Essays in Real Estate Economics. Empirical Investigations of Energy Efficient Properties in Switzerland.

Inauguraldissertation
zur Erlangung des akademischen Grades
eines Doktors der Wirtschaftswissenschaften der

Universität Mannheim

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vorgelegt im Sommersemester 2015

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Tag der mündlichen Prüfung: 11. Juni 2015

Acknowledgement

This thesis has benefited from many people and I owe a great debt of gratitude to them. First and foremost, I am deeply indebted to my supervisor, Paul Gans, for his encouragement during the process of writing the thesis and for his valuable feedback on my work.

Moreover, I owe special thanks to my colleagues at the Center for Corporate Responsibility and Sustainability at the University of Zurich for invaluable discussions and reviews of my work. Moreover, I thank participants in PhD classes at the University of Mannheim. I wrote parts of the thesis while visiting PhD classes at the Study Center Gerzensee, Switzerland. I am thankful for their hospitality and for the opportunity to discuss my work with other PhD students, who challenged my ideas and provided valuable discussions. First drafts of this thesis were presented at the European Real Estate Society (ERES) conference in Edinburgh in 2012. I am very thankful to the participants for their helpful advice. The third part of this thesis "Willingness to Pay for Green Buildings: Empirical Evidence from Switzerland." was published in the Journal of Sustainable Real Estate, Vol. 5, 2013. I thank two anonymous reviewers for helpful comments on the submitted draft.

Last but not least, I would like to thank my parents Wolfgang and Gundula, and my brother Peter. They always had an open ear for all non-academic problems and encouraged me throughout this period of ups and downs.

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Chapter 1

General Introduction

1.1 Compelling Importance of Sustainability

In recent years the theme "sustainability" has become one of the major developments in the global community. The concept of a sustainable development inlcudes the three dimensions economic, ecological, and social development. Especially in the aftermath of the 1973 and 1979 global energy crisis, the world community became aware of the dependence of energy and natural resources and their limited availability. The rapid globalization further increased environmental risks. Since 1987 the United Nations World Commission for Environmental Development established with the Brundtland-Report a well-known definition of a sustainable development. Although there is no clear-cut definition of sustainability, global initiatives such as the United Nations increased the awareness for the need of a sustainability movement in developed and developing countries. Further international conferences shaped the definition of sustainability and spread the awareness among business leaders, policy makers, and the society. However, a balanced relationship between economic, ecological, and social developments is substantial to enable a livable environment for future generations.

Many business leaders and CEOs of major global companies acknowledge the importance of a sustainable development to the extent that "green is the new gold". However, is business doing enough to face the challenges of a sustainable future? Is the world community well-prepared for the developments and envi-

ronmental risks in a globalized world? Following the principle of sustainability provides the chance to conquer the challenges of the future. In this regard a recent study investigated the opinions of more than 1000 top executives from 27 industries across 103 countries about the importance and the impact of sustainability. As a result, 93% of the CEOs regard sustainability as key to success of their future business; 80% of CEOs view sustainability as a route to competitive advantage in their industry; 81% of CEOs believe that the sustainability reputation of their company is important in consumers' purchasing decisions. Astonishingly, only 32% of CEOs believe that the global economy is on track to meet the demands of a growing population within environmental and resource constraints; 33% of CEOs believe that business is doing enough to address global sustainability challenges.[1] These figures illustrate the global importance of the sustainability movement and that there is still capacity to improve the endeavors.

1.2 The Impact of Real Estate on a Sustainable Development

Currently, more than half of world population is living in cities. By 2050 it is expected that 70% of the world population will live in cities. This development reveals the challenge for the real estate industry and city planners. Urbanization rates increased substantially since the 1980s in most countries.[2] This development is especially predominant in developing countries and exhibits high growth rates. Within the next 20 years 3 billion people will achieve a higher living standard due to the urbanization process. The people benefit from better living and working conditions, access to health care, education, culture, and public society in urban areas. Emerging countries are expected to have an upcoming impact on climate change and energy consumption. Rising economic growth leads to expanding expectations, higher living standards such as driving cars or to an increase in the residential floor space which is expected to expand by 50 billion square meter,

[1]The United Nations Global Compact - Accenture CEO Study on Sustainability 2013.
[2]The World Bank, World Development Indicators, Urban population

which is more than the current amount of residential floor space in the US and Europe combined.[3] This development has enormous impact on the building and construction industry. Moreover, this development leads to rising energy demand. Since 1990 the global energy demand increased by 50%. Although the energy intensity decreased in developed countries due to a higher energy efficiency and new technologies, the economic growth in the developing countries lead to a strong increase in the overall energy demand globally.

A sustainable development is inseparable related to the real estate industry. Moreover, the real estate industry exhibits a major impact on energy consumption and greenhouse gas emission, rather it reveals the impact on the economics of climate change. Depending on diverging assumptions and scenarios during 2004 and 2030, greenhouse emissions resulting from the built environment are expected to increase from 8.6 to 15.6 billion tons[4].

> Greenhouse gas emissions are externalities and represent the biggest market failure the world has seen. We all produce emissions, people around the world are already suffering from past emissions, and current emissions will have potentially catastrophic impacts in the future. (Nicholas Stern, The Economics of Climate Change, American Economic Review: Papers & Proceedings 2008, 98:2, 1-37)

Addressing climate change and energy efficiency is the primary task of sustainable real estate to achieve the international 2 degree scenario. In order to take responsibility for our current living and the well-being of further generations addressing sustainability is highly eminent and of major importance.

There are a multitude of examples to illustrate the green building activity in real life decisions. To identify sustainable real estate, real estate labels and certificates established in many countries and are available in different certification systems relying on qualitative and quantitative indicators. Aiming to measure the energy efficiency and the carbon footprint of buildings, real estate labels ex-

[3]Credit Suisse Securities Research & Analytics. "Themes in Energy Efficiency".

[4]Climate Change 2007: Mitigation. Contribution of Working Group III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change.

hibit the performance of a building. Besides energy consumption and carbon footprint, some labels follow a broader approach and capture holistic aspects of sustainability. Although the labeling trend increased in recent years real estate professionals expect a development towards quantitative indicators to achieve a better comparison on international real estate markets.

Many companies take part in global initiatives and contribute to a sustainable development. One prominent example for green buildings is the German headquarter of Deutsche Bank in Frankfurt, Germany. The twintowers are also called the "greentowers". The towers achieved the highest energy efficiency standard with LEED Platinum and the German label DGNB. Due to the refurbishment during 2007 and 2010, greenhouse gas emissions have been reduced by 90%; energy consumption by 50%, and water consumption by more than 70%. With the investment in energy efficient technology the Deutsche Bank achieved one of most efficient office buildings in the world. For more than 3000 employees this place stands for well-being, comford, and environmental friendly design that represents the idea of sustainability. Many other professional investors followed. The impact of green buildings on peoples every day life is also introduced in the Green City Index by Siemens to illustrate the greeness of cities. The top ranked cities show a high livable standard due to environment friendly policies and green buildings.

1.3 Switzerland and the Investigation of Green Buildings

This present thesis consists of three self-contained chapters which contribute to the literature of real estate sustainability. The thesis investigates the economics of green buildings in Switzerland. Interestingly, Switzerland exhibits one of the highest shares of green buildings in the world. Since the late 1990s the real estate label MINERGIE has been established and is now the most common label in Switzerland. The market dispersion of green buildings appears to be very eligible to investigate the case of Switzerland. Due to the federal organization with 26 cantons and more than 2500 municipalities Switzerland is also very applicable to

investigate the diffusion of green buildings.

What drives investment in sustainable real estate? Recent studies reveal the investment potential of green buildings to achieve to global climate change targets. However, there are a multitude of reasons that capture the investment decisions of firms and private homeowners respectively. Notwithstanding, there are barriers to invest that harm the investment potential.

The first paper of the present thesis addresses this question and investigates which factors increase the likelihood of investments in green buildings. The paper analyzes the driving forces for investing in green buildings in Switzerland. To this end, this paper investigates the impact of ecological responsibility of a firm, the impact of institutions of the public sector, and to what extent firms from the third industry sector with a high share of white collar jobs are more likely to invest in green buildings. The first paper analyzes a unique survey database from Switzerland with approximately 200 responding firms from all industry sectors.

Beside the driving forces of an investment in green buildings the willingness to pay for green buildings is a decisive question in the real estate literature. This reveals the economic perspective of an investment in energy efficient buildings. The second paper of the present thesis investigates the willingness to pay for green buildings and to what extent firms accept to pay a premium price for green buildings compared to conventional buildings. The analysis distinguishes between the decisions to lease, purchase, or to retrofit a building. The paper uses survey data that represent stated preferences on the premium prices for green buildings.

The third study analyses the diffusion of green buildings in Switzerland. With a regional economic approach the study analyzes the dynamics of green buildings across all 26 Swiss cantons over a period of 14 years. The paper uses a unique dataset that captures all certified residential buildings. The distribution of energy efficient buildings is highly heterogeneous among Swiss cantons. The study investigates to what extent regional characteristics such as economic and property market conditions, innovation and education characteristics, climate conditions, and the predominant environmental ideology can explain the demand for energy efficient properties.

In the aftermath of the global financial crisis the acceleration of the sustainability movement should be a major endeavor more than ever. For our current well-being and the well-being of future generations there will be no alternative of a sustainable development. If current generations are not successful in addressing climate change, energy consumption, or the consumption of natural ressources, our future will be adverse and severe. The real estate industry can contribute substantially.

Chapter 2

What Drives Investment in Green Buildings? An Empirical Analysis of Switzerland.

Abstract

What factors increase the likelihood of investments in green buildings? To shed light on this question, this paper analyzes the driving forces for investing in green buildings in Switzerland. To this end, this paper investigates the impact of ecological responsibility in a firm, the impact of corporations from the public sector, and to what extent firms from the third industry sector with a high share of white collar jobs are more likely to invest in green buildings. Analyzing survey data from Switzerland with approximately 200 responding firms from all industry sectors, this paper distinguishes between the decisions of firms to lease or buy a property. Using logit and probit regression analysis, this paper confirms that ecological responsibility is an important driver for investment decisions in green buildings. Moreover, this paper finds that firms from the financial service industries are more likely to invest in green buildings. In contrast to other studies, firms from the public sector exhibit ambiguous results.

2.1 Introduction

Since buildings are responsible for approximately 40 percent of global energy consumption, the demand for energy efficient buildings has increased in recent years (Kok, McGraw, Quigley, 2011). Considering the expected growth in energy demand until the year 2050, this development is expected to be an ongoing process

(Houser, 2009). For developed and developing countries, increasing urbanization rates and rising income levels will further increase demands for energy. Currently, over 50 percent of the world's population is living in cities. As energy consumption in the building sector has grown by approximately two percent each year over the past decade, more focus is on the economic and ecological consequenses of the real estate sector (IEA, 2013). In the real estate literature it has been well documented that buildings and construction activity are responsible for about one third of worldwide greenhouse gas emissions (Royal Institute of Chartered Surveyors, 2005). By the year 2050, global greenhouse gas emissions are expected to account for 62 billion tons, whereas 20 billion tons come from buildings (WBCSD, 2009).

Firms invest in energy efficient properties, or so called *green buildings*, for a multitude of reasons.[1] From an environmental perspective, a firm´s investment in green buildings tries to reduce greenhouse gas emissions and energy consumption (Eichholtz, Kok, Quigley, 2013). For the U.S. alone, the real estate sector is associated with 50 percent of the global usage of wood (GRESB Research Report, 2011); of about 40 percent of U.S. energy consumption (Eichholtz, Kok, Quigley, 2011); and of about 70 percent of electricity consumption (Royal Institute of Chartered Surveyors, 2005). As a result, ecological awareness is increasing in the world of real estate. For the Swiss real estate market, Banfi et al. (2008) point out that the heating of buildings is responsible for about 33 percent of Swiss energy consumption. However, only one to two percent of the building stock will be renovated each year. Among those buildings, only 30 to 50 percent account for improvements in energy efficiency. The potential for energy efficiency and for a reduction of greenhouse gas emissions is therefore still significant. The importance of green buildings emerge, while considering that relatively small changes in the build environment might achieve large effects on climate change (Stern, 2008).

In addition, investing in green buildings also has interesting financial implications (Kats, 2003; Ciochetti and McGowan, 2010; Chegut et al., 2013). As

[1]This paper uses the phrases *green buildings*, *energy efficient properties* and *real estate sustainability* synonymously.

Eichholtz, Kok, Quigley (2010) illustrate for office buildings, higher sales and rental prices have been associated with energy efficient buildings compared to conventional buildings. Additionally, green buildings have lower operatinal costs, and their occupancy rates are higher (GRESB Research Report, 2011). Taking further risk measures of conventional buildings into account, financial benefits occur from increased energy efficiency rates. Also in the case of green buildings there is a reduced risk of obsolescence. Although the economic benefits of green buildings have been illustrated, the international trend towards energy efficient buildings have been widely debated (Kok, McGraw, Quigley, 2011). This could suggest that potential profits are uncertain or that other investment barriers exist. Nonetheless, a more detailed analysis on driving factors is needed to shed light on the debate over investment and to understand the trend towards green buildings.

This paper analyzes driving factors for investing in green buildings, with a consideration of the decision to lease or buy. The literature review in section 2 provides distinct reasons why corporations invest in green buildings. Seeking to distinguish between the decision to lease or buy, Eichholtz, Kok, Quigley (2011) and Brounen and Eichholtz (2005) point out that ownership of corporate real estate has recently declined. Whereas over the last century companies normally owned their land and buildings, there seems to be no pressing need for real estate ownership. An enormous advantage of leasing property is obviously the reduced amount of capital, which is otherwise committed for a long period of time. Also, tax considerations are important in this context, which is highly heterogeneous over different countries. Moreover, Brounen and Eichholtz (2005) find that ownership appears to be much more driven by industrial sectors rather than by country specific differences. The present paper takes this into account and investigates the likelihood for investing in green buildings of different industry sectors. As a further result, Brounen and Eichholtz (2005) findings illustrate a negative relation between ownership and the stock performance of a firm. Ownership increases the systematic risk of a firm, and this is particularly true for the communication and business service industries, which use a substantial amount of office buildings.

From this perspective, and considering that firms are reducing their real estate portfolios (Eichholtz, Kok, Quigley, 2011), it is crucial to distinguish between the decision to *lease* versus the decision to *buy*. Therefore, investment drivers might have diverging impacts over the lease or buy decision making of a firm. Due to an associated long term investment, the overall expectation is that, as suggested by surveys, motivational drivers have a stronger impact on the decision to buy than on the decision to lease.

In Switzerland the density of green buildings ranks among the highest in the world (Salvi and Syz, 2011). Currently, more than 25.000 buildings are accounted for as green buildings. The increase of energy efficient real estate in Switzerland has sparked public and academic debate. The real estate label MINERGIE is well known and accepted in Switzerland, both for commercial and residential buildings (Salvi et al., 2010).[2]

The contribution of this paper is to understand which determinants and characteristics influence an investment in energy efficient buildings. Driving factors that might impact the investment in green buildings are often addressed in the literature. Nonetheless, there is a lack of empirical evidence to identify the drivers of investment. Identifying characteristics and industries that are more likely to invest in green buildings is important for researchers and policy makers so that they might increase efficiency in the real estate industry (IEA, 2013). The case of Switzerland contributes to existing literature with its distinctive characteristics, such as its low vacancy rates and its scarce supply of corporate real estate, although the diffusion of green buildings appears to be an international phenomenon.

The remainder of this paper is organized as follows. The next section provides a literature review and develops the hypotheses analyzed in this paper. The paper then describes the data and the methodology. The subsequent section discusses

[2]The website www.minergie.ch provides an overview of the different certification standards and labels by the Minergie Group. Established in 1998 the Minergie label has a substantial distribution in Switzerland and is also available in Austria and France. In recent years additional subtypes of the label had been established and the requirements to achieve the Minergie label increased. Primarily, the distribution of the Minergie label is significant for residential properties.

outcomes, findings, and implications. The paper ends with concluding remarks.

2.2 Literature Review and Hypotheses

What drives the investment in green buildings and to what extent are some industry sectors more likely for investing in energy efficient properties? Recently, the real estate literature has extensively investigated the question who invests in sustainable properties (Bansal and Roth, 2000; Ciochetti and McGowan, 2010; Eichholtz, Kok, Quigley, 2011).

Answering this question illustrates the advantages of investing in sustainable properties. Moreover, it reveals a trade off between costs and benefits in the decision-making processes of firms. Considering utility theory, a firm will invest when expected benefits rise above expected costs. An investment in energy efficient technology in the property environment is a fundamental financial decision. Therefore, and with regard to competitiveness, an investment in green buildings can be ambiguous for a firm (Bansal and Roth, 2000; IEA, 2013; Bio Intelligence Service, 2013). As long as financial performance is decisive, firms only invest in projects if they will lead to a positive net present value (Eichholtz, Kok, Quigley, 2010). This holds true for private and profit-maximizing firms. It will be interesting to analyze if there are any differences in the inventment decision between firms under private and public law, or in other words between profit-maximizing firms and those with non-financial interests.

The investment in green buildings represents an increasing tendency as Kapelina (2010) and Eichholtz, Kok, Quigley (2013) argue. Results from a U.S. building and construction survey indicate that today´s corporations are more willing to pay for green buildings than they were three to four years ago. In a survey, almost 90 percent of construction professionals, architects, and engineers agreed upon this question (Kapelina, 2010). With regard to the demand side, green buildings are interesting for investors because of their higher rental and higher sales prices (Bardhan and Kroll, 2011). Typically, scholary studies for the United States use the CoStar database with *LEED* or *Energy Star* labeled commercial

buildings that allow for distinctive analyses of lease and sales prices. Whereas the U.S. property label Energy Star primary concentrates on energy efficiency, the LEED label follows a wider concept of sustainability attributes. Using CoStar data for the U.S. Eichholtz, Kok, Quigley (2010) find a three percent premium of rental rates and sales prices that are approximately 16 percent above conventional commercial buildings. Taking regional energy prices into account, the economic benefits and values of green buildings will be exposed when each dollar of energy savings yields 18.32 dollars in increased market value (Bardhan and Kroll, 2011), which is equivalent to the findings of Eichholtz, Kok, Quigley (2010). Another study, by Fuerst and McAllister (2011), illustrates the impact of labels and certifications on the rents and prices of green buildings. Using hedonic regression analyses, they find a premium rental price of four to five percent compared to conventional buildings without an environmental label. For Energy Star labeled buildings they find a sales price premium of 26 percent, and for LEED certified buildings, they find a 25 percent premium on average. Another recent study from Kok and Kahn (2012) finds a 9 percent price premium for residential properties in the U.S. market. Controlling for distinctive property attributes such as location, size, vintage and further amenities, the value of green properties is associated with higher sales prices compared to conventional buildings. For the Swiss real estate market the MINERGIE label is prevalent for both commercial and residential properties. With data being scarce for commercial buildings in Switzerland, Salvi et al. (2010) calculated the premium price for labeled residential properties to discover a premium of five to six percent on average.

Regarding costs, both construction and operating costs should be taken into account (Bardhan and Kroll, 2011). The perception that green buildings might not be beneficial is widespread and represents a major obstacle to investment (Kats, 2003; Bio Intelligence Service, 2013). A challenge often seen by real estate decision makers is that green buildings, and the implementation of sustainability, might increase construction costs. Competitors who do not invest in sustainable real estate might have an advantage compared to those who do. Thus, being green might be a disadvantage and constrain competitive capacity instead of being an

advantage as Kapelina (2010) points out. Investments in real estate sustainability need not have an attractive rate of return. Often a long-term amortization is needed to achieve the financial break-even. As well as any other investment, green buildings compete with other assets available in the market. Investors, owners, and real estate decision makers should consider that inefficient spending crowds out more attractive investments. In the context of costs and benefits of green buildings Kats (2003) finds that on average the cost premium is expected to be less than two percent. Kats (2003) demonstrates that the expected premium costs for energy efficient properties are lower than often perceived. These findings stand in line with other empirical studies that find a cost premium not above three percent (Reichardt et al., 2012).

These considerations are of strong interest for investors and profit-maximizing firms. Financial aspects and avoiding competitive constraints are most important for those firms, which simultaneously appear as a barrier to invest (IEA, 2013; Bio Intelligence Service, 2013). Firms under public law, such as governmental institutions, public authorities, and non-profit organizations, generally do not have financial interests similar to private firms. Public firms or governmental institutions have a distinctive awareness of ecological issues and are often first movers within an environmental ideology, as Kahn (2007) illustrates. Moreover, public firms do not display fundamentally competitive behavior. They are not exposed to the competitive pressure of the market. Due to the fact that profit-maximizing is not important for public institutions, environmental concerns are often easier to address. Therefore, the implementation of green buildings might benefit from this perspective. For a long-term implementation of environmental behavior, it is in the interest of public authorities to commit to green issues, especially in green buildings. Eichholtz, Kok, Quigley (2009) find that governmental institutions and non-profit organizations are among prominent green tenants with modern and energy efficient buildings. Therefore fundamental differences between private and public firms might occur with regard to the investment decision. This leads to the following hypothesis:

Hypothesis 1: *Firms from the public sector representing public authorities, governmental institutions, or non-profit organizations are more likely to invest in green buildings.*

Reducing greenhouse gas emissions and energy consumption are often considered part of a firm´s ecological responsibility (Eichholtz, Kok, Quigley, 2013). Firms with a strong sense of ecological awareness aim to protect the natural environment and reduce their ecological footprint. Moreover, long-term expectations regarding energy prices are often part of the decision making of firms. With the debate over costs and benefits in mind Ciochetti and McGowan (2010) suggest three critical factors with impact on firms decision making: *first*, rising energy prices; *second*, the potential for operational savings and increasing net operating income; and *third*, regulatory reasons associated with carbon emissions. By investing in green buildings, property owners can expect lower operational and maintenance costs. Although some studies find ambiguous results with little correlation between energy efficient buildings and their certification levels, a positive effect on energy savings remains unquestionable (Newsham et al., 2009). On average green buildings require 30 percent less energy, which leads to a substantial reduction of energy resources and costs (Kats, 2003; Turner and Frankel, 2008). Taking rising energy prices into account, firms can hedge against future energy prices. The financial benefits emerge from the ecological responsibility of the firm. Further ecological benefits include the reduced usage of water and waste, as well as a better indoor environmental quality.

However, the ecological responsibility is often seen as part of a firms' corporate social responsibility (CSR). In the context of green buildings, Eichholtz, Kok, Quigley (2009) describe corporate real estate as a key element of a firms´ CSR strategy. Concordantly, Reichardt et al. (2012) argue that sustainable properties are an integral part of the CSR strategy for an increased amount of companies. The relation between CSR and the financial performance of a firm is well-documented in the literature (Cochran and Wood, 1984; McWilliams and Siegel, 2000). Although the literature includes ambiguous findings, a positive

relation between a well-defined CSR strategy and the financial performance of a firm is often identified. Besides the impact on the financial performance of a firm, CSR also has been pursued to offset corporate social irresponsibility (CSI). Kotchen and Moon (2011) investigate the hypothesis that companies use CSR to offset corporate misbehavior; they also consider whether or not CSR activity increases with more irresponsible behavior. Kotchen and Moon (2011) find that companies use CSR to mitigate irresponsible behavior. This parallels the question of, whether or not a well-defined CSR strategy impacts the investment decision for green buildings. Although CSR is not defined precisely in the survey design this paper assumes that each firm has a common understanding of a well-defined CSR strategy to account for their ecological responsibility. Therefore, an investment in energy efficient properties highlights the ecological responsibility of a firm, which appears as a substantial investment driver (Bansal and Roth, 2000; Eichholtz, Kok, Quigley, 2010, 2011). This leads to the following hypothesis:

Hypothesis 2: *Firms that respond approvingly to the importance of ecological responsibility are more likely to invest in green buildings.*

However, direct and also indirect benefits occur as investment drivers (Bansal and Roth, 2000). As indirect benefits from an investment in green buildings occur enhancing image and reputation. Eichholtz, Kok, Quigley (2009) acknowledge competitive advantages from green buildings due to the effects of a better reputation. Taking into account that green buildings are unevenly distributed, firms might gain a green image when they are among the first investors. Kapelina (2010) suggests a first mover advantage for firms investing in green buildings regarding their reputation. He points out that real estate decision makers, such as developers, contractors, and employers should recognize the growth potential and financial benefits arising from green buildings. An investment might be important to a firm´s positioning within competitive market environment, attracting tenants and achieving higher occupancy and rental rates. First movers gain public attention, which enhances the image and reputation of a company,

always attractive to potential investors. More investors are following investment strategies that focus on socially responsible firms. This approach, of socially responsible investments (SRI), implies that investors might avoid investing in firms that are not ecologically responsive (Eichholtz, Kok, Quigley, 2009). Institutional investors, who often manage pension funds, are aware of "sin-stocks" and might be reluctant to invest in those firms. The importance of image manifests itself in terms of better credit ratings and an improved attractiveness for potential investors. Besides investors, customers and even employees often care about the image and reputation of a firm (Eichholtz, Kok, Quigley, 2009), which is fundamental to the recruiting process of prospective employees. The importance of image and reputation for a firm is difficult to measure (Eichholtz, Kok, Quigley, 2010). Perceptions might differ across industries, firm sizes, and private and public corporations. Some industries with a problematic image, like the oil & gas industry or the chemical industry, might be particularly interested in investing in green buildings to improve their image and reputation (Eichholtz, Kok, Quigley, 2009). The relevance of image and reputation might be stronger for international firms, particularly for firms that are listed on a stock exchange.

Moreover, these corporations exhibit a strong awareness of employee productivity (Eichholtz, Kok, Quigley, 2009, 2010; Jones Lang LaSalle, 2011; Fisk, 2000). This acclaimed benefit from real estate sustainability, however indirect, is nonetheless important to firms. Employee productivity is seen as a key driver for the decision to invest in green buildings (Eichholtz, Kok, Quigley, 2011). Several studies confirm the impact of a better working environment on employee well-being, which leads to increased employee productivity (Fisk and Rosenfeld, 1997; Fisk, 2000, 2010; Singh et al., 2010). Employee costs represent one of the largest expenditures for a firm, which explains the importance of a suitable working environment for employee productivity (Kats, 2003; Eichholtz, Kok, Quigley, 2009). In the long run, the indirect effects of improved employee productivity are expected to be even larger than construction and energy costs (Kats, 2003). Although employee productivity is of general interest for any firm, industries with skilled labor forces are expected to have a particular interest in green buildings.

One could expect that the third industry sector with white collar jobs would be keen on green buildings (Kapelina, 2010; Eichholtz, Kok, Quigley, 2010). In Switzerland labor is a scarce resource, and unemployment rates are among the lowest in Europe. Well-educated and highly skilled employees are rare, which results in high and constant immigration rates. In some industries, like health care, information technology, and the chemical industry, there is a struggle for talent. As a result, firms have an interest in attractive buildings with all amenities to attract prospective employees (Eichholtz, Kok, Quigley, 2011). Moreover, the aforementioned ecological responsibility, along with corporate image and reputation, are important factors in the recruiting process of human capital (Ciochetti and McGowan, 2010).

Improved employee productivity results from better indoor climate conditions and air quality, better lighting and daylight conditions, ventilation and thermal comfort. Considering that people spend 90% of their time indoors, a higher rate of employee statisfaction can be expected, due to improved indoor characteristics (Kats, 2003; Miller and Pogue, 2009). Although better employee health conditions and improved productivity are hard to measure, the benefits of better indoor conditions are well-known. Less illness leads to lower absenteeism and reduced sick leave. Additionally, better communication, better concentration and networking opportunities are associated in the context of green buildings. Generally, more employee satisfaction leads to positive outcomes and improved employee productivity (Miller and Pogue, 2009; Newsham et al., 2009). Initial non-pecuniary aspects become financially relevant. These considerations lead to the following hypothesis:

Hypothesis 3: *Firms from the third industry sector with an associated high share of white collar jobs, well-educated and highly skilled employees are more likely to invest in green buildings.*

In the real estate literature the aforementioned drivers are well-documented. The present paper takes these driving factors for an investment in green buildings

under consideration and tests their validity for the case of Switzerland. The next section describes the data and the methodology approach, followed by sections for empirical results and a conclusion.

2.3 Data and Methodology

This paper uses survey data from Switzerland to investigate the hypotheses of section 2. In 2012, a corporate real estate and sustainability survey was initiated by the *Center of Corporate Responsibility and Sustainability at the University of Zurich* and by *CBRE*, a major real estate service corporation, in order to analyze the Swiss real estate market. Due to the fact that corporate real estate data is still scarce in Switzerland, the survey was initiated to increase transparency in the Swiss real estate market.[3] The survey analyzed firms' attitude towards real estate sustainability and aimed to capture their motivations for investing in green buildings.

Overall, roughly 1.100 firms were contacted.[4] More than 200 Swiss firms answered the survey questions with an online survey, produced by the Swiss census institute *DemoScope*. The data collection was conducted in two stages. First, a random sample of Swiss firms were contacted by telephone interviews. This allowed for the identification of the proper contact persons with sound experience in real estate issues in each corporation. Especially for larger corporations it was necessary to contact real estate professionals with a distinctive knowledge of the real estate portfolios of the firms. Also the firm characteristics such as number of buildings, number of employees, and the amount of space were documented. In the second stage, firms answered a programmed online survey. Samples from participating firms were collected from all Swiss cantons, in the eastern German-speaking part as well as in western French-speaking part. The

[3]To investigate the transparency of regional real estate markets, Jones Lang LaSalle established an Real Estate Transparency Index, which is also available for real estate sustainability issues. The Transparency Index illustrates that Switzerland is a semi-transparent country with a lack of data availability.

[4]The Swiss census institute DemoScope contacted the corporations in all Swiss municipalities (cantons). during the first and second quarter of 2012.

majority of participating firms came from the eastern part of Switzerland (87%).

2.3.1 Descriptive Statistics

Survey participants represented firms from all types of industries, different firm size and legal forms, such as public, private and semi-public corporations. Following the NOGA-classification (Nomenclature Générale des Activités économiques) from the Swiss Federal Statistical Office, the summary statistics (Table 1) below provide an overview of the survey questions. Although the survey provides a sound distribution across all industries, most of the firms represent the *procession trade industry*, the *finance and banking* sector, and the *commerce industry*. Approximately 65 percent of the firms have more than 250 employees, and about 77 percent are business companies under private law (*Private*), whereas 12 percent of the participating corporations are public authorities related firms (*Public*). Public authorities are not strongly represented among the polled firms. Nonetheless this variable is used as an indicator variable to account for non-profit maximizing firms.

On average, the responding firms have approximately 90 buildings in their real estate portfolios. This large number of buildings results from outliers with more than 1.000 buildings in their real estate portfolios. Public authorities and the processing trade industry account for a large number of buildings. Controlling for outliers, the average number of buildings is approximately 50. Fifty percent of the firms have up to 10 buildings on average. The median space is about 27.000 square meters (sqm) on average. The second industry sector combines about 48%, whereas the third industry sector holds about 52 percent of the participating corporations. The majority of firms (62%) hold their real estate in ownership, and about 38 percent lease their real estate. The majority of the responding firms come the eastern and German speaking part of Switzerland (88%), whereas 12% come from the western and French speaking part of Switzerland.[5] However,

[5]The cultural differences between the German speaking part in the east of Switzerland and the French speaking part in the west of Switzerland are often discussed. In this regard, the phrase "Röstigraben" is well-documented and describes the cultural differences in Switzerland. However, analyzing the impact of regional differences in terms of east and west Switzerland are

Table 2.1: Summary statistics

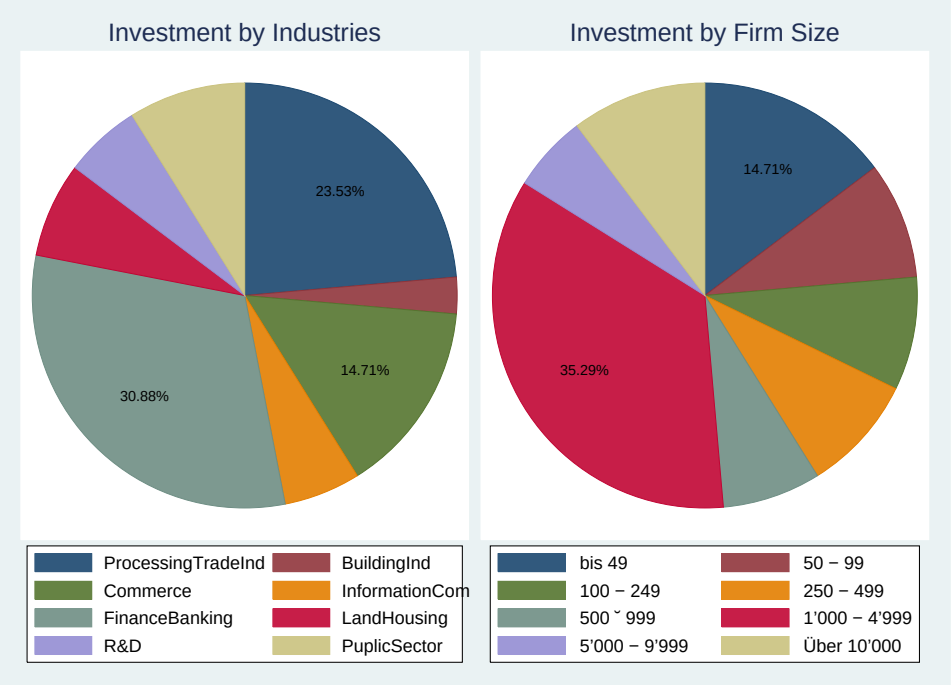
Survey Questions	**N**	**Percent**
Industry Sectors		
Processing Trade Industry	46	0.269
Building Industry	10	0.058
Commerce	26	0.152
Information & Communication	10	0.058
Finance & Banking	44	0.257
Land & Housing	10	0.058
Research & Development	12	0.070
Public Sector	13	0.076
Number of Buildings		
<10 Buildings	75	47.77
10 - 20 Buildings	23	14.65
20 - 30 Buildings	13	8.28
>30 Buildings	46	29.30
Space in sqm		
<1'000 sqm	19	12.93
1'000 - 10'000 sqm	29	19.73
10'000 - 50'000 sqm	44	29.93
50'000 - 100'000 sqm	18	12.24
>100'000 sqm	37	25.17
No. of Employees		
<49	33	19.08
50 - 99	9	5.20
100 - 249	17	9.83
250 - 499	23	13.29
500 - 999	21	12.14
1'000 - 4'999	48	27.75
5'000 - 9'999	8	4.62
>10'000	14	8.09

Source: Own calculation based on Corporate Real Estate Sustainability Survey 2012 dataset.

approximately 50% of the responding firms have international branches. 36% are listed on a stock exchange.

Investigating the question who invests in green buildings, the following statistics illustrate that firms of the finance and banking industry (30%), the processing trade industry (23%), and commerce industry (14%) with more than 1000 but less than 5000 employees exhibit the strongest interest in green buildings (Figure 2.1 and 2.2). The majority of responding firms that signal a willingness to invest are private firms. 36% of the firms have properties with more than 100000 sqm, whereas 14% ranges in the lowest space category of less than 1000 sqm property space.[6] These findings suggest that firms from the third industry sector illustrate the strongest interest in investment in green buildings, which is not pervasive for public authorities.

Figure 2.1: Investment in Green Buildings by Industries and Firm Size.

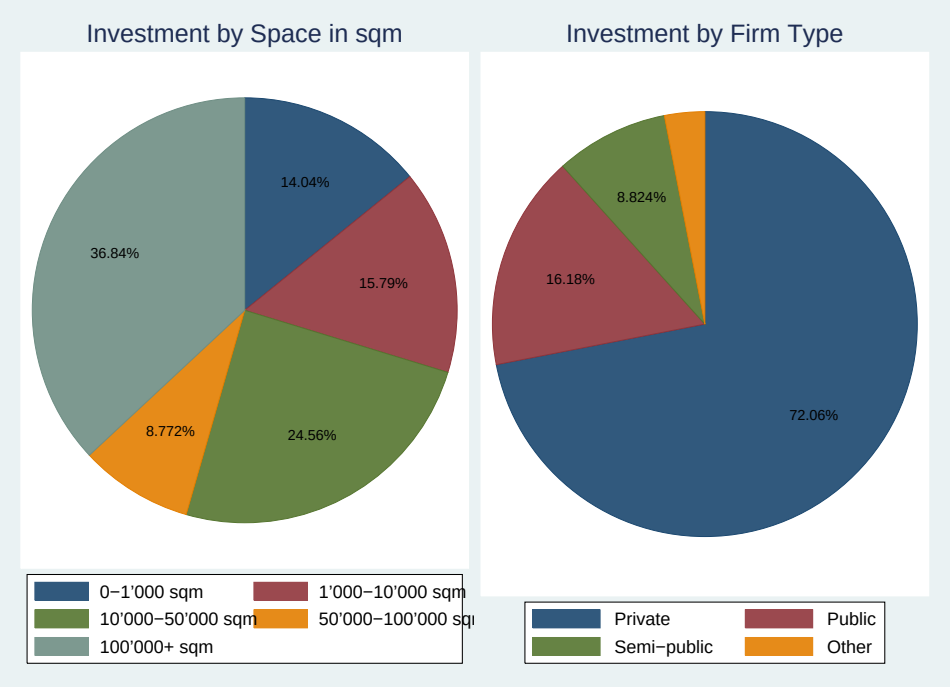


The pie chart represents the share of the responding firms related to each industry sector and firm size categories that acknowledge an investment in green buildings. Source: Own calculation based on Corporate Real Estate Sustainability Survey 2012 dataset.

not relevant in the present paper. Further descriptive statistics are illistrated with Figure A.1 and A.2 in the Appendix.

[6]Within the different industry sectors more than 40% and up to 50% of the responding firms would invest in green buildings. More than 50% of the firms with more than 30 properties in their real estate portfolio signal an interest for investing.

Figure 2.2: Investment in Green Buildings by Property Space and Firm Type.



The pie chart represents the share of the responding firms related to space categories and firm types. Source: Own calculation based on Corporate Real Estate Sustainability Survey 2012 dataset.

Table 2.2: Summary statistics

Survey Question	**Mean**	**N**
Number of buildings	91.510	157
Space in sqm	168.832	147
Share of firms in second sector	0.480	171
Share of firms in third sector	0.520	171
Avg. share of properties for ownership	62.816	147
Avg. share of properties for rent	37.864	147
Private firms	0.778	171
Public firms	0.117	171
Semi-public firms	0.082	171
East Switzerland (region)	0.878	189
West Switzerland (region)	0.122	189
Listed firms (stock exchange)	0.368	133
International firms	0.523	172

Source: Own calculation based on Corporate Real Estate Sustainability Survey 2012 dataset.

2.3.2 Empirical Analysis

This section illustrates the empirical analysis to investigate the hypotheses in the present paper. Moreover, the empirical analysis sheds light on the question which factors increase the likelihood for investing in green buildings. The dependent variable represents the question to the responding firms if they invest in green buildings. The responding firms were asked directly to answer this question for both, the lease decision making and buy decision making. Following this systematic the dependent variable is binary distributed and coded as 0 and 1. When firms respond approvingly and acknowledge their interest in investing in green buildings the value is 1, and when they negate this question the value is 0. Because of a binary dependent variable, the paper uses logit regression analysis. Due to a similar approach of the distribution functions the present paper provides additional outcomes for probit regression analysis (Table 2.4). The results illustrate similar findings for both, logit and probit regression analysis.

To account for the second hypothesis (H2) and to investigate the impact of ecological responsibility on the likelihood for investing in green buildings this paper uses the two indicator variables (EcologicalResponsibility) and (CSR). Moreover, firms were directly asked to answer the extent of ecological responsibility (high, medium, low, don´t know) and meaning of CSR within their corporation (high, medium, low, don´t know). As a result, the majority of firms acknowledge a strong implementation of CSR (80%), whereas 30% signal a distinctive importance of ecological responsibility in their firm. To account for the first hypothesis (H1) the survey participants illustrate directly if they are public authorities, governmental institutions, or non-profit organizations. The third hypothesis (H3) investigates the empirical results from the different industry sectors. The logistic regression analysis (Table 2.3 and 2.4) highlights both, the regression coefficients and the marginal effects. Due to the binary dependent variable the coefficients represented in the regression output are difficult to interpret. Using STATA´s mfx function allows to interpret the regression results as marginal effects, which is equal to an increase or decrease in percentage points. Therefore, the regression results exhibit to what extent the analyzed driving factors impact the probability

for investing in green buildings.[7] Both, logit and probit regression can be written as:

$$Pr(Y = 1|X_1, X_2, ...X_k) = F(\beta_0 + \beta_1 X_1 + \beta_2 X_2 + ... + \beta_k X_k + \epsilon_j)$$

The F funktion has values between $0 < \mathrm{F(z)} < 1$ for all z values.

Using logit and probit models, the logistic function is:

$$F(z) = exp(z)/(1 + exp(z))$$

The probit model with a standard normal cumulative distribution function can be written as:

$$F(z) = \Phi(z) = \int_{-\infty}^{z} \phi(v)dv$$

The resulting model with all indicator variables can be expressed as the following binary depended variable model, both for logit and probit regression analysis.

$$Pr(WTP = 1|X_k) = F(\beta_0 + \beta_1 EcologRespons + \beta_2 PublicSector + \beta_3 Industry + \epsilon_j + controls)$$

2.4 Results and Implications

As a result, the empirical findings illustrate that there are distinctive differences between the decision of a firm to lease or to buy a property. Nonetheless, in terms of lease or buy decision making the results point mostly into the same direction.

The empirical results are illustrated in the tables 2.3 & 2.4. With regard to the second hypothesis (H2), the paper finds that ecological responsibility is a

[7] Instead of converting odd ratios from logit and probit models, marginal effects allow a more tangible interpretation of the regression output. Besides logit and probit regression analysis, I also used linear regression analysis to account for the hypotheses. The empirical outcomes were similar and are not reported in the present paper.

strong driver for an investment in green buildings. This holds for both, lease and buy decision making. The coefficients for both, lease and buy decision making are positive and significant and indicate a substantial impact. The marginal effects are strongly significant to the one percent significance level. As a result for the decision to buy properties, firms that respond approvingly to the ecological responsibility of their firm have a 22% higher probability for investing in green buildings. For the lease decision making the associated probability is more than 33%. Regarding the second hypothesis the importance of a CSR strategy in a firm is also under investigation. The results illustrate that firms with a well-defined CSR strategy are substantially more likely to invest in green buildings. This finding holds for both, lease and buy decision making. Whenever firms confirm ecological responsibility and a strong CSR strategy in their business behavior, they illustrate a substantial awareness of sustainability issues. The findings show that their awareness of sustainability corresponds with the decision to invest in green buildings. Moreover, these firms are associated with a state of the art sustainability report to exhibit their engagement in sustainability issues.

As often proclaimed in the literature, firms from the public sector such as public authorities, governmental institutions or non-profit organizations are expected to be more likely for investing in green buildings (H1). They often act as a first mover with an engagement in ecologic achievements and benefit from an environmental public policy. As a result, the present paper exhibits ambiguous findings. When the responding firms were asked to consider a real estate buy decision the empirical results illustrate a small but negative impact on the probability to invest. Considering lease decision making the likelihood for investing in green buildings increases significantly. Firms from the public sector exhibit a 32% higher probability for investing in green buildings compared to private sector firms. This finding is pervasive for both of the logit and probit model specifications.

With regard to the third hypothesis (H3), firms from the third industry sector with an associated higher share of highly skilled employees might be more likely to invest in green buildings. The empirical results illustrate industry specific differ-

ences. Firms from the building industry, which also includes construction, show diverging results. The findings are not statistical significant and for leasing properties, the likelihood for investing is slightly negative. As the literature reveals the importance of image and reputation for some industries, the financial service and banking industries illustrate a strong positive and statistical significant result. Firms from the financial service industries have a 24% higher probability for investing in green buildings, which holds for leasing properties. For buy decision making the likelihood increases with 16%. Concordantly, this finding holds also for the probit specification models (Table 2.4). Although not statistical significant the land and housing industry, which is strongly associated with real estate sustainability or green building issues, reveals the highest likelihood for investing in green buildings (c30%). The finding that firms with a high share of skilled and highly educated employees are more likely to invest in green buildings will also be supported by the research and development industries. Considering that these industries are distinctively aware of employee productivity the results support the third hypothesis.

The model specifications include different firm size categories from (50-99) to (10,000+) employees to investigate if investing in green buildings is related to firm size.[8] As a result, firms with more than 10,000 employees exhibit the highest likelihood for investing in green buildings, although not statistical significant. Firms with more than 1,000 but less than 5,000 employees also reveal a high probability, which is statistical significant to the 10 percent level. Nonetheless, the findings illustrate that investing in sustainable properties is not necessarily a question of firm size. Smaller firms with less than 100 employees also indicate an increasing probability for investing. All model specifications show a Pseudo-R^2 of at least 0.15 to 0.19, which highlights a proper model fit.

[8]Due to the specification of firm size categories, STATA drops the first firm size class (1-49).

2.5 Conclusion

The impact of real estate on global energy consumption, carbon abatement, and global climate change is distinctive for a sustainable future and the life of further generations. Energy efficient or so called green buildings are defined as sustainable real estate that capture economic, ecologic, and social benefits for investors, owner-occupier, renters, and further stakeholders.

The present paper investigates what factors increase the likelihood for investments in green buildings in Switzerland. Switzerland has one of the highest share of green buildings in the world. The study surveyed more than 200 firms over all industries and firm sizes in Switzerland. Besides asking firms directly to what extent ecological responsibility and corporate social responsibility (CSR) are crucial in their business behavior, the impact of public sector corporations are under investigation. In the real estate literature is has been well-documented that especially governmental institutions or public authorities are driving factors for an accelerating diffusion of green buildings. As a reason, it is often proclaimed that public institutions are not necessarily following a profit-maximizing strategy. Costs and benefits might not be exclusively part of the investment decision making of public institutions. The real estate industry and the society in general might benefit from public institutions with a high awareness of ecological responsibility and a first mover approach to signal their engagement in real estate sustainability issues. The findings of the present paper exhibit ambiguous results for the public sector. The results are divering for leasing and buying real estate properties. Notwithstanding, for leasing properties public authorities highlight a substantial and significant probability for investing in green buildings. These results are in line with the findings of Eichholtz, Kok, Quigley (2009, 2010). Concluding implications suggest that firms from the financial service and banking industries, the land and housing industries, and firms from the research and development sector illustrate the highest probability for investing in green buildings. These findings support that white collar industries are more likely to invest in green buildings, which is intuitive considering that green buildings

require higher investment costs and an awareness of energy efficiency issues. Analyzing the driving factors and industry specific differences on the likelihood of a green building investment is relevant for investors and policy makers. As a barrier to invest the lack of transparency and uncertainty are still predominant.[9]

The present paper contributes to increase the transparency of real estate investment decisions. Moreover, understanding the motivation for green building investments is eminent to achieve more energy efficient and sustainable real estate. Using survey data indicates a limited approach in terms of validity because survey data represent stated and not revealed preferences of the responding firms. Arguably firms can respond to the survey questions in an appropriate way to fulfill society´s expectations. Notwithstanding, the present paper contributes to the recent debate in real estate sustainability and provides insight into the Swiss real estate market. Future research might focus on the willingness to pay for green buildings aiming to quatify investors preferences in Switzerland. Also, still little is known of the barriers to invest, that account as harming factors in real estate sustainability debate.

[9]Jones Lang LaSalle established an real estate transparency index to highlight the heterogeneity of available information of regional real estate markets. One can show that real estate transactions rise with increasing transparency in the markets, which is highly relevant for investors.

Table 2.3: Logit Regression Analysis

	Buy Decision		Lease Decision	
	(1)	(2)	(3)	(4)
DV: Investment=yes	Coeff	Mfx	Coeff	Mfx
EcologicalResponsibility (d)	1.090**	0.220***	1.428***	0.334***
	(0.480)	(0.0844)	(0.427)	(0.0963)
MeaningCSR (d)	1.365***	0.322***	1.038*	0.209**
	(0.490)	(0.114)	(0.621)	(0.104)
PublicFirm (d)	-0.170	-0.0384	1.332*	0.321*
	(0.709)	(0.163)	(0.736)	(0.168)
Industry Sectors				
BuildingInd. (d)	0.536	0.108	-0.109	-0.0245
	(0.821)	(0.147)	(0.964)	(0.214)
Commerce (d)	0.433	0.0900	0.616	0.147
	(0.637)	(0.124)	(0.668)	(0.164)
Information&Commun. (d)	0.735	0.141	0.324	0.0767
	(1.088)	(0.174)	(0.979)	(0.239)
Finance&Banking (d)	0.832	0.168	1.007*	0.240*
	(0.600)	(0.108)	(0.578)	(0.138)
Land&Housing (d)	1.055	0.189	1.252	0.303
	(0.982)	(0.133)	(0.968)	(0.223)
R&D (d)	0.814	0.155	0.902	0.219
	(0.800)	(0.127)	(0.868)	(0.212)
PublicSector (d)	1.244	0.215*	-0.222	-0.0491
	(0.890)	(0.111)	(0.899)	(0.193)
Firm Size (Employees)				
(50-99) (d)	1.140	0.199	1.034	0.252
	(1.204)	(0.151)	(0.972)	(0.234)
(100-249) (d)	0.366	0.0765	0.818	0.198
	(0.766)	(0.150)	(0.796)	(0.196)
(250-499) (d)	0.269	0.0571	0.0424	0.00975
	(0.736)	(0.150)	(0.814)	(0.188)
(500-999) (d)	0.0817	0.0178	-0.336	-0.0735
	(0.742)	(0.160)	(0.856)	(0.178)
(1'000-4'999) (d)	1.107*	0.219*	1.218*	0.288*
	(0.668)	(0.115)	(0.658)	(0.153)
(5'000-9'999) (d)	-0.495	-0.116	0.696	0.169
	(0.967)	(0.237)	(1.004)	(0.250)
(10'000+) (d)	0.597	0.119	1.237	0.299
	(0.899)	(0.157)	(0.882)	(0.204)
Observations	148	148	150	150
Pseudo R^2	0.150	0.150	0.185	0.185

Marginal effects; Standard errors in parentheses

(d) for discrete change of dummy variable from 0 to 1

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Table 2.4: Probit Regression Analysis

	Buy Decision		Lease Decision	
	(1)	(2)	(3)	(4)
DV: Investment=yes	Coeff	Mfx	Coeff	Mfx
EcologicalResponsibility (d)	0.648**	0.219***	0.878***	0.333***
	(0.279)	(0.0851)	(0.254)	(0.0935)
MeaningCSR (d)	0.828***	0.317***	0.591*	0.201*
	(0.292)	(0.110)	(0.352)	(0.104)
PublicFirm (d)	-0.103	-0.0379	0.800*	0.311*
	(0.429)	(0.161)	(0.441)	(0.165)
Industry Sectors				
BuildingInd. (d)	0.329	0.111	-0.109	-0.0401
	(0.488)	(0.150)	(0.579)	(0.208)
Commerce (d)	0.278	0.0963	0.332	0.128
	(0.384)	(0.125)	(0.397)	(0.156)
Information&Commun. (d)	0.341	0.114	0.186	0.0710
	(0.568)	(0.173)	(0.562)	(0.220)
Finance&Banking (d)	0.482	0.164	0.608*	0.234*
	(0.348)	(0.108)	(0.346)	(0.134)
Land&Housing (d)	0.637	0.196	0.809	0.314
	(0.586)	(0.142)	(0.563)	(0.208)
R&D (d)	0.481	0.156	0.551	0.215
	(0.491)	(0.138)	(0.504)	(0.198)
PublicSector (d)	0.768	0.227*	-0.153	-0.0557
	(0.536)	(0.118)	(0.546)	(0.193)
Firm Size (Employees)				
(50-99) (d)	0.634	0.194	0.660	0.258
	(0.671)	(0.161)	(0.605)	(0.233)
(100-249) (d)	0.214	0.0748	0.556	0.217
	(0.464)	(0.154)	(0.481)	(0.189)
(250-499) (d)	0.145	0.0513	0.0355	0.0133
	(0.449)	(0.155)	(0.481)	(0.181)
(500-999) (d)	0.0213	0.00772	-0.189	-0.0686
	(0.435)	(0.157)	(0.502)	(0.175)
(1'000-4'999) (d)	0.641	0.214*	0.773*	0.296**
	(0.393)	(0.118)	(0.398)	(0.149)
(5'000-9'999) (d)	-0.289	-0.110	0.441	0.172
	(0.598)	(0.235)	(0.598)	(0.237)
(10'000+) (d)	0.371	0.124	0.779	0.303
	(0.553)	(0.166)	(0.540)	(0.202)
Observations	148	148	150	150
Pseudo R^2	0.150	0.150	0.188	0.188

Marginal effects; Standard errors in parentheses

(d) for discrete change of dummy variable from 0 to 1

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Chapter 3

Willingness To Pay for Green Buildings. Empirical Evidence from Switzerland.

Abstract

The demand for green buildings and to what extent firms accept to pay a premium price compared to conventional buildings is a lively debate and highly relevant for investors and policy makers. Policy instruments like the Swiss CO_2-enactment and the Swiss Building Program encourage and incentivize investments in energy efficient properties. Based on a corporate real estate survey, I investigate the premium percentage price firms are willing to pay for green buildings. I distinguish between the decisions to *lease*, *purchase*, or *retrofit* a property. On average, I find that Swiss corporations are willing to pay a premium price of 3.0% for leasing, 4.75% for purchasing, and 5.0% for retrofitting. Using censored regression analysis I find that, depending on firm characteristics, the announced premium price ranges from 1.3 to 7.9% compared to conventional properties. My results indicate that firms from the building and financial service industries, as well as public corporations and authorities signal the highest willingness to pay.

3.1 Introduction

Buildings are responsible for approximately 40% of energy consumption and for 24% of worldwide greenhouse gas emissions (IEA, 2006). However, the real estate literature points to a multitude of motivations to invest in energy efficient properties. Economic and ecological benefits appear when firms try to reduce

their energy, water, and waste consumption. With an investment in green buildings, firms hedge against rising energy prices and operating costs, as they try to reduce their ecological footprint (Eichholtz, Kok, Quigley, 2010). In particular, commercial buildings can reduce their CO_2 emissions easily and to a large extent while investing in energy efficient measures. Moreover, green buildings set higher standards and create better environmental quality indoors, which might lead to an improved working environment, healthy conditions and increased employee productivity (Jones Lang LaSalle, 2011). Another likely reason that corporations might increase their demand and be willing to pay for green buildings is acknowledged in terms of image and reputation. A better reputation allows firms to attract prospective employees and investors, and to charge higher sales prices for their business and products (Eichholtz, Kok, Quigley, 2010, 2013). Firms that invest in green buildings illustrate their ecological and social awareness, which is expected to be appreciated by their stakeholders. Some of these advantages and amenities are financially measurable, and some appear as intangible benefits. Therefore, analyzing the willingness to pay for green buildings is associated with a balancing costs and benefits.

In the aftermath of the United Nations Framework Convention on Climate Change in Doha 2012 (the Doha Amendment) and its resolution of a second Kyoto Protocol, the Federal Council of Switzerland (Bundesrat) announced a revised CO_2-enactment and climate change strategy for the time frame 2013 until 2020.[1] Aiming to reduce greenhouse gas emissions by 20 percent in the year 2020 compared to 1990, the real estate sector highlights a substantial part of the federal energy strategy in Switzerland (Bundesamt für Umwelt, 2010; IEA, 2007). It is expected that the real estate sector will contribute the majority (up to 40 percent) in reducing greenhouse gas emissions, whereas 10 percent is expected to come from the traffic and 15 percent from the industrial sector, respectively (Bundesamt für

[1]The Federal Office for Environment (Bundesamt für Umwelt BAFU) illustrates the Swiss federal strategy to reduce greenhouse gas emissions. In this context the CO_2-enactment has been revisited in late 2012. The enactment defines new elements of the Swiss Building Program supported by both, the federal state of Switzerland and cantonal municipalities. The Bundesamt für Umwelt (BAFU) and the Bundesamt für Energie (BFE) provide an overview of the current greenhouse gas strategy in Switzerland, following the *Energy Strategy 2050* with a strong emphasis on the built environment.

Energie, 2012). The CO_2-enactment provides the yearly amount of approximately 200 million Swiss francs to support investments in energy efficient residential and commercial real estate. The program has been enacted for the upcoming 10 years and it is estimated that more than 2 million tons of CO_2 will be saved within that period of time.[2] The Swiss CO_2-enactment allows for a CO_2-tax reduction or for an avoidance, when firms contribute significantly to a reduction of greenhouse gas emissions. Moreover, voluntary corporate initiatives and sustainable business behavior is an integral part of the Swiss carbon abatement strategy. Further investments in green buildings will be expected and institutional regulation is only going to intensify.

The present paper investigates the premium percentage price that firms are willing to pay for green buildings in Switzerland. For the case of Switzerland there is relatively little evidence for private corporations and public authorities displaying a willingness to pay. Most studies related to the Swiss real estate market analyse the willingness to pay of homeowners or the potential of energy efficiency measures for the residential real estate market (Jakob and Madlener, 2004; Jakob, 2007; Alberini, Banfi, Ramseier, 2011). This study contributes to the existing literature and fills the gap for commercial real estate and for firms‘ willingness to pay for green buildings. The analysis is based on the stated preferences of Swiss corporations.

The literature on green buildings provides empirical evidence for diverging lease and sale prices. Considering these differences, the study distinguishes between the decision to lease or to buy (purchase) a corporate real estate. The additional contribution of this paper is the analysis of the willingness to pay for a retrofit. A retrofit, in the present meaning, occurs whenever firms are going to increase the energy efficiency standards of their existing property portfolios by refurbishing the buildings. Moreover, the paper investigates the impact of firm characteristics, such as firm size, legal forms, and industry sectors on the willingness to pay. Besides industry specific characteristics, it is interesting to examine

[2]Besides reducing greenhouse gas emissions, the Swiss federal energy policy tries to increase the independence of oil and gas imports, which is also part of the federal strategy for the following decades (Bundesamt für Energie, 2012)

whether there are any substantial differences between private corporations and public authorities, which is part of a vital debate in the literature. However, the case of Switzerland allows for a distinctive analysis of regional disparities. Due to the Swiss cantonal municipalities (Swiss cantons), the paper also controls for regional differences in terms of Swiss Grand-Regions. Taking into account that the willingness to pay signaled by the surveyed firms is strongly related to their business behavior, this paper also sheds light on firms‘ attitude towards sustainability in terms of economic, ecological, and social contribution.

Based on a survey from 2013, this study includes a sample of 145 Swiss corporations. This paper contributes to the existing literature, even though an analysis of stated preferences can be criticized because the given answers are not real market or transaction based data.[3] Research findings illustrate premium prices that range from 1.3 to 7.9% on average compared to conventional properties. Moreover, the research indicates that corporations from the building and financial service industries are among the firms that recognize the highest willingness to pay for green buildings. Also public authorities signal a substantial willingness to pay. With regard to the diverging investment horizons, the results show that Swiss corporations are willing to pay a premium price of 3.0% for a lease, 4.75% for a purchase, and 5.0% for a decision to retrofit, on average.

The remainder of this paper is organized as follows. The next section provides a literature review and clarifies the empirical findings regarding the premium prices of green buildings as compared to conventional properties. I describe this study´s methodology, including the descriptive and empirical analysis, in order to investigate the willingness to pay for commercial real estate in Switzerland. The subsequent section describes the results and implications. Finally, the paper closes with concluding remarks.

[3]The section Data and Methodology provides an introduction of stated and revealed preferences.

3.2 Related Literature

The real estate literature provides a multitude of studies that deal with the analysis of premium rental and sales prices. Most studies focus on premium prices in order to investigate the financial benefits of green buildings compared to those of conventional real estate. Considering these diverging rental and sales price premiums, it is obviously a crucial distinction, whether firms want to lease or buy. One could expect that the decision to purchase is associated with a longer investment horizon. Buying a property ties up a substantial amount of capital in contrast to leasing. Generally, long term decision-making, including the decision to buy property, is associated with a higher willingness to pay. In relation to the decision to lease or buy, the case of renovation, or retrofitting, will be under investigation.

3.2.1 Diverging Preferences and Inefficient Investments

Differences in stated preferences about the willingness to pay could result from the diverging interests of landlords and tenants. Investments in real estate sustainability suffer when price sensitive decision makers do not directly benefit from energy savings and related amenities (Alberini, Banfi, Ramseier, 2011; Eichholtz, Kok, Quigley, 2011). This situation occurs when landlords or property owners do not occupy their own buildings (Alberini, Banfi, Ramseier, 2011). Therefore, one could expect a significant difference between the decision to lease or to buy, especially because of market failures and other barriers (Kok, Miller, Morris, 2012). Besides differences in the willingness to pay a premium price, market failures and barriers are responsible for inefficient spending in real estate, especially in the areas of sustainability and appliances (Jaffe, Newell, Stavins, 2004). The so-called *energy efficiency paradox* describes the situation of inefficient investments, or simply the lack of investments, in energy efficient technologies (Jaffe and Stavins, 1994b; Metcalf and Hassett, 1999; Klemick and Wolverton, 2013). This occurs although an investment appears to be appropriate, for ecological, social, and economic reasons (Jaffe and Stavins, 1994a; Jaffe, Newell, Stavins, 2004). The real

estate literature provides a multitude of explanations as to why decision makers do or do not invest in energy efficient properties. As Jaffe, Newell, Stavins (2004) point out, it is generally a question of balancing costs and benefits. Costs appear to represent primary considerations, whereas benefits, such as energy savings and reduced energy bills, occur over a longer time horizon. Therefore, discounting future cash flows from energy efficient investments is substantial in this context (Kats, 2003). Moreover, Jaffe, Newell, Stavins (2004) provide an overview of market and non-market failures explaining the energy efficiency gap. Among those explanations is the lack of information; information asymmetry between counterparties in concurrence with the principal-agent problem; transaction costs; uncertainty about future energy prices; or uncertainty about forthcoming technology developments (Hasset and Metcalf, 1993; Jaffe and Stavins, 1994a; Jaffe, Newell, Stavins, 2004). Additionally, a low capitalization rate of energy efficient investments is often proclaimed to be a significant barrier to investment Houser (2009). These barriers to an investment in concurrence with individual preferences indicate their impact on diverging stated preferences regarding the willingness to pay (Eichholtz, Kok, Quigley, 2010, 2011). For some decision makers, it is appropriate to wait with an investment in energy efficient technology and to delay the decision to invest. This also holds for individuals and firms. An analysis of the uncertainty regarding the willingness to pay of Swiss corporations furthers this discussion and is elaborated on in section 3.3.1.

Another reason for diverging preferences regarding the willingness to pay occurs when corporations outsource their properties, as they increasingly do (Eichholtz, Kok, Quigley, 2010). Owning properties is becoming less common, especially in the third industry sector. Ownership of commercial real estate has decreased significantly, as pointed out by Eichholtz, Kok, Quigley (2010) and Brounen and Eichholtz (2005). Although this paper does not control for varying effects across time, differences in the ownership of real estate assets indicate their impact on the willingness to pay.

3.2.2 Empirical Evidence on Premium Prices

In one of their initial studies, Eichholtz, Kok, Quigley (2010) provide empirical evidence on the economic value of green buildings. Based on real estate market transactions, they analyze more than 10.000 commercial buildings with a control sample of conventional properties.[4] They use a geographical information system to control for diverging location preferences and for the overall quality of the building. The control building had to be within a given radius of the corresponding certified building. Using Energy Star and LEED office buildings from the CoStar database, they analyze rents, effective rents, and selling prices.

For the U.S. real estate market the labels *Energy Star* and *LEED* are well documented and describe certified properties or so-called *green buildings*. In collaboration with the U.S. Green Building Council and the U.S. Environmental Protection Agency, the CoStar Group developed a comprehensive database with Energy Star and LEED certified buildings, which is a rich source for a multitude of real estate empirical research. Whereas Energy Star primary concentrates on energy efficiency, the LEED label describes a wider concept of sustainability attributes.

The findings of Eichholtz, Kok, Quigley (2010) indicate a 3% rental premium per square foot, and a 6% premium price for effective rents. Distinguishing between Energy Star and LEED certifications, they find a 3.3% premium rent for Energy Star and a 5.2% premium for LEED certified properties. Using effective rents the premium increases to 10% for Energy Star and 9.4% for LEED, respectively. These findings correspond to decision to lease addressed in the present paper. For the decision to buy, they find a selling price premium of 16% for green buildings on average. With regard to the diverging characteristics of Energy Star and LEED certifications, Eichholtz, Kok, Quigley (2010) acknowledge that for Energy Star labeled properties, the premium price is strongly related to energy savings characteristics. However, they also conclude that the relative premium for green buildings is higher in low-cost and less expensive metropolitan areas.

[4]The data illustrate real market behavior and describe rather revealed preferences than stated preferences.

The percentage increase in rent or sales price is systematically higher in low-cost and more peripheral regions.

Another study, by Fuerst and McAllister (2011), investigates the price effects of green buildings compared to conventional buildings, using hedonic regression analysis. Also for the U.S. commercial real estate market, they use the CoStar database and measure the effect of labeled properties, both for rents and sales prices. They analyze price differentials between commercial LEED and Energy Star labeled properties and conventional properties. They control for differences in property characteristics, such as age, quality in terms of building classes, building height, submarkets and other amenities. To distinguish between rent and sales prices they develop two hedonic regression models, a rent and a transaction price model. The transaction price model estimates the premium price per square foot taken from real estate sales transactions. In contrast to their rent model, the sales price model additionally includes a time trend variable that controls for price inflation and other unobserved trends over time (Fuerst and McAllister, 2011). Moreover, the sales price model provides a control variable for market conditions at the time of sale. The sample includes approximately 200 LEED and 800 Energy Star labeled properties, whereas 15,000 buildings were randomly selected from a control sample. They find a rental premium of 4-5% on average. The sales price premium is substantially higher and achieves up to 25-26% on average.

Similar findings are provided by Miller, Spivey, Florance (2008), also while using the CoStar database. They control for property size, location and age of the building. They use hedonic regressions models to account for sales and rental prices. Although their findings support a positive impact of labeled properties on rents and sales prices, they are not significant at the conventional 10% level. This holds for both, Energy Star and LEED certified properties. Nevertheless, they find a premium sales price of approximately 6% for Energy Star and about 10-11% for LEED certified buildings (Miller, Spivey, Florance, 2008).

A more recent study from Wiley, Benefield, Johnson (2010) analyzing Energy Star and LEED labeled properties in the U.S. market, support the aforementioned

results. They find rental premium prices of approximately 7-9% for Energy Star and even 15-18% for LEED certified buildings. With regard to a sales price premium, they find a 130 dollar per square foot premium for LEED, and a 30 dollar premium per square foot for Energy Star labeled properties. Fuerst and McAllister (2011) acknowledge that these findings might include another premium in addition to the energy efficiency label. The premium price both for rent and sales might contain a premium for a preferred site and location. Although Wiley, Benefield, Johnson (2010) use a dataset with properties from the same metropolitan area, they do not control for possible location differences.

Beyond the *lease* or *buy* decision, the additional contribution of this paper to the existing real estate literature is illustrated in the case of real estate *renovation* and related stated preferences. National and international renovation rates are still too low to achieve global policy goals like the Kyoto-Protocol (Jakob, 2007). As (Eichholtz, Kok, Quigley, 2010) state, in the past decades the annual construction rate of new office buildings account for approximately 2% of the existing building stock. Without a significant rate of energy efficient renovation, achieving global energy efficiency goals in the built environment would be unfeasible. For the case of Switzerland, Jakob (2007) estimates that energy efficient renovations only account for 0.4 to 0.8% of the total building stock per year. Moreover, Jakob (2007) investigates the drivers and barriers for an investment in energy efficiency or, more precisely, for the improvement of the buildings outer surface. For residential properties, he finds that renovations are much more driven by technical parameters and general housing activities, rather than by socio-economic factors such as income, age, and education. However, the renovation case is particularly interesting because building renovation is one of the key elements in achieving energy efficiency in the built environment (Kok, Miller, Morris, 2012). Jakob (2007) emphasizes that the existing building stock has an even greater potential to reduce greenhouse gas emissions than do newly built properties. Following this approach, this paper investigates the willingness to pay for renovations.

In their recent study, Kok, Miller, Morris (2012) analyze the economics of

green retrofits. This is one of the first empirical investigations of premium prices for certified properties in terms of renovation cases. Using the CoStar database for the U.S. real estate market, they analyze premium rents and effective rents of LEED certified buildings after a retrofit.

Kok, Miller, Morris (2012) compare rents and occupancy rates of certified and non-certified buildings in a controlled sample. Moreover, they investigate the achieved energy efficiency improvements after a retrofit, along with the related investment costs. The analyzed certification period is between 2005 and 2010. Using a survey among real estate managers, they account for the attitude towards the costs and benefits of green retrofits. The total sample includes 374 properties in the U.S. office market. They find that the average premium rent for retrofitted commercial LEED properties is about 7.1% compared to non-certified properties. This finding is equivalent to a premium rent of 2 dollars per square foot. Effective rents are approximately 9 percent higher, which corresponds to a 3 dollar per square foot premium. The total dollar amount invested in retrofits, in their sample, is roughly 400,000 dollar per median and 2 million dollar per mean, respectively. The results differ significantly depending on the local real estate market. For example, the differences in premium prices are higher in New York City and Boston than in other markets such as e.g. San Francisco. The results indicate that a retrofit makes sense in terms of the financial payback. On average, the benefits of energy efficient renovations outweigh the costs of renovation. Deeper renovations are beneficial to peak the quality and competitiveness of the buildings and lower the opportunity costs.

It is a matter of fact that data on real estate rental and sales price premiums is a scarce resource. Most of the studies that provide empirical evidence on premium prices for green buildings are limited to the U.S. real estate market.[5] As with this paper, the following studies investigate the Swiss real estate market. So far, empirical studies for Switzerland are only available for the residential real estate market.

Instead of focusing on distinctive premium rent and sales prices, a recent

[5]The CoStar database provides a leading resource for empirical studies.

study by Alberini, Banfi, Ramseier (2011) provides insight into homeowners´ preferences for energy efficiency renovations. They use a survey based on a conjoint choice experiment on Swiss homeowners in five cantons in the year 2010. In their final sample 473 participants were surveyed. The participants could choose between different energy efficient renovation projects to account for upfront costs, monetary benefits from saving energy, time of amortization and the improved thermal comfort. Interestingly, Alberini, Banfi, Ramseier (2011) find that the likelihood of investing in energy efficient renovation projects increases with the amount of subsidy offered by the Swiss federal government. Although the available amount of subsidy accounts for only a minor part of the investment costs, this implicitly impacts the willingness to pay. Moreover, their study shows that decision makers care about the upfront costs of energy efficient investments. Another finding from stated preferences indicates that the public´s attitude towards climate change plays a crucial role for the motivation to invest in renovations. Households that believe in the impact and importance of climate change are more likely to renovate and achieve the status of having a green building (Alberini, Banfi, Ramseier, 2011). Also, expectations about future energy prices appear to be important in the decision making process of homeowners. As Alberini, Banfi, Ramseier (2011) point out, people who expect increasing energy prices for the next 20 years are more likely to invest in renovations. However, analyzing stated preferences of survey participants, uncertainty is a factor under consideration. Participants who signalize uncertainty about future energy prices do not invest or invest with a substantially lower probability in renovation projects. Appraising costs and benefits, Alberini, Banfi, Ramseier (2011) calculate a discount rate of 1.5 to 2.9, which indicates a balanced costs and benefits relation.[6] Benefits such as future energy savings are not discounted very strongly by Swiss homeowners. These results show that related benefits are acknowledged and that there is a distinctive willingness to pay for green buildings.

Another well documented study for Switzerland investigates the willingness to pay for energy saving measures in residential properties (Banfi et al., 2008). This

[6]Diverging discount rates depending on the specification model.

study provides evidence on the marginal willingness to pay derived from discrete choice models. Following an approach similar to the present paper, Banfi et al. (2008) use stated preferences to account for the willingness to pay under different assumptions and energy saving characteristics.[7] The survey included roughly 260 tenants and 250 single-family homeowners. The final sample had 163 tenants and 142 homeowners from five Swiss cantons, whereas the majority covers the German-speaking part of Switzerland. Survey participants were asked to choose between maintaining their status quo and realizing different energy efficiency attributes. Implementing a choice experiment and using fixed effects logit models, Banfi et al. (2008) find that homeowners acknowledge pecuniary benefits resulting from energy savings. Moreover, they find a positive willingness to pay for environmental benefits as well as for thermal, air, and noise comfort attributes. As a further result, Banfi et al. (2008) ascertain a marginal willingness to pay of about 1% to 13% for both rented and purchased properties, depending on renovation attributes. For new buildings, the willingness to pay for enhanced facade insulation is approximately 3%. For a housing ventilation system the premium price ranges from 8% to 13%. Interestingly, they find that the willingness to pay for energy efficient attributes is significantly higher than for related capital costs. Interpreting this finding and considering cost and benefits in relation to an investment decision which manifest in the willingness to pay, the demand for energy efficiency investments appears to be higher than market supply. Or, the resulting marginal willingness to pay values is overestimated in this study, as Banfi et al. (2008) suggest.

These studies, introduced here, illustrate that corporate real estate decision makers value green buildings and they reveal a certain demand in the real estate market. The majority of the cited studies investigate a distinctive premium price for green buildings compared to conventional properties. These results hold for both, commercial and residential properties.

This paper aims to investigate the willingness to pay for energy efficient invest-

[7]Banfi et al. (2008) acknowledge stated preference methods to compare household decision makers that already experienced energy efficiency investments and those who do not.

ments in the built environment. Moreover, the paper concentrates on quantifying the results of stated preferences regarding premium percentage prices and contributes to the debate of low adaption rates of energy efficiency investments. The paper documents to what extend premium prices occur for commercial real estate properties in Switzerland.

3.3 Data and Methodology

To investigate the willingness to pay for green buildings, this paper uses data taken from a corporate real estate and sustainability survey in Switzerland. The survey has been initiated by the *Center of Corporate Responsibility and Sustainability at the University of Zurich* in collaboration with *CB Richard Ellis*, a worldwide major real estate service corporation, and *DemoScope*, a professional market research institution. Aiming to analyze price premiums expressed in percentages for energy efficient properties, the 2013 survey has been revised to quantify the willingness to pay. Moreover, firms were asked about their attitude towards sustainability and its implementation in their business behavior. Precisely, the survey participants were asked to assess the importance of economic, ecologic, and social sustainability from their perspective. Besides the sustainability issues the survey also analyzes possible regional disparities among Swiss corporations and their willingness to pay. In Switzerland, cultural differences are often cited as relevant.[8] Therefore, also the willingness to pay might lead to diverging results over different regions that are merged to Swiss Grand-Regions in this perspective.[9] It will be interesting to see whether there are any differences between the eastern German-speaking part and the francophone western French-speaking part of Switzerland. The study ensured that firms from all over the country, or more precisely from all 26 cantons, were able to participate in

[8]Gantenbein and Volonté (2012) provide a study concerning the relation between cultural differences and corporate governance for the case of Switzerland. Although the law is equal in both, the German and French speaking part of Switzerland, substantial cultural differences appear in both regions.

[9]Swiss Grand Regions are taken from the official definition of the Federal Statistic Office Switzerland.

the survey. With a distribution over all Swiss cantons, this study provides an additional contribution to related literature.

To analyze firms' preferences and their willingness to pay both *revealed* and *stated preferences* is a common technical approach. Revealed preferences refer to a real observation of individual preferences and to a real market behavior. Therefore, revealed preferences are defined as a real world evidence for individual choices. The analysis of premium prices of green buildings, actual choices, and real market behavior is often taken from real estate transaction data or from selling price differences (Eichholtz, Kok, Quigley, 2010). Due to the lack of data availability, stated preferences are used to account for hypothetical situations and questions on the willingness to pay.[10] A prerequisite for using stated preferences is that the survey is purpose-designed. In this paper I use a stated preferences technique to investigate the willingness to pay for green buildings.

With regard to the general methodology I follow Kotchen, Boyle, Leiserowitz (2013). They analyze the willingness to pay and policy-instrument choices for climate-change in the United States. Based on a scale of given prices, households were asked about their willingness to pay for policy instruments aiming to reduce greenhouse-gas emissions. Kotchen, Boyle, Leiserowitz (2013) find that the willingness to pay depends on certain sociodemographic characteristics, especially on educational background, age, and income. Similarly, they controlled for households attitudes to climate-change, specifically whether they believe if global warming is actually happening or not. In the present study, I investigate firm characteristics and control for firms attitude on sustainability issues and whether they acknowledge the importance of sustainability.

Overall, roughly 1.000 Swiss corporations across all industry sectors had been contacted by the Swiss census institute *DemoScope*. More than 100 survey participants started but did not fully complete the survey and were not selected for the analysis. Further 145 firms completed the survey. Although some of these 145 selected participants did not answer single questions, the data could be used for the empirical analysis. The data collection was conducted in two stages. First,

[10] Verhoef and Franses (2002) provide an overview of revealed and stated preference methods.

Table 3.1: Summary statistics

Variable	Mean	N
<10 Buildings	0.500	65
10 - 20 Buildings	0.200	26
20 - 30 Buildings	0.054	7
>30 Buildings	0.246	32
<1,000 sqm	0.152	16
1,000 - 10,000 sqm	0.229	24
10,000 - 50,000 sqm	0.324	34
50,000 - 100,000 sqm	0.124	13
>100,000 sqm	0.171	18
Firms under Puplic Law	0.289	39
Firms under Private Law	0.711	96
International Firms	0.493	69
Employees (>250)	0.681	94
Employess (<250)	0.319	44
Processing Trade Industry	0.288	38
Building Industry	0.053	7
Commerce	0.197	26
Finance & Banking	0.250	33
Land & Housing	0.068	9
Public Sector	0.144	19
Lake Geneva	0.072	10
Middleland	0.159	22
Northwest	0.101	14
Zurich Area	0.406	56
East	0.123	17
Central Area	0.130	18

Note: The figures represent mean percentages and the absolute number of observation in each category. The overall number of participating firms is 145 for the year 2013. Deviations appear due to omitted answered questions by the participants. The industry sector classification follows the NOGA classification from the federal statistical office. Due to a lack of observations, the Information and Communication sector as well as Research and Development is not reported. For the Swiss Grand-Regions, Ticino is not reported due to a lack of observations. Source: Own calculation based on Corporate Real Estate Sustainability Survey 2013 dataset.

telephone interviews ensured a random sample of Swiss firms. This was necessary to recruit suitable contact persons in each firm with a distinctive knowledge and experience in real estate issues. Especially for larger corporations it was highly relevant to contact real estate professionals with sound information about the firms' real estate portfolios. Also, contact persons should be able to comment on the business behavior and the general strategy of the firm. Additionally, a multitude of firm characteristics were recorded at this stage. Second, the participating firms could answer a programmed online survey.

3.3.1 Descriptive Statistics

The following descriptive statistics provide a first overview of the distribution of firm size, legal forms, and industry sectors of the surveyed firms, displayed in Table 3.1. The majority of participating firms have up to 10 buildings in their real estate portfolio. About 25% of the firms have more than 30 buildings. It is imperative to account for different legal types of the firms because of diverging investment requirements. Public corporations such as governmental institutions, non-profit organizations, and other public authorities do not follow a profit-maximizing strategy and are not part of a competitive market environment (Eichholtz, Kok, Quigley, 2011). Moreover, public authorities are among the most prominent owner-occupier and renters of energy efficient properties (Eichholtz, Kok, Quigley, 2011). Therefore, substantial differences might occur in their acceptance of a premium price for green buildings compared to private sector firms. Approximately 68% of the surveyed firms are large corporations with more than 250 employees. This is equivalent to 94 firms or more than 8% of all large corporations in Switzerland.[11]

[11]Swiss Federal Statistical Office, Industry and services, Private businesses and persons employed by size, 2008. Further descriptive statistics are illistrated with Figure A.3, A.4, and A.5 in the Appendix.

Figure 3.1: Willingness to Pay Responses - Percentage Distribution.

The figures represent mean percentages on a given 0% to 15% scale gradually in 2.5% steps. For the lease-case 12.7% the participating firms answered "don't know", whereas 15.5% for the buy-case and 14.0% for the retrofit-case respectively. Source: Own calculation based on Corporate Real Estate Sustainability Survey 2013 dataset.

Stated Preferences for Premium Prices

To state their preferences towards the willingness to pay, firms were asked to answer the following question:

> *Consider that you have to make a real estate lease, buy, or renovation decision. What are you willing to pay for energy efficient or so-called green buildings compared to conventional properties? Please choose your preferred premium price.*[12]

Figure 3.1 provides an overview of stated preferences for each case of a decision to *lease*, *buy*, or *retrofit* a property. On a given scale that ranges from 0% to 15% (or more) firms could announce their preferred premium price in intervals of 2.5%. A literature review suggests that a scale between 0% and 15% is suitable and covers most of the findings of international studies that analyze premium

[12]The survey provided a definition of the phrase "'green buildings"'. Moreover, participating contact persons were real estate professionals to ensure a proper interpretation of the question.

prices for green buildings. The highest price category stands for a premium price of 15% or more.

The stated preferences in Figure 3.1 illustrate substantial differences between the different real estate decision cases. The 0%-answer clarifies that firms are not willing to pay a premium price for energy efficient properties. They value green buildings the same as conventional buildings. Interestingly, the bulk of firms announced that they would not pay more for green buildings when they could *lease* new space for their corporation. Approximately 40% of the firms would not pay an extra amount of money for their new leased property. Substantially fewer firms are not willing to pay a premium price to buy a new property or to retrofit existing buildings. Additionally, the lower bound of price categories is much wider than the upper bound for the *lease* case (Figure 3.1). For the buy and retrofit cases, the stated preferences illustrate higher premium prices compared to the decision to lease. Comparing the willingness to pay on average for each decision making process, I find that firms are accepting a premium price of approximately 3% (lease), 4.75% (buy), and 5% (retrofit), as displayed in Table 3.2.

Table 3.2: Summary statistics

Variable	**Mean**	**Std. Dev.**	**Min.**	**Max.**	**N**
Lease	2.984	3.384	0	15	124
Buy	4.750	3.701	0	15	120
Retrofit	5.020	3.930	0	15	122

* The figures represent mean percentages on a given 0% to 15% scale for (1) lease, (2) buy, and (3) retrofit decision making. Source: Own calculation based on Corporate Real Estate Sustainability Survey 2013 dataset.

These findings are in line with the results from international empirical studies on real estate premium prices. Most of the studies cited in the literature review are calculated on transaction data. Interestingly, the majority of these studies also indicate a higher premium sales price compared to a premium lease price. These findings indicate diverging preferences in terms of the investment horizon. Renting a commercial property might be associated with a shorter time horizon than buying a real estate. Owning real estate might indicate a stronger awareness of long-term sustainability issues like energy efficiency. Another reason for higher

sales prices is associated with a stronger commitment to the property from a firm´s perspective. Moreover, we have to admit that property owners and tenants might have diverging interests in terms of energy efficiency investments.

In order to explain the lower acceptance of lease premium prices, one could argue that a significant sustainability standard is already expected and that prospective tenants are not willing to pay an extra premium price. Due to a very low vacancy rate in the Swiss commercial real estate market, firms´ primary interest is to obtain suitable property space first and foremost.[13] Energy efficiency issues might occur secondarily and lead to a limited awareness of energy efficient properties.

Surprisingly, the premium price for the case of renovation is even higher than the announced premium prices for leasing or buying a property. Taking into account that conventional renovations do not necessarily need to be energy efficient, firms were able to acknowledge their premium price for achieving a green building. These findings also hold for industry specific willingness to pay. Figure 3.2 illustrates the stated preferences depending on the top-4 industries represented by the survey. In concurrence with former results, the non-acceptance of a premium price is again substantially higher for lease decision making compared to the other specifications.

To account for industry specific differences on the willingness to pay, Table 3.3 provides an overview. The results show that on average the premium prices ranges from 1.25% up to 7.9%. In line with previous results the highest acceptance can generally be found for the renovation case. Interestingly, the *building industry*, which also includes civil engineering, represents the highest willingness to pay for green buildings, on average. Moreover, the *finance and banking* industries and the *public sector* signal the highest acceptance of premium prices. With regard to the legal form, Table 3.4 highlights the differences between firms under private and public law. It occurs that firms under public law account for substantially higher premium prices than firms under private law. These findings correspond to

[13]The vacancy rate for commercial real estate is about 1-2 percent, regarding to the agglomeration (Bundesamt für Statistik, 2012).

Table 3.3: Industry specific WTP

Industry Sector	Lease	Buy	Retrofit
Processing Trade	2.647	4.779	5.214
Building Industry	4.642	7.500	7.916
Commerce	1.250	3.214	2.875
Finance & Banking	3.833	5.000	5.833
Land & Housing	2.142	4.285	3.928
Public Sector	4.264	5.882	6.176
Total	2.975	4.786	5.063

* The figures represent mean percentages of the willingness to pay for green buildings on a given 0% to 15% scale for (1) lease, (2) buy, and (3) retrofit decision making over industry sectors. Due to a lack of observations the Information and Communication industry as well as the Research and Development industry is not reported. Source: Own calculation based on Corporate Real Estate Sustainability Survey 2013 dataset.

the often proclaimed pioneer role of public authorities, governmental institutions, and non-profit organizations to acknowledge their awareness of the importance of energy efficient properties. They signal a distinctive leading role to encourage private investments in green buildings, which will be supported by these findings.

Table 3.4: WTP and Legal Form

Legal Form	Lease	Buy	Retrofit
Public Law	3.882	5.526	6.250
Private Law	2.591	4.423	4.500
Total	3.000	4.784	5.063

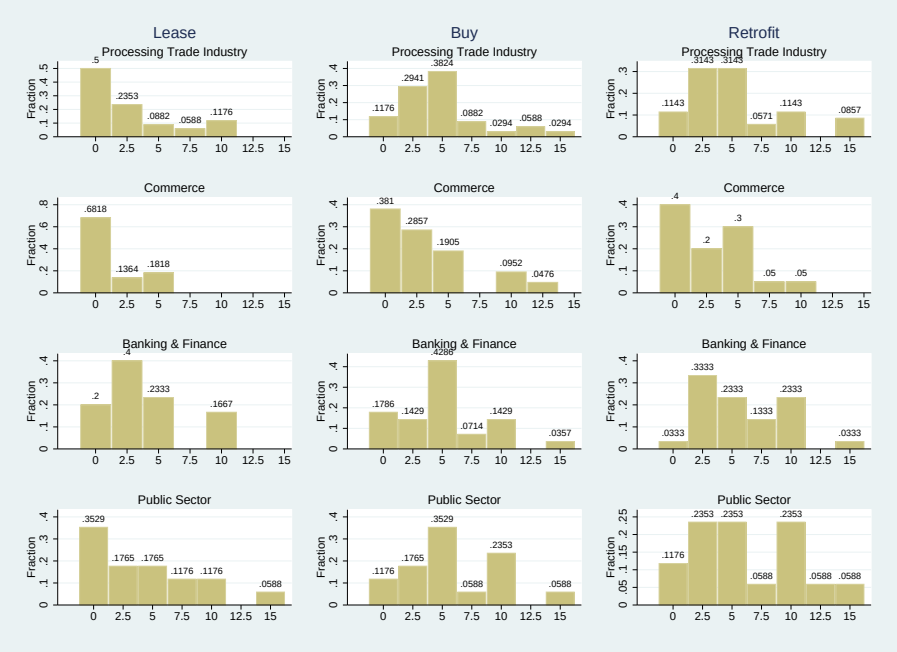
* The figures represent mean percentages on a given 0% to 15% scale for (1) lease, (2) buy, and (3) retrofit decision making. Source: Own calculation based on Corporate Real Estate Sustainability Survey 2013 dataset.

Uncertainty about the Willingness to Pay

An analysis of stated preferences suggests that firms can be uncertain about their willingness to pay and about their acceptance of a premium price.

> *"[]..both real estate developers and institutional investors are understandably uncertain about how far to go in implementing environmental investments, since the economic rationale for the development of*

Figure 3.2: Willingness to Pay over Swiss Industry Sectors



* The figures represent mean percentages on a given 0% to 15% scale for (1) lease, (2) buy, and (3) retrofit decision making for four industry sectors with the largest amount of observations. Source: Own calculation based on Corporate Real Estate Sustainability Survey 2013 dataset.

> *sustainable buildings is based almost entirely on anecdotal evidence."*
>
> (Eichholtz, Kok, Quigley, 2010, AER, p. 2492)

Following Kotchen, Boyle, Leiserowitz (2013) the analysis of a distinctive willingness to pay debate requires an investigation of how firms display uncertainty. It appears to be an expected outcome that uncertainty will harm investment decisions and might decrease the willingness to pay. As previously discussed in section 2, a multitude of potential investment barriers lead to increased uncertainty by decision makers (Alberini, Banfi, Ramseier, 2011). Although this paper does not aim to analyze the barriers to energy efficient investments directly, participating firms should be able to acknowledge their uncertainty about the topic.

Several reasons emerge for firms preferring to answer "don't know" instead of signalizing a certain premium price. Indeed, we tried to reduce uncertainty in the sense of not asking the wrong people who are not able to give a proper answer, because of limited knowledge or other reasons.

It might provide valuable insights into firm decision making to analyze which factors impact the "don´t know" answer and which firm characteristics increase

uncertainty over the willingness to pay. With regard to the different real estate decision making categories (lease, buy, retrofit), it turns out that uncertainty is relatively equal distributed. For the lease case about 13% of the surveyed firms answered "don't know", whereas approximately 15% for the buy case and 14% for the retrofit case respectively. To account for an empirical analyzes of uncertainty, estimating linear probability models did not lead to valuable results. There are no significant differences with respect to firm characteristics and industry sectors, and therefore these results are reported here.[14]

3.3.2 Empirical Analysis

The following section illustrates the empirical analysis, using censored regression models. Due to the survey design, which provides a given range of possible answer categories, I use Tobit models for the regression analysis (Amemiya, 1973).

The dependent variable, which is the stated percentage premium price, is a censored variable. It has a given lower bound including the null price premium for participants who are not willing to pay a premium price. Non-negative values are not possible. The highest value of the dependent variable is "15% or more", so there is no censoring from above. A fundamental characteristic of the data is that there are observations for the premium price that are zero. The linearity assumption and the method of ordinary least squares are not suitable therefore. Following the theoretical Tobit model, we assume a latent dependent variable which is equal the observable dependent variable whenever the latent variable is non-negative (Amemiya, 1984).[15]

$$y_i = \begin{cases} y_i^* & \text{for } y_i^* \geq 0 \\ 0 & \text{for } y_i^* < 0 \end{cases}$$

The latent variable can be written as:

[14] Analyzing the uncertainty by using the "don´t know" answer category provides not a clear contribution. Taking the "don´t know" variable as a dependent variable and using linear probability models, I do not find significant results for diverging uncertainty.

[15] Amemiya (1984) provides an overview of the standard tobit model and numerous applications of the standard tobit model with a description of the dependent variable and the most important independent variable from diverse economic fields.

$$y_i^* = \beta x_i + \epsilon_i$$

The following estimation accounts for the empirical analysis:

$$\begin{aligned} y_i = \beta_0 + \beta_1 Build + \beta_2 Employ + \beta_3 Legal \\ + \beta_4 Space + \beta_5 Industry + \epsilon_j + controls \end{aligned} \tag{3.1}$$

The empirical analysis investigates the impact of distinctive firm characteristics on the willingness to pay. To account for different firm size measures, I use the number of buildings, the number of employees, and space measures (in sqm). Considering different space types, such as office, sales, or storage, space intensity is very diverging over different industry sectors. Firms might have a relatively small amount of employees but still use large amount of space in square meters. This holds for example storage or sales intensive industries. Therefore, I control for diverse measures of firm size. The regression model also includes the legal form of the surveyed corporation to acknowledge differences in expected profit maximizing or non-profit business behavior. Additionally, the industry specification is part of the analysis.[16]

Moreover, the present paper analyzes the impact of the firms´ attitude towards sustainability in general. Fuerst and McAllister (2011) point out that so far there is little empirical evidence that commercial real estate prices are influenced by sustainability characteristics. However, I take this into account and control for sustainability issues. It might have an impact on the announced premium prices, whether firms signal a strong importance of sustainability in their business behavior, or if they negate this question. Responding firms were asked about their attitude towards sustainability in their business behavior. The notion of sustainability issues has been dismantled into the well-documented terms of *economic*, *ecological*, and *social* sustainability. I use a Likert-scale with five possible categories to answer, "Not important at all", "Less important", "Undecided", "Important", "Very important". Despite a loss in information, I simplify

[16]Due to the lack of observations the Information and Communication as well as Research and Development industry is not reported here.

the five categories to a dummy variable coded 1 when the answer given is at least "important" and 0 otherwise.

To control for diverging stated preferences depending on regional disparities, I merge the Swiss cantonal municipalities to Swiss Grand-Regions.[17] Firms from very prosperous regions might signal a higher willingness to pay for green buildings. The Swiss Grand-Regions "Lake Geneva", "Northwest", and "Zurich" account for the highest GDP rates, whereas the regions "Middleland", "East", and "Central" account for substantially lower GDP rates as well as a lower diffusion of corporations. Therefore it is important to control for heterogeneous Grand-Regions.

3.4 Results and Implications

The results of this paper are twofold. At a first stage, the descriptive statistics provide a decent overview of the stated preferences on premium prices and show the willingness to pay of the respondents. Second, the empirical analysis investigates the impact of industry specific and firm characteristics on the announced premium prices.

The participating firms were asked to consider a real estate lease, purchase, or retrofit decision. The analysis implies diverging price announcements for each decision. Moreover, a substantial amount of firms reveal uncertainty about their willingness to pay for green buildings. Particularly, when firms consider to lease a property, instead of a purchase or retrofit decision, approximately 40% of the respondents are not willing to pay a premium price. In contrast to the lease case, the non-acceptance rate of a premium price ranges about 15-18% on average and appears to be similar for the decision to purchase or retrofit a property. The findings for leasing new properties imply that a distinctive energy efficiency standard is already expected without paying a premium price. When the supply of suitable commercial space already provides a decent green building standard including property labels and certifications, there is obviously no need to pay an

[17]Swiss Grand-Regions follow the definition of the Federal Statistical Office. Due to the lack of observations, Ticino is not reported.

extra amount for it. One the other hand, it might also imply that the respondents value the associated additional costs of a green building higher than the benefits.

The empirical analysis indicates that firms with a larger amount of space acknowledge a higher premium price. For example, firms in the highest category of space usage (100,000+ sqm), suggest a 3.8% higher premium price than firms with lower space intensity. These findings are significant at the 5 percent confidence level. The results remain significant when we control for the sustainability attitude and regional disparities. The results do not illustrate a significant impact of space intensity for the decisions to purchase or retrofit a property. Larger firms with more than 250 employees accept a higher premium price compared to smaller firms. The results are positive and significant, especially for the decision to buy a property. This finding is identified as important for employee-intensive industries such as the financial service or commerce industry in Switzerland. It suggests that green buildings are a relevant factor for industries that are attempting to attract high-skilled employees.

The results do not indicate that a larger property portfolio leads to a higher willingness to pay. On the contrary the survey indicates that the empirical results are negative for firms with more than 10 buildings. So, human capital, captured via the number of employees in a firm, has a stronger and more significant impact on the willingness to pay for green buildings than does the number of buildings in a firm´s property portfolio. Concluding, firms that are using more space reflect a positive and significant impact on the willingness to pay, whereas a larger amount of buildings do not support this finding. This might imply that firms that using more space are likely to be larger companies with CSR requirements and be financially able to pay more.

Participating firms under private law account for an assumed profit-maximizing business behavior, which is not the case for governmental institutions, public authorities, and non-profit organizations. Here, the insert dummy variable stands for public corporations. For all specifications the variable "LegalForm" is positive but not significant in terms of the standard significance levels. This result is in line with the related literature that proclaims the importance of public sector

authorities, for their implementation of green policies. This finding also corresponds with the industry specification of the public sector, which is not limited to the legal type of public law.

With regard to industry specific findings, the building industry sector has the strongest positive and significant impact on the willingness to pay. Firms from the building industry that consider leasing a property acknowledge a 4.7-5.8% higher premium price for green property compared to other industry sectors. Also, an increasing impact on the willingness to pay occurs for the finance and banking industry as well as for the public sector. These findings hold, even when we control for different sustainability attributes and regional disparities. This complements to the empirical results from Eichholtz, Kok, Quigley (2010), who point out that firms from the finance, insurance, and real estate industry signal a substantial interest and willingness to pay for green buildings. The industry specific findings suggest, that labor-intensive industries and industries with a distinctive awareness of representative space account for the highest willingness to pay. The impact of image and reputation could be associated for the financial service industry, which has an extensive awareness of customer relationship. Controlling for firms from different Swiss Grand-Regions with heterogeneous macroeconomic conditions show no statistical significant effect. The findings illustrate ambiguous results which is to some extent counterintuitive.

3.5 Conclusion

The contribution of this paper to related literature is twofold. First, it is the first investigation of green building premium prices for the commercial real estate market in Switzerland. Second, in addition to an analysis of the willingness to pay for leasing or buying, the survey respondents were also asked about their willingness to pay for a decision to retrofit a property.

The impact of the built environment on CO_2 emissions is incontrovertible. The Swiss CO_2-enactment aims to encourage and incentivize investments in green buildings. Considering the impact of commercial properties on greenhouse gas

emissions, to understand which firm characteristics and industry specifications determine the willingness to pay, is eminent to policy makers and investors. The empirical analysis suggests that diverging firm attributes determine the acceptance of a premium price for green buildings. As reinforced by descriptive statistics, substantial differences emerge in the decision making process, in terms of whether firms intend to buy, lease, or retrofit a property.

The decision to retrofit a property reveals the interest of the firm to improve the status quo of energy-efficiency in their property portfolio. The debate about insufficient investments in energy efficiency in the built environment is related to several barriers that prevent investments in green buildings. The theoretical energy-efficiency gap, revealed in much of the literature, is caused by a lack of information, by information asymmetry or by principal-agent problems between real estate owner and tenant. Although there are explanations of insufficient investments, the illustrated premium prices for green buildings in this paper account for a distinctive demand and willingness to pay. Moreover, firms state their attitude towards climate change issues and the abatement of greenhouse gas emissions with their acknowledged preferences on sustainability.

It turns out that uncertainty about the acknowledged premium price peaks for the decision to lease a property, which corresponds to the lowest premium price on average. The most prominent industry sectors with the highest willingness to pay are represented by the building industry, the financial service industry, and the public sector. For these industries the benefits of green buildings appear to be higher than additional costs that are associated with green buildings. Although the survey respondents represent all industry sectors in Switzerland, one might expect that firms from the building industry are more aware of the benefits of green buildings. The financial service industry, which is very common for Switzerland, signals a special interest in representative office space. The often proclaimed benefits of green buildings appear to be appreciated in these industry sectors. The findings reveal a relatively low interest in green buildings in the commerce industry. The announced premium prices ranges from 1.3 to 7.9% compared to conventional properties.

Surveying firms and analyzing their willingness to pay is associated with stated preferences rather than revealed preferences. It is taken into account that stated preferences are not revealed in terms of observable or transaction-based investment decisions. Signaling a certain premium price does not necessarily mean that real estate decision makers would actually pay the announced price. Therefore, the findings might be overestimated. On the other hand, the results of the present paper complement the related literature and the empirical findings of transaction-based rental and sales prices. However, the findings in the present paper provide a contribution to the related literature of green buildings in Switzerland. It provides insight into the green economy and reveals the demand for green buildings.

Table 3.5: Censored regression models of the willingness to pay

	(1) Lease	(2) Buy	(3) Retrofit	(4) Lease	(5) Buy	(6) Retrofit	(7) Lease	(8) Buy	(9) Retrofit
Buildings (>10)	-1.847**	-1.129	0.0630	-1.767*	-1.007	0.289	-1.841*	-1.951*	0.0707
	(0.905)	(0.939)	(1.078)	(0.892)	(0.945)	(1.065)	(0.940)	(0.989)	(1.157)
Employees (>250)	0.556	2.124**	0.798	0.114	1.784*	0.134	-0.373	2.216**	0.0956
	(0.866)	(0.923)	(1.045)	(0.865)	(0.930)	(1.030)	(0.926)	(0.982)	(1.136)
LegalForm (Puplic=1)	0.410	0.847	1.625	0.257	0.704	1.372	0.473	0.519	1.191
	(0.809)	(0.860)	(0.991)	(0.784)	(0.840)	(0.939)	(0.813)	(0.867)	(1.009)
Space									
1,000 - 10,000 sqm	0.655	-0.903	-0.889	0.727	-0.663	-0.601	1.057	-0.309	-0.535
	(1.044)	(1.186)	(1.297)	(1.006)	(1.158)	(1.231)	(1.051)	(1.160)	(1.303)
10,000 - 50,000 sqm	2.849**	0.162	0.415	2.796**	0.271	0.424	3.313***	0.879	0.709
	(1.143)	(1.273)	(1.424)	(1.109)	(1.246)	(1.355)	(1.153)	(1.258)	(1.434)
50,000 - 100,000 sqm	3.033**	-0.839	-0.709	2.947**	-0.818	-0.765	3.720***	-0.560	-0.607
	(1.429)	(1.553)	(1.764)	(1.383)	(1.518)	(1.673)	(1.401)	(1.510)	(1.736)
100,000+ sqm	2.429	-0.460	-0.770	3.110**	0.252	0.397	3.806**	1.411	0.784
	(1.506)	(1.628)	(1.852)	(1.478)	(1.626)	(1.794)	(1.527)	(1.647)	(1.901)
Industry Sectors									
Building Industry	4.792**	3.928*	2.905	5.477***	4.621**	4.255*	5.786***	5.224**	4.243*
	(1.989)	(2.131)	(2.426)	(2.014)	(2.194)	(2.411)	(2.039)	(2.172)	(2.503)
Commerce	-0.124	-0.519	-1.593	-0.0247	-0.344	-1.646	-0.119	-0.500	-1.852
	(1.012)	(1.055)	(1.244)	(0.994)	(1.047)	(1.204)	(0.989)	(1.029)	(1.244)
Finance & Banking	2.828***	1.691*	1.704	2.792***	1.703*	1.672	2.878***	1.809*	1.827
	(0.940)	(1.000)	(1.142)	(0.913)	(0.980)	(1.095)	(0.897)	(0.955)	(1.110)
Land & Housing	1.276	0.803	-0.184	0.976	0.669	-0.680	1.020	1.468	-0.463
	(1.406)	(1.497)	(1.704)	(1.372)	(1.477)	(1.635)	(1.402)	(1.483)	(1.719)
Public Sector	3.336***	2.156*	1.431	2.948***	1.791	0.803	2.920***	1.557	0.773
	(1.099)	(1.164)	(1.338)	(1.072)	(1.148)	(1.281)	(1.060)	(1.120)	(1.304)
Sustainability									
EconomicSustain				0.813	0.425	1.401	0.489	0.849	1.397
				(0.949)	(1.050)	(1.156)	(0.950)	(1.041)	(1.202)
EcologicalSustain				-0.148	0.0966	-0.554	-0.0714	0.122	-0.529
				(0.846)	(0.909)	(1.010)	(0.835)	(0.886)	(1.028)
SocialSustain				1.524*	1.421*	2.527***	1.400*	1.272	2.566***
				(0.788)	(0.847)	(0.940)	(0.776)	(0.827)	(0.953)
Swiss Grand-Regions									
Middleland							-1.975	-1.769	0.258
							(1.402)	(1.806)	(1.829)
Northwest							0.174	-0.208	1.399
							(1.674)	(2.034)	(2.159)
Zurich							-1.308	-2.928*	0.252
							(1.343)	(1.713)	(1.725)
East							-2.422	-0.623	0.551
							(1.470)	(1.866)	(1.915)
Central							-0.902	-1.625	-0.224
							(1.511)	(1.857)	(1.929)
Observations	90	88	90	90	88	89	89	87	88
Pseudo R^2	0.059	0.041	0.034	0.073	0.051	0.057	0.086	0.069	0.059

Notes: The dependent variable is the censored response variable to the question "what premium price are you willing to pay for green buildings, compared to conventional buildings", each for lease, buy, and retrofit decision making.
The industry sectors follow the NOGA classification. The omitted variable for space is <1,000 sqm.
"Processing Trade" is omitted for industry sector and "Lake Geneva" for Grand-Region.
Marginal effects; Standard errors in parentheses
* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Chapter 4

The Diffusion of Green Buildings. An Empirical Investigation of Switzerland.

Abstract

This paper investigates the diffusion of green buildings in Switzerland. Switzerland exhibits a substantial demand for green buildings that is the highest among developed countries. Nonetheless, the distribution of energy efficient buildings is highly heterogeneous among Swiss cantons. Using a unique dataset that captures all certified residential buildings, the paper analyzes the dynamics of green buildings across all 26 Swiss cantons over a period of 14 years since 1998. The paper uses panel data analysis to capture regional characteristics such as economic and property market conditions, innovation and education characteristics, climate conditions, and the predominant environmental ideology to explain the demand for energy efficient properties. Results show that income and local rent levels, as well as innovation characteristics, are strongly significant. In contrast to other studies, the findings do not support a significant impact of cultural factors, age, or the environmental ideology of local residents.

4.1 Introduction

The real estate literature provides a multitude of reasons why investments in energy efficient properties are attractive. This holds true for both the decision making of private homeowners and firms. However, in line with prospect theory, investment decisions are the outcome of expected benefits and potential losses.

Although investments in green buildings are associated with potential gains that become profitable in the long run, individual decision making can lead to diverging results. Considering the benefits of green buildings, a low rate of diffusion is frequently seen as a contradiction or a market failure. Moreover, this low rate of diffusion sparked the debate over the energy-efficiency paradox in the context of real estate (Hasset and Metcalf, 1993; Jaffe and Stavins, 1994a,b; Jaffe, Newell, Stavins, 2004).

It is well-documented that the diffusion of energy efficient or so-called "green buildings" is highly heterogeneous in some real estate markets (Kok, McGraw, Quigley, 2011, 2012). The dispersion is not only diverging between developed and developing countries but also within regional real estate markets of a single country, where a heterogeneous diffusion is frequently observable. The present paper investigates the diffusion of energy efficient properties in Switzerland.[1] Switzerland exhibits one of the world´s highest rates of energy efficient properties in the residential sector (Salvi and Syz, 2011; Banfi et al., 2008). The federal organization of Switzerland, with 26 Swiss cantons and more than 2,500 regional municipalities can be seen as a role model for a regional economic approach to discuss the diffusion of energy efficient properties.

However, the preferences of homeowners are difficult to observe or measure. The federal structure provides a multitude of proxy variables that are associated with an environmental lifestyle or a green ideology. Recent international studies show that in some federal states of the U.S. a large share of people with a green ideology frequently use green technology. These people choose environment friendly properties, energy efficient cars or vote for green politicians and parties. In other states the share is negligible (Kahn, 2007), which illustrates the heterogeneity. The objective of the present paper is twofold. First, the paper aims to investigate the dynamics of green buildings in Switzerland in terms of the development over time since the Swiss label Minergie was established. Sec-

[1]The conceptual framework of diffusion follows the general definition of (Rogers, E. M., 2003). In this regard the term diffusion is defined as "the overall spread of an innovation, the process by which an innovation is communicated through certain channels over time among the members of a social system." In the present paper, the innovation is communicated over a distinctive time period. The social system refers to the different cantons of Switzerland.

ond, the study analyzes the extent to which selected determinants can explain the diffusion of green buildings in recent years.[2]

The remainder of this paper is organized as follows. The next section provides a literature review and clarifies the empirical findings regarding the diffusion of green buildings in selected countries and in Switzerland. The following section describes the data, methodology, and hypotheses. The subsequent section illustrates the results and implications. Finally, the paper closes with concluding remarks.

4.2 Related Literature

The literature on the diffusion of residential green buildings is closely related to the literature on consumer choice and individual decision making (Kahn, 2007). Homeowners might have a multitude of reasons why they invest in green buildings despite the economic outcome remaining uncertain. Following prospect theory, an investment decision of private homeowners is uncertain and will depend on individual expectations regarding possible outcomes.[3] This includes certain types of risks such as regulatory obligations, rising energy prices, or the risk of having an inappropriate energy efficiency standard for the building. However, understanding the determinants that impact the diffusion of energy efficient properties is vital for policy makers and investors.

Kok, McGraw, Quigley (2011) provide a study on the diffusion of green buildings for the U.S. property market. Using a panel data approach they investigate energy efficient commercial buildings in 48 metropolitan areas in the U.S. for a time period of 15 years. Based on the well-documented *Energy Star* and *LEED* (Leadership in Environmental and Energy Design) databases, they analyze the dynamics of green buildings.

They consider energy efficient buildings as a kind of innovation and assume

[2]Due to the lack of data availability this study has its focus on residential buildings. Although the distribution of commercial buildings, especially office and retail properties increased in recent years, a fundamental database is still too low for a substantial panel data regression.

[3]Kahneman and Tversky (1979) established the prospect theory as a behavior economic theory to model decision making under uncertainty.

that investment decisions depend on individual expectations in terms of costs and benefits. Kok, McGraw, Quigley (2011) acknowledge that the diffusion of energy efficient buildings appears to be too slow compared to the amenities they provide. Although an investment in green buildings might be beneficial and profitable, real estate decision makers or investors could avoid an investment. The literature on energy efficient buildings describes the lack of investments with the term "energy efficiency paradox" (Jaffe and Stavins, 1994a,b; Jaffe, Newell, Stavins, 2004). However, Kok, McGraw, Quigley (2011) demonstrate that energy efficient buildings as well as property labels and certificates emerged over the past decade. They assume that this development is only going to intensify.

In the U.S., Energy Star certified properties account for about 30% of the total office market (Kok, McGraw, Quigley, 2011). The market adaption of LEED certified buildings is substantially lower.[4] Kok, McGraw, Quigley (2011) show that properties certified by Energy Star have a S-shaped diffusion curve. Starting with relatively low growth rates in the first years since the label was established, the diffusion accelerated consistently.

To explain the diffusion of green buildings, the scholars use several indicators such as economic conditions, industry composition, energy prices, property market conditions, climate conditions, and the availability of building professionals. Moreover, the political ideology as well as governmental regulation and incentives are considerations. Kok, McGraw, Quigley (2011) find that the diffusion of green buildings is highly heterogeneous across the 48 U.S. metropolitan areas analyzed in the study. With regard to the economic conditions, they find that areas with higher incomes and lower unemployment rates show a higher market adoption of green buildings. This is in line with their finding that the share of white-collar service sector jobs is positive and significant, which indicates that the educational background, or the capacity of human capital, is also a decisive factor (Kok, McGraw, Quigley, 2011). As a result, more high-skilled service sector jobs indicate a higher demand for office space and presumably a higher

[4]The Energy Star and LEED labels are the leading real estate labels established in the U.S. and also available in other countries. Whereas the Energy Star label has its focus on energy efficiency attributes the LEED label concentrates more on sustainability issues.

demand for certified space. Surprisingly, the impact of energy prices is ambiguous. Their model specifications show a significant impact of energy prices on Energy Star certified properties. In contrast, energy prices are not significantly related to LEED certified buildings. Property market conditions, such as lower vacancy rates or higher property values, are of minor relevance in their results. To account for climate conditions in the different metropolitan areas, they use cooling and heating degree days, which is a common approach in the literature. Notwithstanding, diverging climate conditions are not significant in their findings (Kok, McGraw, Quigley, 2011). Governmental incentive programs such as grants or subsidies are often suggested to incentivize investments in green buildings (Eichholtz, Kok, Quigley, 2013; Stern, 2008; Stavins, 2003). In their model specifications, local subsidies show a positive and significant impact on the diffusion of LEED certified properties (Kok, McGraw, Quigley, 2011). Their study suggest that governmental incentive programs are relevant for realizing a higher share of green buildings. The impact of building professionals, such as accredited real estate consultants, is ambiguous. While the effect of local building professionals is positive and significant for LEED certified buildings, it is negatively related for Energy Star ones.

In another influential study by Kahn and Vaughn (2009), the spatial distribution of green products is the subject of research. In terms of consumer choice, the scholars analyze both the diffusion of green hybrid cars and LEED certified properties nationwide in the U.S. and in particular in California. LEED certified properties are subjects of study with a special focus on the governmental, residential, and commercial sectors. To explore the diffusion of green products, the scholar primarily use an environmentalism factor.[5] They investigate whether or not environmental ideology can explain consumer choice.[6] Using green voting be-

[5]Kahn and Vaughn (2009) acknowledge that the environmental ideology is difficult to identify. Similar to prior studies, they assume that heterogeneous households sort themselves into homogeneous communities. Moreover, they assume that environmentalists are clustered in metropolitan areas with environmentally friendly public transit as well as other green businesses. The environmentalism factor is based on the political party registration and voting behavior on two environmental initiatives. They identify the green voting percentage for each ZIP code area. For a similar approach investigating the green voting behavior, see Kahn (2007); Salvi and Syz (2011).

[6]The ideology or attitude of private homeowners or decision makers is often used to explain

havior as a proxy for environmentalism, they analyze geographical areas based on U.S. ZIP codes for approximately 10000 registered buildings. They expect that green voters at the ballot box are more likely to purchase green products, such as hybrid cars or energy efficient properties (Kahn and Vaughn, 2009). Moreover, green products are expected to cluster in green communities. Environmentalists are expected to move in areas that capture a green lifestyle including green businesses with amenities in terms of green products (Kahn and Vaughn, 2009; Kahn, 2007).

Using count regression analysis (Kahn and Vaughn, 2009) find that in areas with a high share of environmentalists, a higher share of both hybrid cars and energy efficient properties are predominant. Their finding is statistically significant to the 1% level. For the state of California the results are contrary to the intuition and other empirical findings, such as those in (Kok, McGraw, Quigley, 2011; Salvi and Syz, 2011). Kahn and Vaughn (2009) show that the diffusion of LEED certified properties is not related to higher-income areas. In fact, the opposite holds. Nonetheless, on the national U.S. level, they find a positive relation between income and the diffusion of green buildings. Further explanatory variables are demographics such as age and ethnicity. For California, they find that Whites exhibit a higher demand for green buildings, whereas nationwide all other ethnics also increase the demand for green buildings.

Several studies use economic measures like income to explain the diffusion of green buildings. Surprisingly, the empirical findings are ambiguous. On the one hand, it is proclaimed that a higher income is needed to achieve energy efficient standards, because green buildings are expected to cost more than conventional buildings. On the other hand, other empirical findings indicate that a high income is not necessarily relevant for a distinctive demand of green buildings. Additional factors such as ecological awareness, green ideology and a environmentally-friendly attitude are also relevant (Brounen and Kok, 2011; Brounen, Kok, Quigley, 2013).

the choice of the consumer. The assumption is that a green ideology tends to increase interest in green products.

With regard to a consumer choice perspective, Brounen, Kok, Quigley (2013) show that a deeper market adoption of energy efficient residential properties depends on the awareness and literacy of household energy consumption. Thus, households that are not aware of their energy consumption or understand their energy bills are less likely to invest in green buildings. In their study, Brounen, Kok, Quigley (2013) investigate the awareness and literacy of more than 1,700 households in the Netherlands. They argue that reduced energy bills incentivize households and stimulate investment in energy efficient housing.

The findings of Brounen, Kok, Quigley (2013) show that the awareness and literacy of energy efficiency is relatively low. In the study, 44% of the responding households did not evaluate their investment decisions regarding energy efficient equipment. More than 40% did not know their energy bills. Approximately 40% made irrational choices with respect to the optimal energy efficiency equipment. A substantial amount of households were not able to make appropriate choices between costs and benefits with the result that there is a lack of energy efficient investment. Brounen, Kok, Quigley (2013) illustrate that demographic determinants such as gender and age impact the awareness of energy efficiency. Older and male decision makers are more aware of the energy efficiency of their properties. Surprisingly, income has no impact on energy literacy, and therefore according to these findings richer households do not invest more in energy efficiency. Moreover, they show that environmental awareness depends on individual ideology and attitude. Households that drive more fuel efficient cars and save gas also save a higher share of their disposable income and have a higher literacy on energy efficiency. Contrary to their findings, the voting preference for a green party is unrelated to the awareness of energy consumption. The study of Brounen, Kok, Quigley (2013) suggests that the transparency in energy consumption is still low for a significant number of households. They suggest that an improved allocation of information should lead to more energy conservation. The impact of property labels and certificates might enhance the literacy on energy efficiency. Labels provide information on the energy efficiency of the building and might encourage owner-occupiers to further invest in energy efficient measures (Brounen and

Kok, 2011). Although most studies on the diffusion of green buildings suggest that prosperous economic conditions are positively related to the market adaption of green buildings, (Brounen and Kok, 2011) find the opposite to be true for the Netherlands. Their findings are counterintuitive, indicating that low-income areas in particular account for a higher number of green buildings.

Salvi and Syz (2011) provide one of the first studies on the diffusion of green buildings in Switzerland. They acknowledge that Switzerland has one of the highest densities of green buildings in the world and illustrate that green buildings are heterogeneously distributed over Swiss municipalities. In some municipalities the share of green buildings related to all newly constructed buildings is substantial and accounts for approximately the half of all new buildings. In other municipalities the share is still low. Based on the Minergie database Salvi and Syz (2011) develop a dataset for all 2,571 Swiss municipalities.[7] In contrast to the present paper they investigate regional disparities for Swiss municipalities, which represents the federal level of government below the Swiss cantons. Salvi and Syz (2011) analyze the driving forces that influence the construction of green buildings and hypothesize on the demographic, geographic, social, cultural, and political aspects that might influence the diffusion of green buildings. In particular, the scholars examine the characteristics of the owners of green buildings, as part of a larger analysis of residential properties.

Technically, Salvi and Syz (2011) employ count regression analysis.[8]. As certified properties account for a higher rental and sales price compared to conventional buildings, such investments appear to be appropriate. With regard to their hypotheses, Salvi and Syz (2011) argue that an increased demand for green buildings is associated with a higher rate of income. Achieving an energy efficient property, complete with the related equipment and the certification process, leads to additional costs for homeowners. Their financial resources will impact the investment decision and the choice of the certification standard. Therefore, income

[7]Section 3 provides an introduction of the Minergie database that captures all certified energy efficient properties in Switzerland, both for commercial and residential buildings.

[8]In contrast to the present paper (Salvi and Syz, 2011) do not use a panel data approach to investigate the diffusion of green buildings over time

appears to be a suitable economic proxy variable (Eichholtz, Kok, Quigley, 2010; Fuerst and McAllister, 2011; Kok, McGraw, Quigley, 2011, 2012).[9] Additionally, the age of the homeowners might play a crucial role in the investment decision. Hypothetical, homeowners of retirement age are less likely to invest a substantial amount of money in property (Salvi and Syz, 2011).

Switzerland provides a multitude of diverging characteristics due to its intense federal organization. Diverging cultural norms occur between the German and French speaking part of Switzerland, which Salvi and Syz (2011) take into account. They also control for geographic patterns and hypothesize that the heating and cooling activity is crucial to this debate.[10] They point out that the demand for heating may depend on outside temperatures. Due to different altitudes, temperatures are highly heterogeneous in Switzerland. Some regions have moderate temperatures year round, whereas others exhibit temperatures substantially below zero degrees for months at a time. These geographic characteristics are also considered. As the temperature is highly correlated with the altitude of a municipality, Salvi and Syz (2011) use the altitude as a heating demand indicator variable and hypothesize that the demand for green buildings increases with the altitude of the municipality.

Moreover, Salvi and Syz (2011) control for subsidies available in some municipalities that aim to incentivize investment in green buildings. Investing in green buildings is a distinctive investment decision and highly related to the preferences of the decision makers. With regard to personal attitudes in terms of environmentalism, Salvi and Syz (2011) argue that environmentalists are more likely to invest in green buildings. As proxy variables they create two indicators: first, out of 44 national initiatives, they select 5 initiatives that symbolize voters´ attitudes towards environmentalism. The correlation of "pro" voting behavior across the five initiatives is high. The five ballot initiatives address a reduction of road traffic by half over a ten year period; the introduction of a solar-cent; a tax on

[9]The Minergie Building Agency provides an overview of certification costs for each Minergie standard.

[10]The impact of cooling and heating degree days and its relation to energy savings in the environment of constructed buildings is also under investigation in (Kok, McGraw, Quigley, 2011) and occurs as a proper proxy in the diffusion debate.

non-renewable energy; the gradual abandonment of nuclear power; and the right of appeal for non-governmental organizations (NGOs). Second, they use the voting results taken from the Swiss National Council Election in 2007. They count the votes for the Green Liberal Party (GLP) and Green Party Switzerland (GPS) on the municipal level and create an index. In terms of environmental behavior and investments in green buildings, similar approaches have been undertaken by Kahn (2007); Kahn and Vaughn (2009); Brounen and Kok (2011).

In terms of environmentalism, both indicators show a positive and significant impact on the number of green buildings. This result suggests that green voters illustrate their environmental ideology along with the choice of their properties. Salvi and Syz (2011) find that municipalities with mid- and high-income levels significantly support a stronger diffusion of green buildings. However, language affiliation is highly significant, which explains that green buildings are more common in the German speaking part of Switzerland. As a result, demographic characteristics tend to play a minor role in their findings. The diffusion of Minergie properties rises for a local population with the age of 20-40 years, and for people over 60 years, but is diverging for residents between 40-60 years of age. The altitude shows a positive and significant impact. This result exhibits the impact of climate conditions on the diffusion of green buildings. Government subsidies are negatively correlated, although weakly. Therefore, Salvi and Syz (2011) do not believe that subsidies significantly impact the diffusion of green buildings in Switzerland. They acknowledge that the amount of the subsidy is probably too low.[11]

The related literature illustrates what determinants impact the diffusion of green buildings. Although some of the results are ambiguous and diverge over different countries or regional real estate markets, other factors appear as suitable proxy variables and reveal a substantial impact. The present paper aims to investigate the diffusion of green buildings in Switzerland, a real estate market

[11]The expected premium costs for an energy efficient residential property ranges approximately from 5-10% above conventional properties, which is CHF 25 to 50 thousand for a typical CHF 500 thousand building in Switzerland. The median subsidy is less than 5 thousand CHF.(Salvi and Syz, 2011).

with a high share of green buildings in the residential sector. Moreover, the aim is to analyze what factors are significantly related to the diffusion of green buildings, especially considering that the preferences of the households are not directly observable.

4.3 Data, Methodology, and Hypotheses

The following section describes the data and methodology, followed by the hypotheses regarding the diffusion of green buildings in Switzerland.

4.3.1 The Swiss Label Minergie

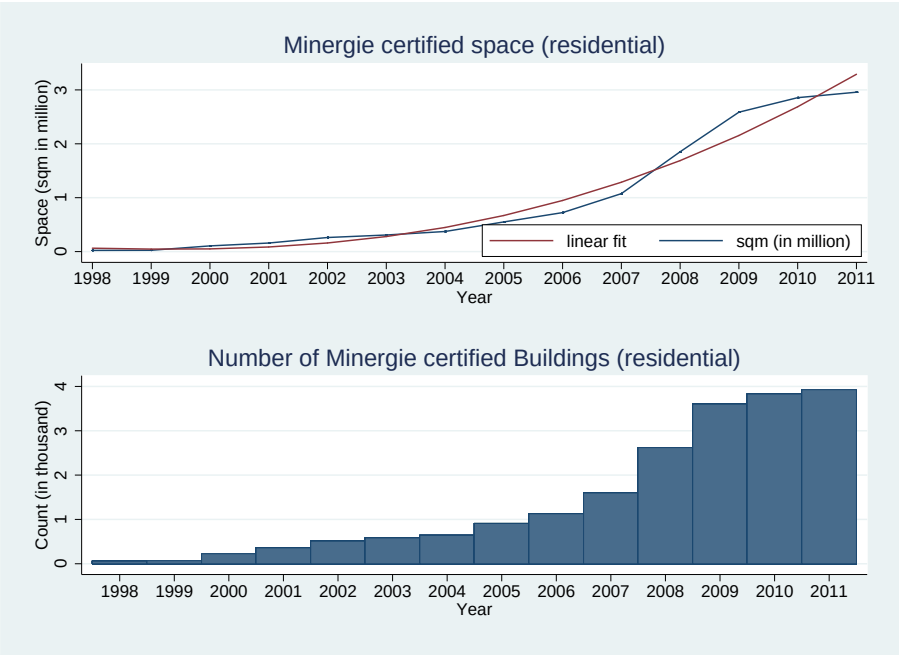
To account for green buildings in Switzerland the present paper uses the real estate energy efficiency label *Minergie*. The label Minergie is the leading energy-efficiency standard for buildings in Switzerland and one of the most widely applied real estate energy-efficiency standards in the world (Minergie Building Agency, 2013; Salvi and Syz, 2011; Bio Intelligence Service, 2013). Currently, more than 25,000 buildings are certified with the Minergie label (Minergie Building Agency, 2013).

The Minergie label was established in 1998. The label is available for both residential and commercial buildings. To achieve the label of energy efficiency many items have to be certified. Due to diverging requirements there are different Minergie standards available.[12] Over the last decade the technology for energy efficiency in the environment of constructed buildings gradually improved, which contributes to higher energy efficiency standards and requirements. However, the most widespread and common standard for residential properties is Minergie (plain standard), which is used in the present paper.[13]

[12]The Minergie certification is available as Minergie (plain), Minergie-P, Minergie-A, and Minergie-Eco, which represents different energy efficiency requirements.

[13]The other available Minergie standards are still not that widespread, so the available number of observations appear to be too low for a panel data regression analysis. In 2014 the Minergie initiative plans to spread the availability of the label in other European countries to further increase the market adaption.

Figure 4.1: Minergie Certified Properties



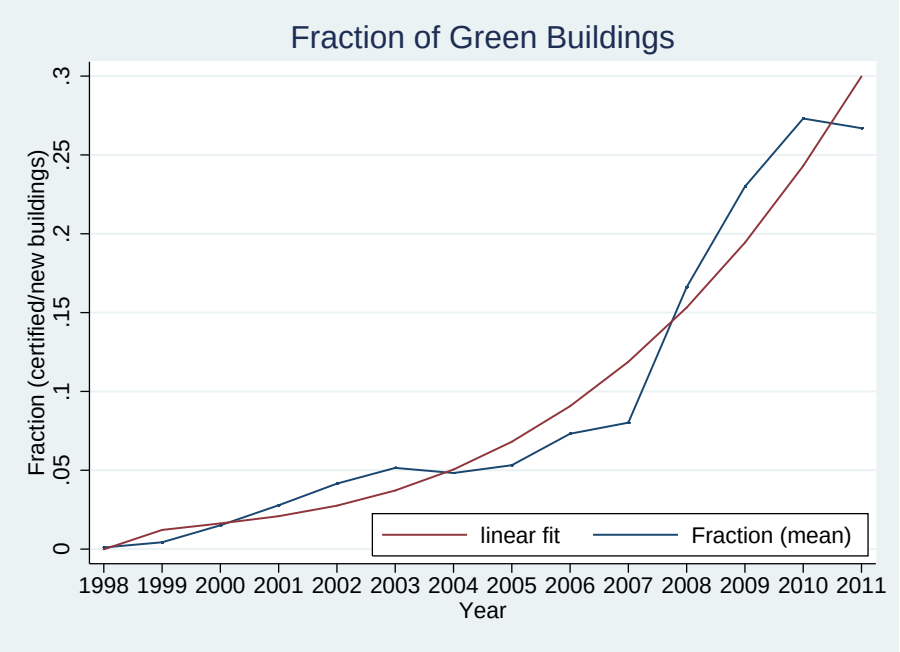
The chart above shows the development of space over time for certified residential properties. The below chart shows the number of certified building in each year. Source: Own calculation based on Minergie dataset 2014.

4.3.2 The Ascent of Green Buildings in Switzerland

Figure 4.1 shows the development of Minergie certified space over time for residential properties. The amount of certified space reached approximately 3 million square meters in the year 2011. In the first two years since its establishment, the certified square meter still ranged below 25,000, hence a substantial increase is observable over the years. Currently more than 35,000 properties have been certified with Minergie. Additionally, Figure 4.1 highlights the number of buildings certified each year since 1998. This development reveals an accelerating diffusion over time. Each year the number of labeled properties increased.

To account for a relative measure of green buildings comparable for all Swiss cantons Figure 4.2 shows the fraction of green buildings over time. The fraction is the number of certified properties over all newly-constructed properties in each canton and in each year. The fraction of green buildings also increased each year in relative terms, demonstrating the strong diffusion and the success of green buildings in Switzerland. Similar to the findings of Kok, McGraw, Quigley (2011), this fraction is revealed as an S-shaped innovation curve.

Figure 4.2: Fraction of Green Buildings



The fraction of green buildings is the number of certified buildings over the number of all new constructed buildings each year in each canton. The present study provides the first investigation of certified buildings in Switzerland using the fraction as the measure in a relative dimension. Source: Own calculation based on Minergie dataset 2014.

Although the overall number of certified properties increased substantially over the years, the distribution of green buildings is highly heterogeneous over Swiss cantons. Whereas in some cantons the fraction, which is defined as all green buildings over all new constructed buildings, reaches up to 50% and more, in other regions the share is still negligible. The Appendix (Figure A 4.6 and A 4.7) provide an overview of the certified properties for each of the 26 Swiss cantons.

4.3.3 The Diffusion of Green Buildings

The descriptive statistics highlight that the diffusion of green buildings is highly heterogeneous. The present paper aims to explain the regional disparities across Swiss cantons to investigate the driving forces. To account for the diffusion of green buildings in Switzerland the following hypotheses are under consideration.

Following the methodology of Salvi and Syz (2011) and also of Kok, McGraw, Quigley (2011), the diffusion of green buildings is highly related to gen-

eral economic conditions of each region. Economic prosperity is heterogeneously distributed in each country, which has implications for different outcomes of consumer choice. One could expect that metropolitan areas with higher income levels have a higher rate of green buildings (Kok, McGraw, Quigley, 2011). Notwithstanding, the findings of different international studies provide ambiguous results regarding the extent to which economic proxies have a significant impact. As a characteristic, energy efficient properties use a higher standard of building components compared to conventional buildings. It is often seen as a superior good and associated with higher costs (Eichholtz, Kok, Quigley, 2009, 2010; Kok, McGraw, Quigley, 2011). Hence regional prosperity, or the prosperity of homeowners, might play a crucial role in the diffusion (Kok, McGraw, Quigley, 2011) of green buildings.

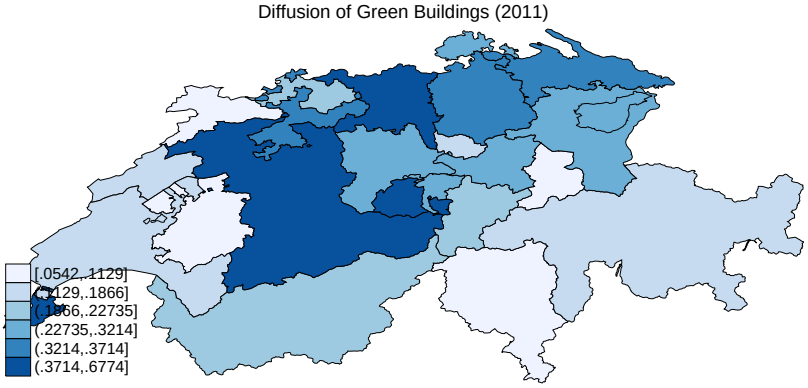
To account for economic conditions, and to provide additional contributions to the real estate literature, this study considers regional income levels, GDP per capita, and unemployment rates on the level of the Swiss cantons.[14]

Hypothesis 1: *The diffusion of green buildings increases with better local economic conditions.*

Besides fundamental economic conditions the present paper investigates the extent to which the local property market impacts the diffusion of green buildings. The real estate literature on the diffusion of green buildings provides diverging results (Kok, McGraw, Quigley, 2011; Kahn and Vaughn, 2009; Brounen and Kok, 2011; Brounen, Kok, Quigley, 2013). Some studies find that in regional markets with high rent levels, green buildings are more common as they provide a label and are attractive in terms of image or marketing. Other studies find the

[14]Several studies in the real estate literature investigate the impact of subsidies on the diffusion of green buildings (Salvi and Syz, 2011; Kok, McGraw, Quigley, 2011, 2012). Kok, McGraw, Quigley (2011) point out that some states have special programs to incentivize energy efficiency investments. This includes subsidies, tax credits or access to advisory services. They find that incentives have a positive impact on the diffusion of green buildings. Swiss cantons have very different policies on providing subsidies. Salvi and Syz (2011) illustrate that subsidies have no significant impact on the diffusion of green buildings in Switzerland. They argue that the amounts of subsidies in relation to housing prices are too small to impact investment decisions.

Figure 4.3: Fraction of new-constructed Green Buildings



This figure illustrates the fraction of new-constructed green buildings in all Swiss cantons during for the year 2011. The fraction is equal to the number of new-constructed energy-efficient buildings over *all* new-constructed buildings in the given year. The scale shows the fraction in percent with the highest category range between 37.14-67.74%. Source: Own calculation based on Minergie dataset 2014.

opposite. The diffusion is higher in regional markets with moderate or low rent levels, so other aspects appear as predominant. Another proxy for the state of the local property market is the vacancy rate. Due to restricted data availability of cantonal vacancy rates, the present paper uses the local rent level. The local rent level is measured in Swiss francs and is available just for the years 2003, 2005, 2007, and 2009.[15]

Hypothesis 2: *The diffusion of green buildings increases with higher rent levels in local property markets.*

Green buildings signal a high standard of energy efficiency. From a technical perspective, green buildings represent an innovation addressing the problem of climate change and improving homeowners´ lives. The diffusion of an innovation also depends on geographic circumstances such as innovative infrastructure, clustered technology firms, research and development institutions, or the concentration of universities and business service firms - all of which increase the potential for innovation. Furthermore, the spatial concentration of these resources can

[15]Kok, McGraw, Quigley (2011) use indicator variables like the total office stock, the vacancy rate, rental price, and average property price for office buildings to account for the composition of the local property market.

reinforce the capacity to innovate (Feldman and Florida, 1994). Moreover, the entrepreneurial spirit of a region can impact the innovation rate. As a consequence, people working for innovative firms might have distinctive preferences in terms of their consumer choices (Kahn, 2007; Kahn and Vaughn, 2009). The present paper hypothesizes that regions with a higher rate of innovation also exhibit a higher diffusion of green buildings. As proper indicator variables for the state of innovation, this study uses all newly-established firms and start-up companies in each Swiss canton, as well as the amount of people that work in innovative industries.[16]

Hypothesis 3: *The diffusion of green buildings increases with a higher regional potential for innovation.*

The aforementioned capacity of innovation in each canton might impact consumer choice indirectly. However, the awareness of energy efficiency issues is also important as well. Therefore, the present paper expects that the educational background of the decision makers is eminent in this debate. Presumably, higher educated people have a higher awareness of environmental and climate change issues. As Brounen, Kok, Quigley (2013) suggest, ecological awareness and literacy are important for investments in energy efficiency. The literature on this debate reveals a lack of literacy that lead to inappropriate or irrational choices and to a misinterpretation of costs and benefits. As proxy variables for the educational background the present paper uses the number of people identified as having no obligatory education, secondary education, and tertiary education in each canton. Additionally, over all Swiss cantons the diverging employee skill levels (lowest, low, medium, high) related to income are under consideration. The employee skill level is provided by Federal Statistical Office and serves as a proxy variable for the educational level.

Hypothesis 4: *The diffusion of green buildings increases with a higher regional*

[16]The two proxy variables ´newly-established firms´ and ´number of people working in innovative industries´ are taken from the Federal Statistical Office.

literacy.

Energy efficient properties have a substantial impact on the reduction of greenhouse gas emissions. Due to the fact that climate conditions can vary substantially across different regions in Switzerland, it is expected that cantons with more heating degree days account for a higher diffusion of green buildings, because energy efficiency appears to be more relevant. To research diverging temperatures in environmental studies, the cooling and heating degree days are often taken into account (Kok, McGraw, Quigley, 2011).[17] However, temperature is strongly related to the altitude of each region. As complementary studies directly use the altitude, the present paper takes the heating degree days for each canton under consideration.

Hypothesis 5: *The diffusion of green buildings is related to climate conditions.*

Although there are a multitude of reasons for investing in energy efficient buildings, decision making is strongly depending on personal beliefs and attitudes towards climate change and towards environmentalism in general (Kahn and Vaughn, 2009; Brounen and Kok, 2011; Brounen, Kok, Quigley, 2013). However, it is difficult to observe consumer choice and consumer ideology. Following Kahn and Vaughn (2009); Salvi and Syz (2011); Kok, McGraw, Quigley (2011), the political behavior of private homeowners or decision makers is noteworthy in this context and provides a decent proxy variable for environmental attitudes. Researching political preferences is a common approach for predicting investments in green buildings. Kok, McGraw, Quigley (2011) use the political preferences in the percentage of votes for republican president candidates in the U.S. and reveal that republican votes are negatively related to the adoption of environmental ideology. As other studies illustrate, green voters might be more likely to invest in green buildings (Kahn, 2007; Kahn and Vaughn, 2009; Salvi and Syz, 2011).

[17]Kok, McGraw, Quigley (2011) find that the diffusion of energy efficient properties is unrelated to climate conditions measured with heating and cooling degree days. Other studies find ambiguous results.

Investigating the voting behavior the present paper uses the voting results for the Swiss National Council during 1999 and 2011 over all Swiss cantons.[18]

Hypothesis 6: *The diffusion of green buildings is related to environmental ideology.*

Table 4.1: Hypotheses, Indicator variables, and Sources

	Hypotheses	Indicator Variable	Source
H1	Economic conditions	Income per capita (CHF)	Federal Statistical Office
		GDP per capita (CHF)	Federal Statistical Office
		Unemployment rate (in %)	Federal Statistical Office
H2	Local property market	Local rent level (avg CHF/sqm)	Wüest & Partner / FSO
H3	Innovation	New established firms	Federal Statistical Office
		Employees in innovative industries	Federal Statistical Office
H4	Education	Employees by sector (1-3)	Federal Statistical Office
		Employee skill level (1-4)	Federal Statistical Office
H5	Climate conditions	Heating degree days	MeteoSchweiz
H6	Environmental ideology	Green voting index (national votes)	Federal Statistical Office

Table 4.1 summarizes the hypotheses tested in the present paper, including related indicator variables and sources of data. A panel data approach allows for an analysis of the diffusion of green buildings across all Swiss cantons over a time frame of 14 years. Figure 4.3 illustrates the fraction of green buildings over all new-constructed buildings in each underlying year as a proper relative measure, which still exhibits a strong heterogeneity. However, the cantons of Basel City (BS), Geneva (GE), Nidwalden (NW), Obwalden (OW), and Zurich (ZH) have the highest rate of green buildings during the time period. The following section illustrates the panel data approach.

[18]The present paper uses an index score to value the environmental program of the Swiss national parties as a proxy variable. The approach follows the methodology of (Kok, McGraw, Quigley, 2011; Salvi and Syz, 2011). The voting results for the Swiss National Council are available for the years 1999, 2003, 2007, and 2011 at the cantonal level. The green parties GPS and GLP get the highest score (5) followed by SPS (4), CVP (3), FDP and LPS (2), and SVP (1). Therefore, the greenest parties receive the highest score value and the most conservative parties receive the lowest score.

4.3.4 Panel Data Analysis

To account for the hypotheses, the fraction of green buildings in each of the 26 Swiss cantons is related to selected indicator variables (Table 4.1). To achieve a comparable measure of green buildings in each canton this study relates the number of certified "green" buildings to the number of newly-constructed buildings in each canton for the underlying years 1998 until 2011.[19] First, the scatter plots illustrate the relationship between the fraction of green buildings and the explanatory variables for each hypothesis.

With regard to regional economic conditions and their impact on the diffusion of green buildings, this study considered GDP per capita, local income, and the unemployment rate. The scatter plots illustrate a positive relationship between GDP per capita and certified properties for each canton (Appendix Figure A.8). The Swiss cantons of Basel City (BS), Zug (ZG), Geneva (GE), and Zurich (ZH) have the highest GDP per capita and exhibit the highest fraction of green buildings. Income is measured as total median income for each canton and shows a positive relationship with the fraction of green buildings (Appendix Figure A.9). The scatter plot for the unemployment rate appears to have a slightly negative relation (Appendix Figure A.10). Overall, the selected economic indicator variables suggest a positive impact on the diffusion of green buildings. Therefore, economic prosperity appears to be beneficial for the subsequent development of green buildings.

The scatter plots for the cantonal rent level show a positive relationship (Appendix Figure A.11). The higher the local rent level, the higher the share of green buildings. This is in line with the finding that higher-income regions show a stronger diffusion. With regard to the innovation hypothesis the newly-established firms (per 1,000 population) show some outliers with more than twice the average. Notwithstanding, the general trend is positive and suggests that regions that are more entrepreneurial and innovative in terms of newly-established firms are also more innovative in their consumer behavior. In these regions green

[19]Due to limited data availability the time period is given for 1998 till 2011. The tables 8, 9, and 10 exhibit the total number of green buildings; the new constructed properties; and the fraction for each canton and each year.

buildings are more common than in others. Another important proxy variable for the innovation hypothesis is the number of employees in innovative industries, as provided by the Federal Statistical Office. As a result, cantons that provide more jobs in innovative industries exhibit also a higher share of green buildings. Among them are the cantons of Schwyz (SH), Basel (BS), and Zug (ZG).

The impact of the educational level is illustrated in Figures A.14 and A.15 (Appendix). Here, the cantonal educational level is available for the categories "no obligatory education"; "secondary education"; and "tertiary education". The scatter plots for each category suggest that educational levels will have an impact on the diffusion of green buildings. Cantons with a higher share of people with no obligatory education reveal the lowest rates of green buildings. Cantons with a high share of tertiary education such as Geneva (GE), Zug (ZG), Zurich (ZH), and Basel (BS) exhibit a high share of green buildings. These results indicate that literacy has a substantial impact on climate preservation and efficient energy consumption.[20]

To control for climate conditions the heating degrees days for each canton in each year are under consideration. However, a clear relationship between the heating degree days and the absolute or relative number of green buildings does not emerge.[21] The scatter plots illustrating environmental ideology, by using a green voting index for both national and cantonal voting, suggest a slightly negative relationship. However, in contrast to other studies the voting behavior for a green party is not expected to have any impact on the diffusion of green buildings in each canton.

To account for the panel (longitudinal) structure of the data the empirical analysis of the present paper uses fixed effects and random effects models (Table 4.2, 4.3, 4.4).[22] The data represent a balanced panel in the given time period

[20]This result complements the findings of Brounen, Kok, Quigley (2012, 2013) that exhibit the importance of energy literacy for energy consumption and general consumer behavior in terms of climate change issues.

[21]Heating degree days stand for the relation between heating degree temperature and the outside air temperature.

[22]Fixed effects models assume that the individual specific effect (unobserved individual effects) is correlated with the independent variables. The time-invariant factors therefore will be excluded from the model. Fixed effects models are designed to study the causes of changes within an entity. Random effects models assume that the individual specific effects are uncor-

for the Swiss cantons. The panel data models estimate the time-variant factors defined as income, unemployment rate, the local rent level, the number of newly-established firms, the educational level, the heating degree days, and the voting score as independent variables. The dependent variable is defined as the fraction of Minergie certified properties for all newly-constructed buildings in each year for each canton. The general model (Table 4.2) can be written as follows:

$$y_{it} = \beta_0 + \beta_1 X_{it} + \alpha_i + \epsilon_{it} \tag{4.1}$$

The factor X represents all explanatory variables that were selected for the tested hypotheses. The alpha variable represents the unobserved heterogeneity. Considering that private homeowners often procrastinate in terms of decision making and that the building process for new houses requires time, the selected explanatory variables are expected to make their impact after a certain amount of time. This holds true especially for economic proxy variables such as the earned income that will not be directly invested. Therefore, a time lag of one year is included in the second model (Table 4.3):

$$y_{it} = \beta_0 + \beta_1 X_{it-1} + \alpha_i + \epsilon_{it} \tag{4.2}$$

Another variation of the empirical investigation is introduced with a dynamic model approach in equation 3. Here, the share of certified properties is included as a lagged dependent variable. In this regard the previous year of the share of certified properties is part of the explanatory variable and can be written as follows (Table 4.4):

$$y_{it} = y_{it-1} + \beta_1 X_{it-1} + \alpha_i + \epsilon_{it} \tag{4.3}$$

The Tables 4.2, 4.3, and 4.4 summarize the empirical results and illustrate the relationship between the selected indicator variables and the diffusion of green buildings.[23] In a complementary approach, the pooled Ordinary Least Squares

related with the independent variables. In this regard, time-variant and time-invariant factors will be estimated.

[23]The present paper provides more than one model specification to illustrate a multitude

(OLS) and the Maximum Likelihood Estimator (MLE) regression model are provided to compare the estimations with the panel regressions in terms of fixed and random effects models.[24] However, the present paper uses the Hausman test to evaluate the consistency of the fixed effects and random effects models. For all model specifications the Hausman test is significant, which suggests considering the fixed effects model specifications instead of random effects.

4.4 Results and Implications

Table 4.2 represents an empirical analysis with the explanatory variable that accounts for the hypotheses. The local income level shows a positive impact on the diffusion of green buildings in all specifications. For the fixed effects (FE) model the income variable is not significant although it is strongly significant in the random effects model. Surprisingly, the unemployment rate is demonstrated to be positive (Table 4.2), which is counter intuitive. Using lagged variables and accounting (as they make their impact on the decision making process), the unemployment rate is negatively related to the diffusion of green buildings. Tables 4.3 and 4.4 illustrate that regions with lower unemployment rates exhibit higher shares of green buildings. However, summarizing the findings for the economic hypothesis, the present paper shows that income is an important driver for the diffusion of green buildings. Swiss cantons with higher levels of prosperity have more green buildings, which is associated with higher incomes and lower unemployment rates. In this regard one could argue that green buildings are a luxury good that only prosperous household can afford. However, this suggests that incentives such as tax credits might be a suitable approach to encourage investments in green buildings. Without a proper institutional financial support a significant number of households might not be able to afford energy efficient housing in the long run, which also raises the issue of mis-allocation.

of empirical analysis to approach panel data. The empirical models are investigated by using STATA and the following supporting literature: Baum (2006); Stock and Watson (2007); Greene (2008); Kohler and Kreuter (2009).

[24] The MLE estimator is similar to the pooled OLS estimator unless it provides more efficient results with lower standard errors.

To control for the local property market conditions the relationship of the local rent level to the diffusion of green buildings is under consideration. The model specifications illustrate a slightly negative and a partly significant result. In this regard one could argue that the certification of properties is of minor interest in regions with the highest rent. Another interesting proxy variable is the number of newly-established firms per 1,000 population. This indicator variable stands for the innovative and entrepreneurial spirit of a region. As new start-up companies are established by creative minds and people with a distinctive passion for innovation, this emerges as a proper proxy variable to investigate the innovation of "green buildings". As a result, the present paper finds to partly ambiguous results. The fixed effects model specifications provide no significant results, whereas the random effects model shows a strong significance and a positive relation. A summarizing result is that the Swiss cantons with more entrepreneurs and newly-established firms are also more willing to invest in green buildings.

The literature on the diffusion of green buildings suggests that the literacy and educational background of decision makers will have an impact on the success story of green buildings. Taking this into account the present paper uses the skill level of the people that reside in each canton. Tables 4.2, 4.3, and 4.4 illustrate that a higher educational background is beneficial for the diffusion of green buildings. The lower the skill level, which is also related to an associated lower income, the lower is the interest in energy efficient properties. The lowest skill level exhibits a negative relationship with the diffusion of green buildings. This finding corresponds with the findings of Brounen, Kok, Quigley (2012, 2013). This result appears to be alarming, namely that lower-income households with a lower educational background care less about energy efficiency. This is especially so because of the fact that lower-income households spend more for energy consumption in terms of relative income.

Heating degree days, used as a proxy for the altitude of different geographic regions, yields ambiguous results. One might expect that cantons with substantially more heating degree days and higher altitudes exhibit a higher demand for energy efficient properties. However, the findings show a slightly negative

relation between heating degree days and the diffusion of energy efficient properties, which is not significant. The present paper uses a green voting index to account for environmental ideology and the attitudes of private homeowners. The assumption is that, green voters signal their environmental attitudes at the ballot box. Therefore, cantons with a higher share of green voters might exhibit a higher share of green buildings. Surprisingly, the empirical results do not indicate a positive relationship between the voting behavior and the investment decision for energy efficient properties. This finding holds for all panel specifications and is significant to the 1% significance level.

4.5 Conclusion

The present paper investigates the diffusion of green buildings in Switzerland. To account for energy efficient properties the study uses the predominant energy-efficiency label Minergie, which is the major energy-efficiency label in Switzerland.[25] The literature on the diffusion of energy efficient properties uses labels and certificates as indicators to identify the prevalence of green buildings. Interestingly, Switzerland provides one of highest rates of certified energy efficient properties in the world. Due to its federal organization with 26 cantons and thousands of municipalities, Switzerland serves as a role model and an appropriate case for the study of the diffusion of green buildings. In this regard the present paper uses a panel data approach that accounts for the Swiss cantons as entities over a 14 year time period. To understand the selected determinants and their relative impacts on the diffusion of green buildings remains an important topic for policy makers and investors. Currently, the share of all certified residential properties reaches up to 65% in the Swiss cantons. Interestingly, the number of green buildings in absolute and relative terms has risen substantially since the establishment of the Minergie label in 1998. The demand for green buildings in Switzerland increased significantly in recent years and shows a high market

[25]Currently more property labels are entering into the Swiss market. The development in the real estate market illustrates a trend to more holistic labels that include social, ecological, and economic determinants, such as the German label DGNB or the US label LEED.

adoption. Internationally, however, the number of different building labels has increased considerably. Most countries have their own building standards with diverging labels and certificates. In this regard it is critically claimed that international building labels are hard to compare, creating a challenge for homeowners and investors.

To investigate the diffusion of green buildings this study investigated the impact of local economic conditions, local property market conditions, the impact of innovation, the educational background, climate conditions, and the ideology of Swiss households. The present paper discovered that more prosperous cantons with higher incomes and lower unemployment rates exhibited a higher share of green buildings. The local property market conditions, in terms of the local rent level as well as diverging climatic conditions, were of minor relevance. The empirical findings indicate that literacy, in terms of the educational background of private homeowners, is relevant to the diffusion of green buildings. Surprisingly, environmental ideology, as measured by the voting behavior for green parties, suggests a negative relationship with the diffusion of green buildings, contrary to the findings of other studies.

The prospective development in the real estate market exhibits a trend from energy-efficiency labels towards more holistic labels covering more categories such as social, ecological, and economic determinants. Internationally, the harmonization of label standards is to be expected. Besides the development of international standardized labels and certificates, real estate sustainability measures will also emerge in terms of defined key performance indicators. The distinctive advantage of key performance indicators that measure e.g., energy, carbon, water or the waste consumption of a property lies in its direct comparability. Moreover, the transparency in terms of real estate sustainability increases for all market participants. From this perspective, a large body of future research can be expected.

Table 4.2: Panel Data Regression Results

(dependent variable: fraction of green buildings)

	(1) Pooled OLS	(2) MLE	(3) FE	(4) RE
Income	0.400**	0.388***	0.381	0.405***
(in 1000 CHF)	(0.150)	(0.139)	(0.272)	(0.156)
Unemploy	0.0260***	0.0163	0.0184	0.0220***
	(0.00890)	(0.0103)	(0.0149)	(0.00847)
Rentlevel	-0.0162*	-0.0257***		-0.0190**
(avg CHF/sqm)	(0.00843)	(0.00936)		(0.00883)
NewFirms	0.0462***	0.0563***	-0.00178	0.0503***
(per 1000 pop)	(0.0123)	(0.0167)	(0.0433)	(0.0134)
Skill1inc	0.0606	0.0575**	0.0661**	0.0565
(top-skill)	(0.0409)	(0.0238)	(0.0303)	(0.0380)
Skill2inc	-0.256***	-0.239***	-0.136	-0.257***
(medium-skill)	(0.0640)	(0.0712)	(0.130)	(0.0696)
Skill3inc	-0.178	0.116	0.335	-0.0713
(low-skill)	(0.146)	(0.152)	(0.258)	(0.149)
Skill4inc	0.219	-0.0528	-0.399*	0.131
(lowest-skill)	(0.139)	(0.176)	(0.222)	(0.146)
HeatingDDays	-0.00621	-0.0185	-0.0566	-0.00975
	(0.0110)	(0.0145)	(0.0361)	(0.0110)
VotingScore	-0.0221***	-0.0222***	-0.0193**	-0.0227***
	(0.00552)	(0.00627)	(0.00758)	(0.00589)
Observations	171	171	171	171
(Pseudo) R^2	0.4957	-0.546		

Notes: The dependent variable is the fraction of certified buildings over all new built buildings in each Swiss cantons during 1998-2011.
LR-Test: 127.42 (0.000); Wald chi2: 185.16 (0.000); F-Test: 23.41 (0.000)
To decide between fixed effects and random effects model specification the Hausman test was significant, which suggest to take the fixed effects model.
Marginal effects; Standard errors in parentheses
* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Table 4.3: Panel Data Regression Results

(dependent variable: fraction of green buildings using time-lagged independent variables)

	(1) Pooled OLS	(2) MLE	(3) FE	(4) RE
Income	0.426**	0.368**	0.416	0.410**
(in 1000 CHF)	(0.176)	(0.156)	(0.329)	(0.179)
Unemploy	0.0207*	-0.00135	-0.0210	0.0117
	(0.0115)	(0.0131)	(0.0158)	(0.0117)
Rentlevel	-0.0147	-0.0207**		-0.0168*
(avg CHF/sqm)	(0.00877)	(0.00989)		(0.00908)
NewFirms	0.0423***	0.0503***	-0.0243	0.0460***
(per 1000 pop)	(0.0119)	(0.0183)	(0.0480)	(0.0122)
Skill1inc	0.0765	0.0685**	0.0677**	0.0708
(top-skill)	(0.0475)	(0.0270)	(0.0279)	(0.0436)
Skill2inc	-0.302***	-0.248***	0.00298	-0.290***
(medium-skill)	(0.0619)	(0.0844)	(0.102)	(0.0672)
Skill3inc	-0.161	0.127	0.0961	-0.0316
(low-skill)	(0.127)	(0.160)	(0.256)	(0.120)
Skill4inc	0.243	0.0213	-0.232	0.152
(lowest-skill)	(0.152)	(0.181)	(0.320)	(0.170)
HeatingDDays	-0.0148	-0.0237	-0.0503	-0.0183
	(0.0122)	(0.0152)	(0.0308)	(0.0120)
VotingScore	-0.0197***	-0.0200***	-0.0179***	-0.0203***
	(0.00471)	(0.00702)	(0.00593)	(0.00457)
Observations	171	171	171	171
(Pseudo) R^2	0.5013	-0.663		

Notes: The dependent variable is the fraction of certified buildings over all new built buildings in each Swiss cantons during 1998-2011.
To decide between fixed effects and random effects model specification the Hausman test was significant, which suggest to take the fixed effects model.
Marginal effects; Standard errors in parentheses
* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Table 4.4: Dynamic Panel Regression Results

(dependent variable: fraction of green buildings using AR(1) and time-lagged independent variables)

	(1) FE	(2) RE
Lag.Fraction	0.366***	0.599***
	(0.105)	(0.121)
Income	0.277	0.187**
(in 1000 CHF)	(0.268)	(0.0936)
Unemploy	-0.0278	0.00518
	(0.0169)	(0.00902)
Rentlevel		-0.00499
(avg CHF/sqm)		(0.00522)
NewFirms	-0.0237	0.0146*
(per 1000 pop)	(0.0427)	(0.00869)
Skill1inc	0.0435*	0.0401
(top-skill)	(0.0241)	(0.0295)
Skill2inc	0.0527	-0.149***
(medium-skill)	(0.0779)	(0.0461)
Skill3inc	-0.0268	-0.0542
(low-skill)	(0.192)	(0.0736)
Skill4inc	-0.0858	0.112
(lowest-skill)	(0.286)	(0.106)
HeatingDDays	-0.0296	-0.0110*
	(0.0393)	(0.00636)
VotingScore	-0.0108*	-0.00649*
	(0.00532)	(0.00347)
Observations	171	171
Pseudo R^2		

Notes: The dependent variable is the fraction of certified buildings over all new built buildings in each Swiss cantons during 1998-2011.
To decide between fixed effects and random effects model specification the Hausman test was significant, which suggest to take the fixed effects model.
Marginal effects; Standard errors in parentheses
* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Table 4.5: Summary statistics

Variable	Mean	Std. Dev.	Min.	Max.	N
Share of green buildings	0.095	0.123	0	0.677	364
No of greeb buildungs	56.3	114.051	0	867	390
Square meter	38067	91332	0	744645	364
Population	485.765	980.548	27.2	5033.900	390
Age (1-19)	0.209	0.016	0.165	0.238	390
Age (20-64)	0.618	0.014	0.587	0.639	390
Age (65+)	0.174	0.017	0.142	0.208	390
German	0.687	0.342	0.058	0.955	390
French	0.201	0.334	0	0.922	390
Income	5.405	0.386	4.446	6.349	364
GDP (avg)	6.757	2.347	4.736	14.64	390
Umemploym (rate)	2.874	1.337	0.700	7.4	260
Employm (sector1)	0.038	0.043	0	0.209	390
Employm (sector2)	0.038	0.035	0.002	0.135	390
Employm (sector3)	0.038	0.047	0.001	0.222	390
Rentlevel (avg)	15.894	2.598	12.542	21.645	285
New firms (rate)	1.341	0.944	0.313	6.157	260
Educat (skill1)	9.790	0.919	7.953	12.819	364
Educat (skill2)	6.537	0.417	5.438	7.771	364
Educat (skill3)	5.284	0.311	4.599	6.067	364
Educat (skill4)	4.278	0.22	3.204	4.727	364
HDD (avg)	331.381	121.318	217	668	286
Voting (score)	15.87	2.317	2.87	22.85	330

Source: Own calculation based on data sources from Table 4.1.

Table 4.6: Amount of green residential buildings over all 26 Swiss cantons 1998-2011

Canton	**Code**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	sum
Aargau	AG	1	2	17	29	26	55	64	74	97	247	414	513	566	648	2753
Appenzell I. Rh.	AI	0	0	1	0	4	4	2	2	6	3	4	2	8	3	39
Appenzell A. Rh.	AR	0	1	4	4	14	6	9	13	10	11	17	31	32	19	171
Bern	BE	8	8	26	57	87	51	63	103	100	168	233	273	282	303	1762
Basel-Landschaft	BL	0	0	0	1	4	7	28	27	37	53	147	114	130	173	721
Basel-Stadt	BS	0	0	0	0	1	1	2	1	3	4	7	7	11	21	58
Freiburg	FR	0	2	6	19	16	38	27	50	55	41	56	98	98	70	576
Genf	GE	0	0	0	1	3	2	6	18	26	83	143	79	168	173	702
Glarus	GL	0	0	2	4	6	6	5	4	4	4	19	8	20	7	89
Graubünden	GR	0	0	2	12	2	21	15	23	20	45	58	115	105	100	518
Jura	JU	0	0	1	0	4	4	3	7	8	2	16	8	21	19	93
Luzern	LU	0	4	8	9	9	13	20	28	25	38	85	168	189	183	779
Neuenburg	NE	0	0	2	13	4	41	8	27	12	21	33	10	20	26	217
Nidwalden	NW	0	1	3	7	0	4	22	6	23	8	10	5	21	18	128
Obwalden	OW	0	1	2	3	2	2	4	1	1	1	6	8	11	28	70
St. Gallen	SG	0	0	12	42	70	57	39	37	41	123	135	193	204	228	1181
Schaffhausen	SH	0	0	0	5	5	8	6	8	33	28	36	80	54	63	326
Solothurn	SO	0	2	6	19	15	21	29	34	40	47	72	133	122	134	674
Schwyz	SZ	0	2	2	7	17	9	7	17	9	12	79	52	93	102	408
Thurgau	TG	7	11	36	23	36	36	41	59	85	69	133	216	318	299	1369
Tessin	TI	0	0	0	1	2	3	6	16	24	37	44	62	35	36	266
Uri	UR	0	1	2	0	0	2	3	2	0	2	11	14	34	13	84
Waadt	VD	0	1	6	9	14	27	32	25	26	20	66	236	272	246	980
Wallis	VS	1	15	28	24	39	45	34	32	53	65	88	195	219	200	1038
Zug	ZG	0	2	2	3	7	12	11	13	29	17	56	112	43	35	342
Zürich	ZH	39	16	58	66	121	107	153	281	360	447	652	867	752	779	4698
Sum		**56**	**69**	**226**	**358**	**508**	**582**	**639**	**908**	**1127**	**1596**	**2620**	**3599**	**3828**	**3926**	**20042**

Source: Own calculation based on Minergie dataset 2014.

Table 4.7: Amount of new constructed residential buildings over all 26 Swiss cantons 1998-2011

Canton	**Code**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	sum
Aargau	AG	1993	1974	1841	1440	1540	1568	1856	1798	1913	1820	1752	1506	1336	1386	23723
Appenzell I. Rh.	AI	17	45	35	32	40	27	52	40	51	47	39	36	32	42	535
Appenzell A. Rh.	AR	90	101	92	74	63	65	69	65	70	106	79	69	82	87	1112
Bern	BE	1853	1915	1902	1477	1600	1635	1874	1778	1675	1594	1728	1406	1357	1411	23205
Basel-Landschaft	BL	978	878	986	708	518	568	660	722	745	536	706	521	552	494	9572
Basel-Stadt	BS	45	52	64	55	88	62	38	26	86	29	39	46	37	31	698
Freiburg	FR	705	786	788	756	787	818	1019	1088	1215	1130	1162	1005	1086	1111	13456
Genf	GE	524	620	552	493	461	382	459	471	391	572	332	338	358	296	6249
Glarus	GL	62	72	80	54	51	56	72	69	92	78	53	49	64	62	914
Graubünden	GR	533	499	461	409	435	512	561	531	549	591	613	455	490	536	7175
Jura	JU	141	170	154	124	140	163	185	204	169	198	213	136	155	190	2342
Luzern	LU	867	912	854	700	759	732	945	773	809	851	741	746	758	766	11213
Neuenburg	NE	163	206	208	247	145	180	193	265	253	246	223	155	156	213	2853
Nidwalden	NW	109	76	80	60	84	52	89	140	91	128	69	59	46	56	1139
Obwalden	OW	87	64	130	110	80	83	92	96	86	89	98	85	90	51	1241
St. Gallen	SG	1018	1168	1188	977	900	975	1153	1010	969	986	1047	889	1003	911	14194
Schaffhausen	SH	135	161	131	93	92	130	128	199	158	191	208	147	159	202	2134
Solothurn	SO	692	744	661	583	591	607	664	587	632	568	601	522	606	567	8625
Schwyz	SZ	463	445	531	338	352	393	346	397	402	497	358	426	349	317	5614
Thurgau	TG	907	800	683	562	607	623	794	753	803	788	815	671	775	805	10386
Tessin	TI	606	640	655	745	643	657	692	826	766	758	773	730	597	664	9752
Uri	UR	107	96	63	76	67	75	62	55	98	87	93	56	55	62	1052
Waadt	VD	875	958	1055	1123	954	1176	1389	1553	1553	1500	1286	1198	1404	1250	17274
Wallis	VS	751	800	765	792	766	909	1062	1199	1282	1206	1347	988	1156	1171	14194
Zug	ZG	209	404	163	298	187	232	213	214	174	143	153	185	187	206	2968
Zürich	ZH	2936	2851	2840	2341	2235	2522	2639	2131	2160	2312	2150	1742	1846	2106	32811
	sum	16866	17437	16962	14667	14185	15202	17306	16990	17192	17051	16678	14166	14736	14993	224431
	avg	649	671	652	564	546	585	666	653	661	656	641	545	567	577	8632

Source: Own calculation based on Minergie dataset 2014.

Table 4.8: Fraction of green residential buildings over all new constructed buildings in the 26 Swiss cantons 1998-2011

Canton	**Code**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	average
Aargau	AG	0.0005	0.0010	0.0092	0.0201	0.0169	0.0351	0.0345	0.0412	0.0507	0.1357	0.2363	0.3406	0.4237	0.4675	0.1295
Appenzell I. Rh.	AI	0.0000	0.0000	0.0286	0.0000	0.1000	0.1481	0.0385	0.0500	0.1176	0.0638	0.1026	0.0556	0.2500	0.0714	0.0733
Appenzell A. Rh.	AR	0.0000	0.0099	0.0435	0.0541	0.2222	0.0923	0.1304	0.2000	0.1429	0.1038	0.2152	0.4493	0.3902	0.2184	0.1623
Bern	BE	0.0043	0.0042	0.0137	0.0386	0.0544	0.0312	0.0336	0.0579	0.0597	0.1054	0.1348	0.1942	0.2078	0.2147	0.0825
Basel-Landschaft	BL	0.0000	0.0000	0.0000	0.0014	0.0077	0.0123	0.0424	0.0374	0.0497	0.0989	0.2082	0.2188	0.2355	0.3502	0.0902
Basel-Stadt	BS	0.0000	0.0000	0.0000	0.0000	0.0114	0.0161	0.0526	0.0385	0.0349	0.1379	0.1795	0.1522	0.2973	0.6774	0.1141
Freiburg	FR	0.0000	0.0025	0.0076	0.0251	0.0203	0.0465	0.0265	0.0460	0.0453	0.0363	0.0482	0.0975	0.0902	0.0630	0.0396
Genf	GE	0.0000	0.0000	0.0000	0.0020	0.0065	0.0052	0.0131	0.0382	0.0665	0.1451	0.4307	0.2337	0.4693	0.5845	0.1425
Glarus	GL	0.0000	0.0000	0.0250	0.0741	0.1176	0.1071	0.0694	0.0580	0.0435	0.0513	0.3585	0.1633	0.3125	0.1129	0.1067
Graubünden	GR	0.0000	0.0000	0.0043	0.0293	0.0046	0.0410	0.0267	0.0433	0.0364	0.0761	0.0946	0.2527	0.2143	0.1866	0.0722
Jura	JU	0.0000	0.0000	0.0065	0.0000	0.0286	0.0245	0.0162	0.0343	0.0473	0.0101	0.0751	0.0588	0.1355	0.1000	0.0384
Luzern	LU	0.0000	0.0044	0.0094	0.0129	0.0119	0.0178	0.0212	0.0362	0.0309	0.0447	0.1147	0.2252	0.2493	0.2389	0.0727
Neuenburg	NE	0.0000	0.0000	0.0096	0.0526	0.0276	0.2278	0.0415	0.1019	0.0474	0.0854	0.1480	0.0645	0.1282	0.1221	0.0755
Nidwalden	NW	0.0000	0.0132	0.0375	0.1167	0.0000	0.0769	0.2472	0.0429	0.2527	0.0625	0.1449	0.0847	0.4565	0.3214	0.1327
Obwalden	OW	0.0000	0.0156	0.0154	0.0273	0.0250	0.0241	0.0435	0.0104	0.0116	0.0112	0.0612	0.0941	0.1222	0.5490	0.0722
St. Gallen	SG	0.0000	0.0000	0.0101	0.0430	0.0778	0.0585	0.0338	0.0366	0.0423	0.1247	0.1289	0.2171	0.2034	0.2503	0.0876
Schaffhausen	SH	0.0000	0.0000	0.0000	0.0538	0.0543	0.0615	0.0469	0.0402	0.2089	0.1466	0.1731	0.5442	0.3396	0.3119	0.1415
Solothurn	SO	0.0000	0.0027	0.0091	0.0326	0.0254	0.0346	0.0437	0.0579	0.0633	0.0827	0.1198	0.2548	0.2013	0.2363	0.0832
Schwyz	SZ	0.0000	0.0045	0.0038	0.0207	0.0483	0.0229	0.0202	0.0428	0.0224	0.0241	0.2207	0.1221	0.2665	0.3218	0.0815
Thurgau	TG	0.0077	0.0138	0.0527	0.0409	0.0593	0.0578	0.0516	0.0784	0.1059	0.0876	0.1632	0.3219	0.4103	0.3714	0.1302
Tessin	TI	0.0000	0.0000	0.0000	0.0013	0.0031	0.0046	0.0087	0.0194	0.0313	0.0488	0.0569	0.0849	0.0586	0.0542	0.0266
Uri	UR	0.0000	0.0104	0.0317	0.0000	0.0000	0.0267	0.0484	0.0364	0.0000	0.0230	0.1183	0.2500	0.6182	0.2097	0.0981
Waadt	VD	0.0000	0.0010	0.0057	0.0080	0.0147	0.0230	0.0230	0.0161	0.0167	0.0133	0.0513	0.1970	0.1937	0.1968	0.0543
Wallis	VS	0.0013	0.0188	0.0366	0.0303	0.0509	0.0495	0.0320	0.0267	0.0413	0.0539	0.0653	0.1974	0.1894	0.1708	0.0689
Zug	ZG	0.0000	0.0050	0.0123	0.0101	0.0374	0.0517	0.0516	0.0607	0.1667	0.1189	0.3660	0.6054	0.2299	0.1699	0.1347
Zürich	ZH	0.0133	0.0056	0.0204	0.0282	0.0541	0.0424	0.0580	0.1319	0.1667	0.1933	0.3033	0.4977	0.4074	0.3699	0.1637
average_year		0.0010	0.0043	0.0151	0.0278	0.0415	0.0515	0.0483	0.0532	0.0732	0.0802	0.1661	0.2299	0.2731	0.2670	

Source: Own calculation based on Minergie dataset 2014.

Chapter 5

General Conclusion

The present thesis reveals the intersection of sustainability and real estate. Both fields of research developed significantly in recent years. The conjunction of both topics towards "real estate sustainability" or so called "green buildings" is lively debated in the academics and the public. However, a vast amount of literature has been established in recent years. Several academic journals were founded and publish literature specifically on real estate sustainability themes. Although there is no clear-cut definition of sustainable real estate one can observe a lively debate about the amenities green buildings provide. Notwithstanding, there are also controversies in this debate. To what extent green buildings achieve profitability is not always observable and even seen as an unprofitable investment with only modest financial returns. Moreover, there are barriers to invest in green buildings leading to the so-called energy efficiency paradox, which describes the lack of investments although it is socially and environmentally eligible.

Advocators acclaim that green buildings provide higher and more stable returns, generate higher cash flows, attract more tenants and achieve longer lease contracts. Furthermore, the associated risks are lower in terms of lower operating costs and a lower vacancy. Sustainable properties are less exposed to macroeconomic cycles and provide a decent hedge function against several market risks and uncertainties. Green buildings are often related to the occurrence of a premium price. Some market participants are willing to pay a higher price for green buildings while others do not accept premium prices. Researchers reveal under what

market conditions and to what extent investors are willing to pay a premium price for sustainable properties compared to conventional real estate. Based on the transaction price differences or the announced willingness to pay, the debate on premium prices and whether green buildings are profitable is one of the most prominent discussions in the real estate literature.

Other amenities that are related to green buildings are better indoor climate conditions, proper daylight and ventilation conditions. This is related to a better well-being, less absentees due to sick leaves and a higher productivity of employees. Moreover, working in a green building appears to be attractive for prospective employees. Investors or property owners signal their interest in green buildings for marketing reasons as well. Image and reputation are often part of the investor decision making. Green buildings are prominently debated in the literature and the public due to its major impact on global challenges the society is dealing with.

Climate change as well as energy and resource efficiency occur as major global challenges the world community has to cope with. Frequently, the agenda of the World Economic Forum (WEF) identifies climate change as well as environment and resource security as the global challenges of today. Worldwide leading philanthropic initiatives such as The Clinton Global Initiative (CGI) engage in the abatement of greenhouse gas emissions and address climate change on top of the agenda:

> "In cities and forests across the globe, our programs are proving that we can confront the debilitating effects of climate change in a way that makes sense for governments, businesses, and economies. From iconic projects like the retrofit of the Empire State Building to a tree-planting program that generates income for farmers in Malawi, our work to build more energy efficient cities, promote clean energy, and reverse deforestation has reduced global greenhouse gas emissions by tens of thousands of tons per year while also creating local jobs and boosting economies."(Clinton Global Initiative.)

Since the 1990s the world community joined the United Nations Framework

Convention on Climate Change to limit the global temperature increase to 2 degrees Celsius. As a result, in 1997 the participating countries adopted the Kyoto Protocol to define binding targets on the reduction of greenhouse gas emissions. Currently, more than 190 countries joined the Kyoto Protocol. However, leading studies provide evidence that properties are responsible for approximately 30 percent of all greenhouse gas emissions; circa 40 percent of energy consumption, and 50 percent of all natural resources. These figures signal the superior importance of the present topic and illustrate the motivation to ascertain the present thesis. As a result, the so called de-carbonization, which defines the reduction of greenhouse gas emission, is at the forefront of climate change initiatives.

The present thesis consists of three papers, which are cohesively designed to deal with energy and resource efficiency in the real estate environment in Switzerland. Switzerland has one of the highest densities of properties that are labeled or certified as energy and resource efficient, which illustrates a distinctive motivation to analyze the market of sustainable real estate for the case of Switzerland. The federal organization of the 26 Swiss cantons allows interesting empirical investigations related to the field of regional economics.

The first paper "What drives Investment in Green Buildings? An Empirical Analysis of Switzerland", aims to investigate what driving factors increase the likelihood of investments in green buildings. To this end the paper investigates the impact of ecological responsibility in a firm, the impact of the corporate social responsibility, the impact of corporations of public sector, and what extent firms from the third industry sector with a high share of white collar jobs are more likely to invest in green buildings. Analyzing survey data from Switzerland with approximately 200 responding firms from all industry sectors, this paper distinguishes between the decisions of firms to lease or buy a property. Using logit and probit regression analysis, this paper confirms that ecological responsibility is an important driver for investment decisions in green buildings. Moreover, this paper finds that firms from the financial service industries are more likely to invest in green buildings. In contrast to other studies, firms from the public sector exhibit ambiguous results.

The second paper "Willingness to Pay for Green Buildings. Empirical Evidence from Switzerland", investigates to what extent firms are willing to pay a premium price for green buildings compared to conventional buildings. This paper was published in the Journal of Sustainable Real Estate, Vol. 5 2013. Based on unique survey data from Switzerland the study distinguishes between the decisions to lease, purchase, or retrofit a property. On average the paper finds that Swiss corporations are willing to pay a premium price of 3.0% for leasing, 4.75% for purchasing, and 5% for retrofitting. Using censored regression analysis the empirical results illustrate that depending on firm characteristics, the announced premium price ranges from 1.3 to 7.9% compared to conventional properties. As a result, firms from the building industries, firms from the financial service industries, as well as public corporations and authorities signal the highest willingness to pay.

The third paper "The Diffusion of Green Buildings. An Empirical Investigation of Switzerland", analyzes regional disparities in the distribution of energy efficient buildings. In particular, this paper takes into account that Switzerland has one of the highest densities of green buildings in the world. Using a unique dataset that captures all certified residential buildings, the paper analyzes the dynamics of green buildings across all 26 Swiss cantons over a period of 14 years since 1998. The paper uses panel data analysis to capture regional characteristics such as economic conditions and property market conditions, innovation and education characteristics, climate conditions, and the predominant environmental ideology to explain the demand for energy efficient properties. Results illustrate that income and local rent levels, as well as innovation characteristics are strongly significant. In contrast to other studies, the findings do not support a significant impact of cultural factors, age, or the environmental ideology of local residents.

The accelerating development of energy and resource efficient properties is an outcome of a transformation to a sustainable future. There must be a transition to an environment friendly, cleaner, and energy-efficient global economy where sustainable properties contribute significantly. The present thesis aims to contribute to the real estate sustainability literature. Notwithstanding, there is still

a lot of capacity for future research. At the forefront of empirical investigations are solid datasets. Future research is expected to investigate the economic outcome of investments in green buildings. To this extent, real transaction data are the most solid approach, but still hard to get. As the real estate business is a long-term business, it might be interesting to investigate long-term benefits sustainable properties provide. Another approach is to combine macroeconomic data with real estate investment cycles to research whether there is a decent demand for green buildings independent of macro cycles, and compared to conventional buildings. It is generally a difficult endeavor to compare different real estate markets with each other. Due to different local rent prices, macroeconomic conditions and income situations, real estate markets are local markets that follow cycles in terms of demand or prices. In this regard the present thesis analyzes this case of Switzerland. Further research can focus on the different label and certificate standards that are available in Europe or literally all over the world. To what extent are these labels comparable? Moreover, will there be a harmonized label standard used consistently by all market participants. Hence, there is still a substantial capacity for future research.

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Eidesstattliche Erklärung

Hiermit erkläre ich, die vorliegende Dissertation selbständig angefertigt und mich keiner anderen als der in ihr angegebenen Hilfsmittel bedient zu haben. Insbesondere sind sämtliche Zitate aus anderen Quellen als solche gekennzeichnet und mit Quellenangaben versehen.

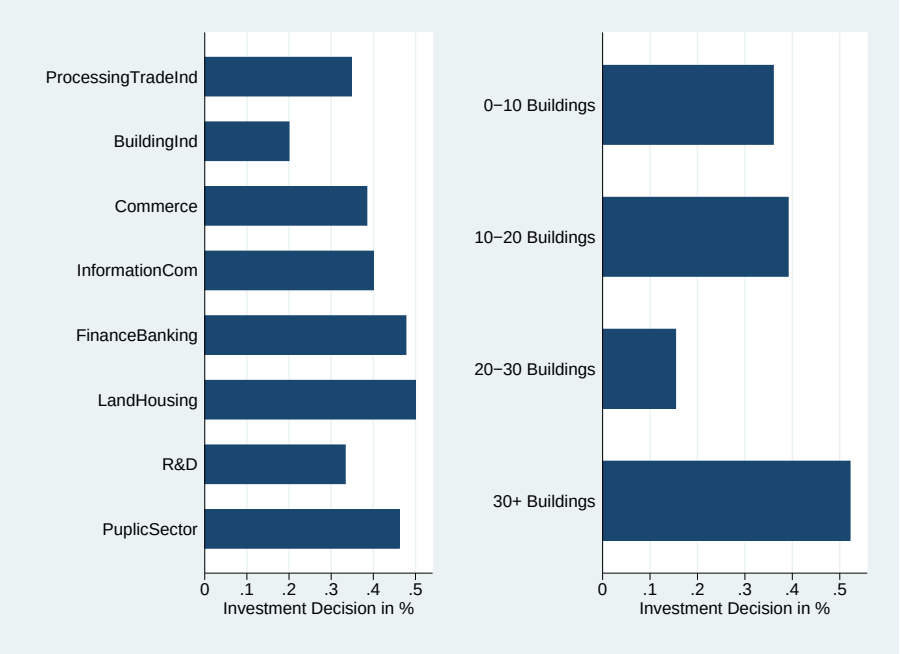
Zürich, 10.01.2015 *Andreas Wiencke*

Appendix A

Appendix

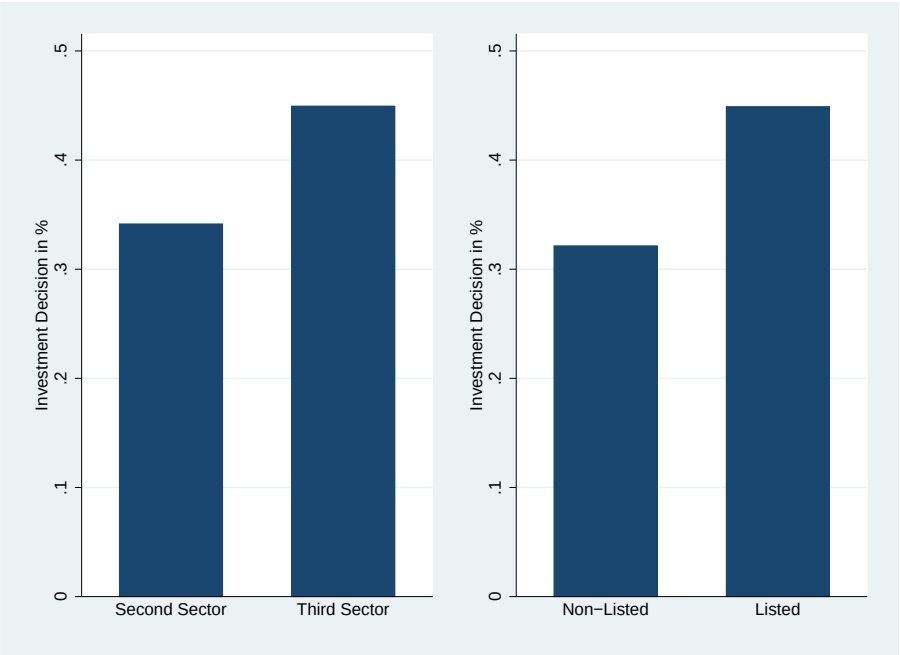
A.1 Appendix 1

Figure A.1: Responding firms by industry sector and number of buildings.



The bar chart represents the share of the responding firms related to each industry sector and each buildings category that acknowledge an investment in green buildings. Source: Own calculation based on Corporate Real Estate Sustainability Survey 2012 dataset.

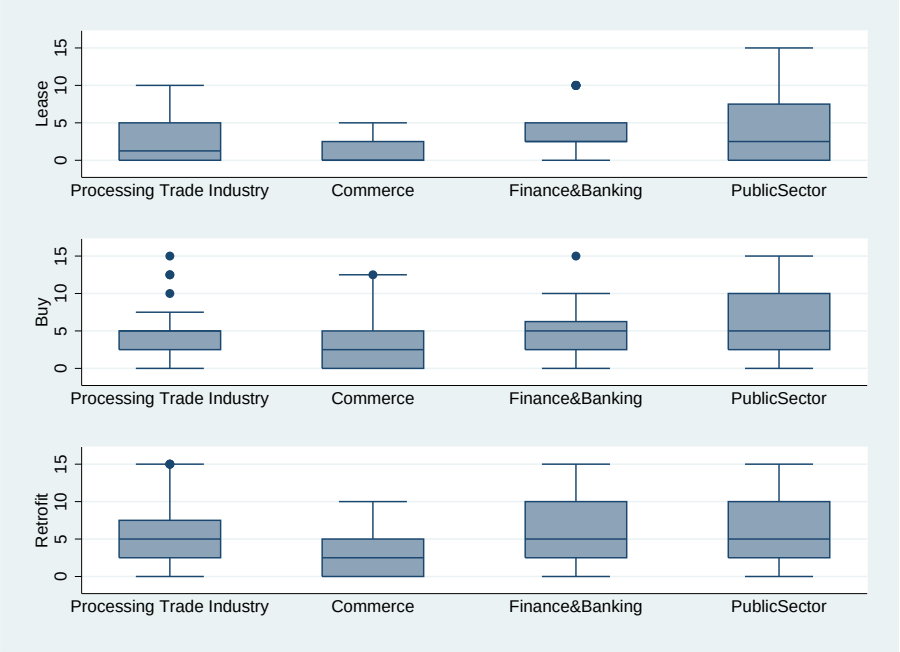
Figure A.2: Responding firms investing in green buildings.



The bar chart represents the share of the responding firms related to each industry sector that acknowledge an investment in green buildings. Source: Own calculation based on Corporate Real Estate Sustainability Survey 2012 dataset.

A.2 Appendix 2

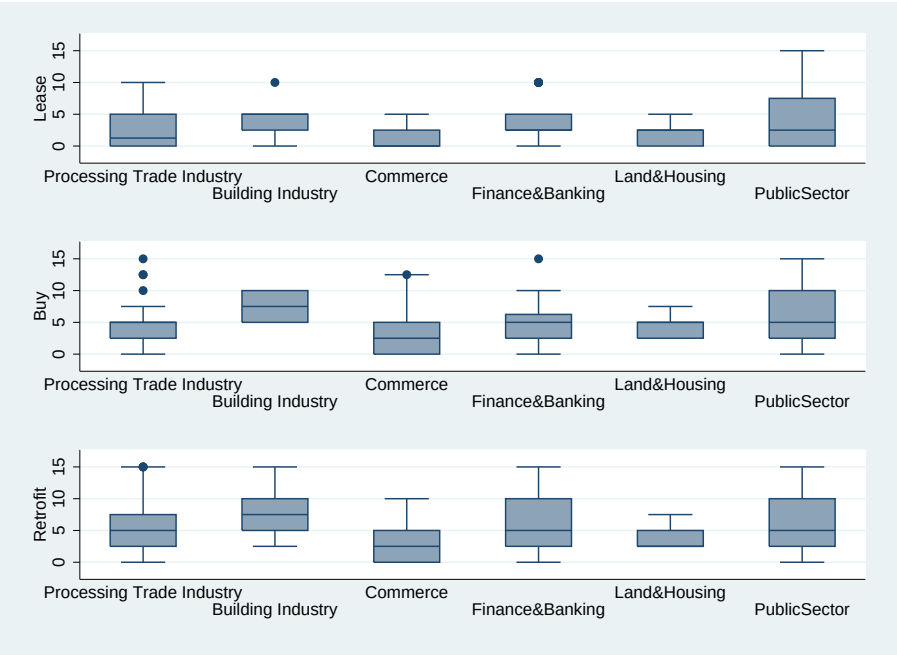
Figure A.3: Willingness to Pay over Swiss Industry Sectors



The figures represent mean percentages on a given 0% to 15% scale for (1) lease, (2) buy, and (3) retrofit decision making. Source: Own calculation based on Corporate Real Estate Sustainability Survey 2013 dataset.

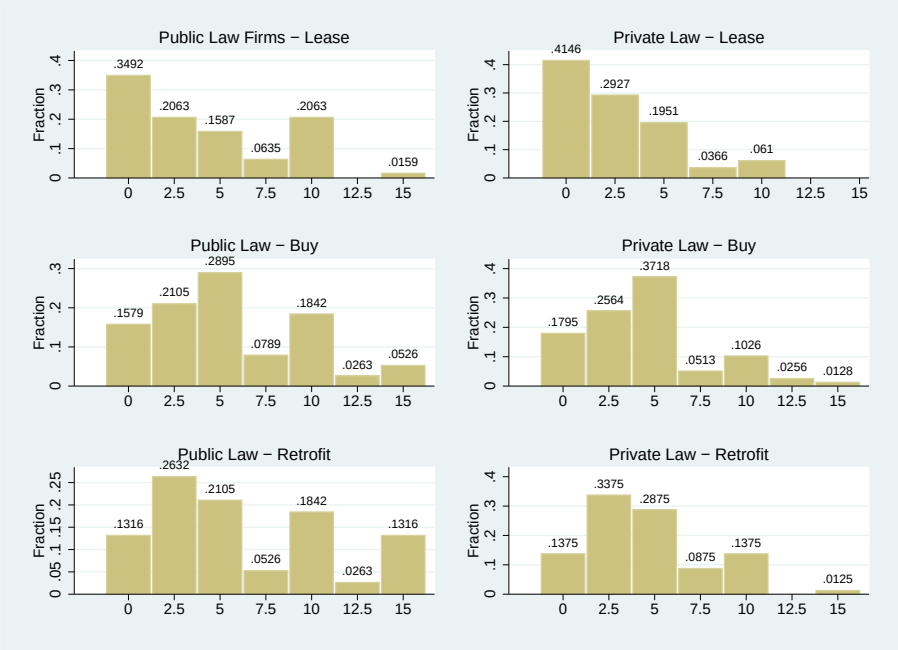
A.3 Appendix 3

Figure A.4: Willingness to Pay over Swiss Industry Sectors



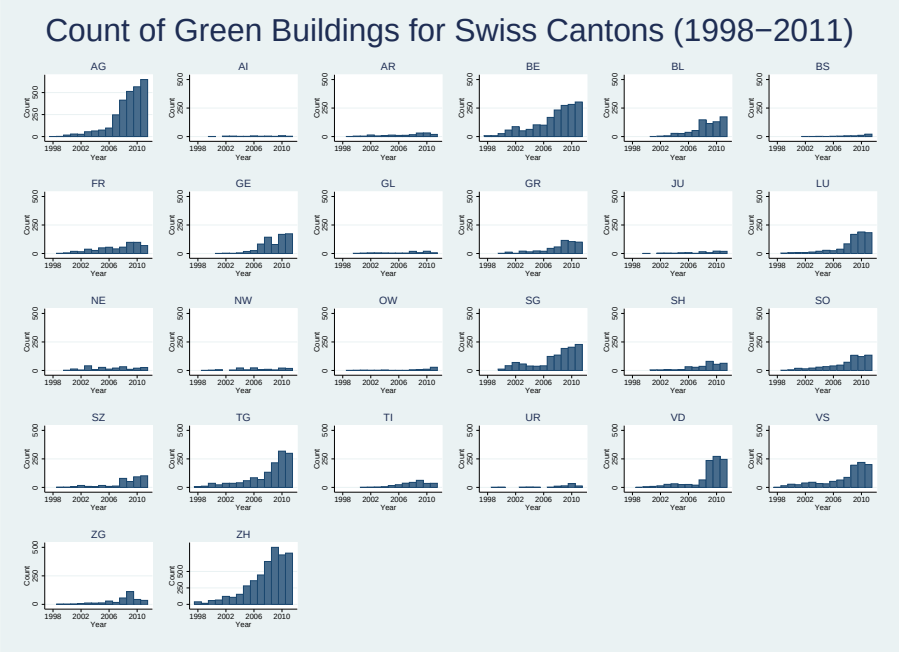
The figures represent mean percentages on a given 0% to 15% scale for (1) lease, (2) buy, and (3) retrofit decision making. Source: Own calculation based on Corporate Real Estate Sustainability Survey 2013 dataset.

Figure A.5: Willingness to Pay and Legal Form



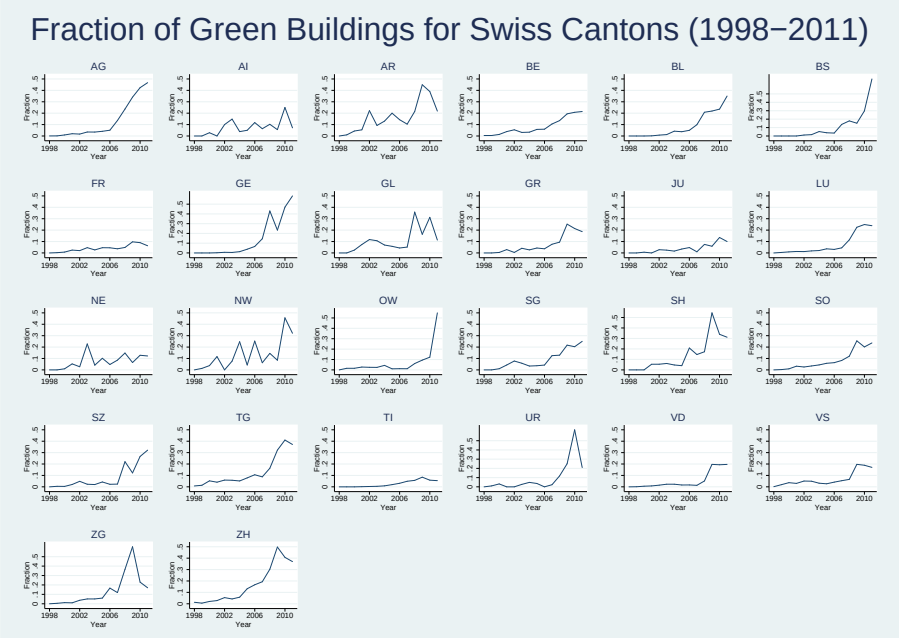
The figures represent mean percentages on a given 0% to 15% scale for (1) lease, (2) buy, and (3) retrofit decision making. Source: Own calculation based on Corporate Real Estate Sustainability Survey 2013 dataset.

Figure A.6: Number of Green Buildings for all Swiss Cantons



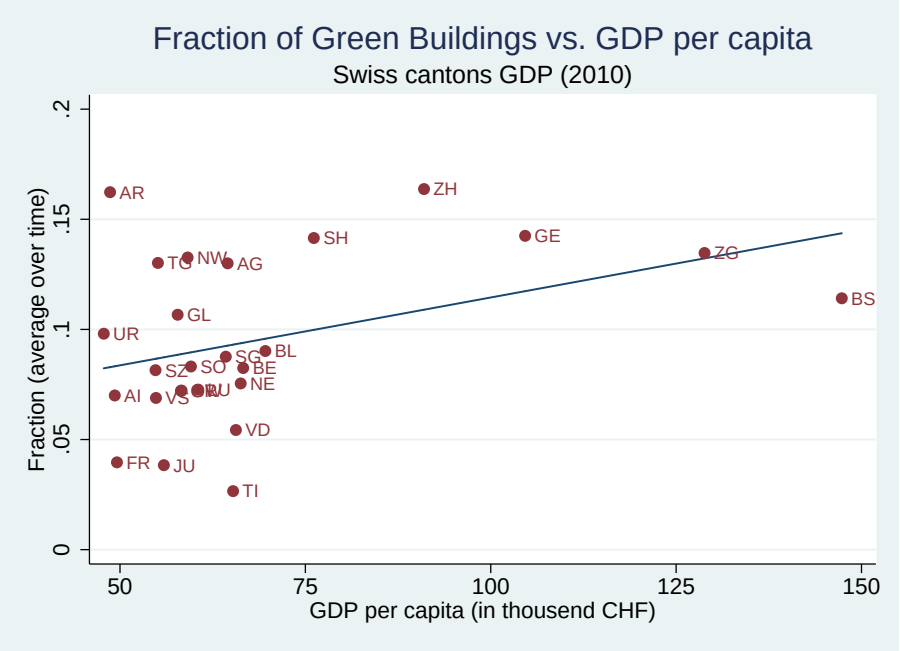
This figure illustrates the heterogeneous distribution of certified properties over all Swiss cantons in absolute measures. Source: Own calculation based on Minergie dataset 2014.

Figure A.7: Fraction of Green Buildings for all Swiss Cantons



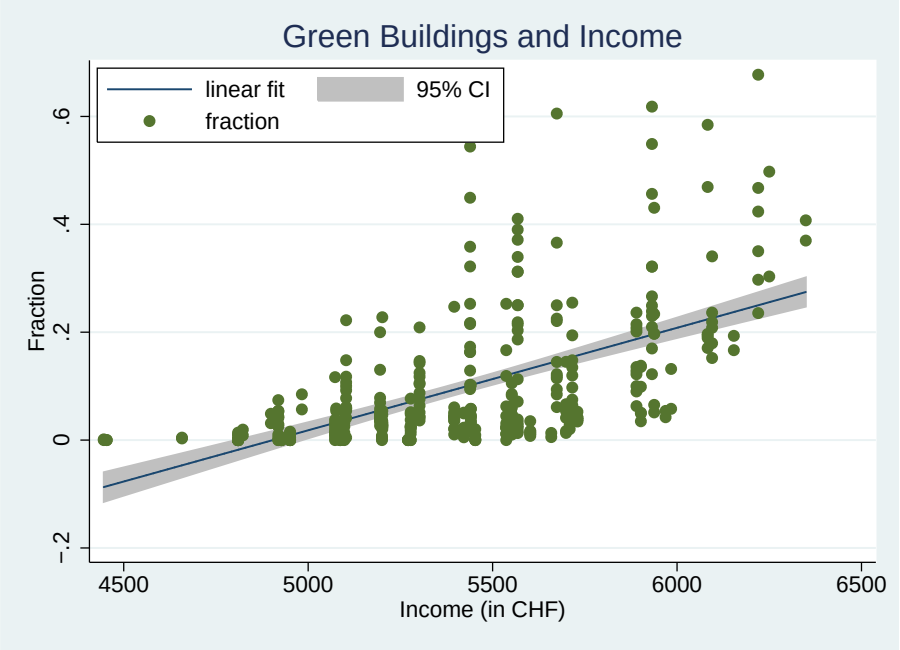
This figure illustrates the heterogeneous distribution of certified properties over all Swiss cantons in relative measures. Source: Own calculation based on Minergie dataset 2014.

Figure A.8: Economic indicator: GDP per capita



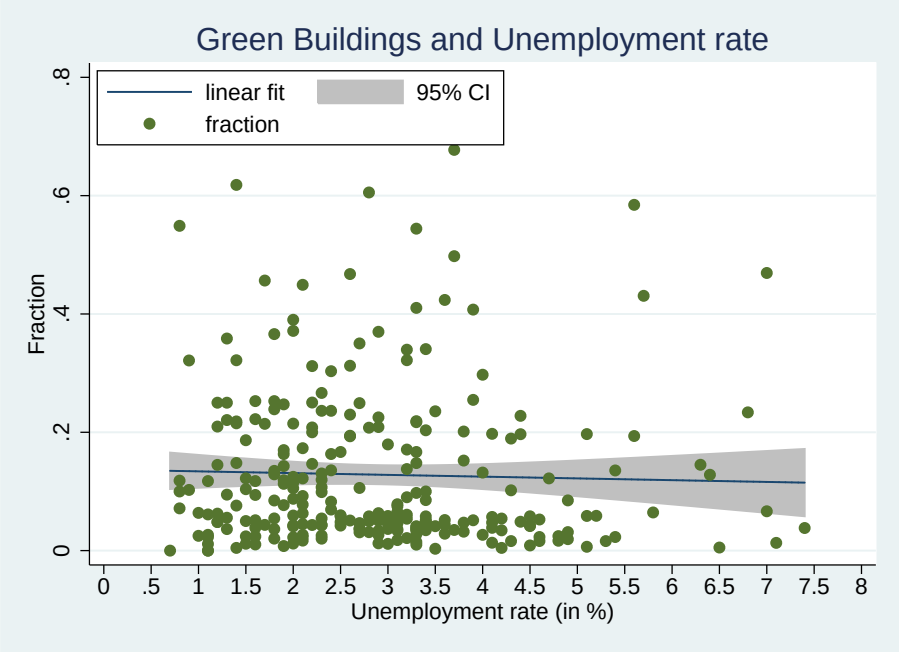
Due to limited data availability on cantonal level the GDP per capita is illustrated for the year 2010. The fraction of certified properties is calculated in average terms. Source: Own calculation based on Federal Statistical Office 2014.

Figure A.9: Economic indicator: Income per capita



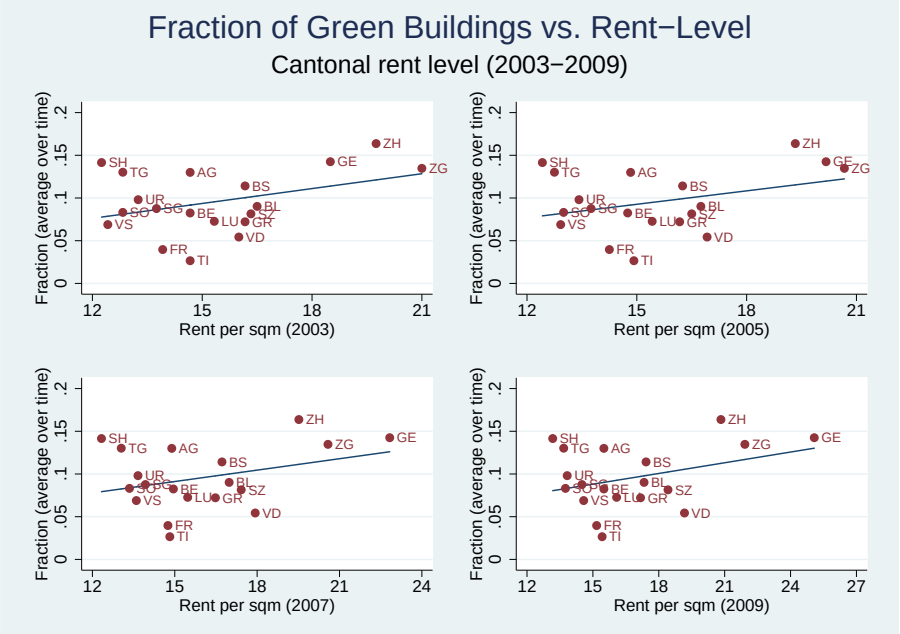
Source: Own calculation based on Federal Statistical Office 2014.

Figure A.10: Economic indicator: Unemployment rate



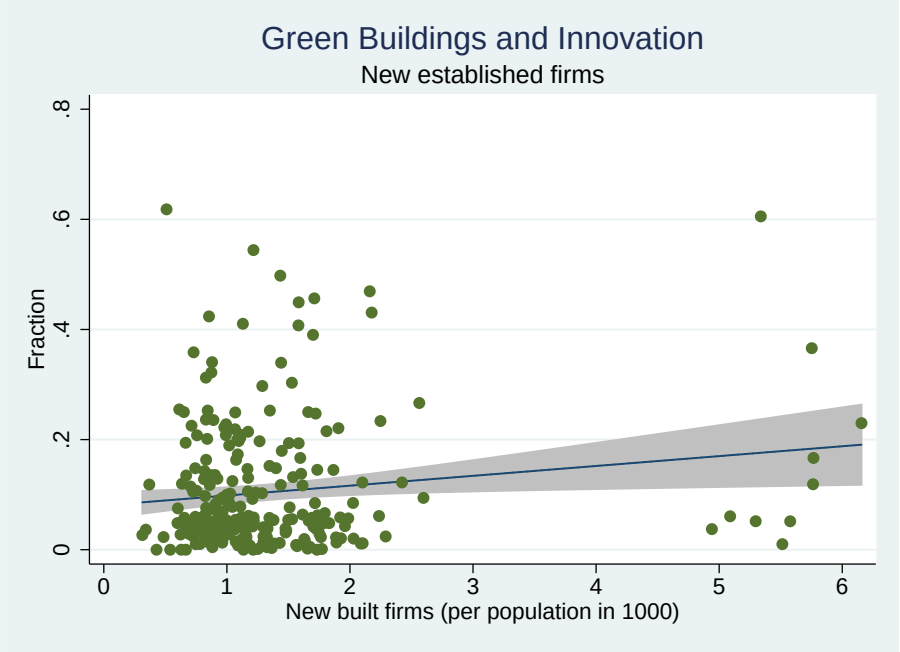
Source: Own calculation based on Federal Statistical Office 2014.

Figure A.11: Local property market indicator: Rent level



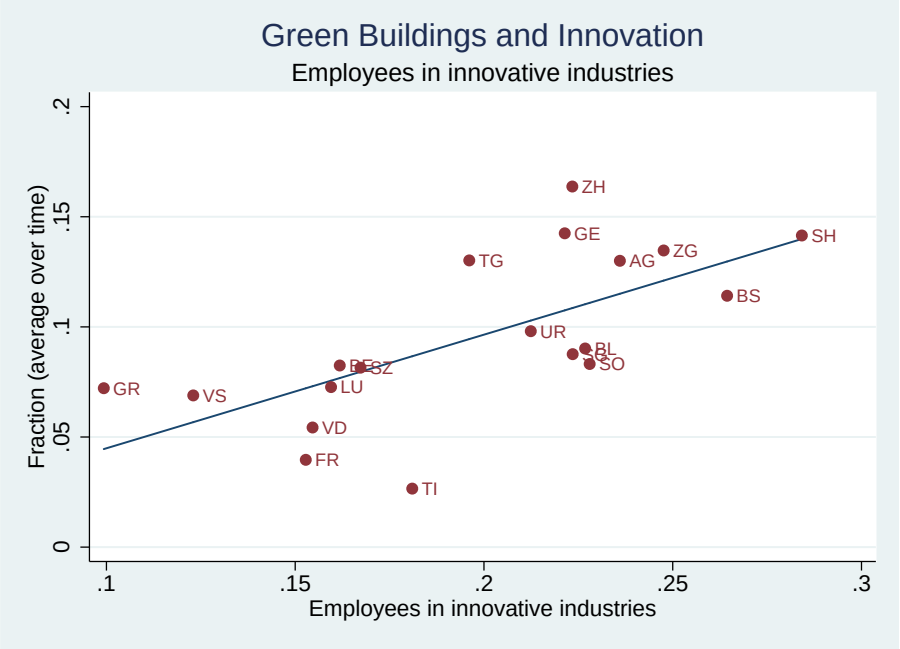
Source: Own calculation based on Wuest&Partner and Federal Statistical Office 2014.

Figure A.12: Innovation indicator: Newly established Firms



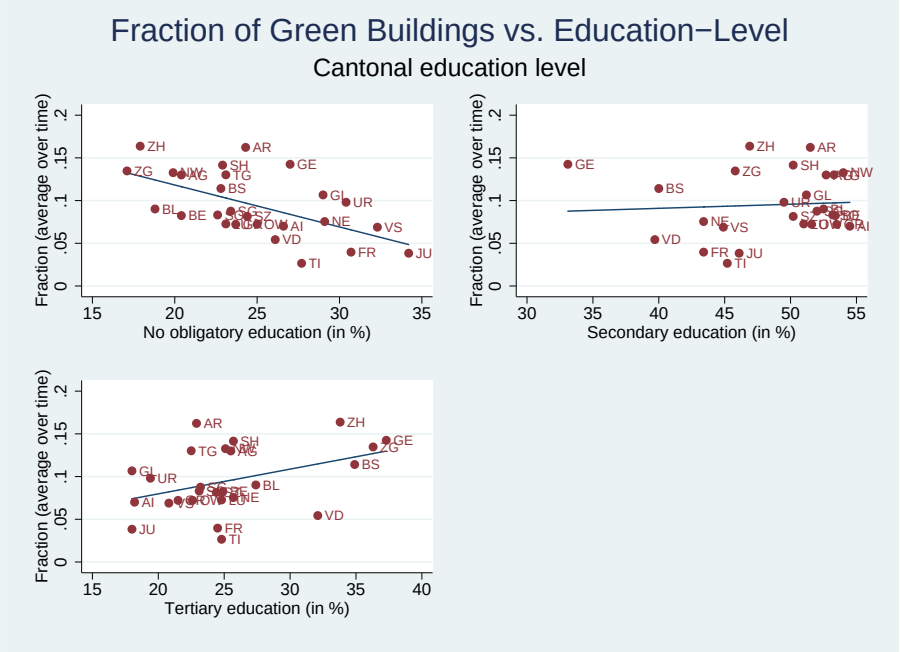
Due to limited data availability on cantonal level the GDP per capita is illustrated for the year 2010. The fraction of certified properties is calculated in average terms. Source: Own calculation based on Federal Statistical Office 2014.

Figure A.13: Innovation indicator: Employees in innovative industries.



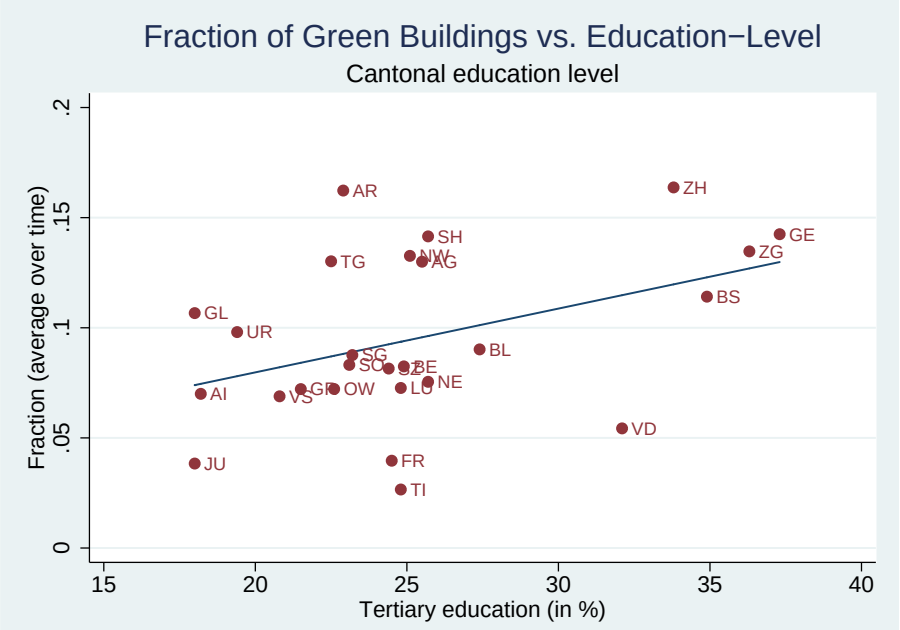
Due to limited data availability on cantonal level the GDP per capita is illustrated for the year 2010. The fraction of certified properties is calculated in average terms. Source: Own calculation based on Federal Statistical Office 2014.

Figure A.14: Educational indicator: Cantonal educational level.



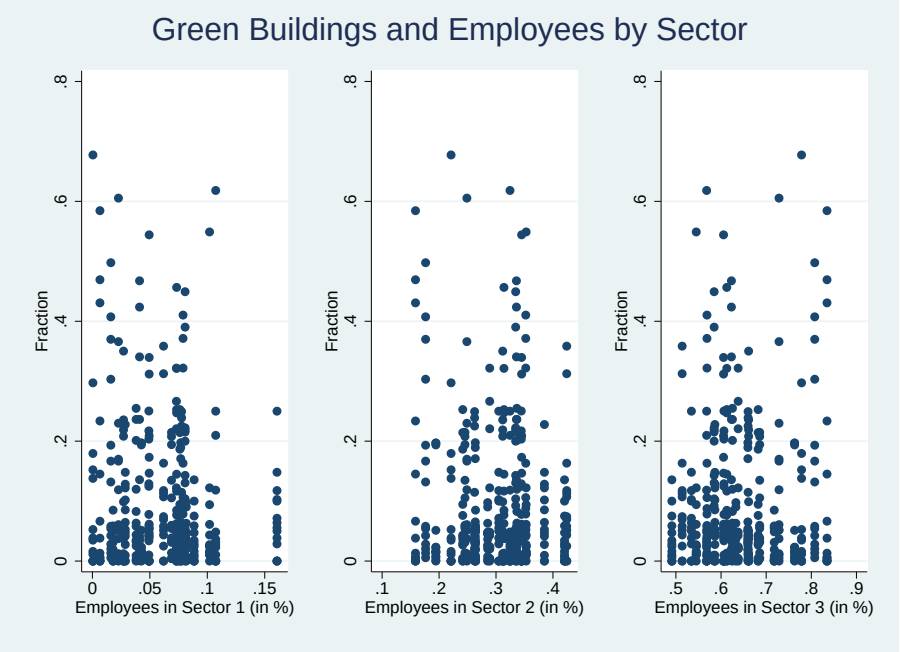
Source: Own calculation based on Federal Statistical Office 2014.

Figure A.15: Tertiary Education and Diffusion of Green Buildings.



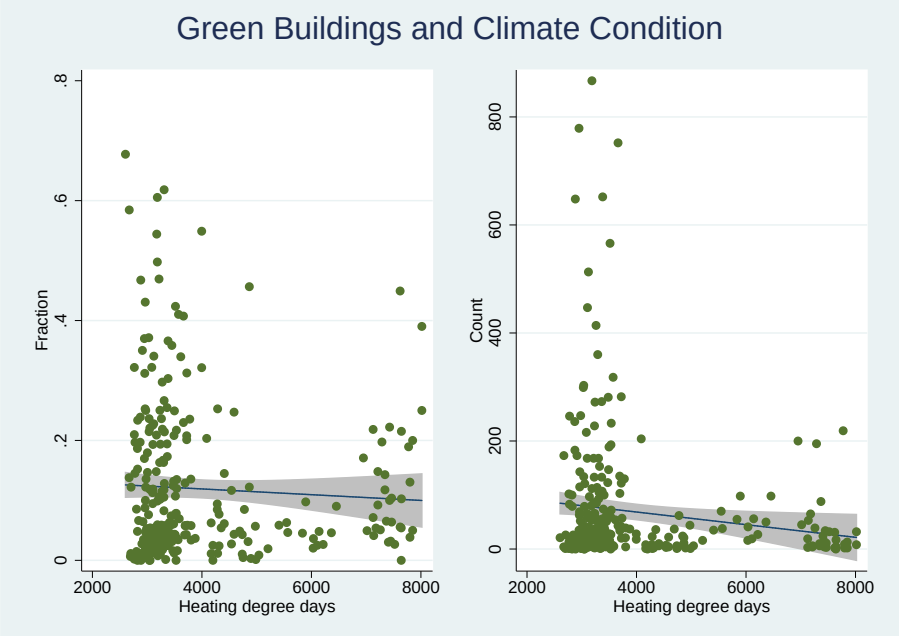
Source: Own calculation based on Federal Statistical Office 2014.

Figure A.16: Educational indicator: Employees by Sector.



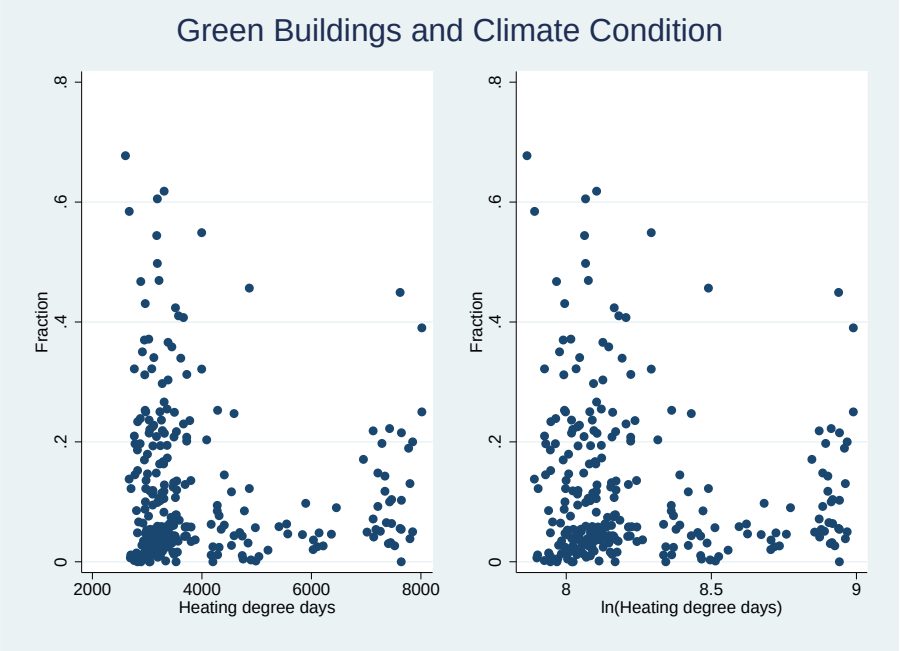
Source: Own calculation based on Federal Statistical Office 2014.

Figure A.17: Climate indicator: Heating Degree Days (1).



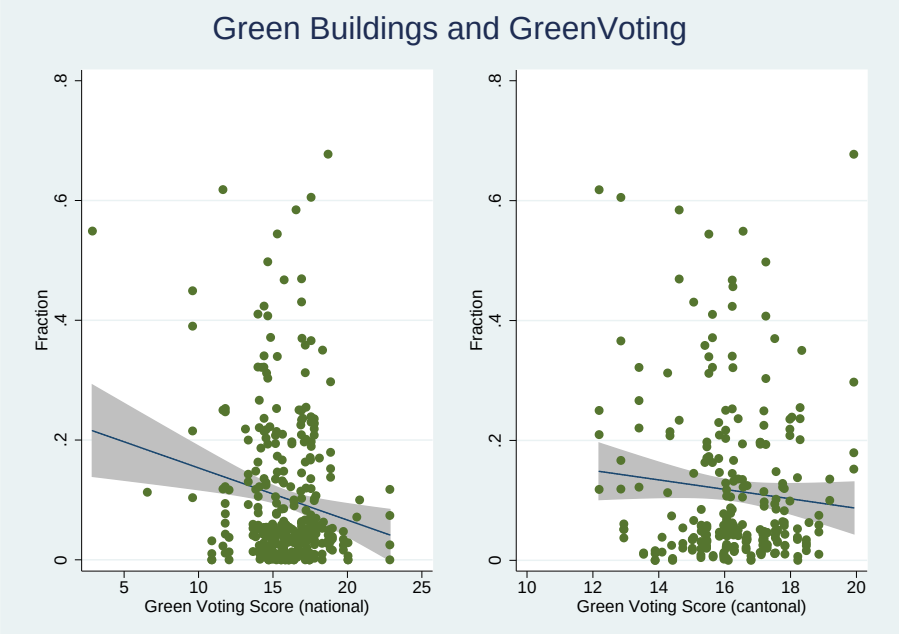
Source: Own calculation based on MeteoSchweiz 2014.

Figure A.18: Climate indicator: Heating Degree Days (2).



Source: Own calculation based on MeteoSchweiz 2014.

Figure A.19: Environmental ideology indicator: Voting Behavior.



Source: Own calculation based on Federal Statistical Office 2014.

CURRICULUM VITAE June 2015

ANDREAS WIENCKE

PROFESSIONAL EXPERIENCE

Since 10/2013	**Credit Suisse AG,** **Real Estate Investment Management**, Zurich, Switzerland
04/2011 – 09/2013	**University of Zurich**, **Center for Corporate Responsibility and Sustainability**, Zurich, Switzerland Research Associate
03/2010 – 05/2010	**Morgan Stanley** Summer Analyst, Investment Banking Division
01 – 09/2009	**Institute for Small and Medium Sized Companies (ifm),** **University of Mannheim**, Chair of Entrepreneurship, Prof. Woywode Research Assistant
01/2009 – 01/2010	**University of Mannheim,** Chair of Business Administration, Prof. Oechsler Research Assistant

EDUCATION

07/2011 – 06/2015	**University of Mannheim**, Mannheim, Germany PhD candidate in Economics
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07 – 09/2008	**University of California at Berkeley**, Berkeley, US Graduate studies, Contemporary Political Economics
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