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Construction Costs and Initial Yield Effects of MINERGIE Certification and Sustainable Construction Measures in New Multifamily Houses in Switzerland

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ABSTRACT

In this study, the influence of MINERGIE certifications, sustainable building measures that lead to certification, and further amenities and quality measures not compulsory for certification on the construction costs and net initial (asking) rents of building projects in Switzerland is investigated. The hedonic regression results show construction cost premiums of 1.6–5.1% for MINERGIE-certified apartments. These cost premiums yield higher net initial rents of approximately 2.6–6.6*% (*not significant). In contrast, most specific sustainable building measures, such as district heating, heat pumps, or solar energy, show significant cost premiums, without higher net initial rents in the market. Whereas MINERGIE certification can translate construction costs to higher net initial rents, single sustainable construction measures do not. Such an adverse cost-benefit ratio could impede specific green investments in the short term, whereas a favorable ratio of the MINERGIE standard could promote the spread of green buildings.

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Green buildings; green rent and cost premiums; hedonic regression; MINERGIE

Introduction

According to the Global Alliance for Buildings and Construction, International Energy Agency and United Nations Environment Programme (2019), the real estate industry and its buildings accounted for 36% of final energy use and 39% of energy and process-related carbon dioxide (CO_2) emissions in 2018. The real estate sector thus plays a crucial role in realizing sustainable and resource-efficient global economic development. The Swiss Federal Office of Energy (SFOE, 2020) summarized the impact of building stock on Switzerland's environment as follows: "Today, approximately 50% of Switzerland's primary energy consumption is spent on buildings, 30% for heating, air conditioning, and hot water, 14% for electricity, and approximately 6% for manufacturing and maintenance. Exploiting the still considerable savings potential in the building sector is of great economic interest. Moreover, the building sector is also substantially responsible for the consumption of material resources, waste generation, and the environmental impact on our society." There is an ecological necessity for sustainable building methods, highlighting the urgent need for further research in the real estate sector.

Ultimately, regulation could set rules for greater sustainability in buildings. One example is the European Green Deal, with its goal of enhancing the energy performance of buildings and helping to reach building and renovation goals. For this purpose, the European Union has established a legislative framework that includes the "Energy Performance of Buildings Directive" (EPBD) 2010/31/EU. Energy Performance Certificates (EPCs) and inspections of heating and cooling systems are crucial instruments of the EPBD (European Commission, 2022) and have inspired research on the topic. Nevertheless, the question remains: are there economic incentives to go green? That is, are there financial arguments that explain why investors should build sustainably? In the last quarter of 2021, oil, gas, and energy prices surged. Energy-intense industries, owners of fuel-based car, and inhabitants of fossil-heated housing experienced high costs. However, producers and consumers who invested early in clean technology experienced more stable energy prices. The presumed higher up-front

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costs of cleaner technology appeared to pay off or provide a buffer against increasing fossil energy prices. Nevertheless, the cost-benefit ratio of green residential buildings remains unclear in the real estate sector. This raises the question: will sustainable construction measures appear beneficial to investors due to higher earnings?

According to Dwaikat and Ali (2016), there is a consensus about the benefits associated with green buildings. However, there is ongoing debate comparing the costs of green and conventional construction methods. This study examines whether green buildings—that is, buildings with sustainable building measures and components—and those holding MINERGIE[1] certification incur higher construction costs and yield higher net initial (asking) rents than conventional buildings when first put on the market after construction. Additionally, it examines the cost of and return to certification and that of underlying components that lead to certification, as well as that of amenities and quality characteristics, which are typically independent of certification status.

Associating the construction data on building costs with listing information allows an estimate of the costs and benefits of green versus nongreen construction and how certification itself and its underlying technology impact costs and yields.

To assess the cost-benefit ratio of sustainable measures, a comparison of potentially higher returns, in the form of net rents, and upstream construction costs can be considered. Zhang et al. (2018) describe green building development as a complex process involving various stakeholders throughout the building life cycle. They analyzed the costs and benefits of green buildings from the perspective of the two primary decision-makers: developers and occupants. The division of costs and benefits between them may lead to a split incentive and principal-agent problem (Fuerst et al., 2016, and Jaffe & Stavins, 1994, as cited in Zhang et al., 2018). For instance, construction costs are borne by developers, whereas occupants enjoy some of the benefits of living green. Zhang et al. (2018) argue that sustainable practices will prevail only when all stakeholders benefit from the cost-benefit ratio of "going green."

Based on these considerations, this analysis focuses on the perspective of developers or investors. This raises the question: do green construction cost premiums exist during the design and construction phase? Furthermore, it examines whether green measures yield higher net initial rents for investors (Figure 1).

Sustainable housing research in Switzerland has focused on analyzing rent and price premiums, that is, revenue. Studies by Feige et al. (2013), Marty et al. (2016), Marty and Meins (2017), Salvi et al. (2008), Salvi et al. (2010), and Schuster and Füss (2016) indicated the existence of green rent and price premiums in the range of 1.78–12% for MINERGIE-certified buildings in the Swiss residential market. The primary drivers of these higher rental and sales prices include increased quality of living, greater comfort, lower energy costs, and improved property value retention (MINERGIE, 2020). Furthermore, globally, studies by Bond and Devine (2015), Cajias et al. (2019), and Koirala et al. (2014) showed green rental and sales premiums of 1.4–23.25%, according to international sustainability standards. Therefore, there is consensus in the literature that certified buildings have a positive effect on rents and sales.

According to Dwaikat and Ali (2016), owners and investors often perceive sustainable buildings as being expensive, which is cited as the primary reason for the lower market penetration of green buildings. Most studies on construction cost premiums have examined the commercial sector, whereas the residential market has scarcely been studied. Overall, the literature on the construction costs of sustainable buildings compared to conventional buildings identified three different cases. First, studies by Kaplan et al. (2009), Matthiessen and Morris (2007), and Rehm and Ade (2013) identified no significant cost differences in the construction of sustainable and conventional buildings. Second, studies by Ade and Rehm (2020), Galuppo and Tu (2010), Kim et al. (2014), Shrestha and Pushpala (2012), Zhang et al. (2011), and Kats et al. (2003) revealed higher costs for constructing sustainable buildings. Third, Lucuik et al. (2005) and Hydes and Creech (2010) found lower costs for constructing sustainable buildings.

In contrast to the predominantly positive benefits of sustainable building labels on rents and prices, the cost effects of green-certified real estate are ambiguous. Based on these gaps in the existing literature, this study addresses the following hypotheses: in Switzerland, (I) sustainable residential properties are associated with higher construction costs and (II) higher initial rental income is obtained compared to conventional properties. By testing these hypotheses, it is possible to assess the advantages and disadvantages of green building measures and certifications. This study examines whether green investments yield, in general, a favorable cost-benefit ratio. Further, it examines the situation thoroughly to understand the effects of the costs and yields of certification and the

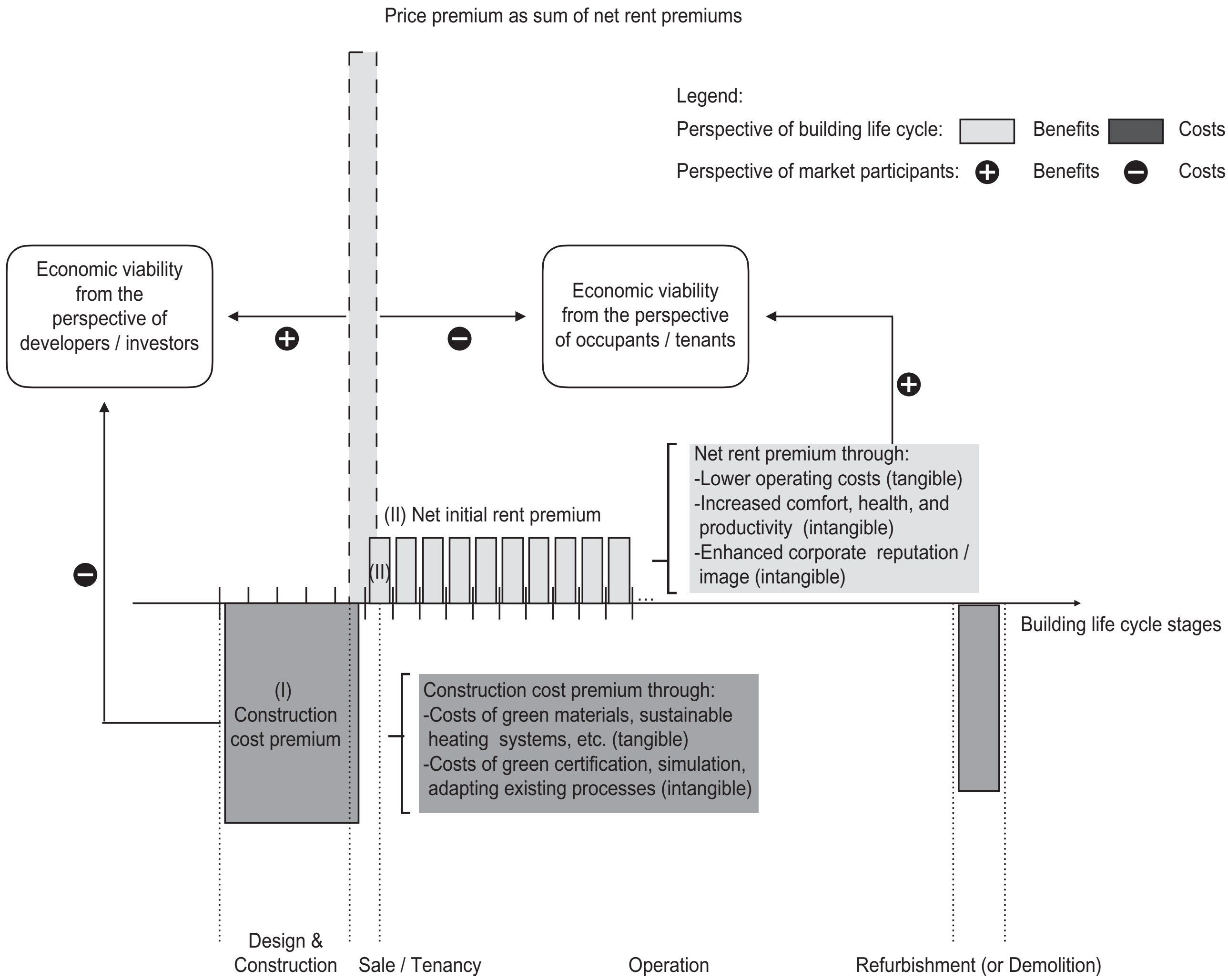

Figure 1. (I) Construction cost premium vs. (II) Net initial rent premium based on Zhang et al. (2018).

underlying building measures that lead to certification.

This study examines "greenness" in two ways. First, the analysis distinguishes between individual (green) construction components and measures that lead to certification—that is, *technology controls* such as non-fossil heating systems, MINERGIE standard roofing, façade, windows, insulation, and controlled room ventilation/comfort ventilation. For example, the analysis compares the construction costs and net initial rents of clean technology such as geothermal energy, which is in line with the certification standard, against conventional fossil-based heating, for which certification is not allowed. Second, hedonic regression specifications include whether a project was certified according to a certain MINERGIE standard or not. Thus, the study addresses whether premiums on construction costs and net rents can be ascribed to a MINERGIE certification, which requires a bundle of sustainable characteristics (MINERGIE, 2022). Therefore, the analysis reveals the cost and rent premiums from the construction measure perspective as well as from the certification perspective. Furthermore, the study controls for *amenity and quality measures* that are independent from certification status, such as green roofing, wood windows, or elevators.

For this purpose, a new data set was assembled. The data include detailed information on construction projects, including costs, and are linked with first-time listing data of the newly constructed dwellings. This unique database is then enriched with information on the existence of MINERGIE certifications.

Based on these data, it is possible to estimate the influence of environmental technology investments that lead to certification and MINERGIE certification itself on construction costs and net initial rents. Comparing the significance and direction of these influences allows a deeper understanding of the costs and yields of certification, including the underlying components. Additionally, the analysis provides insight into the assessment of the cost-benefit ratio of specific green construction measures and certification. Moreover, this study analyzes whether a higher willingness to pay (WTP) for green construction originates from green construction practices or only from certification.

Literature on Green Construction Costs and Rent Premiums

This section reviews relevant publications on green rent and cost premiums in Switzerland and globally, focusing on the residential real estate market.

Swiss Studies on Green Rent Premiums

In Switzerland, studies typically define green buildings based on certain standards such as MINERGIE, SNBS, MuKEn, and SGNI; ratings such as GEAK and ESI; or guidelines such as SIA 112/1, SIA 2040, and NUWEL (Meins, 2014). Most studies that examine a green price or rent premium compare MINERGIE buildings to noncertified controls.

In 2008, Salvi et al. analyzed 9,000 real estate transactions in the canton of Zurich between 1998 and 2008. Two hundred fifty properties were MINERGIE certified and included a green sales price premium of 7% for single-family houses and 3.5% for condominiums. Therefore, the price premium for MINERGIE-certified buildings could partially compensate for the maximum additional costs of 10% prescribed by the MINERGIE association. Salvi et al. (2010) identified net rental premiums for MINERGIE-certified properties of 6.0% for Switzerland and 6.2% for the canton of Zurich. Schuster and Füss (2016) also identified a positive net rental premium of 1.78% for MINERGIE residential properties based on 130,591 rental contracts.

Feige et al. (2013) examined 2,500 residential properties in Switzerland using the five sustainability criteria of the Economic Sustainability Indicator (ESI): (1) flexibility and polyvalence; (2) energy and water consumption; (3) location and mobility; (4) safety; and (5) health and comfort. They found statistically significant higher rental premiums for building characteristics that enhanced water efficiency, health and comfort level, and the safety and security of buildings. Marty et al. (2016) analyzed rental rates based on a similar framework used by Feige et al. (2013). Their analysis revealed that all criteria except flexibility and polyvalence positively impacted rental rates. Furthermore, they found that explicit MINERGIE label requirements, such as high-energy efficiency and comfort ventilation, impacted rental rates, albeit not significantly. This contradicts earlier studies considering MINERGIE rent premium impacts. However, earlier studies on MINERGIE rent premiums did not distinguish between the different dimensions of sustainability. Marty and Meins (2017) analyzed the impact of sustainability features on the existing rents of 3,120 apartments with respect to the ESI rating. The study concluded that health and comfort and location and mobility showed the highest positive effect on net rental income. Additionally, they identified a rental discount for flexibility and heating demand.

Thus, Switzerland-based studies on rent and price premiums of sustainable residential real estate identified significantly positive single-digit markups.

International Studies on Green Rent Premiums

The two predominant international green building labels, LEED and BREEAM, primarily certify commercial and nonresidential buildings, so most global studies have focused on the green rent premiums in the commercial sector, whereas studies on the residential market have been limited. The following section summarizes global studies on green rent premiums in the residential sector.

Fuerst and Dalton (2019) conducted a meta-analysis of 42 international studies that examined the effect of sustainability on rent and sales prices in the residential and commercial property markets. Overall, they reported an average rent premium of 6% and a sales premium of 7.6%. They identified an average rent premium of 8.2% in the residential market. According to the authors, most studies (19 out of 22) on green rent premiums showed a positive rent effect. Only the studies of Fuerst and McAllister (2011), Gabe and Rehm (2014), and Zheng et al. (2012) reported absent or negative rent premiums.

Studies by Cajias and Piazolo (2013), Cajias et al. (2019), Dressler et al. (2017), and Hyland et al. (2013) examined the effects of EPCs and Building Energy Rating (BER) on rents and sales prices. Cajias and Piazolo (2013) used a large panel of German residential buildings to analyze the effect of energy consumption levels on total return and rent prices. They showed that energy-efficient buildings (EPC1) exhibited a 0.76 EUR/m^2 higher rent than inefficient buildings (EPC8). Additionally, the analysis showed a positive effect of 0.015% total return for a 1% reduction in energy consumption. Furthermore, it showed that the market value and rent prices increased by 0.45 and 0.08%, respectively, for a 1% increase in energy efficiency, while holding all other variables constant (ceteris paribus). In a later study, Cajias et al. (2019) examined the influence of EPCs on rental values. They developed hedonic regression models with a sample of 760,000 observations from 403 local markets in Germany. They identified evidence that energy-efficient rental units showed a rental premium and concluded that a landlord who improves the EPC rating from D to A could expect an increase of 1.4% in rent. Additionally, they identified shorter marketing periods of energy-efficient dwellings. Dressler et al. (2017) estimated the effect of EPCs on rents using rental advertisements from 2010–2014 in the Brussels residential rental market. They found rent premiums of 6.8 and 1.9% for green (ABC) and orange (DE) EPC ratings, respectively, compared to the reference of red (FG) EPC ratings. They concluded that highly energy-efficient dwellings earned a rent premium, provided EPCs were disclosed. This premium might incentivize investments in energy efficiency. Additionally, dwellings with mediocre energy performance were penalized for disclosing an EPC, which might provide a strategic motivation to conceal energy performance. Hyland et al. (2013) estimated the effect of energy efficiency on rents and property values based on listings from 2008 to 2012 in Ireland, where the BER was adopted following the EU's EPBD. They found larger premiums for property sales compared to rentals. In the rental market, A-rated properties had 1.8% higher rents, and counterintuitively, B-rated properties had 3.9% higher rents than the reference category of D-rated properties. Lower energy ratings E, F, and G received 1.9, 3.2, and 2.3% lower rents than D-rated properties.

In the US, Bond and Devine (2015) identified an 8.9% rent premium for LEED multifamily rental apartments. Additionally, they found the first indication that LEED certification resulted in an additional markup over noncertified apartments that were advertised as being green (9.1 and 4.7%, for LEED and noncertified buildings, respectively). Therefore, the results showed that LEED certification is more convincing to tenants than an open statement regarding property greenness. Another US study from Koirala et al. (2014) estimated that energy-efficient building codes increased monthly housing rents by 23.25%. The building codes compensated for the higher rents by a 6.47% reduction in monthly energy expenditures. They calculated a net implicit price (or net marginal effect) for these building codes of approximately US$ 140.87 per month in 2006. However, this estimated effect varied significantly by region, energy type, and rent gradient.

In addition to differentiating between certified buildings and their noncertified counterparts, some studies considered other energy-efficient features and sustainable measures in their analysis. Im et al. (2017) analyzed more than 159,000 rental property listings, their attributes, and energy efficiency measures from 10 cities in the US. Using the propensity score matching and conditional mean comparison methods, they analyzed the impact of energy-efficient features on rents in each city. The authors identified energy efficiency premiums for apartment rental units ranging from 3.2% in Indianapolis to 16.1% in Atlanta. For single-family units, they generally identified even higher rental premiums.

A study by Fuerst and Warren-Myers (2018) on sale and lease transactions during 2011–2016 in the Australian Capital Territory revealed that the reported energy-efficiency ratings (EER) and other sustainability-related characteristics influenced the pricing of sales and rental transactions in the residential market. For instance, they found a rental premium of 3.5% associated with 5-star rated dwellings compared to the reference of 3-star rated properties. The 6-, 7-, and 8–10-star rated properties showed 3.6, 2.6, and 3.5% markups, respectively. Additionally, the results indicated rent premiums for systems that did not belong to the formal rating assessment, such as solar photovoltaics (4.8–5.4%) and heating and cooling systems (e.g., reverse cycle heating with 1.3–7.7% rental premiums). They concluded that the reported energy-efficiency level and other attributes that were outside the formal assessment were significantly reflected in rents and sales prices, as tenants and buyers estimated their expected utility charges based on the EER.

Hahn et al. (2018) examined the impact of distinct types of heating technology on prices and rents in German residential real estate markets. They studied whether the obsolescence of heating technology resulted in a significant decrease in price and whether the use of more advanced (and more environmentally friendly) heating systems led to a price premium in the market. The authors divided the heating technologies into three groups: green (e.g., combined heat and power unit, wood pellet heating, thermal solar heating, and thermal heat pumps), standard (e.g., central heating technology, underfloor heating, gas-fueled heating, and nonprogressive or conventional heating technology), and brown (e.g., room-based heating, oven heating technology, oil-fueled heating of any appliance). Their regression analysis on more than 400,000 observations, covering German residential properties in 2015, revealed a premium of 3% on sales and 2.4% on rents for green technologies over standard technologies (reference category). Additionally, they reported a brown discount of 4.2% for sales and 2.4% for rents for properties that explicitly advertised conventional heating technologies, which are obsolete, compared to standard technologies.

In summary, the global literature on green rent premiums shows that the market rewards energy-efficient and certified residential properties with a green positive markup ranging from 1.4% to 23.25% (Table 1).

Swiss Studies on Green Cost Premiums

This section and the one that follows focus on cost premiums in the residential market and are based primarily on the literature reviews provided by Ade and Rehm (2020), Dwaikat and Ali (2016), and Zhang et al. (2018).

In Switzerland, studies on green cost premiums are scarce. Wegner et al. (2010) studied whether a MINERGIE-P certification in a multi- and single-family house incurred additional costs. For these two MINERGIE-P–certified buildings, they simulated conventional twin buildings. Furthermore, they compared the conventional twin with its energy-efficient MINERGIE counterpart. The additional construction costs of a MINERGIE-P–certified building were between 5 and 14% of the total construction costs. The study revealed that the cost premium was primarily due to the additional construction costs and that certification fees played only a minor role. Moreover, only about one-third of the additional construction costs can be compensated by energy cost savings.

The MINERGIE (2011) association requires that the cost premium not exceed 10% for the MINERGIE standard, 15% for the stricter MINERGIE-P standard, and no limits for the most energy-efficient MINERGIE-A standard. Calculations of the MINERGIE (2020) association show that the additional investment costs of a multifamily house with three residential units compared to a building constructed according to the Mustervorschriften der Kantone im Energiebereich (MuKEn14)[2] is between 2.8% for MINERGIE and 6.9% for MINERGIE-P, depending on the building standard.

The MINERGIE (2020) association and Wegner et al. (2010) conclude that sustainable construction in Switzerland is associated with increased construction costs in single-digit percentages.

International Studies on Green Cost Premiums

Ade and Rehm (2020) identified three types of research on cost premiums in both the residential and commercial property markets. First, qualitative surveys were conducted by perception studies of industry professionals (Hwang et al., 2017; Turner Construction Company, 2005, as cited in World Green Building Council, 2013). Second is the quantitative analysis of case study dwellings (Ade, 2018; Kim et al., 2014). Third, the least represented approach is the quantitative analysis of actual capital construction costs of residential dwellings (Ade & Rehm, 2020; Kaplan et al., 2009).

Hwang et al. (2017) conducted a survey-based study of the cost premiums and cost performance of green building projects in Singapore. Most respondents perceived green cost premiums to be between 5 and 10%, with green residential buildings exhibiting the highest additional costs, followed by green commercial and office buildings. These results agreed with the green building barometer published by the Turner Construction Company (2005). The authors reported that experienced building professionals believed the cost increase to be up to 13%. In contrast, inexperienced professionals believed the cost markup to be up to 18%. The study showed that, whereas a lack of experience did increase the perceived cost premiums of green buildings, even experienced professionals tended to overestimate the additional costs.

Ade and Rehm (2020) analyzed the actual capital construction costs of 718 newly built single-family homes in Auckland, New Zealand. Owing to the sensitive nature of property-level construction data, their study is the first to use hedonic cost modeling to analyze actual construction costs of single-family homes. The study identified a 12% cost premium for 6-Homestar certification, comprising 11% hard cost premium and 1% additional soft costs.

In an earlier study, Ade (2018) simulated the modifications that would be required for 10 building code–compliant stand-alone and terraced residential houses in the Auckland region to achieve a Homestar rating of 6–10. The study identified a wide range of results across the different house designs, with cost premiums

Table 1. Literature on green rent premiums in the residential market.

Study	Market	Label	Estimated green premium	Interpretation/Findings
Switzerland-based studies				
Feige et al. (2013)	Residential properties (Switzerland)	ESI	Positive premiums for water efficiency, health and comfort level, and building safety and security from about 9–12%	Positive premiums for a set of sustainability dimensions
Marty et al. (2016)	Residential properties (Switzerland)	ESI	All ESI sustainability criteria, excepting flexibility and polyvalence, exert positive impact on rents. MINERGIE requirements do not	MINERGIE's minimal energy efficiency standard and comfort ventilation exert no significant impact on rents
Marty and Meins (2017)	Residential properties (Switzerland)	ESI	Significant positive effect of health and comfort (i.e., inside air quality, low noise exposure, sufficient natural light), whereas thermal heat usage shows negative sign, indicating negative impact on net rents	Health and comfort as important drivers
Salvi et al. (2008)	Residential properties (Switzerland)	MINERGIE	3.5% (Sales prices for apartments) 7.0% (Sales prices for single-family homes)	General existence of a sales premium
Salvi et al. (2010)	Residential properties (Switzerland)	MINERGIE	6.0% (Rents for Switzerland) 6.2% (Rents for the canton of Zurich)	General existence of a rent premium
Schuster and Füss (2016)	Residential and commercial buildings (Switzerland)	MINERGIE	1.78% (Net rent premium for residential) 13.2% (Net rent premium for commercial)	General existence of a rent premium
International studies				
Bond and Devine (2015)	Residential (US)	LEED	8.9% Rent premium for LEED multifamily rental apartments	Additional premium for LEED (8.9%) compared to noncertified, advertised as being green (4.7%)
Cajias and Piazolo (2013)	Residential (Germany)	Energy performance Certificate (EPC)	Rent difference between low (EPC1) and high (EPC8) consumption: 0.76 EUR /m^2	Energy-efficient buildings yield higher returns and rents than inefficient buildings
Cajias et al. (2019)	Residential (Germany)	Energy Performance Certificate (EPC)	1.4% Rent premium for rating A compared to standard D	Energy-efficient buildings show a rental premium and shorter marketing periods
Dressler et al. (2017)	Residential (Belgium)	Energy Performance Certificate (EPC)	6.8% For green (ABC) EPC, 1.9% for orange (DE) EPC compared to red (FG) EPC rating (reference category)	Energy efficiency and information effect
Fuerst and Warren-Myers (2018)	Residential (Australia)	Energy-efficiency ratings (EER)	3.5, 3.6, 2.6, and 3.5% rent premium of 5-, 6-, 7-, and 8–10-star compared to 3-star rated properties (reference)	Reported energy-efficiency level and other "green" attributes are reflected in rents and sales
Fuerst and Dalton (2019)	Residential & Commercial (International)	Various	Overall market: 6% rent and 7.6% sales premium Residential market: 8.3% average rent premium	19 out of 22 studies find a positive rent effect
Hahn et al. (2018)	Residential (Germany)	Distinct types of heating technology (Green, Standard & Brown)	Green premium: 3% sales and 2.4% rent Brown discount: 4.2% sales and 2.4% rent	Effect of heating technologies on rents and sales
Hyland et al. (2013)	Residential (Ireland)	Building Energy Rating (BER)	Rent premium of 1.8% for A- and 3.9% for B-rated compared to reference category D-rated properties. Rent discount for E, F, and G of −1.9, −3.2, and −2.3%	Energy efficiency has a positive effect on sales and rental prices. Effect on sales is stronger than on rents
Im et al. (2017)	Residential (US)	Analysis of key phrases in listing text	Energy efficiency premiums for apartment rental units ranging from −3.2% in Indianapolis to 16.1% in Atlanta	Impact of energy-efficient features on rents in each city
Koirala et al. (2014)	Residential (US)	International Energy Conservation Code (IECC)	Building codes increase monthly housing rents by 23.25% and compensate higher rents by a 6.47% reduction in monthly energy expenditures	Energy-efficient building codes increase rents and decrease household energy expenditures

Source: Author' representation.

from 3 to 26%. Ade concluded that the case study results from a single dwelling were not representative of a broader sample.

The analysis by Kim et al. (2014) showed that residential projects with a green building code in California, incorporating green building features such as energy-efficient appliances, equipment, and lighting, increased construction costs by 10.77%, compared to a traditional building. Going green required only two additional working days. Their results can be used to broadly evaluate the initial financial investment in a project and compare the benefits of energy cost savings throughout the building life cycle.

Kaplan et al. (2009) compared the costs of 15 LEED residential new construction projects with 22 non-LEED projects. They concluded that the difference between the LEED and non-LEED samples was probably due to natural variations in the population. Student's *t*-test showed no statistically significant cost difference between the LEED and non-LEED samples.

Burnett et al. (2008) examined the costs and financial benefits of office and residential buildings certified as green under the Hong Kong Building Environmental Assessment Method (HK-BEAM). The authors reported a minimum total construction cost premiums of approximately 0–4%, depending on the certification performance grade achieved. The costs of financing, additional design time and fees, and certification fees were not considered. Residential buildings with an HK-BEAM 4 Silver, Gold, and Platinum certification had construction cost premiums of 0.8, 1.7, and 3.4%, respectively. According to Burnett et al. (2008), it would not be appropriate to extrapolate these estimates to a particular development, given the variability of site conditions, building scale, and design and data quality. Nonetheless, these cost premiums could be perceived as representative and indicative of green building stock in Hong Kong.

Glossner et al. (2015) studied the additional costs of LEED-certified single-family homes in Kentucky by communicating with LEED professionals and home building organizations. The study reported premiums of 4, 7, 10, and 13% for LEED Certified, Silver, Gold, and Platinum, respectively—that is, construction costs rose with increasing levels of certification.

Zhang et al. (2018) summarized two Chinese studies from MOHURD of China (2015) and Yip et al. (2013). Both studies reported incremental cost premiums in RMB/m^2, which were converted to percentages using the construction costs of ordinary residential buildings (2,250 RMB/m^2). MOHURD of China (2015) reported incremental costs based on the Chinese Green Building Label (CGBL): 1.0% for 1-star, 2.9% for 2-star, and 5.4% for 3-star. Yip et al. (2013) identified less distinct but similar ranges of cost premiums for residential buildings with a CGBL: 0.0–7.5% for 1-star, 0.9–2.6% for 2-star, and 0.5–7.0% for 3-star.

An extensive cost study of the commercial real estate sector in the UK from Chegut et al. (2019) found that the average marginal cost of green-labeled construction projects was smaller than the price premiums found in the literature. The authors examined a sample of 336 green buildings and 2,060 conventional buildings between 2003 and 2014. On average, the study found a construction cost premium of 6.5%—decreasing with the environmental BREEAM ratings. Buildings with BREEAM ratings of Very Good, Excellent, and Outstanding were built at a higher cost compared to conventional constructions, whereas those with BREEAM Pass or Good ratings showed no cost markup. Additionally, the study found that buildings certified as green exhibit on average an 11% longer construction project duration.

The literature on residential properties showed cost premiums ranging from 0 to 26%, whereas none of the studies reported statistically significant cost discounts. Only Kaplan et al. (2009) failed to find a statistically significant green cost premium. The green cost premiums appeared to increase with the level of certification.

Interestingly, only Ade and Rehm (2020) and Kaplan et al. (2009) performed quantitative analyses to examine the green cost premium in the residential real estate market. However, other than Kaplan et al. (2009), the author knows of no extensive analysis of multifamily houses and their green construction costs. According to Ade and Rehm (2020), the lack of quantitative research is due to the limited accessibility of construction cost information. These data typically remain with the original developer or landlord and are therefore not readily available (Table 2).

Methodology and Model Description

In a hedonic regression model,[3] the *construction costs*/m^2 and *net initial rents*/m^2 (asking data) of multifamily apartments are regressed on their structural attributes, location, and time controls. The results of the hedonic regressions identified the effects of different green and conventional building measures on the costs and expected earnings. Additionally, by including information about whether a building is certified according to MINERGIE or not, it is possible to

Table 2. Literature on green cost premiums in the residential market.

Study	Market	Label	Estimated green cost premium	Interpretation/Findings
Swiss studies				
Wegner et al. (2010)	Residential (Switzerland)	MINERGIE-P	5–14% Cost premium	About one-third of the cost premium can be compensated by energy cost savings
MINERGIE (2011)	Residential (Switzerland)	MINERGIE	MINERGIE association requires a maximum of: 10% cost premium for MINERGIE (standard certification) 15% cost premium for MINERGIE-P none for MINERGIE-A	MINERGIE association defines these cost premium barriers
MINERGIE (2020)	Residential (Switzerland)	MINERGIE	MINERGIE vs. MuKEn14: 2.8% cost premium MINERGIE-P vs. MuKEn: 6.9% cost premium	MINERGIE with slightly higher costs compared to MuKEn
International studies				
Ade (2018)	Residential (New Zealand)	6 to 10-Homestar v4	Cost premiums varied from 3 to 26%	Theoretical analysis on 10 dwellings—cost premiums vary across house designs
Ade and Rehm (2020)	Residential (New Zealand)	6-Homestar certification	12% Cost premium for 6-Homestar certification 11% Hard cost premium and 1% in additional soft costs	First hedonic modeling of actual construction costs of single-family homes
Burnett et al. (2008)	Residentital (HKSAR, China)	HK-BEAM	Platinum: 3.4%, Gold: 1.7%, Silver: 0.8%	Indicative green cost premiums between 0 and 4%
Glossner et al. (2015)	Residential (US)	LEED (single-family home)	Platinum: 13%, Gold: 10%, Silver: 7%, Certified: 4%	Insights from LEED professionals and LEED homebuilding organizations
Hwang et al. (2017)	Office, Commercial & Residential (Singapore)	Green Mark	Mean of green cost premiums residential 4.3–12.5%	Perceived green cost premium around 5–10%
Kaplan et al. (2009)	Residential (US)	LEED	No statistically significant cost premium	No cost difference found
Kim et al. (2014)	Residential (US)	Green Building Code	Single-family residential building cost premium of 10.77% to implement new building code in California	Construction cost increase as a result of implementing green features
MOHURD of China (2015) as reported by Zhang et al. (2018)	Residential (China)	CGBL	3-Star: 5.4%, 2-Star: 2.9%, 1-Star: 1.0%	Study not available
Turner Construction Company (2005) in World Green Building Council (2013)	Residential	Undisclosed	Building professionals with and without experience in constructing green buildings believe the cost premiums to be up to 13 and 18%	Lack of experience tends to overestimate green cost premium
Yip (2013) as reported by Zhang et al. (2018)	Residential (China)	CGBL	3-Star: 0.5–7.0%, 2-Star: 0.9–2.6%, 1-Star: 0.0–7.5%	Study not available

Source: Author's representation.

distinguish between effective sustainable building measures that lead to certification (e.g., heat pumps versus oil heating) and a green labeling certification effect (MINERGIE versus non-MINERGIE).

This approach allows estimation of the relationship between the treatment variables—that is, MINERGIE certification, sustainable building components and measures leading to certification (e.g., nonfossil heating systems, MINERGIE standard roofing, façade, windows, insulation, controlled room ventilation/-comfort ventilation), and additional amenities and quality measures not needed for certification (e.g., green roofing, wood windows, elevator)—as well as the outcome variables *construction costs*/m^2 and *net initial rents*/m^2 (Table 3 for the descriptive statistics of treatment and controls). The model controls for other factors that determine costs and rents, such as size (e.g., number of dwellings, stories, number of rooms), location or centrality (e.g., accessibility by public transport, population density per hectare), and time (year). Following the above methodology, two models (I and II) were formulated for the determination of construction cost and net rent premiums (Table 4). The term *net initial rents* in this study refers to the asking rents of first-time listings. The Swiss residential housing market exhibited low vacancies over the last decade and can be seen as a lessors' market. Therefore, it is reasonable to assume that asking rents equal contractual rents.

Data

Data from building applications (construction data) on newly built residential real estate in Switzerland submitted between January 2010 and June 2020 were used. They were combined with the listings data on net initial rents and label information on MINERGIE certifications. The construction data (from Docu Media Schweiz GmbH) comprised detailed information on structural components such as supporting structures, roofs, roofing, façades, windows, and heating systems. Additionally, there was information on equipment such as conveyor systems, ventilation, and electricity (solar energy). Linked to these construction projects were listings from Fahrländer Partner AG (FPRE), which contains information on the average rents, number of rooms, and living area of projects. Where possible, FPRE linked the construction cost data from Docu Media Schweiz GmbH with the FPRE listing data using geographic matching. To the best of the author's knowledge, this is the first time that extensive data on construction projects could be linked to listing data of first-time lettings in Switzerland. Finally, the author enriched these data with information on MINERGIE certifications, such as whether the project was certified according to a certain MINERGIE standard using the nearest neighbor matching in ArcGIS. Detailed information on the data used is presented in Table 3.

Admission Criteria

The empirical analysis focused on the apartments and condominiums in newly constructed multifamily houses. Single-family houses, terraced houses, holiday homes, or others were excluded from the analysis. Certain admission criteria were imposed on the data to avoid data errors and extreme values or outliers: the analysis considered only apartments that showed construction costs between CHF 100,000 and 2,000,000 per apartment, construction costs between 500 and 10,000 CHF/m^2, and net rents between 100 and 1,000 CHF/$m^2 a$. The construction costs per apartment showed a distinct peak at costs of CHF 500,000. A closer examination of the data revealed that 1,550 projects exhibited exactly CHF 500,000 as the construction cost per apartment. This peak indicated that construction costs were derived partly by the number of apartments during planning. Therefore, the construction cost data should be regarded as reasonable estimates. The histograms and certain other parameters of the response variables are shown in Figure 2 and Table 5.

Discussion of Variables and Descriptive Statistics

Table 3 describes the variables used in the analysis and shows the means separately for certified and noncertified dwellings. Table 3 illustrates how much overlap exists in the use of energy-efficient technologies between certified and noncertified projects and how balanced the sample is for possible quality measures between certified and noncertified buildings. The data can be divided into dependent and independent (structural, location, and time) variables. The dependent variable *Construction costs*/m^2 was defined by dividing the total construction costs by the surface area of the project, which was further derived by dividing the volume (m^3) of projects by 3 m, which corresponded to the approximate average height from floor to floor in residential buildings in Switzerland. Additionally, the square area of a project was included as a size control in the regression to capture the

Table 3. Descriptive statistics of newly constructed multi-family dwellings.

Newly constructed multi-family houses	Variable with data source in footnote	Units	Construction cost sample: Certified ($n = 1{,}118$) Mean	Certified SD	Noncertified ($n = 10, 875$) Mean	Noncertified SD	Net initial rent sample: Certified ($n = 227$) Mean	Certified SD	Noncertified ($n = 3, 335$) Mean	Noncertified SD
Dependent variables	Construction cost per apartment[b]	CHF	449385.3414	203644.2259	446733.6631	197801.9184	487778.0042	252200.6789	467069.9858	245669.7531
	Construction costs/m[2b]	CHF/m^2	2135.4063	753.3928	2096.1719	719.6800	2288.3086	1236.5168	4087.7842	62327.3870
	Net rent/m^2a[d]	CHF/m^2	287.1751	101.9666	293.6619	576.7603	281.6702	94.3080	271.4843	83.1879
Sample	Owner-occupied property[b]	D	0.4741	0.4996	0.4087	0.4916	0.3436	0.4760	0.2945	0.4559
Structural variables	MINERGIE Y/N[e]	D	1.0000	0.0000	0.0000	0.0000	1.0000	0.0000	0.0000	0.0000
	MINERGIE standard[e]	D	0.9150	0.2790	0.0000	0.0000	0.8987	0.3024	0.0000	0.0000
	MINERGIE-P or higher[e]	D	0.0850	0.2790	0.0000	0.0000	0.1013	0.3024	0.0000	0.0000
	Number of apartments[b]	Apartments	16.9759	23.1528	16.0709	26.4631	19.5595	27.3714	13.5346	19.1538
	Square area per project (VOLUME/3 m) [estimated][b]	m^2	3431.1622	4519.9777	3320.0083	5382.2540	4102.7847	5135.6326	2862.2410	4198.5954
	Square area per apartment [estimated][b]	m^2	217.8972	85.5770	220.1153	84.2089	244.9220	245.3839	227.7206	131.6168
	Stories[b]	Stories	3.5984	1.3609	3.5705	1.3849	3.8767	1.6000	3.6579	1.3545
	Mean net floor area[d]	m^2	101.7150	42.9675	105.5882	211.5633	102.2845	40.4133	101.0909	33.0203
	Mean number of rooms[d]	Rooms	3.7227	1.1930	3.7753	1.2198	3.7975	1.0748	3.7862	1.0515
Roofing[b]	**MINERGIE standard**	D	0.0787	0.2694	0.0538	0.2256	0.0969	0.2965	0.0546	0.2272
Roofing finishes[b]	Green roofing	D	0.2952	0.4563	0.3282	0.4696	0.4846	0.5009	0.4009	0.4902
Façade[b]	**MINERGIE standard**	D	0.0832	0.2763	0.0573	0.2324	0.1013	0.3024	0.0558	0.2295
	Wood	D	0.1869	0.3900	0.1516	0.3587	0.1322	0.3394	0.1151	0.3192
	Metal/steel/light metal	D	0.0224	0.1479	0.0161	0.1258	0.0308	0.1733	0.0147	0.1203
	Natural stone	D	0.0224	0.1479	0.0142	0.1182	0.0132	0.1145	0.0114	0.1062
	Glass	D	0.0331	0.1790	0.0219	0.1463	0.0617	0.2411	0.0228	0.1493
	Façade elements: concrete/lightweight concrete/artificial stone	D	0.0179	0.1326	0.0121	0.1095	0.0132	0.1145	0.0114	0.1062
	Ventilated curtain façades	D	0.1011	0.3016	0.1076	0.3099	0.1454	0.3533	0.1226	0.3281
	Fiber cement plates	D	0.0259	0.1590	0.0299	0.1703	0.0352	0.1848	0.0372	0.1892
	Ceramic	D	0.0054	0.0731	0.0075	0.0865	0.0088	0.0937	0.0078	0.0880
	Exposed masonry/brickwork	D	0.0089	0.0942	0.0080	0.0891	0.0176	0.1319	0.0069	0.0828
	Sandwich panels	D	0.0036	0.0597	0.0048	0.0690	0.0044	0.0664	0.0027	0.0519
	Exposed concrete	D	0.0322	0.1766	0.0280	0.1648	0.0264	0.1608	0.0282	0.1655
	Compact façades	D	0.0143	0.1188	0.0160	0.1255	0.0264	0.1608	0.0174	0.1307
	Façades without specifications	D	0.0546	0.2272	0.0579	0.2336	0.0661	0.2490	0.0738	0.2614
	Ref. Cat. = Plastered masonry/brickwork		0.7639	0.4249	0.7635	0.4250	0.7093	0.4551	0.7412	0.4380
Windows[b]	**MINERGIE standard**	D	0.0796	0.2708	0.0553	0.2285	0.0969	0.2965	0.0552	0.2284
	Wood windows	D	0.0778	0.2680	0.0543	0.2265	0.0220	0.1471	0.0372	0.1892
	Metal/lightweight metal windows	D	0.0564	0.2307	0.0419	0.2004	0.0132	0.1145	0.0243	0.1540
	Thermal and acoustic insulated windows	D	0.9991	0.0299	0.9992	0.0288	1.0000	0.0000	0.9985	0.0387
	Balcony and terrace windows	D	0.0286	0.1668	0.0144	0.1193	0.0220	0.1471	0.0093	0.0960
	Wood/metal windows	D	0.2889	0.4535	0.2954	0.4562	0.4097	0.4929	0.3346	0.4719
	Windows without specifications	D	0.0608	0.2391	0.0657	0.2479	0.0881	0.2841	0.0930	0.2904
	Ref. Cat. = Plastic windows		0.3131	0.3131	0.3260	0.4688	0.2423	0.4294	0.2747	0.4464
Electricity[b]	**Solar energy**	D	0.0707	0.2564	0.0819	0.2743	0.0749	0.2638	0.0615	0.2402
Supporting structure[b]	Wood	D	0.0903	0.2868	0.0870	0.2818	0.0793	0.2708	0.0762	0.2653
	Brick	D	0.6914	0.4621	0.7274	0.4453	0.7753	0.4183	0.7637	0.4249
	Aerated concrete blocks	D	0.0116	0.1073	0.0060	0.0771	0.0044	0.0664	0.0018	0.0424
	Sand-lime brick	D	0.0036	0.0597	0.0017	0.0418	0.0000	0.0000	0.0018	0.0424
	Skeleton construction (concrete, steel, wood)	D	0.0215	0.1450	0.0141	0.1178	0.0132	0.1145	0.0078	0.0880
	Steel	D	0.0188	0.1358	0.0142	0.1182	0.0176	0.1319	0.0111	0.1048
	Double-shell masonry/brickwork	D	0.0322	0.1766	0.0234	0.1513	0.0132	0.1145	0.0201	0.1403
	Exposed masonry/brickwork	D	0.0009	0.0299	0.0016	0.0395	0.0044	0.0664	0.0003	0.0173

(*continued*)

Table 3. Continued.

Newly constructed multi-family houses	Variable with data source in footnote	Units	Construction cost sample				Net initial rent sample			
			Certified ($n = 1,118$)		Noncertified ($n = 10, 875$)		Certified ($n = 227$)		Noncertified ($n = 3, 335$)	
			Mean	SD	Mean	SD	Mean	SD	Mean	SD
	Single-layer masonry/brickwork	D	0.0116	0.1073	0.0121	0.1095	0.0176	0.1319	0.0171	0.1296
	Supporting structure without specifications	D	0.0635	0.2440	0.0711	0.2570	0.0837	0.2776	0.0822	0.2746
	Ref. Cat. = Concrete		0.9275	0.2593	0.9208	0.2700	0.9383	0.2411	0.9163	0.2769
Heating[b]	**District heating**	D	0.0894	0.2855	0.0922	0.2894	0.1454	0.3533	0.0870	0.2818
	Heat pumps	D	0.6637	0.4727	0.6188	0.4857	0.6211	0.4862	0.5730	0.4947
	Solar heating systems	D	0.1556	0.3627	0.2017	0.4013	0.1542	0.3619	0.1598	0.3665
	Geothermal energy/ground probes/ collectors	D	0.3023	0.4595	0.2979	0.4574	0.3480	0.4774	0.2984	0.4576
	Wood-fired heating	D	0.0116	0.1073	0.0187	0.1354	0.0000	0.0000	0.0108	0.1034
	Wood-chip heating	D	0.0072	0.0843	0.0055	0.0741	0.0132	0.1145	0.0051	0.0712
	Pellet heating	D	0.0358	0.1858	0.0262	0.1598	0.0441	0.2057	0.0210	0.1434
	Controlled room ventilation/comfort ventilation	D	0.1145	0.3185	0.0839	0.2772	0.2026	0.4029	0.0939	0.2917
	Gas-fired heating	D	0.1118	0.3153	0.1626	0.3690	0.1189	0.3244	0.1856	0.3888
	Electric heating	D	0.0063	0.0789	0.0026	0.0507	0.0000	0.0000	0.0006	0.0245
	Chimney/Chimney stove	D	0.1073	0.3097	0.0943	0.2923	0.0969	0.2965	0.0711	0.2570
	Floor heating	D	0.6449	0.4788	0.6680	0.4710	0.7753	0.4183	0.7694	0.4213
	Radiators/Flat panel radiators	D	0.0089	0.0942	0.0073	0.0849	0.0044	0.0664	0.0108	0.1034
	Heating without specifications	D	0.0841	0.2776	0.0833	0.2764	0.0881	0.2841	0.1310	0.3375
	Ref. Cat. = Oil-fired heating		0.0125	0.1113	0.0125	0.1111	0.0088	0.0937	0.0102	0.1005
Insulation[b]	**MINERGIE standard**	D	0.1020	0.3027	0.0618	0.2408	0.1013	0.3024	0.0567	0.2312
	Internal thermal insulation	D	0.0510	0.2201	0.0477	0.2132	0.0308	0.1733	0.0474	0.2125
	External thermal insulation	D	0.5859	0.4928	0.5665	0.4956	0.6960	0.4610	0.6441	0.4789
	In-between thermal insulation	D	0.0572	0.2324	0.0577	0.2333	0.0749	0.2638	0.0594	0.2364
	Thermal insulation of earth-contacting components	D	0.1691	0.3750	0.2018	0.4014	0.0793	0.2708	0.1121	0.3156
	Insulation and seal without specifications	D	0.1377	0.3448	0.1143	0.3182	0.1101	0.3137	0.1205	0.3256
Flooring[b]	Floor underlay	D	1.0000	0.0000	0.9983	0.0407	1.0000	0.0000	0.9985	0.0387
	Artificial stone flooring	D	0.0903	0.2868	0.0794	0.2703	0.0529	0.2243	0.0660	0.2483
	Parquet flooring	D	0.5340	0.4991	0.5811	0.4934	0.5595	0.4975	0.5826	0.4932
	Linoleum flooring/synthetic flooring	D	0.0072	0.0843	0.0062	0.0783	0.0044	0.0664	0.0051	0.0712
	Textile flooring	D	0.0107	0.1031	0.0075	0.0865	0.0176	0.1319	0.0060	0.0772
	Ceramic flooring	D	0.7335	0.4424	0.7528	0.4314	0.7401	0.4396	0.7298	0.4441
	Wooden flooring	D	0.0170	0.1293	0.0135	0.1155	0.0000	0.0000	0.0069	0.0828
	Concrete flooring	D	0.6449	0.4788	0.6416	0.4796	0.6696	0.4714	0.6318	0.4824
	Raised/false flooring	D	0.0367	0.1880	0.0411	0.1985	0.0529	0.2243	0.0546	0.2272
	Natural stone flooring	D	0.0250	0.1563	0.0139	0.1170	0.0132	0.1145	0.0120	0.1089
	Laminate flooring	D	0.0188	0.1358	0.0177	0.1320	0.0044	0.0664	0.0177	0.1318
	Industrial jointless flooring	D	0.0063	0.0789	0.0053	0.0728	0.0044	0.0664	0.0090	0.0944
Equipment[b]	Air conditioner	D	0.0027	0.0518	0.0027	0.0516	0.0000	0.0000	0.0024	0.0489
	Conveyor system	D	0.7612	0.4266	0.7679	0.4222	0.8502	0.3576	0.7988	0.4010
	Sun and weather protection	D	0.9991	0.0299	0.9992	0.0288	1.0000	0.0000	0.9988	0.0346
	Building automation	D	0.6601	0.4739	0.6817	0.4658	0.7137	0.4531	0.7037	0.4567
	Safety technology	D	0.6691	0.4708	0.6923	0.4616	0.7225	0.4488	0.7106	0.4535
	Garage gate	D	0.7469	0.4350	0.7632	0.4251	0.7797	0.4153	0.7682	0.4220
	Landscaping	D	0.9991	0.0299	0.9971	0.0533	1.0000	0.0000	0.9955	0.0669
	Cooling systems	D	0.0483	0.2145	0.0498	0.2176	0.0617	0.2411	0.0606	0.2386
	Tank installations (areas with heating)	D	0.0009	0.0299	0.0007	0.0271	0.0000	0.0000	0.0009	0.0300
	Terraces/balconies	D	0.9946	0.0731	0.9939	0.0777	0.9956	0.0664	0.9934	0.0810
	Ventilation	D	0.6288	0.4833	0.6617	0.4732	0.6960	0.4610	0.6798	0.4666

(*continued*)

Table 3. Continued.

Newly constructed multi-family houses	Variable with data source in footnote	Units	Construction cost sample				Net initial rent sample			
			Certified ($n = 1{,}118$)		Noncertified ($n = 10{,}875$)		Certified ($n = 227$)		Noncertified ($n = 3{,}335$)	
			Mean	SD	Mean	SD	Mean	SD	Mean	SD
	Habitat/pond	D	0.0009	0.0299	0.0004	0.0192	0.0000	0.0000	0.0006	0.0245
	Pergola	D	0.1199	0.3249	0.1267	0.3327	0.1322	0.3394	0.1373	0.3442
	External lighting	D	0.0403	0.1966	0.0352	0.1843	0.0308	0.1733	0.0258	0.1585
	Irrigation system	D	0.0000	0.0000	0.0004	0.0192	0.0000	0.0000	0.0003	0.0173
	Controlled parking system	D	0.0036	0.0597	0.0011	0.0332	0.0000	0.0000	0.0006	0.0245
Locational variables	Population density per hectare[c]	People/ha	37.8649	45.1422	42.8879	45.7290	57.0573	51.0736	56.0000	50.3577
	Accessibility by public transport[a]	D								
	Mobilité Spatiale regions[b]	D								
Time fixed effects	Year of building application[b]	Year	2013.7996	2.8166	2014.6384	2.9387	2013.5815	2.4542	2014.3832	2.6710

Source: Data from [a]ARE (2020b), [b]Blaublatt/Bauinfo-Center Docu Media (2020), [c]FSO (2018), [d]FPRE (2020), [e]MINERGIE (2021).
Legend: (A) certificates (light gray), (B) technology controls that lead to certification (bold), (C) amenity controls independent from certification (gray).

economies of scale in construction. The second response variable *Net rent/m²a* indicated the net rent in CHF paid per square meter per year for the initial letting of the average apartment or condominium in a project. Parallel to the construction costs model, *mean net floor area* was added as a size control in the regression to capture decreasing marginal return—that is, that total rents rise with square meters more slowly than 1 for 1. Table 5 shows that the average construction cost for new multifamily dwellings was approximately 2,100 CHF/m^2. The net initial rent was approximately 272 CHF/m^2a.

The Swiss Federal Statistical Office (FSO, 2021a) reported the average actual rent to be 196.8 CHF/m^2a in 2019. Therefore, the net initial rent in this sample was 38% higher than the existing average rent in Switzerland. This was expected because the FSO (2021a) average rent reflected the protected existing rents, whereas the listing data included only first-time rentals, where rents could be set according to the market.

The dummy *owner-occupied property* was used to differentiate between rental and property (condominium) markets. Forty-one percent of the projects were owner-occupied multifamily houses in the construction sample. Approximately 30% of the net rent sample were condominium projects. The rentals in the owner-occupied market were buy-to-let investments. Apartments in the rental housing market were typically units of an apartment building owned by a single owner. The certified dwellings has a 5–7% higher share of owner-occupied properties than the noncertified apartments.

The primary variables of interest were MINERGIE dummies, indicating whether a project was built according to any MINERGIE standard (MINERGIE: Y/N) or whether it meets the criteria of MINERGIE (standard certification) or MINERGIE-P or higher. Approximately, 9% of the construction cost sample had a MINERGIE certification, and 6% of the net rent sample had a MINERGIE certification. The detailed certification parameter descriptions are presented in Table 6.

The descriptive statistics on certification showed that MINERGIE and noncertified apartments exhibited a similar number of apartments, building height, floor area, and number of rooms, indicating the comparability of the treatment and control samples. Comparing the average construction costs/m^2 of MINERGIE (standard certification) and MINERGIE-P or higher with noncertified buildings showed a cost markup of 1.8 and 3.0%, respectively. Looking at the

Table 4. Model description.

(I)		$\ln\left(Construction\ costs/\mathrm{m}^2\right) = c_0 + \beta z_i + \gamma l_i + \phi t_i + \epsilon_i,$
(II)		$\ln\left(Net\ rent/\mathrm{m}^2\ and\ year_i\right) = c_0 + \beta z_i + \gamma l_i + \phi t_i + \epsilon_i,$
where:		
c_0	=	Constant
β, γ, ϕ	=	Vectors of regression coefficients or implicit hedonic prices
z_i	=	z_i Vector of structural variables market, project size, and individual components of the construction project:
	–	MINERGIE
		MINERGIE Y/N
		MINERGIE, "MINERGIE-P or higher"
	–	Market
		Owner-occupied property market (=dummy variable), rental market and total market (both)
	–	Size
		ln(Number of apartments)
		ln(Square area per project)
		ln(Stories)
		ln(Mean net floor area)
		ln(Mean number of rooms)
	–	Individual components of construction project (see Appendices A1 and A2)
l_i	=	l_i vector of locational variables of construction project:
	–	Mobilité Spatiale regions: 1 to 106, reference category = MS 1 (City of Zurich)
	–	Accessibility by public transport "ÖV-Güteklasse," A, B, C, D, none (=reference category)
	–	Population density per hectare: Permanent population, total per hectare
t_i	=	t_i vector of time trend variable of construction project:
	–	Year 2010 to 2020 (reference category = 2010), year in which the construction application was approved
ϵ_i	=	Error term

average net initial rents/m^2a, MINERGIE (standard certification) showed a 2.4% markup, and MINERGIE-P or higher exhibited a 15.0% markup. These descriptive statistics provided the first indication of cost and rental premiums in the data, although the analysis did not control for covariates here.

The structural variables (*number of apartments* and *stories*) were considered the control for project size in the construction cost data set. The values of *mean net floor area* and *mean number of rooms* were considered the control for the average apartment size in the rental dataset. On average, approximately 14–16 apartments with approximately 3.6 stories were constructed per project in the new multifamily dwellings. The FPRE (2020) rental data reported an average net floor area of approximately 100 m^2 per apartment with 3.8 rooms. This indicates that the net floor area approximately corresponded to the average apartment size of 99 m^2, as per the Swiss Federal Statistical Office (FSO, 2021b). The construction data provided detailed information on roofing, roofing finishes, façade, windows, supporting structures, heating, insulation, and electricity. The building data were modeled as dummy variables that assumed the value 1 or 0 based on whether an attribute was present or not, respectively. Thus, the mean values corresponded to the percentage frequency of a characteristic (Table 3). For instance, green roofing was present in approximately 30% of the certified and 33% of the noncertified newly constructed multifamily houses in the construction cost sample. Wooden façades and supporting structures were used in approximately every seventh to eleventh project. Over 60% of the newly constructed multifamily dwellings were equipped with heat pumps as part of the heating system. The presence of other heating systems was considerably lower. For instance, oil-fired heating was used only in about 1% of the projects. Solar heating systems were used in 15–20% of the certified and noncertified projects. In 7–8% of the projects, solar energy was used for electricity generation.

The energy-efficient technologies that lead to certification are printed in bold in Table 3. MINERGIE standard roofing, façade, windows, and insulation clearly occur more frequently in the certified construction cost and net initial rent sample. Moreover, controlled room ventilation/comfort ventilation is mentioned more often in certified construction projects. The nonfossil efficient technologies, such as district heating, heat pumps, solar heating systems, geothermal energy, wood-fired heating, wood-chip heating, and pellet heating, overlap by approximately ±5% for the certified and noncertified samples. Gas-fired heating is built in approximately 11% of the certified and 16–19% of the noncertified projects.

Certification might correlate with many unobservable factors, not just additional unobservable investments required for certification beyond the observable investments. Investors who plan to certify a building might tend to design that structure to be more attractive in terms of other amenities, not just green features. This issue of unobservables is well examined in relation to housing prices and school quality in the work of Clapp et al. (2008) and Dhar and Ross (2012). The planning application contains a detailed description of building measures and materials.

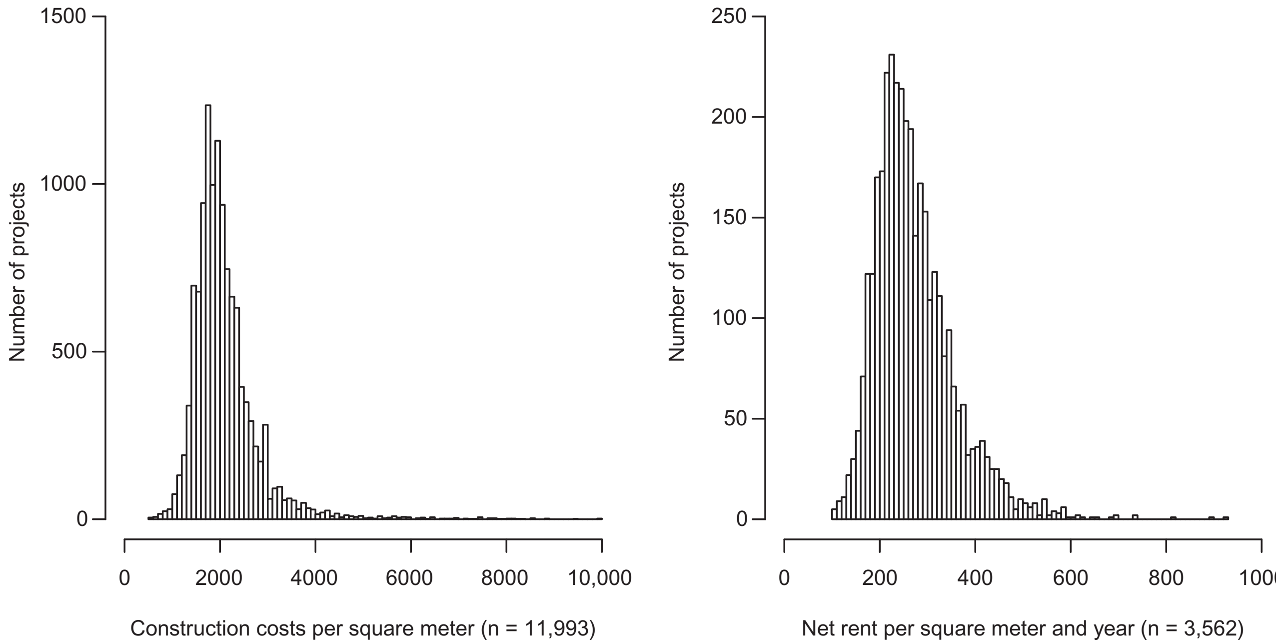

Figure 2. Histograms of construction costs/m² and net initial rent/m²a.

Table 5. Descriptive statistics of construction costs/m² and net rent/m²*a*.

	Construction costs/m²*a* in CHF	Net rent (CHF/m²*a*)
n	11,993	3,562
Mean	2,100	272.13
SD	723	83.96
Median	1,957	256.17
Min	553	100.54
Max	10,000	921.60
Skew	3.11	4.19
Kurtosis	18.17	1.41

Source: Data from Blaublatt/Bauinfo-Center Docu Media (2020), FPRE (2020).

Quality measures and amenities not necessarily needed for certification are shaded in gray in Table 3. Approximately 5–10% of the data specifications on façades, windows, supporting structure, heating, and insulation and seal are missing or unobservable (data without specifications). In most cases, detailed information on the building parts is available. There is a balanced distribution of quality measures between certified and noncertified buildings. Some visible quality characteristics, such as wood, natural stone, or glass façade and natural stone flooring, appear more often in certified projects, reflecting the high quality of these buildings. However, the presence of these high-quality characteristics in the certified projects was infrequent at 2–19%. For most quality characteristics, there was a large overlap between certified and noncertified dwellings, which supports the comparability of the samples.

Furthermore, the regression models controlled for location using Mobilité Spatiale (MS) regions, public transport quality (ÖV-Güteklasse), and population density per hectare. According to Schuler et al. (2005), the 106 MS regions (Table 4) represent area-wide, economically homogeneous microregions. For example, the cities of Zurich, Basel, and Geneva corresponded to MS regions 1, 47, and 105, respectively. According to the Federal Office for Spatial Development (ARE, 2020b), the public transport quality classes are essential indicators of accessibility by public transport. The accessibility quality is categorized into classes A (very good accessibility), B (good accessibility), C (medium accessibility), D (low accessibility), and *none* (marginal or no public transport accessibility) (ARE, 2020a). The Statistics of Population and Households (STATPOP) provided another location or density criterion (FSO, 2018). The population density was assigned a numeric variable representing the total permanent residential population per hectare for each project. Table 3 shows that certified multifamily dwellings were built in areas with an average population density of 38 persons per hectare. The projects in the noncertified sample were built in areas with an average of 43 persons per hectare. Therefore, MINERGIE-certified buildings are built in less densely populated areas.

Finally, the regression model controlled for time effects by modeling the year of the building application for each project as a categorical variable using dummy coding. Thus, the model accounted for annual effects such as general economic conditions, price levels of construction costs, and vacancy rates. The reference year was 2010.

Table 6. Descriptive statistics of MINERGIE-certified and noncertified projects.

	Construction cost sample					Net rent sample					
New construction Multi-family houses	Observations (*n*)	Construction costs/m^2	Construction costs per apartment in CHF	Number of apartments	Stories	Observations (*n*)	Net rent/m^2/a in CHF	Number of apartments	Stories	Mean net floor area	Mean number of rooms
Overall	11,993					3,562					
Mean		2099.83	446981	16.16	3.57		272.13	13.92	3.67	101.17	3.79
Median		1956.82	408000	8	3		256.17	8	3	97.5	3.69
Std. Dev.		722.95	198347	26.17	1.38		83.96	19.83	1.37	33.53	1.05
Certified MINERGIE or not	1,118					227					
Mean		2135.41	449385	16.98	3.60		281.67	19.56	3.88	102.28	3.8
Median		1956.76	415909	9	3		261.82	9	4	97.24	3.64
Std. Dev.		753.39	203644	23.15	1.36		94.31	27.37	1.6	40.41	1.07
Certified MINERGIE	1,023					204					
Mean		2133.27	447855	16.94	3.58		278.22	19.64	3.89	102.65	3.8
Median		1955.99	416667	8	3		260.43	9	4	96.98	3.63
Std. Dev.		745.36	199949	23.41	1.35		93.25	27.68	1.61	40.67	1.05
Certified MINERGIE-P or higher	95					23					
Mean		2158.37	465862	17.35	3.77		312.31	18.83	3.74	99.07	3.77
Median		2000	413333	9	4		295.02	8	3	98	3.83
Std. Dev.		839.06	240477	20.3	1.43		100.22	24.99	1.51	38.81	1.28
Noncertified	10,875					3,335					
Mean		2096.17	446734	16.07	3.57		271.48	13.53	3.66	101.09	3.79
Median		1957.33	406429	8	3		255.91	8	3	97.62	3.69
Std. Dev.		719.68	197802	26.46	1.38		83.19	19.15	1.35	33.02	1.05
MINERGIE											
MINERGIE	1,013					204					
MINERGIE-ECO	10					0					
Certified MINERGIE	1023					204					
MINERGIE-P	67					18					
MINERGIE-P-ECO	14					1					
MINERGIE-A	11					4					
MINERGIE-A-ECO	3					0					
Certified MINERGIE-P or higher	95					23					

Source: Data from ARE (2020), Blaublatt/Bauinfo-Center Docu Media (2020), FSO (2018), FPRE (2020), MINERGIE (2021).

Table 3 shows the descriptive statistics of specific relevant attributes considered in this study.

Estimation Results and Discussion

The regression results are presented in the following sections. First, the distinction between MINERGIE-certified properties and noncertified buildings is discussed. Subsequently, results for the individual building measures, such as heating systems, façades, roofing finishes, and electricity, are discussed.

The analysis commences by running a model that omits the key *technology controls* that lead to certification and includes only the *certification* (see specifications [III] and [IV] in Tables 7 and 8). This allows us to observe estimates for the energy-efficient investments leading to certification separately from certification (see specifications [I]–[VI] in Tables 7 and 8). Additionally, these specifications reveal the total cost of or return from certification and how much of that cost or return is explained by adding the observable environmental investments that lead to certification.

Moreover, there are quality and amenity controls that are independent from certification status. However, as the descriptive statistics showed (Table 3), many of the high-quality characteristics were slightly overrepresented in certified buildings. Running regressions with and without these extra controls showed that adding these variables eroded the estimates on certification and the green investments made in the building (compare specifications [III]–[VI] vs. [VII]–[VIII] in Tables 7 and 8).

Additionally, the model was rerun for environmental technology investments that lead to certification and amenity and quality controls separately for certified and noncertified buildings (see Appendices Table C1 and C2). Regressing construction costs and net initial rents on the environmental technology and amenity controls separately for certified and noncertified buildings led to a deeper understanding of these explanatory variables within the treated and nontreated groups. For instance, it answered the following questions: Is there a higher cost and return premium to environmental technologies within noncertified buildings? Additionally, are the cost (and return) markups for green investments smaller within certified buildings?

Cost and yield effects of MINERGIE-certified apartments

Adding the MINERGIE labeling information to the base regression specification [I] (Table 7) maintained the robustness of the effects of other technology controls in specifications [V] and [VI], while increasing the coefficients of determination, R^2, marginally. The same held true if *amenity controls* were added to specifications [II] and [VII] and [VIII]. The regression specifications [III], [V], and [VII] included information on whether a dwelling was certified according to MINERGIE (see line a in Tables 7 and 8). The specifications [IV], [VI], and [VIII] considered a more differentiated view and distinguished between the MINERGIE (standard certification) and MINERGIE-P or higher certification (see lines b and c in Tables 7 and 8).

Starting with a model that omits the key *technology and amenity controls* and includes only the *certificates*, the market showed a positive construction cost premium of $e^{0.0251} - 1 = 2.6\%$ for MINERGIE versus noncertified buildings (see specification [III] in Table 7). The cost premiums were 2.2% and 5.9% for MINERGIE (standard certification) and MINERGIE-P or higher (see specification [IV] in Table 7).

Adding the key technology controls that lead to certification to this model also led to specifications [V] and [VI]. As expected, cost premiums for certification according to MINERGIE erode down to 2.2% (see specification [V] in Table 7), and those for MINERGIE (standard certification) and MINERGIE-P or higher decreased to 1.9 and 5.5%, respectively.

Additionally, controlling quality and amenities that do not necessarily contribute to green status further erodes the cost premium for MINERGIE certification to 1.9% (see specification [VII]). The cost premiums for MINERGIE (standard certification) and MINERGIE-P or higher decrease to 1.6 and 5.1% (see specification [VIII]).

The results show that even after controlling for *technology* and *amenity controls*, a statistically significant cost premium for MINERGIE certification persists. Only a part of the certification cost is explained by adding the observable environmental investments that lead to certification.

Additionally, the regressions were run separately for the certified and noncertified samples. The construction cost coefficients within the noncertified group showed significant premiums for almost all environmental technology investments that would lead to certification, including district heating, geothermal energy, wood-chip heating, pellet heating, controlled room ventilation/comfort ventilation, MINERGIE standard insulation, and solar energy (see specifications (C) and (D) in Appendices Table C1 and C2). In contrast, the green technology investments within

Table 7. Regression results of construction costs/m^2.

			Specifications	(I)	(II)	(III)	(IV)	(V)	(VI)	(VII)	(VIII)
			A) Certificates			[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
			B) Technology controls	[redacted]	[redacted]			[redacted]	[redacted]	[redacted]	[redacted]
			C) Amenity controls		[redacted]					[redacted]	[redacted]
			D) Market & size controls	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
			E) Location controls	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
			F) Time controls	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
			G) Constant	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
			H) Regression statistics	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
		OLS		Construction costs/m^2							
		Specifications		(I)	(II)	(III)	(IV)	(V)	(VI)	(VII)	(VIII)
		Dependent variable:		ln(Construction costs/m^2)							
		Structural variables:									
	Line:										
A) Certificates	a	Certificates Ref. Cat. = Noncertified buildings	MINERGIE Y/N			0.0251*** (0.0079)		0.0220*** (0.0079)		0.0187** (0.0077)	
	b		MINERGIE				0.0219*** (0.0082)		0.0189** (0.0082)		0.0157* (0.0081)
	c		MINERGIE-P or higher				0.0577** (0.0244)		0.0535** (0.0246)		0.0496** (0.0241)
B) Technology controls	d	Roofing Ref. Cat. = all others	**MINERGIE standard**	0.0257 (0.0314)	0.0184 (0.0310)			0.0256 (0.0313)	0.0254 (0.0313)	0.0186 (0.0309)	0.0183 (0.0309)
	e	Façade Ref. Cat. = all others for Spec. (1), (5) & (6) Ref. Cat. = Plastered masonry/brickwork for Spec. (2), (7) & (8)	**MINERGIE standard**	0.0315 (0.0356)	0.0090 (0.0365)			0.0318 (0.0355)	0.0329 (0.0355)	0.0095 (0.0364)	0.0102 (0.0364)
	f	Windows Ref. Cat. = all others for Spec. (1), (5) & (6) Ref. Cat. = Plastic windows for Spec. (2), (7) & (8)	**MINERGIE standard**	−0.0594 (0.0450)	−0.0685 (0.0438)			−0.0593 (0.0451)	−0.0592 (0.0451)	−0.0683 (0.0439)	−0.0682 (0.0438)
	g	Heating Ref. Cat. = all others for Spec. (1), (5) & (6) Ref. Cat. = Oil-fired heating for Spec. (2), (7) & (8)	**District heating**	0.0277*** (0.0094)	0.0489*** (0.0135)			0.0273*** (0.0094)	0.0273*** (0.0094)	0.0484*** (0.0135)	0.0487*** (0.0135)
	h		**Heat pumps**	−0.0033 (0.0064)	0.0281** (0.0120)			−0.0036 (0.0064)	−0.0035 (0.0064)	0.0278** (0.0120)	0.0280** (0.0120)
	i		**Solar heating systems**	−0.0008 (0.0069)	0.006 (0.0071)			−0.0006 (0.0069)	−0.0006 (0.0069)	0.0061 (0.0071)	0.0061 (0.0071)
	j		**Geothermal energy/ ground probes/collectors**	0.0369*** (0.0059)	0.0311*** (0.0058)			0.0368*** (0.0059)	0.0367*** (0.0059)	0.0310*** (0.0058)	0.0310*** (0.0058)
	k		**Wood-fired heating**	0.0097 (0.0174)	0.0279 (0.0189)			0.0103 (0.0174)	0.0104 (0.0174)	0.0283 (0.0189)	0.0285 (0.0189)
	l		**Wood chip heating**	0.0313 (0.0235)	0.0504** (0.0239)			0.0308 (0.0234)	0.0307 (0.0234)	0.0498** (0.0239)	0.0498** (0.0239)
	m		**Pellet heating**	0.0392** (0.0154)	0.0596*** (0.0173)			0.0390** (0.0154)	0.0392** (0.0154)	0.0594*** (0.0173)	0.0597*** (0.0173)

(*continued*)

Table 7. Continued.

			Specifications	(I)	(II)	(III)	(IV)	(V)	(VI)	(VII)	(VIII)
	n		**Controlled room ventilation/ comfort ventilation**	0.0184*	0.0180*			0.0174*	0.0177*	0.0171*	0.0175*
				(0.0099)	(0.0099)			(0.0099)	(0.0100)	(0.0099)	(0.0099)
	o	Insulation	**MINERGIE standard insulation**	0.0217	0.0545*			0.0206	0.019	0.0529*	0.0520*
		Ref. Cat. = all, but MINERGIE standard for Spec. (1), (5) & (6)		(0.0219)	(0.0281)			(0.0219)	(0.0220)	(0.0281)	(0.0282)
		Ref. Cat. = all others (2), (7) & (8)									
	p	Electricity	**Solar energy (electricity)**	0.0300***	0.0247***			0.0299***	0.0298***	0.0246***	0.0246***
		Ref. Cat. = all others		(0.0080)	(0.0080)			(0.0080)	(0.0080)	(0.0080)	(0.0080)
C) Amenity Controls					Appendix Tables A2 and B1					Appendix Tables A2 and B1	Appendix Tables A2 and B1
D) Market & size controls	q	Market	Owner-occupied property	0.0384***	0.0356***	0.0392***	0.0392***	0.0382***	0.0382***	0.0354***	0.0355***
				(0.0049)	(0.0049)	(0.0049)	(0.0049)	(0.0049)	(0.0049)	(0.0049)	(0.0049)
	r	Size	ln(Number of apartments)	0.2262***	0.2504***	0.2250***	0.2250***	0.2262***	0.2263***	0.2504***	0.2505***
				(0.0095)	(0.0098)	(0.0095)	(0.0095)	(0.0095)	(0.0095)	(0.0097)	(0.0097)
	s		ln (Square area per project [m^2])	−0.3125***	−0.3506***	−0.3079***	−0.3079***	−0.3127***	−0.3127***	−0.3508***	−0.3509***
				(0.0093)	(0.0103)	(0.0093)	(0.0093)	(0.0093)	(0.0093)	(0.0103)	(0.0102)
	t		ln(Stories)	0.0390***	0.0232**	0.0386***	0.0384***	0.0389***	0.0388***	0.0231**	0.0229**
				(0.0095)	(0.0096)	(0.0095)	(0.0095)	(0.0095)	(0.0095)	(0.0096)	(0.0096)
	u		ln(Mean net floor area)								
	v		ln(Mean number of rooms)								
E) Location Controls		Locational variables:									
	w	Mobilité Spatiale regions		y	y	y	y	y	y	y	y
	x	Location Class "ÖV-Güteklasse"		y	Appendix Table B1	y	y	y	y	Appendix Table B1	Appendix Table B1
	y	Population density per hectare		y	Appendix Table B1	y	y	y	y	Appendix Table B1	Appendix Table B1
F) Time Control		Time fixed effects:									
	z	Year of building application		y	Appendix Table B1	y	y	y	y	Appendix Table B1	Appendix Table B1
G) Constant			Constant	9.4336***	9.6325***	9.4279***	9.4285***	9.4330***	9.4334***	9.6331***	9.6344***
				(0.0567)	(0.1323)	(0.0565)	(0.0565)	(0.0567)	(0.0567)	(0.1324)	(0.1324)
H) Regression statistics		N		11,993	11,993	11,993	11,993	11,993	11,993	11,993	11,993
		R^2		0.2913	0.321	0.2869	0.287	0.2918	0.2919	0.3214	0.3215
		Adjusted R^2		0.2831	0.3092	0.2793	0.2794	0.2835	0.2836	0.3095	0.3095
		Residual Std. error		0.2422	0.2378	0.2428	0.2428	0.2421	0.2421	0.2377	0.2377
				(df = 11,855)	(df = 11,786)	(df = 11,867)	(df = 11,866)	(df = 11,854)	(df = 11,853)	(df = 11,785)	(df = 11,784)
		F Statistic		35.5703***	27.0538***	38.1877***	37.9018***	35.3869***	35.1468***	26.9608***	26.8409***
				(df = 137; 11,855)	(df = 206; 11,786)	(df = 125; 11,867)	(df = 126; 11,866)	(df = 138; 11,854)	(df = 139; 11,853)	(df = 207; 11,785)	(df = 208; 11,784)

Source: Data from ARE (2020), Blaublatt/Bauinfo-Center Docu Media (2020), FSO (2018), FPRE (2020), MINERGIE (2021).
Note: White heteroskedasticity-consistent (robust) standard errors HC1 are clustered for each location cluster within parentheses. Significance values 0.10, 0.05, and 0.01 are indicated by *, **, and ***, respectively.

the certified group showed a significant markup only for the expensive geothermal energy (see specifications (A) and (B) in Appendices Table C1 and C2). Regarding net initial rents, the coefficients for environmental technology that lead to certification did not differ largely within the certified and noncertified samples (see specifications (E)–(H) in Appendices Table C1 and C2).

We analyzed whether the higher construction costs owing to MINERGIE certification were reflected in higher net initial rents. In general, the data show that in addition to the structural attributes of the building, the main driver of rent was location.

Without technology and amenity controls, there was a net initial rental premium of 3.6% for MINERGIE-certified apartments compared to noncertified apartments (specification [III], Table 8). The standard certification yielded 3.2% higher net rents, whereas MINERGIE-P or higher yielded 7.6% higher rents (specification [IV], Table 8).

Adding the key technology controls that lead to certification only slightly decreased the coefficients for MINERGIE-certified dwellings (see specifications [V] and [VI] in Table 8). This shows that environmentally friendly heating and energy systems, as well as construction according to MINERGIE standards, did not impact net initial rents significantly. Thus, tenants were not willing to pay more for these technological attributes through higher net rents, since they do not benefit directly from the fact that heat pumps or oil heating provides warmth.

However, tenants are willing to pay higher rents for certain amenities that directly benefit them. For instance, glass façades, wood/metal windows, chimney/chimney stoves, double-shell masonry/brickwork, and a conveyor system leads to statistically significant net initial rent premiums (Appendix Tables A2 and B1). Including these and other amenity and quality controls erode the coefficients for MINERGIE down to 3.0% (see specification [VII] in Table 8). The standard certification yielded 2.6% statistically significant higher net rents, and the MINERGIE-P or higher certification yielded 6.6% higher rents, although this was not statistically significant (see specification [VIII] in Table 8).

Table 8 shows that including *technology controls* does not affect the rent premiums for certification, as tenants were largely unwilling to pay for nonperceptible environmental investments. However, including *amenity controls* that directly impact tenants' well-being and willingness to pay reduced the coefficients for MINERGIE. For MINERGIE-P or higher, the coefficient became statistically insignificant (see specification [VIII] in Table 8).

The analysis of the cost-benefit ratio revealed the following: First, significant cost and rent premiums for MINERGIE certifications were identified. This suggests that investors can expect above market returns through higher net initial rents for their green up-front construction cost markups.

Second, cost and rent premiums for MINERGIE certifications declined when technology and amenity controls were added to the regressions. However, even when controlling for both, statistically significant cost and rent markups persisted.

Third, the results aligned with the literature. MINERGIE (2020) reported similar additional investment costs for a multifamily dwelling with MINERGIE (standard certification) (2.8%) and MINERGIE-P (6.9%). Generally, similar graduations in construction costs and rents for different levels of certification were observed: with higher levels of certification, construction costs and net rents increased.

Cost and Yield Effects of Sustainable Building Measures

To study the effects of heating systems on construction costs and net initial rents, dummy variables were created for the individual technologies (Appendix Table A2, lines g-m). The interaction terms of different heating systems (e.g., gas and geothermal) were not modeled. Consequently, the coefficient of each heating system corresponds to its average individual effect on construction costs and rents; that is, the coefficients reflect a mixed effect of composite and individual systems. In the regression model, oil-fired heating was the reference category. Compared to oil-fired heating, solar heating systems and wood-fired heating showed no statistically significant cost premium, whereas district heating with a 5.1% premium, heat pumps with 2.8%, wood chips with 5.1%, pellet heating with 6.2%, and geothermal energy with 3.1% exhibited statistically significant construction cost premiums (see Table 7, specification [VIII]). In the case of geothermal energy, the higher construction costs were reflected in increased net initial rents of approximately 2% (see Table 8, line j). Thus, part of the higher up-front costs of geothermal energy was returned to the investor through increased net rents. Excluding geothermal energy, no other statistically significant effects of heating systems on net initial rents were identified. Overall cost premiums outweigh yield effects for sustainable heating system. Typically,

Table 8. Regression results net rent/m²a.

			Specifications	I	II	III	IV	V	VI	VII	VIII
			A) Certificates			■	■	■	■	■	■
			B) Technology controls	■	■			■	■	■	■
			C) Amenity controls		■					■	■
			D) Market & size controls	■	■	■	■	■	■	■	■
			E) Location controls	■	■	■	■	■	■	■	■
			F) Time controls	■	■	■	■	■	■	■	■
			G) Constant	■	■	■	■	■	■	■	■
			H) Regression statistics	■	■	■	■	■	■	■	■
		OLS		Net rent/m²a							
		Specifications		(I)	(II)	(III)	(IV)	(V)	(VI)	(VII)	(VIII)
		Dependent variable:		ln(Net rent/m²a)							
		Structural variables:									
	Line:										
A) Certificates	a	Certificates	MINERGIE Y/N			0.0358***		0.0351***		0.0296**	
		Ref. Cat. = Noncertified buildings				(0.0122)		(0.0124)		(0.0125)	
	b		MINERGIE				0.0312**		0.0309**		0.0254**
							(0.0128)		(0.0131)		(0.0129)
	c		MINERGIE-P or higher				0.0733*		0.0696*		0.0637
							(0.0379)		(0.0383)		(0.0454)
B) Technology controls	d	Roofing	**MINERGIE standard**	0.1221	0.0908			0.1231	0.119	0.0907	0.0873
		Ref. Cat. = all others		(0.2082)	(0.1963)			(0.2074)	(0.2079)	(0.1962)	(0.1966)
	e	Façade	**MINERGIE standard**	−0.0785	−0.0883			−0.0801	−0.0823	−0.0896	−0.0916
		Ref. Cat. = all others for Spec. (1), (5) & (6)		(0.0753)	(0.0673)			(0.0747)	(0.0745)	(0.0670)	(0.0670)
		Ref. Cat. = Plastered masonry/brickwork for Spec. (2), (7) & (8)									
	f	Windows	**MINERGIE standard**	−0.0649	−0.048			−0.0623	−0.0564	−0.0457	−0.0398
		Ref. Cat. = all others for Spec. (1), (5) & (6)		(0.0887)	(0.0815)			(0.0877)	(0.0884)	(0.0811)	(0.0821)
		Ref. Cat. = Plastic windows for Spec. (2), (7) & (8)									
	g	Heating	**District heating**	−0.0139	0.0038			−0.0156	−0.0157	0.0021	0.0017
		Ref. Cat. = all others for Spec. (1), (5) & (6)		(0.0132)	(0.0213)			(0.0132)	(0.0132)	(0.0214)	(0.0214)
		Ref. Cat. = Oil-fired heating for Spec. (2), (7) & (8)									
	h		**Heat pumps**	−0.0022	0.0193			−0.0031	−0.003	0.0182	0.0179
				(0.0089)	(0.0191)			(0.0089)	(0.0089)	(0.0191)	(0.0191)
	i		**Solar heating systems**	0.0047	−0.0028			0.0049	0.0048	−0.0024	−0.0026
				(0.0107)	(0.0110)			(0.0107)	(0.0107)	(0.0110)	(0.0110)
	j		**Geothermal energy/ ground probes/ collectors**	0.0256***	0.0192**			0.0255***	0.0255***	0.0191**	0.0191**
				(0.0089)	(0.0088)			(0.0089)	(0.0089)	(0.0088)	(0.0088)
	k		**Wood-fired heating**	−0.0216	−0.0119			−0.0195	−0.0197	−0.0102	−0.0106
				(0.0311)	(0.0316)			(0.0311)	(0.0311)	(0.0316)	(0.0316)
	l		**Wood-chip heating**	−0.0221	0.0123			−0.0262	−0.0254	0.0084	0.0091
				(0.0345)	(0.0353)			(0.0332)	(0.0333)	(0.0341)	(0.0343)
	m		**Pellet heating**	−0.013	0.0075			−0.016	−0.0153	0.0046	0.0049

(*continued*)

Table 8. Continued.

			Specifications	I	II	III	IV	V	VI	VII	VIII
				(0.0198)	(0.0242)			(0.0195)	(0.0196)	(0.0241)	(0.0241)
	n		**Controlled room ventilation/ comfort ventilation**	0.0128	0.005			0.0107	0.0108	0.0032	0.0033
				(0.0135)	(0.0133)			(0.0136)	(0.0136)	(0.0134)	(0.0134)
	o	Insulation	**MINERGIE standard insulation**	0.0189	0.034			0.0164	0.0164	0.0329	0.0319
		Ref. Cat. = all, but MINERGIE standard for Spec. (1), (5) & (6)		(0.0729)	(0.0826)			(0.0723)	(0.0722)	(0.0817)	(0.0817)
		Ref. Cat. = all others (2), (7) & (8)									
	p	Electricity	**Solar energy (electricity)**	−0.0074	−0.0008			−0.0078	−0.0076	−0.0011	−0.0009
		Ref. Cat. = all others		(0.0149)	(0.0148)			(0.0150)	(0.0150)	(0.0148)	(0.0148)
C) Amenity controls					Appendix Tables A2 and B1					Appendix Tables A2 and B1	Appendix Tables A2 and B1
D) Market & size controls	q	Market	Owner-occupied property	0.0096	−0.0011	0.0098	0.0097	0.0092	0.0091	−0.0014	−0.0015
				(0.0074)	(0.0077)	(0.0074)	(0.0074)	(0.0074)	(0.0074)	(0.0077)	(0.0077)
	r	Size	ln(Number of apartments)	−0.0195***	−0.0306***	−0.0207***	−0.0207***	−0.0201***	−0.0201***	−0.0311***	−0.0311***
				(0.0047)	(0.0051)	(0.0045)	(0.0045)	(0.0047)	(0.0047)	(0.0051)	(0.0051)
	s		ln(Square area per project [m2])								
	t		ln(Stories)	0.015	0.008	0.012	0.0119	0.0148	0.0147	0.0078	0.0077
				(0.0136)	(0.0139)	(0.0134)	(0.0134)	(0.0136)	(0.0136)	(0.0139)	(0.0139)
	u		ln(Mean net floor area)	−0.3293***	−0.3484***	−0.3244***	−0.3242***	−0.3293***	−0.3291***	−0.3483***	−0.3481***
				(0.0228)	(0.0228)	(0.0229)	(0.0229)	(0.0228)	(0.0228)	(0.0228)	(0.0228)
	v		ln(Mean number of rooms)	0.0388	0.0498*	0.0373	0.0374	0.0382	0.0382	0.0491*	0.0491*
				(0.0260)	(0.0258)	(0.0263)	(0.0263)	(0.0259)	(0.0259)	(0.0257)	(0.0257)
E) Location controls		Locational variables:									
	w	Mobilité Spatiale regions		y	y	y	y	y	y	y	y
	x	Location Class "ÖV-Güteklasse"		y	Appendix Table B1	y	y	y	y	Appendix Table B1	Appendix Table B1
	y	Population density per hectare		y	Appendix Table B1	y	y	y	y	Appendix Table B1	Appendix Table B1
F) Time control		Time fixed effects:									
	z	Year of building application		y	Appendix Table B1	y	y	y	y	Appendix Table B1	Appendix Table B1
G) Constant			Constant	7.3174***	7.2658***	7.3123***	7.3115***	7.3166***	7.3156***	7.2690***	7.2689***
				(0.0886)	(0.1325)	(0.0885)	(0.0886)	(0.0886)	(0.0887)	(0.1323)	(0.1324)
H) Regression statistics		*N*		3,562	3,562	3,562	3,562	3,562	3,562	3,562	3,562
		R^2		0.5812	0.608	0.5796	0.5798	0.582	0.5821	0.6086	0.6087
		Adjusted R^2		0.5649	0.5844	0.5649	0.5649	0.5656	0.5656	0.5849	0.5849
		Residual Std. Error		0.1899	0.1856	0.1899	0.1899	0.1898	0.1898	0.1855	0.1855
				(df = 3428)	(df = 3359)	(df = 3440)	(df = 3439)	(df = 3427)	(df = 3426)	(df = 3358)	(df = 3357)
		F Statistic		35.7644***	25.7933***	39.2029***	38.8892***	35.6046***	35.3450***	25.7188***	25.5953***
				(df = 133; 3428)	(df = 202; 3359)	(df = 121; 3440)	(df = 122; 3439)	(df = 134; 3427)	(df = 135; 3426)	(df = 203; 3358)	(df = 204; 3357)

Source: Data from ARE (2020), Blaublatt/Bauinfo-Center Docu Media (2020), FSO (2018), FPRE. (2020), MINERGIE (2021).
Note: White heteroskedasticity-consistent (robust) standard errors HC1 are clustered for each location cluster within parentheses. Significance values 0.10, 0.05, and 0.01 are indicated by *, **, and ***, respectively.

listings do not disclose the type of heating systems. As prospective tenants lack information on a possible sustainable solution, the type of heating system does not influence their willingness to pay. However, this might change with surging oil, gas, and energy prices.

Plastered masonry/brickwork was identified in approximately two-thirds of the façades of newly constructed multifamily dwellings and serves as the reference category in the analysis. The market showed a construction cost premium of approximately 1.5% for wooden façades; however, it does not reward these increased investment costs with higher net initial rents (Appendix Table A2, line e). In contrast, the market does reward expensive ceramic and glass façades with increased net initial rents (see Appendix Table A2, line e); that is, the market rewards perceptible quality on the outside of the building with higher net initial rents. Ventilated curtain façades and exposed concrete show cost markups of 2.7 and 4.6%, respectively, which are not reflected in higher net initial rents in the market.

In Switzerland, approximately every third multifamily dwelling constructed between January 2010 and June 2020 possesses green roofing. Green roofing exhibited construction cost premiums of 3.2% compared to other roofing finishes in the analysis. Investors received higher net initial rents of 7.0% for these increased up-front costs (see Appendix Table A2, line d). The data suggest that the aesthetic and climatic advantages of green roofing provided a perceptible benefit to the tenant. Therefore, the analysis shows that additional costs for green roofing pay off.

Solar energy showed construction cost premiums of 2.5% in the market (see line p in Tables 7 and 8). In contrast, there were no statistically significant effects on rents. Despite this unfavorable cost-benefit ratio, the popularity of solar energy is increasing strongly, and the data show that solar energy is on the rise in Switzerland.

To conclude, specific sustainable construction measures cost more than conventional building measures. However, except for geothermal energy and green roofing, no statistically significant effects on net initial rents were found for the individual green building measures. Other details concerning building measure effects are discussed by Kraft and Kempf (2021).

Conclusion

This study investigated whether sustainable residential multifamily dwellings exhibit (I) higher construction costs and (II) increased net initial rents compared to conventionally constructed buildings. Furthermore, the study analyzed how costs and rents are attributed to the following drivers: MINERGIE certificates, technology controls (that lead to certification), and amenity controls (independent from certification). Hence, the results advance our understanding of the cost of and return from certification, including the underlying components of green buildings.

The analysis showed that after controlling for technology and amenities, a statistically significant cost premium for MINERGIE certification of approximately 1.9% persists (1.6% for MINERGIE (standard certification) and 5.1% for MINERGIE-P or higher). In addition, sustainable technology that led to certification also demanded a statistically significant cost premium. The empirical results showed statistically significant cost premiums for the sustainable construction measures: 5.0% for district heating and 3.1% for geothermal energy, with the reference category oil-fired heating, and 3.2% for green roofing over other roofing finishes (see specification [VIII] in Appendix Table A2). In general, higher costs were incurred for specific sustainable construction measures and MINERGIE certifications. However, with a few exceptions, no statistically significant effects on net initial rents were identified for the individual green building measures. For MINERGIE, the results were different. MINERGIE (standard certification) and MINERGIE-P or higher yielded higher net initial rents of 2.6 and 6.6% (not significant) for apartments. However, the analysis showed that environmentally friendly technology (technology controls) did not significantly impact net initial rents. In contrast, high-quality materials and amenities that deliver a perceptible benefit to tenants exhibited statistically significant rental premiums.

These results suggest that green building practices without labels or certifications are not rewarded by the market through increased rents. The implementations require credible labels, such as MINERGIE certification, to yield a green rent premium. This aligns with the work of Bond and Devine (2015), who found that certification was more convincing than just stating that a property was green.

A secondary inference that reinforces the findings in the literature is that the construction costs and net initial rents increase with the level of certification (Dressler et al., 2017; Glossner et al., 2015).

This analysis focused on construction costs and their initial returns, rather than taking a holistic life cycle costs and returns approach, and it showed that there might be a discrepancy between costs and returns with respect to single construction measures in the short run. Furthermore, for solar energy, the data showed a high market penetration, despite an adverse cost-benefit ratio. For other measures, the results suggested that MINERGIE certification could counteract this disincentive in Switzerland. Nonetheless, this myopic incentive problem might impede a fast change toward a highly sustainable construction industry; therefore, a full cost and return analysis in the future would certainly be worthwhile.

The focus of this empirical analysis was short term because of the limited availability of long-term data (i.e., whole building life cycle data). MINERGIE entered the market in 1998, and heat pumps became popular around the same time in Switzerland (FWS, 2022). Assuming a typical life cycle of 60 years for buildings in Switzerland, large-scale empirical data will be available for future research (King & Trübestein, 2018). Nonetheless, hypothetical net present value calculations at the case study level could be informative for a holistic cost-benefit consideration of sustainable vs. conventional buildings in Switzerland.

During work on this paper, resource and energy prices experienced extreme peaks, highlighting the need to build more sustainably, with less resource dependence in the long run. The price shock related to oil, gas, and electricity has altered the cost-benefit ratio of fossil fuel heating solutions and sustainable systems. Fossil fuel heating systems suddenly experienced increased operating costs due to high gas and oil prices. More expensively constructed green heating systems, such as heat pumps and geothermal energy, also encountered higher electricity prices. Given the challenging economic situation with supply chain problems and volatile prices, evaluating the costs and benefits of different heating and construction systems becomes more complex. However, the resource savings associated with more efficient, sustainable systems might more than compensate for the construction cost premiums found in this study, considering the whole building life cycle. Additionally, cost premiums on new sustainable technologies might decrease with greater market penetration and regulatory pressure toward zero carbon emissions. For instance, in the canton of Zurich (Switzerland), the "cantonal energy law" amendment came into force on September 1, 2022. This law requires the replacement of oil and gas heating systems at the end of their service life with environmentally friendly heating solutions (Zürich, 2022). Evaluating the above thoughts on the cost-benefit ratio requires future research.

Notes

1. MINERGIE is a Swiss green building standard. For detailed information on the standard, see https://www.minergie.com/.
2. The MuKEn14. (2020) is a body of energy regulations in the building sector. The Konferenz Kantonaler Energiedirektoren (EnDK) recommends that cantons adopt MuKEn to the extent possible when enacting energy regulations. According to MuKEn14, a new building requires approximately 3.5 L of heating oil equivalents of thermal energy, whereas comprehensively renovated properties require approximately 8 L of heating oil equivalents.
3. The hedonic method for house price estimation was introduced by Rosen (1974) and is still the standard method for estimating real estate prices. The idea behind this valuation method is that the price, rent, or construction costs of a property are determined by the sum of its structure- (z_i), location- (l_i), and time-related (t_i) characteristics. Implicit prices β, γ, ϕ are attributed to the individual value-, rent-, or cost-determining attributes such as living space, centrality, or construction year, and the summation results in the property price, rent, or costs.

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References

Ade, R. (2018). *The cost of Homestar: A case study on how to achieve a 6–10 Homestar rating for stand-alone and terraced housing in Hobsonville Point*. BRANZ.

Ade, R., & Rehm, M. (2020). Reaching for the stars: Green construction cost premiums for Homestar certification. *Construction Management and Economics*, *38*, 570–580. https://doi.org/10.1080/01446193.2019.1640370

ARE. (2020a). *Verkehrserschliessung in der schweiz*. Retrieved March 3, 2023, from https://www.are.admin.ch/are/de/home/verkehr-und-infrastruktur/grundlagen-und-daten/verkehrserschliessung-in-derschweiz.html.

ARE. (2020b). *ÖV-Güteklassen ARE | opendata.swiss*. Retrieved November 13, 2020, from https://opendata.swiss/de/dataset/ov-guteklassen-are1.

Baublatt/Bauinfo-Center Docu Media. (2020). Data on planning applications.

Bond, S. A., & Devine, A. (2015). Certification matters: Is green talk cheap talk? *The Journal of Real Estate Finance and Economics*, *52*, 117–140. https://doi.org/10.1007/s11146-015-9499-y

Burnett, J., Chau, C., Lee, W., & Edmunds, K. (2008). *Costs and financial benefits of undertaking green building assessments: final report*. Construction Industry Institute-Hong

Kong. Retrieved March 3, 2023, from http://hdl.handle.net/10397/2352
Cajias, M., Fuerst, F., & Bienert, S. (2019). Tearing down the information barrier: The price impacts of energy efficiency ratings for buildings in the German rental market. *Energy Research & Social Science*, *47*, 177–191. https://doi.org/10.1016/j.erss.2018.08.014
Cajias, M., & Piazolo, D. (2013). Green performs better: Energy efficiency and financial return on buildings. *Journal of Corporate Real Estate*, *15*, 53–72. https://doi.org/10.1108/JCRE-12-2012-0031
Chegut, A., Eichholtz, P., & Kok, N. (2019). The price of innovation: An analysis of the marginal cost of green buildings. *Journal of Environmental Economics and Management*, *98*, 102248. https://doi.org/10.1016/j.jeem.2019.07.003
Clapp, J. M., Nanda, A., & Ross, S. L. (2008). Which school attributes matter? The influence of school district performance and demographic composition on property values. *Journal of Urban Economics*, *63*, 451–466. https://doi.org/10.1016/j.jue.2007.03.004
Dhar, P., & Ross, S. L. (2012). School district quality and property values: Examining differences along school district boundaries. *Journal of Urban Economics*, *71*, 18–25. https://doi.org/10.1016/j.jue.2011.08.003
Dressler, L., & Cornago, E. (2017). *The rent impact of disclosing energy performance certificates: Energy efficiency and information effects. European Center for Advanced Research in Economics and Statistics Working Papers*, Universitté Libre de Bruxelles. Bruxelles.
Dwaikat, L. N., & Ali, K. N. (2016). Green buildings cost premium: A review of empirical evidence. *Energy and Buildings*, *110*, 396–403. https://linkinghub.elsevier.com/retrieve/pii/S0378778815303856.
European Commission. (2022). *Certificates and inspections*. Retrieved March 7, 2023, from https://energy.ec.europa.eu/topics/energy-efficiency/energy-efficient-buildings/certificates-and-inspections_en
Feige, A., Mcallister, P., & Wallbaum, H. (2013). Rental price and sustainability ratings: Which sustainability criteria are really paying back? *Construction Management and Economics*, *31*, 322–334. https://doi.org/10.1080/01446193.2013.769686
FPRE. (2020). Listing data on initial net rents from Fahrländer Partner AG (FPRE).
FSO. (2018). Statistik der Bevölkerung und der Haushalte (STATPOP) ab 2010.
FSO. (2021a). *Durchschnittlicher Mietpreis pro m2 in Franken nach Zimmerzahl und Kanton*. Retrieved March 7, 2023, from https://www.bfs.admin.ch/bfs/de/home/statistiken/bau-wohnungswesen/wohnungen/mietwohnungen.assetdetail.15104289.html
FSO. (2021b). *Wohnungsgrösse*. Retrieved February 17, 2021, from https://www.bfs.admin.ch/bfs/de/home/statistiken/bau-wohnungswesen/wohnungen/groesse.html
Fuerst, F., & Dalton, B. (2019). Gibt es einen wissenschaftlichen Konsens zur Wirtschaftlichkeit nachhaltiger Immobilien? *Zeitschrift Für Immobilienökonomie*, *5*, 173–191. https://doi.org/10.1365/s41056-019-00041-0
Fuerst, F., & McAllister, P. (2011). Green noise or green value? Measuring the effects of environmental certification on office values. *Real Estate Economics*, *39*, 45–69. https://doi.org/10.1111/j.1540-6229.2010.00286.x
Fuerst, F., McAllister, P., Nanda, A., & Wyatt, P. (2016). Energy performance ratings and house prices in Wales: An empirical study. *Energy Policy*, *92*, 20–33. https://doi.org/10.1016/j.enpol.2016.01.024
Fuerst, F., & Warren-Myers, G. (2018). Does voluntary disclosure create a green lemon problem? Energy-efficiency ratings and house prices. *Energy Economics*, *74*, 1–12. https://doi.org/10.1016/j.eneco.2018.04.041
FWS. (2022). *Statistiken-Statistik 2021*. Retrieved January 2, 2023, from https://www.fws.ch/statistiken/
Gabe, J., & Rehm, M. (2014). Do tenants pay energy efficiency rent premiums? *Journal of Property Investment & Finance*, *32*, 333–351. https://doi.org/10.1108/JPIF-09-2013-0058
Galuppo, L., & Tu, C. (2010). Capital markets and sustainable real estate: What are the perceived risks and barriers? *Journal of Sustainable Real Estate*, *2*, 143–159. https://doi.org/10.1080/10835547.2010.12091800
Global Alliance for Buildings and Construction, International Energy Agency and the United Nations Environment Programme. (2019). *2019 Global status report for buildings and construction sector: Towards a zero-emission, efficient and resilient buildings and construction sector*. Retrieved March 7, 2023, from https://www.unep.org/resources/publication/2019-global-status-report-buildings-and-construction-sector.
Glossner, S. J., Adhikari, S., & Chapman, H. (2015). Assessing the cost effectiveness of LEED certified homes in Kentucky. *The Journal of Technology Studies*, *41*, 10–19. http://www.jstor.org/stable/90003802.
Hahn, J., Hirsch, J., & Bienert, S. (2018). Does "clean" pay off? Housing markets and their perception of heating technology. *Property Management*, *36*, 575–596. https://doi.org/10.1108/pm-08-2017-0051
Hwang, B.-G., Zhu, L., Wang, Y., & Cheong, X. (2017). Green building construction projects in Singapore: Cost premiums and cost performance. *Project Management Journal*, *48*, 67–79. https://doi.org/10.1177/875697281704800406
Hydes, K. R., & Creech, L. (2010). Reducing mechanical equipment cost: The economics of green design. *Building Research & Information*, *28*, 403–407. https://doi.org/10.1080/096132100418555
Hyland, M., Lyons, R. C., & Lyons, S. (2013). The value of domestic building energy efficiency–evidence from Ireland. *Energy Economics*, *40*, 943–952. https://doi.org/10.1016/j.eneco.2013.07.020
Im, J., Seo, Y., Cetin, K. S., & Singh, J. (2017). Energy efficiency in US residential rental housing: Adoption rates and impact on rent. *Applied Energy*, *205*, 1021–1033. https://doi.org/10.1016/j.apenergy.2017.08.047
Jaffe, A. B., & Stavins, R. N. (1994). The energy paradox and the diffusion of conservation technology. *Resource and Energy Economics*, *16*, 91–122. https://doi.org/10.1016/0928-7655(94)90001-9
Kaplan, S., Crawford, J., Dubin, M., Knops, P., Leigh, R., Matthiessen, L. F., Rios, J., Rudin, M., Sparko, A., & Unger, R., US Green Building Council Chapter. (2009). Cost of green in NYC. In (Ed.), *New York Urban Green Council*.

Kats, G., Alevantis, L., Berman, A., Mills, E., & Perlman, J. (2003). *The costs and financial benefits of green buildings: A report to California's sustainable building task force*. Capital E Washington.

Kim, J.-L., Greene, M., & Kim, S. (2014). Cost comparative analysis of a new green building code for residential project development. *Journal of Construction Engineering and Management*, *140*, 05014002. https://doi.org/10.1061/(ASCE)CO.1943-7862.0000833

King, M., & Trübestein, M. (2018). *Optimierungsstrategien im Nutzungszyklus von Immobilien*. Springer Fachmedien Wiesbaden.

Koirala, B. S., Bohara, A. K., & Berrens, R. P. (2014). Estimating the net implicit price of energy efficient building codes on U.S. households. *Energy Policy*, *73*, 667–675. https://doi.org/10.1016/j.enpol.2014.06.022

Kraft, C., & Kempf, C. (2021). *Nachhaltige Wohnungswirtschaft in der Schweiz—Erkenntnisse aus Forschung und Praxis*. Springer Gabler. https://doi.org/10.1007/978-3-658-34808-3

Lucuik, M., Trusty, W., Larsson, N., & Charette, R. (2005). *A business case for green building in Canada* [Paper presentation]. Industry Canada.

Marty, R., & Meins, E. (2017). Der Schweizer Mietimmobilienmarkt belohnt andere Nachhaltigkeitsmerkmale als Energieeffizienz. *Swiss Real Estate Journal*, *15*, 47–54.

Marty, R., Meins, E., Bächinger, C. (2016). *Sustainability and real estate rental rates: Empirical evidence for Switzerland Universität Zürich*. CCRS Working Paper Series.

Matthiessen, L. F., & Morris, P. (2007). *Cost of green revisited: Reexamining the feasibility and cost impact of sustainable design in the light of increased market adoption*. Continental Automated Buildings Association.

Meins, E. (2014). *Nachhaltigkeit und Risiken bei Immobilieninvestitionen Konzepte und Entscheidungsgrundlagen für die Praxis*. Verlag Neue Zürcher Zeitung.

MINERGIE. (2011). *Besser bauen, besser leben. Info Bauherrschaften*. Retrieved March 7, 2023, from https://docplayer.org/78148929-Besser-bauen-besser-leben.html.

MINERGIE. (2020). *Finanzielle Vorteile*. Retrieved November 4, 2020, from https://www.minergie.ch/de/ueber-minergie/unsere-themen/finanziellevorteile/

MINERGIE. (2021). *MINERGIE—aktuelle Gebäudeliste*. https://www.minergie.ch/de/gebaeude/gebaeudeliste/.

MINERGIE. (2022). *Mit minergie zertifizieren*. Retrieved March 7, 2023, from https://www.minergie.ch/de/zertifizieren/minergie/

MOHURD of China. (2015). 2014 Statistic report of green buildings [in Chinese]. *Construction Science and Technology* (2015), 20–23.

MuKEn14. (2020). *MuKEn*. Retrieved November 4, 2020, from https://www.endk.ch/de/energiepolitik-der-kantone/muken

Rehm, M., & Ade, R. (2013). Construction costs comparison between "green" and conventional office buildings. *Building Research & Information*, *41*, 198–208. https://doi.org/10.1080/09613218.2013.769145

Rosen, S. (1974). Hedonic prices and implicit markets: Product differentiation in pure competition. *Journal of Political Economy*, *82*, 34–55. https://doi.org/10.1086/260169

Salvi, M., Horehájová, A., & Müri, R. (2008). *Der Nachhaltigkeit von Immobilien einen finanziellen Wert geben–Minergie macht sich bezahlt*. Center for Corporate Responsibility and Sustainability.

Salvi, M., Horehájová, A., & Neeser, J. (2010). *Der Nachhaltigkeit von Immobilien einen finanziellen Wert geben-Der Minergie-Boom unter der Lupe*. Center for Corporate Responsibility and Sustainability, Universität Zürich.

Schuler, M., Dessemontet, P., Joye, D., & Perlik, M. (2005). *Die Raumgliederung der Schweiz*. BFS, Neuchâtel.

Schuster, T., & Füss, R. (2016). *Mietprämien von MINERGIE-Gebäuden im Immobilienmarkt Schweiz*. Universität St. Gallen.

Shrestha, P. P., & Pushpala, N. (2012). Green and non-green school buildings: An empirical comparison of construction cost and schedule. *American Society of Civil Engineers*, (2012), 1820–1829. https://doi.org/10.1061/9780784412329.183.

Swiss Federal Office of Energy (SFOE). (2020). *Energie in Gebäuden*. Retrieved July 21, 2020, from https://www.bfe.admin.ch/bfe/de/home/versorgung/energieeffizienz/energie-in-gebaeuden.html

Turner Construction Company. (2005). Green building market barometer.

Wegner, J., Stokar, M., Hoffmann, C. (2010). *Studie zur Untersuchung von Mehrkosten von MINERGIE-P®-Bauten*. Retrieved March 7, 2023, from https://www.baselland.ch/politik-und-behorden/direktionen/bau-und-umweltschutz-direktion/umweltschutz-energie/energie/publikationen/downloads-1/mehrkostenstudie_minergie-p.pdf/@@download/file/mehrkostenstudie_minergie-p.pdf

World Green Building Council. (2013). *The business case for green building*. Retrieved January 12, 2022, from https://www.worldgbc.org/news-media/business-case-green-building-review-costs-and-benefitsdevelopers-investors-and-occupants

Yip, S., Song, L., & Li, H. (2013). *Study on the economics of green buildings in China* [in Chinese]. China Architecture and Building Press.

Zhang, L., Wu, J., & Liu, H. (2018). Turning green into gold: A review on the economics of green buildings. *Journal of Cleaner Production*, *172*, 2234–2245. https://doi.org/10.1016/j.jclepro.2017.11.188

Zhang, X., Platten, A., & Shen, L. (2011). Green property development practice in China: Costs and barriers. *Building and Environment*, *46*, 2153–2160. https://doi.org/10.1016/j.buildenv.2011.04.031

Zheng, S., Wu, J., Kahn, M. E., & Deng, Y. (2012). The nascent market for "green" real estate in Beijing. *European Economic Review*, *56*, 974–984. https://doi.org/10.1016/j.euroecorev.2012.02.012

Zürich, K. (2022). *Bauvorschriften gebäude und energie*. Retrieved January 2, 2023, from https://www.zh.ch/de/planen-bauen/bauvorschriften/bauvorschriften-gebaeude-energie.html

Appendix

Table A1. Individual components of construction project.

B) Technology controls that lead to certification

C) Amenity controls independent from certification

Reference category (amenity controls in gray), if amenity controls are not included. See specifications [I], [V], and [VI]

Reference category (italic), if amenity controls are included for regression specifications [II], [VII], and [VIII]

Roofing:	Supporting structure:	Flooring:
MINERGIE standard	Wood	Floor underlay
Reference category = all others	Brick	Artificial stone flooring
	Aerated concrete blocks	Parquet flooring
Roofing finishes:	Sand-lime brick	Linoleum flooring/synthetic flooring
Green roofing	Skeleton construction (concrete, steel, wood)	Textile flooring
Ref. Cat. = all others	Steel	Ceramic flooring
	Double-shell masonry/brickwork	Wooden flooring
Façade:	Exposed masonry/brickwork	Concrete flooring
MINERGIE standard	Single-layer masonry/brickwork	Raised/false flooring
Wood	Supporting structure without specifications	Natural stone flooring
Metal/steel/light metal	*Ref. Cat. = Concrete*	Laminate flooring
Natural stone		Industrial jointless flooring
Glass	Heating:	*Ref. Cat. = all others*
Façade elements: concrete/lightweight concrete/artificial stone	**District heating**	
Ventilated curtain façades	**Heat pumps**	Interior:
Fiber cement plates	**Solar heating systems**	Not differentiated
Ceramic	**Geothermal energy/ground probes/collectors**	
Exposed masonry/brickwork	**Wood-fired heating**	Equipment:
Sandwich panels	**Wood-chip heating**	Air conditioner
Exposed concrete	**Pellet heating**	Conveyor system
Compact façades	**Controlled room ventilation/comfort ventilation**	Sun and weather protection
Façades without specifications	Gas-fired heating	Building automation
Ref. Cat. = Plastered masonry/brickwork	Electric heating	Safety technology
	Chimney/Chimney stove	Garage gate
Windows:	Floor heating	Landscaping
MINERGIE standard	Radiators/Flat panel radiators	Cooling systems
Wood windows	Heating without specifications	Tank installations (areas with heating)
Metal/lightweight metal windows	*Ref. Cat. = Oil-fired heating*	Terraces/balconies
Thermal and acoustic insulated windows		Ventilation
Balcony and terrace windows	Insulation:	Habitat/pond
Wood/metal windows	**MINERGIE standard**	Pergola
Windows without specifications	Internal thermal insulation	External lighting
Ref. Cat. = Plastic windows	External thermal insulation	Irrigation system
	In-between thermal insulation	Controlled parking system
Electricity:	Thermal insulation of earth-contacting components	*Ref. Cat. = all others*
Solar energy	Insulation and seal without specifications	
Ref. Cat. = all others	*Ref. Cat. = all others*	

Table A2. Full-blown regression results of construction costs/m^2 and net rent/m^2a including amenity controls (specifications [II], [VII], and [VIII]) 1/2.

			Specifications	(II)	(VII)	(VIII)	(II)	(VII)	(VIII)
			A) Certificates						
			B) Technology controls						
			C) Amenity controls						
			D) Market & size controls						
			E) Location controls						
			F) Time controls						
			G) Constant						
			H) Regression statistics						
		OLS		Construction costs/m^2			Net rent/m^{2}a		
		Specifications		(II)	(VII)	(VIII)	(II)	(VII)	(VIII)
		Dependent variable:							
		Structural variables:							
	Line:								
A) Certificates	a	Certificates	MINERGIE Y/N		0.0187**			0.0296**	
		Ref. Cat. = Noncertified buildings			(0.0077)			(0.0125)	
	b		MINERGIE			0.0157*			0.0254**
						(0.0081)			(0.0129)
	c		MINERGIE-P or higher			0.0496**			0.0637
						(0.0241)			(0.0454)
B) Technology & C) Amenity controls	d	Roofing	**MINERGIE standard**	0.0184	0.0186	0.0183	0.0908	0.0907	0.0873
		Ref. Cat. = all others		(0.0310)	(0.0309)	(0.0309)	(0.1963)	(0.1962)	(0.1966)
		Roofing finishes	Green roofing	0.0316***	0.0313***	0.0313***	0.0681***	0.0678***	0.0678***
		Ref. Cat. = all others		(0.0058)	(0.0058)	(0.0058)	(0.0081)	(0.0081)	(0.0081)
	e	Façade	**MINERGIE standard**	0.0090	0.0095	0.0102	− 0.0883	− 0.0896	− 0.0916
		Ref. Cat. = Plastered masonry/ brickwork for Spec. (2), (7) & (8)		(0.0365)	(0.0364)	(0.0364)	(0.0673)	(0.0670)	(0.0670)
			Wood	0.0146*	0.0147*	0.0146*	−0.0193	−0.0197	−0.0197
				(0.0084)	(0.0084)	(0.0084)	(0.0136)	(0.0136)	(0.0136)
			Metal/steel/light metal	0.0036	0.0031	0.0028	−0.0423	−0.0435	−0.0431
				(0.0181)	(0.0181)	(0.0181)	(0.0295)	(0.0294)	(0.0294)
			Natural stone	0.0371	0.0370	0.0369	0.0503	0.0498	0.0505
				(0.0233)	(0.0233)	(0.0233)	(0.0348)	(0.0347)	(0.0347)
			Glass	0.0664***	0.0661***	0.0661***	0.0612**	0.0586**	0.0585**
				(0.0172)	(0.0172)	(0.0172)	(0.0250)	(0.0251)	(0.0252)
			Façade elements: concrete/lightweight concrete/artificial stone	0.0264	0.0258	0.0262	0.0108	0.0108	0.0112
				(0.0219)	(0.0219)	(0.0219)	(0.0421)	(0.0420)	(0.0421)
			Ventilated curtain façades	0.0263***	0.0263***	0.0263***	0.0163	0.0162	0.0158
				(0.0092)	(0.0092)	(0.0092)	(0.0142)	(0.0141)	(0.0142)
			Fiber cement plates	−0.0062	−0.0062	−0.0063	−0.0403*	−0.0400*	−0.0394*
				(0.0147)	(0.0147)	(0.0147)	(0.0216)	(0.0216)	(0.0216)
			Ceramic	0.0348	0.0353	0.0354	0.0654*	0.0657*	0.0663*
				(0.0299)	(0.0298)	(0.0298)	(0.0347)	(0.0345)	(0.0345)
			Exposed masonry/brickwork	0.0226	0.0224	0.0226	0.0036	0.0023	0.0026
				(0.0231)	(0.0231)	(0.0231)	(0.0428)	(0.0430)	(0.0430)
			Sandwich panels	−0.0122	−0.0121	−0.0125	−0.0218	−0.0228	−0.0264
				(0.0423)	(0.0422)	(0.0422)	(0.0743)	(0.0746)	(0.0752)
			Exposed concrete	0.0450***	0.0450***	0.0452***	0.0084	0.0083	0.0086
				(0.0144)	(0.0144)	(0.0144)	(0.0243)	(0.0244)	(0.0244)
			Compact façades	0.0157	0.0153	0.0156	−0.0181	−0.0191	−0.0193
				(0.0165)	(0.0165)	(0.0165)	(0.0243)	(0.0242)	(0.0242)
			Façades without specifications	0.0000	−0.0003	−0.0005	−0.0262	−0.0268	−0.0262
				(0.0195)	(0.0195)	(0.0195)	(0.0251)	(0.0251)	(0.0252)

(continued)

Table A2. Continued.

		Specifications	(II)	(VII)	(VIII)	(II)	(VII)	(VIII)
f	Windows	**MINERGIE standard**	− 0.0685	− 0.0683	− 0.0682	− 0.048	− 0.0457	− 0.0398
	Ref. Cat. = Plastic windows		(0.0438)	(0.0439)	(0.0438)	(0.0815)	(0.0811)	(0.0821)
	for Spec. (2), (7) & (8)	Wood windows	0.0536***	0.0534***	0.0533***	0.0034	0.0041	0.0043
			(0.0115)	(0.0115)	(0.0115)	(0.0191)	(0.0191)	(0.0191)
		Metal/lightweight metal windows	0.0400***	0.0404***	0.0406***	0.0023	0.0037	0.0042
			(0.0126)	(0.0127)	(0.0127)	(0.0264)	(0.0264)	(0.0264)
		Thermal and acoustic insulated windows	0.0708	0.0727	0.0724	0.0848	0.0845	0.0835
			(0.0878)	(0.0873)	(0.0874)	(0.0598)	(0.0594)	(0.0594)
		Balcony and terrace windows	0.0112	0.0104	0.0107	−0.0196	−0.0223	−0.0215
			(0.0197)	(0.0196)	(0.0196)	(0.0387)	(0.0389)	(0.0388)
		Wood/metal windows	0.0459***	0.0457***	0.0457***	0.0139*	0.0135*	0.0135*
			(0.0058)	(0.0058)	(0.0058)	(0.008)	(0.008)	(0.008)
		Windows without specifications	0.005	0.0051	0.005	0.0182	0.0184	0.0181
			(0.0170)	(0.0170)	(0.0170)	(0.0211)	(0.0211)	(0.0211)
g	Heating	**District heating**	0.0489***	0.0484***	0.0487***	0.0038	0.0021	0.0017
	Ref. Cat. = Oil-fired heating		(0.0135)	(0.0135)	(0.0135)	(0.0213)	(0.0214)	(0.0214)
h	for Spec. (2), (7) & (8)	**Heat pumps**	0.0281**	0.0278**	0.0280**	0.0193	0.0182	0.0179
			(0.0120)	(0.0120)	(0.0120)	(0.0191)	(0.0191)	(0.0191)
i		**Solar heating systems**	0.006	0.0061	0.0061	−0.0028	−0.0024	−0.0026
			(0.0071)	(0.0071)	(0.0071)	(0.0110)	(0.0110)	(0.0110)
j		**Geothermal energy/ground probes/collectors**	0.0311***	0.0310***	0.0310***	0.0192**	0.0191**	0.0191**
			(0.0058)	(0.0058)	(0.0058)	(0.0088)	(0.0088)	(0.0088)
k		**Wood-fired heating**	0.0279	0.0283	0.0285	−0.0119	−0.0102	−0.0106
			(0.0189)	(0.0189)	(0.0189)	(0.0316)	(0.0316)	(0.0316)
l		**Wood-chip heating**	0.0504**	0.0498**	0.0498**	0.0123	0.0084	0.0091
			(0.0239)	(0.0239)	(0.0239)	(0.0353)	(0.0341)	(0.0343)
m		**Pellet heating**	0.0596***	0.0594***	0.0597***	0.0075	0.0046	0.0049
			(0.0173)	(0.0173)	(0.0173)	(0.0242)	(0.0241)	(0.0241)
n		**Controlled room ventilation/comfort ventilation**	0.0180*	0.0171*	0.0175*	0.005	0.0032	0.0033
			(0.0099)	(0.0099)	(0.0099)	(0.0133)	(0.0134)	(0.0134)
		Gas-fired heating	0.0206*	0.0207*	0.0209*	0.0258	0.0252	0.0249
			(0.0125)	(0.0125)	(0.0125)	(0.0192)	(0.0192)	(0.0192)
		Electric heating	0.0186	0.0175	0.0181	0.0087	0.0086	0.009
			(0.0293)	(0.0293)	(0.0293)	(0.1243)	(0.1245)	(0.1243)
		Chimney/Chimney stove	0.0430***	0.0432***	0.0432***	0.0330**	0.0324**	0.0323**
			(0.0081)	(0.0080)	(0.0080)	(0.0132)	(0.0132)	(0.0132)
		Floor heating	−0.0043	−0.0048	−0.0048	0.0122	0.0124	0.0123
			(0.0084)	(0.0085)	(0.0085)	(0.0135)	(0.0135)	(0.0135)
		Radiators/Flat panel radiators	0.0241	0.0238	0.0237	0.0106	0.0114	0.0116
			(0.0275)	(0.0274)	(0.0274)	(0.0245)	(0.0245)	(0.0246)
		Heating without specifications	0.0545***	0.0539***	0.0540***	0.0193	0.0189	0.0186
			(0.0152)	(0.0152)	(0.0152)	(0.0217)	(0.0217)	(0.0218)
o	Insulation	**MINERGIE standard insulation**	0.0545*	0.0529*	0.0520*	0.034	0.0329	0.0319
	Ref. Cat. = all others		(0.0281)	(0.0281)	(0.0282)	(0.0826)	(0.0817)	(0.0817)
		Internal thermal insulation	−0.0243**	−0.0244**	−0.0244**	−0.0005	−0.0001	0.00004
			(0.0111)	(0.0111)	(0.0111)	(0.0162)	(0.0162)	(0.0162)
		External thermal insulation	−0.0152	−0.0158*	−0.0158*	−0.0245*	−0.0253*	−0.0251*
			(0.0094)	(0.0094)	(0.0094)	(0.0144)	(0.0144)	(0.0144)
		In-between thermal insulation	0.0260**	0.0251*	0.0249*	−0.0285	−0.0293	−0.0294
			(0.0129)	(0.0129)	(0.0129)	(0.0214)	(0.0214)	(0.0214)

(*continued*)

Table A2. Continued.

			Specifications	(II)	(VII)	(VIII)	(II)	(VII)	(VIII)
			Thermal insulation of earth-contacting components	0.0065	0.006	0.006	−0.0296	−0.029	−0.0293
				(0.0115)	(0.0115)	(0.0115)	(0.0205)	(0.0205)	(0.0205)
			Insulation and seal without specifications	0.0201	0.0196	0.0198	−0.0169	−0.0166	−0.0168
				(0.0123)	(0.0123)	(0.0123)	(0.0196)	(0.0196)	(0.0196)
	p	Electricity	**Solar energy**	0.0247***	0.0246***	0.0246***	−0.0008	−0.0011	−0.0009
		Ref. Cat. = all others		(0.0080)	(0.0080)	(0.0080)	(0.0148)	(0.0148)	(0.0148)
		Supporting Structure	Wood	−0.0138	−0.0139	−0.0142	0.0157	0.0156	0.0157
		Ref. Cat. = Concrete		(0.0107)	(0.0107)	(0.0107)	(0.0167)	(0.0167)	(0.0166)
			Brick	−0.0019	−0.002	−0.0021	0.0127	0.0125	0.0125
				(0.0071)	(0.0072)	(0.0072)	(0.0122)	(0.0122)	(0.0122)
			Aerated concrete blocks	−0.1297***	−0.1287***	−0.1296***	−0.055	−0.0549	−0.0537
				(0.0379)	(0.0379)	(0.0379)	(0.0686)	(0.0687)	(0.0685)
			Sand-lime brick	0.0397	0.0379	0.0385	0.0381	0.04	0.0399
				(0.0473)	(0.0471)	(0.0471)	(0.0560)	(0.0562)	(0.0561)
			Skeleton construction (concrete, steel, wood)	−0.0081	−0.0071	−0.0074	−0.0081	−0.0095	−0.0085
				(0.0294)	(0.0294)	(0.0294)	(0.0497)	(0.0497)	(0.0497)
			Steel	−0.0329	−0.0329	−0.033	0.0134	0.0137	0.0145
				(0.0206)	(0.0206)	(0.0206)	(0.0211)	(0.0210)	(0.0211)
			Double-shell masonry/brickwork	0.0224	0.0223	0.0219	0.0629**	0.0632**	0.0633**
				(0.0189)	(0.0189)	(0.0189)	(0.0281)	(0.0281)	(0.0281)
			Exposed masonry/brickwork	0.0244	0.0248	0.0251	0.0125	0.0012	0.0037
				(0.0421)	(0.0424)	(0.0424)	(0.0684)	(0.0795)	(0.0782)
			Single-layer masonry/brickwork	−0.0087	−0.0094	−0.0094	−0.0281	−0.0291	−0.0288
				(0.0213)	(0.0213)	(0.0214)	(0.0294)	(0.0293)	(0.0293)
			Supporting structure without specifications	0.0088	0.0088	0.0088	0.0549**	0.0539**	0.0537**
				(0.0152)	(0.0152)	(0.0152)	(0.0244)	(0.0243)	(0.0243)

Source: Data from ARE (2020), Blaublatt/Bauinfo-Center Docu Media (2020), FSO (2018), FPRE (2020), MINERGIE (2021).
Note: White heteroskedasticity-consistent (robust) standard errors HC1 are clustered for each location cluster within parentheses. Significance values 0.10, 0.05, and 0.01 are indicated by *, **, and ***, respectively.

Table B1. Full-blown regression results of construction costs/m^2 and net rent/m^2a including amenity controls (specifications [II], [VII], and [VIII]) 2/2.

		Specifications	(II)	(VII)	(VIII)	(II)	(VII)	(VIII)
		A) Certificates **B) Technology controls** C) Amenity controls D) Market & size controls E) Location controls F) Time controls G) Constant H) Regression statistics	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
	OLS							
	Specifications		(II)	(VII)	(VIII)	(II)	(VII)	(VIII)
	Dependent variable:		Construction costs/m^2			Net rent/m^{2}a		
	Structural variables:							
Line:								
B) Technology & C) Amenity controls	Flooring *Ref. Cat. = all others*	Floor underlay	−0.0305	−0.0336	−0.0335	−0.0106	−0.0121	−0.0118
			(0.0737)	(0.0737)	(0.0737)	(0.0598)	(0.0594)	(0.0593)
		Artificial stone flooring	−0.0431***	−0.0430***	−0.0427***	−0.0212	−0.0214	−0.0214
			(0.0109)	(0.0109)	(0.0109)	(0.0172)	(0.0171)	(0.0171)
		Parquet flooring	−0.0123**	−0.0124**	−0.0124**	−0.0214**	−0.0214**	−0.0213**
			(0.0059)	(0.0059)	(0.0059)	(0.0088)	(0.0088)	(0.0088)
		Linoleum flooring/synthetic flooring	0.0355	0.0353	0.0348	0.0217	0.0224	0.0204
			(0.0255)	(0.0255)	(0.0254)	(0.0434)	(0.0429)	(0.0426)
		Textile flooring	−0.0404*	−0.0402*	−0.0399	−0.0053	−0.0077	−0.0072
			(0.0244)	(0.0244)	(0.0244)	(0.0429)	(0.0427)	(0.0427)
		Ceramic flooring	−0.0024	−0.0019	−0.0019	−0.0092	−0.0089	−0.0089
			(0.0070)	(0.0071)	(0.0071)	(0.0111)	(0.0111)	(0.0111)
		Wooden flooring	−0.0013	−0.0011	−0.0017	−0.0395	−0.0372	−0.0373
			(0.0218)	(0.0218)	(0.0218)	(0.0450)	(0.0447)	(0.0448)
		Concrete flooring	−0.0251**	−0.0253**	−0.0253**	0.0060	0.0062	0.0064
			(0.0104)	(0.0104)	(0.0104)	(0.0146)	(0.0147)	(0.0147)
		Raised/false flooring	0.0315**	0.0317**	0.0317**	0.0215	0.0216	0.0219
			(0.0125)	(0.0124)	(0.0124)	(0.0161)	(0.0161)	(0.0161)
		Natural stone flooring	0.0834***	0.0832***	0.0834***	0.001	0.0017	0.0017
			(0.0199)	(0.0199)	(0.0199)	(0.0305)	(0.0306)	(0.0306)
		Laminate flooring	−0.0265	−0.0261	−0.0262	−0.0337	−0.0323	−0.0324
			(0.0170)	(0.0169)	(0.0169)	(0.0262)	(0.0263)	(0.0263)
		Industrial jointless flooring	0.0107	0.0107	0.0111	−0.0163	−0.0147	−0.0145
			(0.0337)	(0.0337)	(0.0336)	(0.0433)	(0.0432)	(0.0433)
	Interior							
	Not differentiated							
	Equipment	Air conditioner	0.0553	0.0562	0.0576	−0.0137	−0.0104	−0.0106
			(0.0384)	(0.0386)	(0.0385)	(0.0386)	(0.0387)	(0.0387)
		Conveyor system	0.0202***	0.0200***	0.0200***	0.0374***	0.0370***	0.0371***
			(0.0070)	(0.0070)	(0.0070)	(0.0103)	(0.0103)	(0.0103)
		Sun and weather protection	−0.0313	−0.0302	−0.031	0.0567	0.0559	0.0554
			(0.1047)	(0.1052)	(0.1051)	(0.0958)	(0.0955)	(0.0958)
		Building automation	0.0433**	0.0433**	0.0430**	0.0145	0.0149	0.0143
			(0.0214)	(0.0213)	(0.0214)	(0.0349)	(0.0345)	(0.0346)
		Safety technology	−0.0193	−0.0192	−0.019	−0.0473	−0.0472	−0.0467
			(0.0192)	(0.0192)	(0.0192)	(0.0330)	(0.0326)	(0.0327)
		Garage gate	0.0049	0.0051	0.0053	0.0477***	0.0478***	0.0481***

(*continued*)

Table B1. Continued.

			Specifications	(II)	(VII)	(VIII)	(II)	(VII)	(VIII)
				(0.0074)	(0.0074)	(0.0074)	(0.0108)	(0.0108)	(0.0108)
			Landscaping	−0.0745	−0.0749	−0.0752	−0.0448	−0.0456	−0.0464
				(0.0504)	(0.0503)	(0.0503)	(0.0500)	(0.0501)	(0.0502)
			Cooling systems	0.0516***	0.0517***	0.0517***	0.0001	0.0002	0.0001
				(0.0108)	(0.0108)	(0.0108)	(0.0154)	(0.0154)	(0.0154)
			Tank installations (areas	−0.0179	−0.017	−0.0163	0.1442	0.1454	0.145
			with heating)	(0.1423)	(0.1422)	(0.1422)	(0.0893)	(0.0906)	(0.0907)
			Terraces/balconies	0.0254	0.026	0.0263	−0.0187	−0.0185	−0.0167
				(0.0335)	(0.0336)	(0.0336)	(0.0466)	(0.0462)	(0.0458)
			Ventilation	0.0211	0.0213	0.0213	−0.0200	−0.0201	−0.0200
				(0.0144)	(0.0144)	(0.0144)	(0.0207)	(0.0207)	(0.0207)
			Habitat/pond	0.0445	0.0447	0.0452	−0.1847***	−0.1849***	−0.1849***
				(0.0731)	(0.0731)	(0.0733)	(0.0392)	(0.0391)	(0.0391)
			Pergola	0.0212**	0.0211**	0.0211**	−0.0035	−0.0039	−0.0039
				(0.0087)	(0.0087)	(0.0087)	(0.0121)	(0.0121)	(0.0121)
			External lighting	0.017	0.017	0.0168	0.0227	0.0227	0.0225
				(0.0127)	(0.0127)	(0.0127)	(0.0224)	(0.0224)	(0.0224)
			Irrigation system	0.0226	0.0254	0.026	0.1960***	0.1954***	0.1950***
				(0.0935)	(0.0938)	(0.0939)	(0.0614)	(0.0613)	(0.0612)
			Controlled parking system	0.0543	0.0517	0.0491	−0.0647*	−0.0617*	−0.0617*
				(0.0553)	(0.0556)	(0.0550)	(0.0365)	(0.0364)	(0.0364)
D) Market & size controls	q	Market	Owner-occupied property	0.0356***	0.0354***	0.0355***	−0.0011	−0.0014	−0.0015
				(0.0049)	(0.0049)	(0.0049)	(0.0077)	(0.0077)	(0.0077)
	r	Size	ln(Number of apartments)	0.2504***	0.2504***	0.2505***	−0.0306***	−0.0311***	−0.0311***
				(0.0098)	(0.0097)	(0.0097)	(0.0051)	(0.0051)	(0.0051)
	s		ln(Square area per project [m^2])	−0.3506***	−0.3508***	−0.3509***			
				(0.0103)	(0.0103)	(0.0102)			
	t		ln(Stories)	0.0232**	0.0231**	0.0229**	0.008	0.0078	0.0077
				(0.0096)	(0.0096)	(0.0096)	(0.0139)	(0.0139)	(0.0139)
	u		ln(Mean net floor area)				−0.3484***	−0.3483***	−0.3481***
							(0.0228)	(0.0228)	(0.0228)
	v		ln(Mean number of rooms)				0.0498*	0.0491*	0.0491*
							(0.0258)	(0.0257)	(0.0257)
E) Location		Locational variables:							
	w	Mobilité Spatiale regions		y	y	y	y	y	y
	x	Accessibility by public transport	A	0.0249**	0.0254**	0.0258**	0.0846***	0.0846***	0.0848***
		Ref. Cat. = none		(0.0115)	(0.0115)	(0.0115)	(0.0163)	(0.0164)	(0.0164)
			B	0.0161*	0.0168*	0.0169*	0.0613***	0.0611***	0.0611***
				(0.0088)	(0.0088)	(0.0088)	(0.0133)	(0.0133)	(0.0133)
			C	0.0011	0.0018	0.0019	0.0422***	0.0421***	0.0422***
				(0.0072)	(0.0072)	(0.0072)	(0.0118)	(0.0118)	(0.0118)
			D	0.0032	0.0038	0.0037	0.0188	0.0185	0.0184
				(0.0061)	(0.0061)	(0.0061)	(0.0116)	(0.0116)	(0.0116)
	y	Population density per hectare		−0.0060**	−0.0059**	−0.0059**	−0.0133***	−0.0131***	−0.0131***
				(0.0023)	(0.0023)	(0.0023)	(0.0035)	(0.0035)	(0.0035)
F) Time		Time fixed effects:							
	z	Year of building application	2011	0.0415***	0.0418***	0.0418***	0.0166	0.0159	0.0161
		Ref. Cat. = 2010		(0.0103)	(0.0103)	(0.0103)	(0.0145)	(0.0145)	(0.0145)
			2012	0.0841***	0.0843***	0.0843***	0.0222	0.0216	0.0219
				(0.0104)	(0.0104)	(0.0104)	(0.0146)	(0.0146)	(0.0146)

(*continued*)

Table B1. Continued.

		Specifications	(II)	(VII)	(VIII)	(II)	(VII)	(VIII)
		2013	0.0882***	0.0889***	0.0889***	0.015	0.0157	0.0159
			(0.0101)	(0.0101)	(0.0101)	(0.0138)	(0.0138)	(0.0138)
		2014	0.0901***	0.0906***	0.0906***	0.0093	0.0098	0.01
			(0.0104)	(0.0104)	(0.0104)	(0.0139)	(0.0139)	(0.0139)
		2015	0.0967***	0.0972***	0.0974***	0.0128	0.0129	0.0131
			(0.0104)	(0.0104)	(0.0104)	(0.0139)	(0.0139)	(0.0139)
		2016	0.1113***	0.1121***	0.1122***	0.0013	0.002	0.0021
			(0.0107)	(0.0107)	(0.0107)	(0.0136)	(0.0136)	(0.0136)
		2017	0.1057***	0.1066***	0.1066***	0.0081	0.0087	0.0084
			(0.0106)	(0.0107)	(0.0107)	(0.0152)	(0.0152)	(0.0152)
		2018	0.0986***	0.0999***	0.0999***	−0.0196	−0.0183	−0.0183
			(0.0106)	(0.0106)	(0.0106)	(0.0172)	(0.0172)	(0.0172)
		2019	0.1320***	0.1335***	0.1334***	−0.0758***	−0.0744***	−0.0743***
			(0.0118)	(0.0118)	(0.0118)	(0.0203)	(0.0203)	(0.0203)
		2020	0.1255***	0.1269***	0.1267***	−0.2356***	−0.2339***	−0.2349***
			(0.0135)	(0.0135)	(0.0135)	(0.0326)	(0.0326)	(0.0326)
G) Constant		Constant	9.6325***	9.6331***	9.6344***	7.2658***	7.2690***	7.2689***
			(0.1323)	(0.1324)	(0.1324)	(0.1325)	(0.1323)	(0.1324)
H) Regression statistics	*N*		11,993	11,993	11,993	3,562	3,562	3,562
	R^2		0.321	0.3214	0.3215	0.608	0.6086	0.6087
	Adjusted R^2		0.3092	0.3095	0.3095	0.5844	0.5849	0.5849
	Residual Std. Error		0.2378	0.2377	0.2377	0.1856	0.1855	0.1855
			(df = 11786)	(df = 11785)	(df = 11784)	(df = 3359)	(df = 3358)	(df = 3357)
	F Statistic		27.0538***	26.9608***	26.8409***	25.7933***	25.7188***	25.5953***
			(df = 206; 11786)	(df = 207; 11785)	(df = 208; 11784)	(df = 202; 3359)	(df = 203; 3358)	(df = 204; 3357)

Source: Data from ARE (2020), Blaublatt/Bauinfo-Center Docu Media (2020), FSO (2018), FPRE (2020), MINERGIE (2021).
Note: White heteroskedasticity-consistent (robust) standard errors HC1 are clustered for each location cluster within parentheses. Significance values 0.10, 0.05, and 0.01 are indicated by *, **, and ***, respectively.

Table C1. Regression results for separated samples of certified and noncertified building projects 1/2.

			Specifications	(A)	(B)	(C)	(D)	(E)	(F)	(G)	(H)
			A) Certificates	■	■	■	■	■	■	■	■
			B) Technology controls		■		■		■		■
			C) Amenity controls	■	■	■	■	■	■	■	■
			D) Market & size controls	■	■	■	■	■	■	■	■
			E) Location controls	■	■	■	■	■	■	■	■
			F) Time controls	■	■	■	■	■	■	■	■
			G) Constant	■	■	■	■	■	■	■	■
			H) Regression statistics	■	■	■	■	■	■	■	■
		Sample		Certified sample		Noncertified sample		Certified sample		Noncertified sample	
		OLS		Construction costs/m^2				Net rent/m^2a			
		Specifications		(A)	(B)	(C)	(D)	(E)	(F)	(G)	(H)
		Dependent variable:		ln(Construction costs/m^2)				ln(Net rent/m^2a)			
		Structural variables:									
	Line:										
A) Certificates	a	Certificates	MINERGIE Y/N								
		Ref. Cat. = noncertified buildings									
	b		MINERGIE								
	c		MINERGIE-P or higher								
B) Technology & C) Amenity controls	d	Roofing	**MINERGIE standard**	−0.046	−0.0152	0.0302	0.0185	−0.0837	0.1215	0.1342	0.0883
		Ref. Cat. = all others		(0.1130)	(0.1106)	(0.0313)	(0.0305)	(0.0867)	(0.1914)	(0.2721)	(0.2601)
		Roofing finishes	Green roofing		0.0269		0.0314***		−0.0031		0.0711***
		Ref. Cat. = all others			(0.0226)		(0.0061)		(0.0429)		(0.0085)
	e	Façade	**MINERGIE standard**	0.1014	0.1301	0.0247	−0.0021	0.2284	0.3615	−0.0977	−0.1027
		Ref. Cat. = Plastered masonry/		(0.1569)	(0.1942)	(0.0348)	(0.0352)	(0.1736)	(0.3339)	(0.0801)	(0.0718)
		brickwork for Spec. (2), (7) & (8)	Wood		0.0712**		0.0056		0.1948*		−0.0242*
					(0.0305)		(0.0089)		(0.1021)		(0.0140)
			Metal/steel/light metal		0.0303		−0.002		−0.0596		−0.0469
					(0.0609)		(0.0192)		(0.1290)		(0.0323)
			Natural stone		0.0392		0.0322		0.1810		0.0457
					(0.0638)		(0.0250)		(0.1118)		(0.0377)
			Glass		0.0875*		0.0623***		0.0386		0.0662**
					(0.0527)		(0.0186)		(0.0725)		(0.0278)
			Façade elements: concrete/lightweight concrete/artificial stone		0.0297		0.0237		0.1323		0.0097
					(0.0625)		(0.0240)		(0.1615)		(0.0457)
			Ventilated curtain façades		0.0114		0.0295***		−0.1381		0.0152
					(0.0355)		(0.0096)		(0.0984)		(0.0146)
			Fiber cement plates		0.0747		−0.0148		0.0989		−0.0373*
					(0.0633)		(0.0152)		(0.1247)		(0.0214)
			Ceramic		0.0373		0.0333		0.0596		0.055
					(0.0589)		(0.0320)		(0.1824)		(0.0367)
			Exposed masonry/brickwork		−0.0429		0.0272		−0.1138		0.0109
					(0.0583)		(0.0255)		(0.1214)		(0.0486)
			Sandwich panels		0.1557*		−0.0259		0.3161		−0.021
					(0.0807)		(0.0444)		(0.4007)		(0.0851)
			Exposed concrete		−0.0128		0.0532***		0.0636		0.0115
					(0.0478)		(0.0153)		(0.1453)		(0.0258)
			Compact façades		0.046		0.0134		−0.0237		−0.0258
					(0.0545)		(0.0176)		(0.0956)		(0.0259)
			Façades without specifications		0.0219		−0.0019		−0.1708		−0.0256
					(0.0601)		(0.0203)		(0.1246)		(0.0256)

(*continued*)

Table C1. Continued.

		Specifications	(A)	(B)	(C)	(D)	(E)	(F)	(G)	(H)
f	Windows	**Minergie standard**	−0.0100	0.0221	−0.0614	−0.0688*	−0.0501	−0.2176	−0.076	−0.0596
	Ref. Cat. = Plastic windows		(0.2321)	(0.2086)	(0.0400)	(0.0385)	(0.0932)	(0.1493)	(0.1217)	(0.1134)
	for Spec. (2), (7) & (8)	Wood windows		0.0808**		0.0475***		−0.2252*		0.0053
				(0.0363)		(0.0123)		(0.1224)		(0.0198)
		Metal/lightweight metal windows		−0.0455		0.0457***		0.2956		0.0023
				(0.0458)		(0.0133)		(0.1895)		(0.0277)
		Thermal and acoustic insulated windows		−0.3645***		0.1065				0.0737
				(0.1055)		(0.0920)				(0.0589)
		Balcony and terrace windows		0.1240*		−0.0151		0.0935		−0.0167
				(0.0684)		(0.0195)		(0.1388)		(0.0438)
		Wood/metal windows		0.0455*		0.0443***		−0.0282		0.0147*
				(0.0235)		(0.0061)		(0.0417)		(0.0085)
		Windows without specifications		−0.0794*		0.0074		0.1698		0.0187
				(0.0472)		(0.0179)		(0.1083)		(0.0220)
g	Heating	**District heating**	0.0089	0.0397	0.0288***	0.0528***	0.0129	0.0396	−0.0156	−0.0004
	Ref. Cat. = Oil-fired heating		(0.0297)	(0.0418)	(0.0099)	(0.0145)	(0.0512)	(0.0949)	(0.0141)	(0.0228)
h	for Spec. (2), (7) & (8)	**Heat pumps**	−0.0009	0.0423	−0.0043	0.0293**	−0.0077	0.0414	−0.0034	0.0176
			(0.0221)	(0.0378)	(0.0068)	(0.0128)	(0.0469)	(0.0677)	(0.0091)	(0.0206)
i		**Solar heating systems**	−0.0234	−0.0209	0.0001	0.008	−0.0461	−0.1051	0.0060	−0.0022
			(0.0250)	(0.0261)	(0.0073)	(0.0075)	(0.0600)	(0.0830)	(0.0109)	(0.0112)
j		**Geothermal energy/ground probes/collectors**	0.0545***	0.0429**	0.0349***	0.0293***	0.0665*	0.0769	0.0257***	0.0186**
			(0.0208)	(0.0214)	(0.0062)	(0.0061)	(0.0394)	(0.0519)	(0.0093)	(0.0092)
k		**Wood-fired heating**	0.0905	0.1302*	0.0043	0.0256			−0.0164	−0.0094
			(0.0815)	(0.0764)	(0.0178)	(0.0197)			(0.0314)	(0.0327)
l		**Wood-chip heating**	0.0218	0.0578	0.0246	0.0448*	0.1050	0.2019	−0.0575*	−0.0254
			(0.0736)	(0.0743)	(0.0252)	(0.0256)	(0.0940)	(0.1893)	(0.0328)	(0.0320)
m		**Pellet heating**	0.0642	0.0522	0.0352**	0.0599***	0.1017	0.167	−0.0254	−0.0049
			(0.0512)	(0.0559)	(0.0163)	(0.0184)	(0.0675)	(0.1033)	(0.0207)	(0.0257)
n		**Controlled room ventilation/comfort ventilation**	−0.0481	−0.0226	0.0209*	0.0183*	0.0138	0.0231	0.0134	0.0053
			(0.0306)	(0.0332)	(0.0108)	(0.0107)	(0.0482)	(0.0779)	(0.0148)	(0.0147)
		Gas-fired heating		0.0552		0.02		0.0688		0.0255
				(0.0416)		(0.0133)		(0.0776)		(0.0206)
		Electric heating		0.0443		0.0097				0.0215
				(0.0756)		(0.0335)				(0.1190)
		Chimney/Chimney stove		0.0614*		0.0404***		0.0379		0.0339**
				(0.0326)		(0.0084)		(0.0814)		(0.0140)
		Floor heating		−0.0125		−0.0053		0.0435		0.0153
				(0.0290)		(0.0089)		(0.0842)		(0.0142)
		Radiators/Flat panel radiators		0.0492		0.0187		−0.3573		0.0154
				(0.0783)		(0.0298)		(0.2881)		(0.0255)
		Heating without specifications		0.034		0.0585***		0.0928		0.0202
				(0.0512)		(0.0162)		(0.0842)		(0.0231)
o	Insulation	**Minergie standard insulation**	−0.0489	−0.1443	0.0307	0.0713***	−0.0912	−0.2721	0.0352	0.0598
	Ref. Cat. = all others		(0.0763)	(0.1324)	(0.0224)	(0.0275)	(0.0980)	(0.1875)	(0.0973)	(0.1058)
		Internal thermal insulation		0.0259		−0.0311***		−0.04		−0.0013
				(0.0461)		(0.0114)		(0.0908)		(0.0169)
		External thermal insulation		−0.0498		−0.0148		0.0276		−0.0231
				(0.0335)		(0.0098)		(0.0867)		(0.0152)
		In-between thermal insulation		0.0215		0.0252*		0.0894		−0.0292
				(0.0441)		(0.0137)		(0.0993)		(0.0228)

(*continued*)

Table C1. Continued.

			Specifications	(A)	(B)	(C)	(D)	(E)	(F)	(G)	(H)
			Thermal insulation of earth-contacting components		–0.0157		0.0066		–0.1029		–0.0408*
					(0.0357)		(0.0123)		(0.1367)		(0.0215)
			Insulation and seal without specifications		–0.0429		0.0267**		0.0148		–0.0186
					(0.0395)		(0.0131)		(0.1084)		(0.0204)
	p	Electricity	**Solar energy**	–0.0037	–0.0276	0.0326***	0.0286***	–0.0436	–0.0127	–0.0033	0.0043
		Ref. Cat. = all others		(0.0274)	(0.0292)	(0.0084)	(0.0084)	(0.0408)	(0.0578)	(0.0159)	(0.0159)
		Supporting Structure	Wood		0.0013		–0.013		–0.1707		0.0175
		Ref. Cat. = Concrete			(0.0377)		(0.0113)		(0.1144)		(0.0175)
			Brick		–0.0085		–0.0015		0.1141		0.0112
					(0.0220)		(0.0077)		(0.0828)		(0.0128)
			Aerated concrete blocks		–0.1197		–0.1438***		0.0908		–0.0473
					(0.1153)		(0.0405)		(0.5186)		(0.0700)
			Sand-lime brick		0.04150		0.0265				0.03810
					(0.1110)		(0.0489)				(0.0575)
			Skeleton construction (concrete, steel, wood)		0.0134		0.0026		–0.2265		–0.0015
					(0.1162)		(0.0309)		(0.1500)		(0.0546)
			Steel		–0.0629		–0.0290		0.1321		0.0107
					(0.0464)		(0.0229)		(0.1422)		(0.0232)
			Double-shell masonry/brickwork		0.1070		0.0180		0.0065		0.0579**
					(0.0768)		(0.0195)		(0.1440)		(0.0290)
			Exposed masonry/brickwork		–0.1870**		0.0353		–0.1164		0.0971
					(0.0778)		(0.0443)		(0.1807)		(0.0621)
			Single-layer masonry/brickwork		–0.0420		–0.0076		0.2825		–0.0386
					(0.0702)		(0.0223)		(0.2050)		(0.0304)
			Supporting structure without specifications		0.0731		0.0035		0.1430**		0.0465*
					(0.0472)		(0.0161)		(0.0716)		(0.0243)

Source: Data from ARE (2020), Blaublatt/Bauinfo-Center Docu Media (2020), FSO (2018), FPRE (2020), MINERGIE (2021).
Note: White heteroskedasticity-consistent (robust) standard errors HC1 are clustered for each location cluster within parentheses. Significance values 0.10, 0.05, and 0.01 are indicated by *, **, and ***, respectively.

Table C2. Regression results for separated samples of certified and noncertified building projects 2/2.

		Specifications	(A)	(B)	(C)	(D)	(E)	(F)	(G)	(H)
		A) Certificates **B) Technology controls** C) Amenity controls D) Market & size controls E) Location controls F) Time controls G) Constant H) Regression statistics								
	Sample		Certified sample		Noncertified sample		Certified sample		Noncertified sample	
	OLS		Construction costs/m^2				Net rent/m^2a			
	Specifications		(A)	(B)	(C)	(D)	(E)	(F)	(G)	(H)
	Dependent variable:		ln(Construction costs/m^2)				ln(Net rent/m^2a)			
	Structural variables:									
Line:										
B) Technology & C) Amenity controls	Flooring	Floor underlay				−0.0268				−0.0077
	Ref. Cat. = all others					(0.0740)				(0.0591)
		Artificial stone flooring		−0.0639		−0.0460***		−0.0801		−0.0236
				(0.0423)		(0.0113)		(0.1259)		(0.0180)
		Parquet flooring		−0.0057		−0.0136**		−0.008		−0.0220**
				(0.0248)		(0.0061)		(0.0461)		(0.0092)
		Linoleum flooring/synthetic flooring		0.0344		0.0363		0.7714***		0.0125
				(0.0770)		(0.0271)		(0.2176)		(0.0434)
		Textile flooring		−0.0902		−0.036		−0.1763		−0.0125
				(0.0874)		(0.0257)		(0.1814)		(0.0484)
		Ceramic flooring		−0.0386		0.001		0.0362		−0.0101
				(0.0268)		(0.0074)		(0.0547)		(0.0117)
		Wooden flooring		0.0111		0.0017				−0.0342
				(0.0681)		(0.0232)				(0.0446)
		Concrete flooring		0.0174		−0.0285***		0.1824**		−0.0017
				(0.0348)		(0.0110)		(0.0832)		(0.0155)
		Raised/false flooring		0.0788*		0.0279**		−0.1002		0.0227
				(0.0448)		(0.0132)		(0.1185)		(0.0169)
		Natural stone flooring		0.0638		0.0863***		0.0385		0.0049
				(0.0549)		(0.0220)		(0.1972)		(0.0323)
		Laminate flooring		0.0560		−0.0291*		0.2595		−0.0351
				(0.0665)		(0.0174)		(0.3180)		(0.0268)
		Industrial jointless flooring		−0.0437		0.0095		0.0475		−0.0222
				(0.1394)		(0.0343)		(0.2522)		(0.0447)
	Interior									
	Not differentiated									
	Equipment	Air conditioner		0.0175		0.0569				0.0084
				(0.0982)		(0.0426)				(0.0414)
		Conveyor system		0.0514*		0.0171**		0.0607		0.0384***
				(0.0271)		(0.0074)		(0.0573)		(0.0108)
		Sun and weather protection		0.4713***		−0.0746				0.0482
				(0.1009)		(0.1125)				(0.0967)
		Building automation		0.1341		0.0323		−0.7000***		0.0183
				(0.0988)		(0.0220)		(0.2511)		(0.0355)
		Safety technology		−0.073		−0.0166		0.7092***		−0.0551*
				(0.0882)		(0.0199)		(0.2651)		(0.0331)

(*continued*)

Table C2. Continued.

			Specifications	(A)	(B)	(C)	(D)	(E)	(F)	(G)	(H)
			Garage gate		−0.0388		0.0094		−0.0282		0.0474***
					(0.0270)		(0.0078)		(0.0804)		(0.0113)
			Landscaping		−0.2892**		−0.0588				−0.0524
					(0.1355)		(0.0514)				(0.0511)
			Cooling systems		0.0375		0.0533***		−0.1084		0.0013
					(0.0425)		(0.0114)		(0.1127)		(0.0161)
			Tank installations (areas with heating)		−0.1831		−0.0123				0.1408
					(0.1304)		(0.1589)				(0.0913)
			Terraces/balconies		0.1922**		0.0118				−0.0053
					(0.0858)		(0.0353)				(0.0463)
			Ventilation		−0.0468		0.0312**		−0.1438		−0.0115
					(0.0535)		(0.0151)		(0.1605)		(0.0217)
			Habitat/pond		0.0958		−0.0022				−0.1888***
					(0.1264)		(0.0805)				(0.0406)
			Pergola		0.0208		0.0218**		0.0305		−0.0038
					(0.0293)		(0.0093)		(0.0744)		(0.0129)
			External lighting		0.0262		0.0166		0.1743		0.0235
					(0.0442)		(0.0132)		(0.1549)		(0.0241)
			Irrigation system				0.0214				0.2108***
							(0.1013)				(0.0702)
			Controlled parking system		−0.0100		0.0799				−0.0846**
					(0.1470)		(0.0568)				(0.0388)
D) market & size controls	q	Market	Owner-occupied property	0.0530***	0.0469**	0.0372***	0.0344***	−0.0251	−0.0692	0.01	−0.0007
				(0.0169)	(0.0182)	(0.0051)	(0.0051)	(0.0306)	(0.0613)	(0.0077)	(0.0080)
	r	Size	ln(Number of apartments)	0.2083***	0.2286***	0.2280***	0.2513***	−0.0462**	−0.0971***	−0.0183***	−0.0290***
				(0.0328)	(0.0349)	(0.0099)	(0.0102)	(0.0191)	(0.0342)	(0.0048)	(0.0053)
	s		ln(Square area per project [m^2])	−0.2961***	−0.3247***	−0.3150***	−0.3529***				
				(0.0322)	(0.0367)	(0.0098)	(0.0107)				
	t		ln(Stories)	0.0717**	0.0254	0.0365***	0.0225**	0.0770	0.2595***	0.0105	0.0024
				(0.0335)	(0.0332)	(0.0099)	(0.0100)	(0.0548)	(0.0706)	(0.0142)	(0.0146)
	u		ln(Mean net floor area)					−0.4593***	−0.5948***	−0.3264***	−0.3441***
								(0.1104)	(0.1372)	(0.0234)	(0.0235)
	v		ln(Mean number of rooms)					0.1843	0.3473*	0.0352	0.0447*
								(0.1473)	(0.1833)	(0.0265)	(0.0265)
E) Location		Locational variables:									
	w	Mobilité Spatiale regions		y	y	y	y	y	y	y	y
	x	Accessibility by public transport	A	0.0864**	0.0994**	0.0502***	0.0231*	0.1760**	0.2400**	0.1037***	0.0801***
		Ref. Cat. = none		(0.0385)	(0.0408)	(0.0122)	(0.0122)	(0.0807)	(0.1006)	(0.0169)	(0.0171)
			B	0.0563*	0.0515	0.0300***	0.013	0.1347*	0.1934*	0.0740***	0.0555***
				(0.0333)	(0.0328)	(0.0092)	(0.0092)	(0.0746)	(0.1130)	(0.0137)	(0.0138)
			C	−0.0053	0.0057	0.011	0.0027	0.0991	0.125	0.0511***	0.0384***
				(0.0248)	(0.0254)	(0.0077)	(0.0076)	(0.0604)	(0.0812)	(0.0124)	(0.0124)
			D	0.0008	0.0108	0.0079	0.005	0.0567	0.0761	0.0199	0.0144
				(0.0202)	(0.0207)	(0.0066)	(0.0064)	(0.0690)	(0.0900)	(0.0122)	(0.0120)
	y	Population density per hectare		−0.0105	−0.0125	−0.0075***	−0.0062**	−0.0228	−0.0400*	−0.0135***	−0.0126***
				(0.0075)	(0.0079)	(0.0025)	(0.0025)	(0.0155)	(0.0239)	(0.0038)	(0.0037)
F) Time		Time fixed effects:									
	z	Year of building application	2011	0.0505	0.0648*	0.0352***	0.0382***	0.0658	0.0619	0.0111	0.0155
		Ref. Cat. = 2010		(0.0317)	(0.0339)	(0.0112)	(0.0110)	(0.0572)	(0.0666)	(0.0153)	(0.0153)
			2012	0.1055***	0.0934***	0.0753***	0.0806***	0.0613	0.0577	0.0203	0.023

(*continued*)

Table C2. Continued.

		Specifications	(A)	(B)	(C)	(D)	(E)	(F)	(G)	(H)
			(0.0318)	(0.0322)	(0.0114)	(0.0111)	(0.0537)	(0.0795)	(0.0153)	(0.0153)
		2013	0.1085***	0.1315***	0.0774***	0.0813***	0.0112	0.0134	0.0100	0.0190
			(0.0377)	(0.0388)	(0.0108)	(0.0106)	(0.0563)	(0.0714)	(0.0142)	(0.0144)
		2014	0.1168***	0.1311***	0.0796***	0.0857***	0.0081	0.06	0.0064	0.012
			(0.0322)	(0.0340)	(0.0112)	(0.0111)	(0.0566)	(0.0889)	(0.0143)	(0.0147)
		2015	0.1025***	0.1293***	0.0836***	0.0934***	0.1004**	0.1145	0.0026	0.0137
			(0.0348)	(0.0365)	(0.0110)	(0.0110)	(0.0466)	(0.0806)	(0.0143)	(0.0148)
		2016	0.0874***	0.1169***	0.1014***	0.1108***	0.0464	0.0996	−0.0072	0.004
			(0.0323)	(0.0337)	(0.0115)	(0.0113)	(0.0607)	(0.1244)	(0.0142)	(0.0144)
		2017	0.1292***	0.1472***	0.0903***	0.1003***	−0.0198	0.0241	0.0036	0.0112
			(0.0362)	(0.0368)	(0.0112)	(0.0112)	(0.0615)	(0.0961)	(0.0154)	(0.0161)
		2018	0.1577***	0.1880***	0.0838***	0.0942***	0.0671	0.0059	−0.0294	−0.0176
			(0.0381)	(0.0414)	(0.0112)	(0.0111)	(0.0566)	(0.1076)	(0.0179)	(0.0179)
		2019	0.1448***	0.1775***	0.1217***	0.1302***	0.1302	0.0748	−0.0882***	−0.0734***
			(0.0403)	(0.0449)	(0.0124)	(0.0123)	(0.1101)	(0.1561)	(0.0212)	(0.0210)
		2020	0.1179**	0.1400***	0.1188***	0.1214***	−0.4106***	−0.7603**	−0.2282***	−0.2260***
			(0.0471)	(0.0533)	(0.0141)	(0.0141)	(0.1078)	(0.3355)	(0.0341)	(0.0334)
G) Constant		Constant	7.1462***	7.3295***	7.2577***	7.4553***	7.7519***	7.7003***	7.3016***	7.2574***
			(0.1962)	(0.2891)	(0.0596)	(0.1352)	(0.3807)	(0.5401)	(0.0925)	(0.1351)
H) Regression statistics	*N*		1,118	1,118	10,875	10,875	227	227	3,335	3,335
	R^2		0.3764	0.446	0.291	0.3206	0.8672	0.9266	0.5729	0.6011
	Adjusted R^2		0.2936	0.3267	0.282	0.3074	0.7655	0.7727	0.5554	0.5756
	Residual Std. Error		0.2460	0.2402	0.2418	0.2375	0.1465	0.1443	0.1913	0.1869
			(df = 986)	(df = 919)	(df = 10737)	(df = 10668)	(df = 128)	(df = 73)	(df = 3203)	(df = 3134)
	F Statistic		4.5436***	3.7368***	32.1718***	24.4337***	8.5264***	6.0209***	32.7943***	23.6107***
			(df = 131; 986)	(df = 198; 919)	(df = 137; 10737)	(df = 206; 10668)	(df = 98; 128)	(df = 153; 73)	(df = 131; 3203)	(df = 200; 3134)

Source: Data from ARE (2020), Blaublatt/Bauinfo-Center Docu Media (2020), FSO (2018), FPRE (2020), MINERGIE (2021).
Note: White heteroskedasticity-consistent (robust) standard errors HC1 are clustered for each location cluster within parentheses. Significance values 0.10, 0.05, and 0.01 are indicated by *, **, and ***, respectively.