the occupancy rate. Although, the coefficients' sign shows in the expected direction, the hypothesis, that the minegie coefficient is equal to zero, can not be rejected. The reason for this insignificance of the Minergie dummy could be in the small sample size of only 16 Minergie buildings. This small sample size does not allow for a statistical significant statement in the hedonic OLS model. Regardless, the logit model indicates a positive effect of Minergie certification on occpancy on a 10% level of significance. However, the logit coefficient of 0.6056 is in log-odds units and can not be interpreted as a regular OLS coefficient. Although, a quantitative interpretation of this coefficient is difficult it indicates a positive causality between Minergie certification and occupancy. This positive relation between green labeled office buildings and occupancy is found in several studies of the literature reviewed. Their results range from small positive occupancy premium of about 1% in the

study of Fuerst and McAllister (2011a) to highly significant 10% for Energy Star to 18% for LEED buildings in the paper of Wiley et al. (2010).

Table 5.15 – Regression Results Occupancy - Commercial

	Hedonic OLS		**Logit Model**	
Variable	**Coefficient**	**Sign.**	**Coefficient**	**Sign.**
Intercept	0.7237	***	-1.5271	***
ln(sumsurrentable)	0.0075	**	0.1179	***
built1 (before 1920)	0.0704		1.3507	**
built2 (1921-1960)	0.1027	**	2.1026	***
built3 (1961-1980)	0.1111	***	1.8757	***
built4 (1981-2000)	0.1158	***	1.7368	***
built5 (2001-2010)	0.0336		1.0164	***
built6 (2011-2015)	0.0000	(base period)	0.0000	(base period)
age	0.0009	**	0.0038	
ln(avggrossrentmqyear)	0.0104		0.3953	***
avgfloorcats	-0.0238	***	-0.2077	***
minergie	0.0142		0.6056	*
ratingmicroch	0.0012	***	0.0092	**
Sample Size:	Sample Size: 2'391		Sample Size: 18'081	
	(thereof 16 Minergie buildings)		(thereof 125 Minergie contracts)	
* Significant at the 90% level, ** Sign. at the 95% level, *** Sign. at the 99% level				

Source: Own representation.

Results Occupancy Premium - Residential

By rearranging the general formula for a hedonic rent model (e.g. Equation 5.5), the following regression equation with the occupancy rate as the dependent variable results:

$$\begin{aligned} OR = \beta_0 + \beta_1 ln(sumsurrentable) + \beta_2 built1 + \beta_3 built2 + \beta_4 built3 + \beta_5 built4 + \beta_6 built5 \\ + \beta_7 built6 + \beta_8 age + \beta_9 ln(avggrossrentmqyear) + \beta 10 avgroomscats \\ + \beta_{11} avgfloorcats + \beta 12 minergie + \beta 13 ratingmicroch + \varepsilon \end{aligned} \tag{5.12}$$

Table 5.16 shows the results of the hedonic regression on occupancy of the residential sample. As in the commercial model above, a second logistic regression model is run to support the findings of the hedonic OLS regression. An interesting fact of the hedonic parameter table below is, that the base period *built6* shows as expected a significantly lower occupancy rate than the other building periods.

As already mentioned above this significantly lower occupancy rate for the years 2011 to 2015 could embody hidden renovation activity. The variable of interest, the *minergie* dummy, shows a positive coefficient, which is statistically significant on a 95% level of confidence in the hedonic OLS model. Although in this sample the logit model can not support the significance for the *minergie* dummy, the positive coefficient of 0.4463 at least indicates that there is a positive causality between Minergie and occupancy. However, the positive significant *minergie* coefficient of 0.0206 in the hedonic OLS regression even allows for a quantitative interpretation of the relation between Minergie certification and occupancy rate. Therefore, it can be stated that a Minergie certified building shows a ceteris paribus 2.06% higher occupancy rate than conventional buildings in the residential real estate market.

Table 5.16 – Regression Results Occupancy - Residential

	Hedonic OLS		**Logit Model**	
Variable	**Coefficient**	**Sign.**	**Coefficient**	**Sign.**
Intercept	0.9562	***	3.5806	***
ln(sumsurrentable)	0.0037	***	-0.1284	*
built1 (before 1920)	0.0697	***	0.4560	
built2 (1921-1960)	0.0574	***	0.9877	***
built3 (1961-1980)	0.0534	***	0.8273	***
built4 (1981-2000)	0.0520	***	1.0820	***
built5 (2001-2010)	0.0404	***	0.2505	
built6 (2011-2015)	0.0000	(base period)	0.0000	(base period)
age	-0.0001		0.0068	*
ln(avggrossrentmqyear)	-0.0096	***	-0.0377	
avgroomscats	-0.0055	***	-0.3187	***
avgfloorcats	-0.0029	**	-0.1807	***
minergie	0.0206	**	0.4463	
ratingmicroch	0.0014	***	0.0766	***
Sample Size:	Sample Size: 6'851 (thereof 37 Minergie buildings)		Sample Size: 101'146 (thereof 361 Minergie contracts)	

* Significant at the 90% level, ** Sign. at the 95% level, *** Sign. at the 99% level

Source: Own representation.

According to the literature review in Chapter 4, green office buildings are expected to show rather small premium concerning occupancy compared to the ones on sales and rent. In this study no statistically significant higher occupancy rates for commercial Minergie buildings compared to their conventional counterparts could be found. The coefficients however at least indicate a positive

causality. On the other hand, the residential real estate data set in this work shows a statistically significant occupancy premium of about 2.06% for Minergie certified buildings in the hedonic OLS regression model. Therefore, these results support the hypothesis that green buildings mitigate risks through lower vacancies in the residential Swiss real estate market.

Chapter 6

An Investor's Perspective

6.1 Merging the Sales-, Rent- and Occupancy Premia in an Investor's Cap Rate Based Analysis

In this last part of the study, the results from the empirical analysis regarding sales-, rent- and occupancy premia of green buildings in Switzerland shall be validated and discussed. For this purpose a yield analysis by means of cap rates or internal rate of return (IRR) is conducted. In order to perform this comparative analysis between Minergie certified and non-certified buildings, some simplifications and assumptions are made. First, a representative average building for Minergie and conventional buildings is defined based on the data from the homegate.ch sales sample:

Table 6.1 – A Representative Minergie and Conventional Building

	Minergie	Conventional
age	2 years	22 years
surface	365 m2	365m2
V (price)	CHF 1'365'692	CHF 1'103'233
	123.79%	100%
sales premium	CHF 262'459	
	23.79%	
net rent / m2 (monthly)	CHF 21.14	CHF 18.11
	116.75%	100%
rent premium	CHF 3.03	
	16.75%	
total net rent (yearly) [22]	CHF 92'591	CHF 79'307

Source: Own representation.

The table above incorporates the information gained on sales- and rent premia from hedonic regression analysis of the empirical part in Chapter 5. Moreover, a typical building of the sales sample is characterized by its usable floor space of 365 m^2 and an average age of 2 and 22 years respectively.

In the following a shortcut of an IRR determination in a discounted cash flow (DCF) valuation is performed. Hereby the IRR equals the cap rate as the rents (cash flows) are assumed to be constant in perpetuity. Additionally, the growth rate is set to zero. Appendix Table A7 shows that under these assumptions the IRR of a DCF valuation is equal to the cap rate. Thus, dividing the Net Operating Income *NOI* by the price *V* results in the *Cap Rate*, which is the same as the *IRR* under these conditions:

$$Cap\ Rate\ (\text{IRR}) = \frac{NOI}{V} \tag{6.1}$$

[22] Corresponds to gross rental income in Table 6.2.

The prices V for the Minergie and conventional buildings are estimated by the hedonic models of Chapter 5.2 and given in the third line of Table 6.1. The Net Operating Income or net rental income is derived by subtracting operating costs and accruals from the gross rental income. For this purpose common average rates for operating costs and accruals in percentage of gross rental income are applied. These percentages are suggested by Lehmann and Conca (2005). Into this calculation the results of a possible occupancy premium of this study comes into play. As for the commercial sector no statistically significant premium is found in the data, the same vacancy costs are assumed for Minergie and conventional buildings. The table below illustrates how the net operating income (here net rental income) is derived:

Table 6.2 – Net Operating Income Derivation

	in % of gross rental income	Minergie	Conventional
gross rental income		CHF 92'591	CHF 79'307
service charges	4-8%		
maintanance costs	6-15%		
administration costs	3-7%		
vacancy costs	0-6%		
operating costs	20% (15%-25%)	CHF 18'518	CHF 15'861
accruals	11% (7-15%)	CHF 10'185	CHF 8'724
NOI or net rental income		CHF 63'888	CHF 54'722

Source: Own representation; percentages according to Lehmann and Conca (2005, pp. 24-25).

The net rental income is especially of great interest from a home owner or investor's perspective as it represents the amount of cash that is used to serve the interest of the invested capital (equity and debt). Inserting the values for *NOI* and *V (price)* of Tables 6.1 and 6.2 into Equation 6.1 leads to the following cap rates for Minergie and conventional buildings:

$$Cap\ Rate_{Minergie} = \frac{\text{CHF 63'888}}{\text{CHF 1'365'692}} = 4.6781\% \tag{6.2}$$

$$Cap\ Rate_{Conventional} = \frac{\text{CHF 54'722}}{\text{CHF 1'103'233}} = 4.9601\% \tag{6.3}$$

These cap rates can be interpreted as internal rates of return. The IRR as a discount rate serves to convert future dollars into their present value equivalents. Thereby, the discount rate has two primary tasks. On the one hand it shall discount future cash flow streams and thus account for the time value of money. Furthermore, the discount rate shall take the risk in the expected future cash flows into account by means of a risk premium. Thus, according to Geltner et al. (2013) the discount rate or total return (here cap rate or IRR) can be broken into a risk-free interest component and a risk premium component and writes as follows:

$$r = r_f + RP \tag{6.4}$$

Equation 6.4 helps in the understanding of the difference between the cap rates of Minergie certified and conventional buildings. As the risk-free interest rate[23] accounts for the time value of money and should be the same for both types of investments, the distinguishing part of the two cap rates represents the risk premium RP (Geltner et al., 2013). Therefore, conventional buildings seem to have higher risk premia compared to Minergie-certified buildings in the examined data. In other words, Minergie-certified buildings show lower risk premia and thus their cash flows are less risky than their conventional counterparts and therefore have effectively lower cost of capital in the asset markets. These results are confirmed by findings of Ambec and Lanoie (2008), which conclude that there is evidence that better environmental performance in general leads to a reduction in cost of capital. Ambec and Lanoie (2008) list some of the reasons why higher environmental performance leads to higher financial performance and thus to a lower cost of capital: First, eco-friendly firms have easier access to capital markets through the proliferation of many green mutual funds. Second, firms with good environmental performance can borrow more easily and under better conditions from banks. Third, shareholders may be generally sensitive to news on ecological performance of firms and their reactions can be reflected in the stock market. The study of Eichholtz et al. (2013) also supports the existence of lower risk premia for sustainable commercial real estate. The authors find evidence, that real estate investors value the lower risk premium, which perhaps could be explained by the insurance function against future increases in energy prices or a shift in preferences of tenants and

[23] As a risk-free investment in this context could serve a 10 year Swiss government bond.

investors towards more environmental issues. Another study of McGrath (2013) quantifies the effect of eco-certification on excess capitalization rates[24] in the U.S. Through hedonic regression analysis the question whether the premia in rent and sales price of eco-certified buildings translate into lower excess capitalization rates is scrutinized. Results show that overall eco-certified buildings (LEED & Energy Star) have excess capitalisation rates that are 0.364% lower as their conventional counterparts and therefore underpin the results found in this study. However, this study does not run regression analysis to investigate the cap rates of Minergie and conventional buildings directly. Nonetheless, the computation of the cap rates above integrates the sales-, rent- and occupancy premia, which are all derived by hedonic regression analysis in Chapter 5. Finally, the results above suggest that cap rates of Minergie certified buildings are about 0.282% lower than their conventional counterparts and thus are in line with the theoretical and empirical evidence from Ambec and Lanoie (2008) and McGrath (2013). According to McGrath (2013), the lower cap rates of green buildings indicate that there is less perceived investment risk or risk premium for such investments, which also reflects an increasing demand for these sustainable buildings and higher expected future income growth rates.

In order to classify and reason the obtained cap rates of 4.68% and 4.96% for Minergie and conventional buildings respectively, the net cap rates or initial yields for office buildings in Switzerland of Colliers (2013, 2015) are considered. These numbers represent data that was gathered based on investor interviews. The cap rates show nearly the same period under observation (2009-2014) as the homegate.ch data set (2009-2016), from which the cap rates for Minergie and conventional buildings are derived.

Table 6.3 – Net Cap Rates for Office Buildings in Switzerland

	2009	2010	2011	2012	2013	2014	**Average**
Office Yield - Class A	4.4%	4.1%	4.0%	3.8%	3.6%	3.2%	**3.9%**
Office Yield - Class B	5.2%	4.8%	4.6%	4.5%	4.4%	4.2%	**4.6%**
Office Yield - Class C	6.7%	6.0%	6.0%	6.2%	6.2%	6.5%	**6.3%**

Source: Own representation according to Colliers (2013, 2015).

Table 6.3 provides two important insights. First and foremost, the cap rates for Minergie and

[24] Excess capitalization rates are capitalization rates in excess of the risk-free rate. McGrath (2013) used the three month T-bill for the risk-free rate.

conventional buildings calculated above are in the bandwidth of the numbers of Colliers (2013, 2015). This fact makes the derivation of the cap rates from above plausible. The second insight of Table 6.3 is the fact, that higher classed office buildings demand for lower cap rates or lower risk premia. This also holds true for the comparison between the $Cap\ Rate_{Minergie}$ and $Cap\ Rate_{Conventional}$ and implies that Minergie-certified buildings are associated with better quality buildings and lower investment risks. According to Table 6.3, the Minergie buildings of the scrutinized data would classify into Class B buildings and their conventional counterparts somewhere between Class B and C. However, as the cap rates calculated in Equations 6.2 and 6.3 strongly depend on the assumptions made on operating costs and accruals in Table 6.2, they are appropriate for relative comparison between them, but their absolute values should be interpreted with caution.

6.2 Do Energy Savings from Minergie Buildings Pay?

According to Minergie (2015b) there are three main advantages of its building standard: higher energy cost savings, superior comfort and enhanced conservation of value. Out of these three benefits the energy cost savings might be the easiest to analyze and quantify. In this context the question of profitability urges how long does it take, until the sales price premium pays for an investor, if only energy savings are contemplated? In other words, what is the payback period until the initial investment (here the price premium for Minergie) is paid back through energy savings. To answer this question some assumptions according to Salvi et al. (2008) have to be made. Firstly, it is assumed that the sales price premium for an average Minergie certified office building corresponds to the 23.79% found in this study and thus amounts to CHF 262'459. Moreover, for the sake of comparability the energy demand is translated into heating oil, although most Minergie buildings already use other energy sources. For a Minergie office building an annual energy demand of 40 kWh/m^2 is assumed.[25] This corresponds roughly to 4 litres heating oil per year and per square meter. The corresponding average value for a conventional office building is according to Weber (2002, p. 113) about 120 kWh/m^2 a[26] This three times higher energy demand corresponds to an

[25] 40 kWh/m^2 a corresponds to the Minergie limit value for a new built administration office.

[26] This number is calculated by converting the mean of the whole sample of the study of Weber (2002, p. 113) of 443 MJ/m^2 a into about 120 kWh/m^2 a.

average for an office building in the 1990s and is appropriate due to the fact that conventional buildings in the homegate.ch sales sample show an average age of about 22 years. Furthermore, an average price for 100 litres heating oil in CHF for the sample period of 2009-2015 is calculated in order to express the heating oil savings in terms of money (BFS, 2016). This reasoning and its underlying assumptions lead to the following calculations:

Table 6.4 – Exemplary Energy Savings Calculation

Calculation Steps	Designation	Sample Calculation	
a	Average office (all) surface:	365	m2
b	Average sales price office:	1'103'233	CHF
c=b*1.2379	Sales price of (comparable Minergie office with premium (+23.79%), ceteris paribus):	1'365'692	CHF
c-b	Average sales price premium:	262'459	CHF
	Energy cost calculations based on heat energy indices		
d	Heat energy index Minergie office building:	40	kWh/m2 a
e	Heat energy index conventional office building built in the 1990s:	120	kWh/m2 a
f=e-d	Δ savings:	80	kWh/m2 a
g=a*f	Total yearly energy savings:	29'200	kWh p.a.
h	1 litre extra light heating oil = 9.9 kWh:	9.9	kWh p.a./l
i=g/h	Total yearly heating oil savings:	2'949	l
j	Average price of 100 l heating oil in CHF for the period 2009-2015:	91	CHF/100l
k=(i/100)*j	Annual savings in CHF for Minergie vs. conventional Building:	2'673	CHF p.a.
(c-b)/k	Static payback period (w/o cost of capital):	98	years

Source: Own calculations.

The calculations in Table 6.4 show that the annual savings for Minergie-certified buildings amounts to about CHF 2'673 p.a. Applying a static payback period calculation by simply dividing the average sales price premium of CHF 262'459 by the annual savings and not taking any capital costs into account, shows that only after 98 years the premium price would be paid back, when only the energy savings are considered. Salvi et al. (2008) performs a similar calculation. However, instead of searching for the payback period of the additional costs for building according to Minergie, the authors raise the question of up to which point the oil price has to climb, until the additional Minergie-investment pays off. Their study concludes, that for a single-family home the oil price needs to surge to CHF 218 per 100 litres in order to amortize the investment by means of energy cost sav-

ings within 30 years. Considering the same assumptions for a condominium, a Minergie-investment pays already if the oil price amounts to CHF 102 per 100 litres. These numbers of the residential real estate sector confirm that premia paid on Minergie buildings can not be justified by energy savings alone.

Assuming that the annual energy savings of CHF 2'673 are capitalized by the Minergie cap rate of 4.6781% from Equation 6.2 would lead to a total energy saving of about CHF 57'139. The owner of an office building could therefore adjust its net rents upwards due to lower heating and ancillary costs without increasing the gross rent. However, these energy savings explain only about 22% of the total premium paid for a Minergie certified office building in Switzerland. According to Binz and Bürgi (2010) the energy savings of a Minergie-P building amortizes not more than 1/3 of the additional costs for building green over a timespan of 25 years. Although the sales price premium of CHF 262'459 constitutes a price mark-up based on listings and not real transaction data, its corresponding hypothetical energy savings of about 22% is in the range of what Binz and Bürgi (2010) found in their study on Minergie-P buildings. However, the question remains why an investor should pay the other 78% premium for a Minergie-certified building. Thus, there must be other reasons than energy savings for this high willingness to pay for Minergie-certified buildings.

6.3 What drives the High Willingness to Pay for Minergie Buildings?

This last section shall get to the bottom of why there is a high willingness to pay for Minergie buildings in the sales and rental market. As the last section has shown, the advantage of greater energy efficiency of a Minergie office building could be worth of about 22% of the premium paid. But what about the other 78%? This section shall reason in a qualitative manner what other factors could explain a high willingness to pay for a Minergie versus a conventional building. As already mentioned, Minergie (2015b) lists three main advantages of its standard: higher energy cost savings, superior comfort and enhanced conservation of value. As the higher energy cost savings benefit was already dealt with in Chapter 6.2, this chapter qualitatively discusses the superior comfort and enhanced conservation of value.

Green buildings not only consume less energy and value sustainable building materials, they also value a superior comfort of living for their inhabitants. In the case of Minergie the comfort ventilation is a fixed part of the building standard and should not only maintain the good condition of the building envelope but should also add to the health and quality of living of its inhabitants. According to Kats et al. (2003) the 20-year Net Present Value (NPV) of a LEED (Gold and Platinum) certified building is about ten times higher for the productivity and health value than the value from energy savings. This fact underpins the relatively large importance of productivity and health gains due to building green. Because of the fact that the direct and indirect costs of employees (especially the costs of absenteeism) carry much more weight for a company than energy or construction costs, even small enhancements in health and productivity lead to great financial benefits. Therefore, productivity gains due to superior comfort or better working environment must be considered and might be another reason for a high willingness to pay for Minergie certified buildings.

The third main advantage of the Minergie standard is the enhanced conservation of value. Building according to Minergie protects the home owner against future raising energy prices and reduces dependence on conventional energy sources such as oil. Moreover, sustainable buildings help to comply with possible stricter future environmental regulations. Additionally, a home owner can profit more easily from subsidies when building according to Minergie standards. The "Gebäudeprogramm", a joint program of several governmental institutions[27] awards subsidies for reducing the energy consumption of buildings. Therefore whether a project is a total renovation according to Minergie standards positively influences the amount of subsidies the home owner gets (EnDK et al., 2016). Minergie does provide financial benefits and might also reduce the risk of mortgage financing. This lower risk premium of a Minergie certified building is for example also reflected by the reduction of interest of up to 0.80% on ZKB's product "Umweltdarlehen" for a private person (ZKB, 2016). Of course, the banks' decision to give cost reduction on sustainability related renovations might also be driven by marketing motives. Nonetheless, the fact that a bank like ZKB encourages investments in Minergie underlines their faith in building green.

The above arguments all try to qualitatively reason the high premia found for the sales, rents

[27] The "Gebäudeprogramm" was developed by the "Konferenz kantonaler Energiedirektoren EnDK", "Bundesamt für Energie" BFE and "Bundesamt für Umwelt" BAFU.

and occupancies of Minergie certified buildings in this work. In other words, these argumentations and facts underpin the high willingness to pay for a sustainable Minergie building in Switzerland.

Chapter 7

Conclusion

Over the last 25 years, an increasing interest in sustainable buildings has risen globally. Switzerland sets a good example as about every fourth newly constructed building has been certified according to Minergie, since the label first entered the Swiss market in 1998 (Tännler, 2015). Although the initiative for building green has been largely left to private property investors as well as owner-occupiers, there seems to persist a high willingness to pay for additional certification fees as well as significantly higher construction costs. As the Swiss real estate market represents one of the highest densities of sustainable buildings, it is an ideal object of study to challenge the how and to what extent green buildings mitigate risk (Salvi and Syz, 2011).

The existing studies on green buildings have mainly focused on their premia in prices and rents, whereas risk mitigation is often left out. As a risk-return conscious investor needs to consider both dimensions, this master thesis has shown that a premium in occupancies acts as a risk mitigating factor for building green. The predominant Swiss green building label Minergie mainly certifies residential real estate. Therefore, existing literature on green premia on the Swiss market have focused on single- and multi-family homes, as they account for about 87% of all Minergie certified buildings. Hence, commercial real estate, as for example administration offices, industry or insurance buildings are under-represented. Because of the relatively small number of certified commercial real estate and restricted data availability, there has been a gap in the academic literature on green premia in the Swiss commercial real estate sector. Thus, this study complements the existing literature on

green sales- and rent premia in the residential sector with evidence in the commercial real estate sector. Moreover, this master thesis shows a green occupancy premium in the commercial as well as the residential sector. All three premia on sales, rents and occupancies have been examined by running regression analysis in a hedonic model. This allows for isolating the ceteris paribus effect of a Minergie certification on prices, rents and occupancies compared to a conventional property.

For the sales- and rent premium listing data from the internet real estate platform homegate.ch was analyzed. Additionally, these models were refined with some locational and time trend variables in order to best isolate the effect of Minergie certification in the hedonic models. Results revealed, that Minergie certification exhibits a 23.79% sales premium in the listing data. As expected from the reviewed literature, the rent listing sample also shows a highly significant premium for Minergie buildings of 16.75% compared to their conventional counterparts. In summary, it can be stated that these results underpin and confirm the existence of a green premium on sales prices and rents in the Swiss commercial real estate market. Thus, based on these findings one can conclude that Minergie certified commercial space is offered at significant higher sales prices as well as rents on the Swiss market. The occupancy premium is scrutinized based on contractual data from REIDA. In contrast to the homegate.ch data, the sample from REIDA indicates whether the space for residential as well as commercial facilities is occupied or vacant. Consequently, an analysis of occupancies becomes feasible. However, the hedonic OLS model could not confirm a statistically significant relation between Minergie certification and higher occupancies for commercial buildings, even though the coefficient indicates the expected sign. The missing statistical significance can be reasoned by too few Minergie buildings in the commercial sample. Nevertheless, the logit model reveals a positive causality between Minergie and occupancy on a 90% level of confidence. The hedonic OLS model of the residential sector shows an occupancy premium of 2.06%, ceteris paribus. This result is statistically significant even on a 95% confidence level. To sum up, it can be said that there are indications of a green occupancy premium in the REIDA sample, but the small sample sizes and limited amount of control variables restrict the significance of the analysis.

In the last part of the master thesis, the insights gained from the preceding analysis were quantitatively as well as qualitatively reflected. For this purpose a comparative cap rates analysis consolidated the results found for the sales-, rent- and occupancy premia. It was shown that Minergie buildings

have lower risk premia compared to their conventional counterparts. Moreover, it is reasoned how and to what extent energy savings on its own might explain the high willingness to pay for commercial real estate in Switzerland. An exemplary calculation reveals that additional money paid for Minergie will only be paid back after 98 years. Expressed differently, energy savings can only explain about 22% of a premium paid for Minergie. The remaining high willingness to pay is attributable to Minergie's superior comfort and enhanced conservation of value.

This master thesis contributes to the academic field on green buildings in Switzerland in two ways. First, it complements the findings on price and rent premia of residential real estate with insights of the commercial sector. Second, the thesis is able to show evidence for higher occupancies in both, the residential and commercial real estate sector. However, the limitations of the study are clearly given by the constrained data availability. Thus, the analysis is not able to differentiate between different levels of certification within the data at hand and how they would effect the premia. For the occupancy sample a broader commercial sample of Minergie buildings would be desirable in order to draw statistically significant conclusions. Assuming rising certifications in the commercial real estate market and corresponding data availability, further research might be able to differentiate more precisely between certification levels and building types within the commercial sector.

Conclusively, the development and prevalence of green buildings in Switzerland is undoubtedly a success story. This testifies also the launch of a new label called SNBS (2016) (Standard Nachhaltiges Bauen Schweiz) in the year 2013. Compared to Minergie, which mainly focuses on energy-related criteria, this new label shall constitute a more holistic approach towards sustainability. The emergence of such new sustainability labels shows that the market for green buildings is far from being saturated. To the contrary, there seems to exist a demand for building greener into the future.

Appendices

Appendix

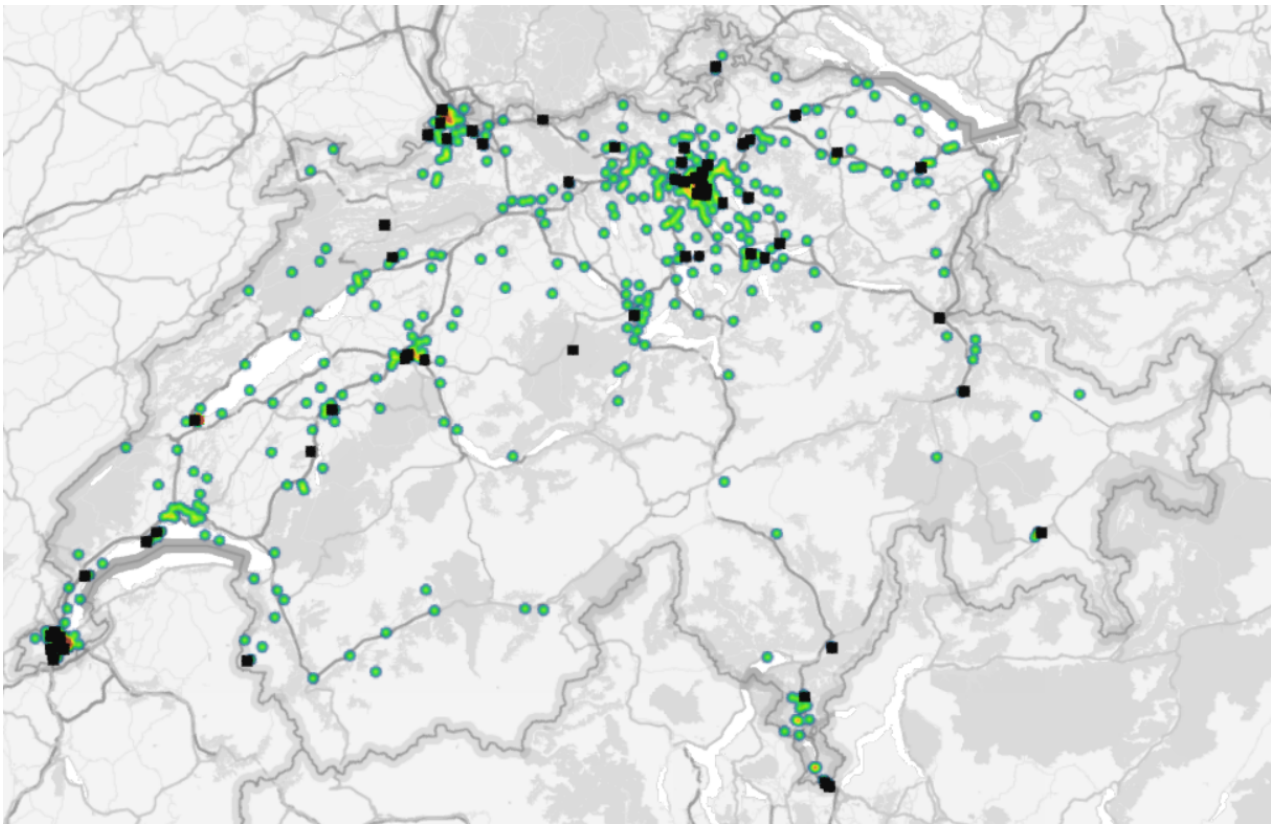
Figure A1 – Map of Switzerland - Sale Sample

Source: Own Presentation based on homegate.ch data set. Map of Switzerland: Black Squares = Minergie Certified Buildings; Dots in Heatmap-Style = Control Buildings.

Table A1 – Counts of Minergie- and Control Buildings by Cantons - Sale Sample

Canton	Minergie	Conventional			
AG	3	48	NW	1	5
AR	0	3	OW	0	2
AI	0	0	SH	2	10
BL	5	47	SZ	2	13
BS	2	60	SO	2	30
BE	5	47	SG	3	36
FR	1	28	TI	7	57
GE	13	152	TG	1	23
GL	0	0	UR	0	0
GR	0	7	VD	10	160
JU	0	2	VS	1	17
LU	1	45	ZG	1	39
NE	2	16	ZH	17	315
			Total	**79**	**1162**

Figure A2 – Map of Switzerland - Rent Sample



Source: Own Presentation based on homegate.ch data set. Map of Switzerland: Black Squares = Minergie Certified Buildings; Dots in Heatmap-Style = Control Buildings.

Table A2 – Counts of Minergie- and Control Buildings by Cantons - Rent Sample

Canton	Minergie	Conventional			
AG	3	78	NW	0	5
AR	0	9	OW	0	5
AI	0	1	SH	1	9
BL	5	76	SZ	2	33
BS	1	65	SO	2	40
BE	4	79	SG	4	52
FR	3	45	TI	4	55
GE	9	172	TG	2	30
GL	0	1	UR	0	2
GR	2	12	VD	7	243
JU	0	2	VS	1	25
LU	2	39	ZG	3	37
NE	0	22	ZH	20	397
			Total	**75**	**1534**

Table A3 – Hedonic OLS Regression Results - Commercial

Variable	Coefficient	Standard Error	t-Statistic	P-Value	Sign.	VIF
Intercept	0.7237	0.0395	18.3427	2.15E-70	***	0.0000
ln(sumsurrentable)	0.0075	0.0031	2.4403	0.0147	**	2.1545
before 1920	0.0704	0.0516	1.3635	0.1729		23.7349
1921-1960	0.1027	0.0406	2.5291	0.0115	**	26.0357
1961-1980	0.1111	0.0355	3.1326	0.0018	***	18.5651
1981-2000	0.1158	0.0324	3.5770	0.0004	***	15.8318
2001-2010	0.0336	0.0326	1.0284	0.3039		5.0724
2011-2015	0.0000	(base period)				
age	0.0009	0.0004	2.1266	0.0336	**	10.9687
ln(avggrossrentmqyear)	0.0104	0.0068	1.5193	0.1288		2.3280
avgfloorcats	-0.0238	0.0057	-4.1704	3.15E-05	***	1.8368
minergie	0.0142	0.0464	0.3054	0.7601		1.1249
ratingmicroch	0.0012	0.0004	2.7762	0.0055	***	1.2859

R^2=0.0504; Adj. R^2=0.0460; DurbinWatsonD = 1.8868
Sample Size: 2'391 (thereof 16 minergie buildings)
* Significant at the 90% level, ** Sign. at the 95% level, *** Sign. at the 99% level

Source: Own representation

Table A4 – Logit Model Regression Results - Commercial

Variable	Coefficient	Standard Error	z-Statistic	P-Value	Sign.
Intercept	-1.5271	0.3167	-4.8215	1.42E-06	***
ln(surrentable)	0.1179	0.0324	3.6346	0.0003	***
before 1920	1.3507	0.5313	2.5423	0.0110	**
1921-1960	2.1026	0.3714	5.6617	1.50E-08	***
1961-1980	1.8757	0.2908	6.4495	1.12E-10	***
1981-2000	1.7368	0.2558	6.7891	1.13E-11	***
2001-2010	1.0164	0.2479	4.0999	4.13E-05	***
2011-2015	0.0000	(base period)			
age	0.0038	0.0041	0.9246	0.3552	
ln(grossrentmqyear)	0.3953	0.0556	7.1063	1.19E-12	***
floorcats	-0.2077	0.0241	-8.6159	6.94E-18	***
minergie	0.6056	0.3434	1.7633	0.0779	*
ratingmicroch	0.0092	0.0039	2.3631	0.0181	**
Sample Size: 18'081 (thereof 125 minergie contracts)					
* Significant at the 90% level, ** Sign. at the 95% level, *** Sign. at the 99% level					
LikelihoodRatioIndex	0.0420		AIC	8436	
PearsonChiSquare	18162		BIC	8530	

Source: Own representation

Table A5 – Hedonic OLS Regression Results - Residential

Variable	Coefficient	Standard Error	t-Statistic	P-Value	Sign.	VIF
Intercept	0.9562	0.0237	40.4193	1.69E-320	***	0.0000
ln(sumsurrentable)	0.0037	0.0012	3.0331	0.0024	***	1.5029
before 1920	0.0697	0.0136	5.1398	2.83E-07	***	10.5207
1921-1960	0.0574	0.0090	6.3433	2.39E-10	***	30.9115
1961-1980	0.0534	0.0076	7.0582	1.85E-12	***	23.2644
1981-2000	0.0520	0.0067	7.7802	8.31E-15	***	14.5048
2001-2010	0.0404	0.0065	6.1806	6.75E-10	***	5.5289
2011-2015	0.0000	(base period)				
age	-0.0001	0.0001	-1.1861	0.2356		11.0672
ln(avggrossrentmqyear)	-0.0096	0.0037	-2.6299	0.0086	***	1.4271
avgroomscats	-0.0055	0.0009	-6.3200	2.78E-10	***	1.2536
avgfloorcats	-0.0029	0.0012	-2.5390	0.0111	**	1.4347
minergie	0.0206	0.0105	1.9693	0.0490	**	1.0630
ratingmicroch	0.0014	0.0001	12.0595	3.74E-33	***	1.3062
R^2=0.0466; Adj. R^2=0.0450; DurbinWatsonD = 1.9667						
Sample Size: 6'851 (thereof 37 minergie buildings)						
* Significant at the 90% level, ** Sign. at the 95% level, *** Sign. at the 99% level						

Source: Own representation

Table A6 – Logit Model Regression Results - Residential

Variable	Coefficient	Standard Error	z-Statistic	P-Value	Sign.
Intercept	3.5806	0.7035	5.0897	3.59E-07	***
ln(surrentable)	-0.1284	0.0668	-1.9209	0.0547	*
before 1920	0.4560	0.5129	0.8891	0.3740	
1921-1960	0.9877	0.3090	3.1966	0.0014	***
1961-1980	0.8273	0.2663	3.1071	0.0019	***
1981-2000	1.0820	0.2370	4.5655	4.98E-06	***
2001-2010	0.2505	0.2271	1.1030	0.2700	
2011-2015	0.0000	(base period)			
age	0.0068	0.0035	1.9303	0.0536	*
ln(grossrentmqyear)	-0.0377	0.0892	-0.4230	0.6723	
roomscats	-0.3187	0.0231	-13.8136	2.11E-43	***
floorcats	-0.1807	0.0200	-9.0351	1.64E-19	***
minergie	0.4463	0.2920	1.5287	0.1263	
ratingmicroch	0.0766	0.0027	28.8554	4.33E-183	***
Sample Size: 101'146 (thereof 361 minergie contracts)					
* Significant at the 90% level, ** Sign. at the 95% level, *** Sign. at the 99% level					
LikelihoodRatioIndex	0.0734		AIC	17384	
PearsonChiSquare	99903		BIC	17508	

Source: Own representation

Table A7 – Discounted Cash Flow Calculation for IRR and Cap Rate

Discounted Cash Flow													
Minergie			**t1**	**t2**	**t3**	**t4**	**t5**	**t6**	**t7**	**t8**	**t9**	**t10**	**t11**
			CF1	**CF2**	**CF3**	**CF4**	**CF5**	**CF6**	**CF7**	**CF8**	**CF9**	**CF10**	**PV(TV)**
V	1'365'692	CFt (NOI)	63'888	63'888	63'888	63'888	63'888	63'888	63'888	63'888	63'888	63'888	
PV(0)	1'365'692	Discount Factor (IRR)	0.9553	0.9126	0.8718	0.8329	0.7956	0.7601	0.7261	0.6937	0.6627	0.6331	
IRR	**0.046781**	PV(CFt)	61'033	58'305	55'699	53'210	50'832	48'561	46'390	44'317	42'337	40'445	864'562
g	0	ΣPV(CFt) + PV(TV)	1'365'692										
Minergie													
NOI	63'888												
V	1'365'692												
Cap Rate =	**0.046781**												
NOI / V													
Conventional			**t1**	**t2**	**t3**	**t4**	**t5**	**t6**	**t7**	**t8**	**t9**	**t10**	**t11**
			CF1	**CF2**	**CF3**	**CF4**	**CF5**	**CF6**	**CF7**	**CF8**	**CF9**	**CF10**	**PV(TV)**
V	1'103'233	CFt (NOI)	54'722	54'722	54'722	54'722	54'722	54'722	54'722	54'722	54'722	54'722	
PV(0)	1'103'233	Discount Factor (IRR)	0.9527	0.9077	0.8648	0.8240	0.7850	0.7479	0.7126	0.6789	0.6468	0.6162	
IRR	**0.049601**	PV(CFt)	52'136	49'672	47'325	45'088	42'958	40'927	38'993	37'151	35'395	33'722	679'866
g	0	ΣPV(CFt) + PV(TV)	1'103'233										
Conventional													
NOI	54'722												
V	1'103'233												
Cap Rate =	**0.049601**												
NOI / V													

Source: Own calculations

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