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Sustainability and Real Estate Rental Rates: Empirical Evidence for Switzerland

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Abstract

We analyze the relation between Swiss properties' sustainability and their financial performance. For this purpose we use a unique dataset that contains a broad range of financial variables and sustainability criteria. All the properties were assessed with the Economic Sustainability Indicator (ESI) which consists of a wide-ranging set of sustainability subindicators. The aggregate ESI-Indicator allows to quantify a property's overall sustainability from an investor's point of view using various building characterstics. This indicator thus can be used to measure how a property's overall sustainability impacts its rental rate. As it is possible to select specific subsets of the ESI-subindicators, investigations are also possible at a disaggregated level. We specify two versions of a modified hedonic pricing model, and obtain significant and robust estimates of the properties' sustainability impact (i.e. ESI-Indicators) on their rental rates. Additionally we can show that the effect of a one point increase of a property's ESI-Indicator is as much as a 15 percent rise of its rental rate. On a disaggregated level it is found that of the ESI-Indicator's five sustainability criteria, all but one criteria (i.e. Flexibility and Polyvalence) have a positive impact on real estate's rental rates. Finally, it can be shown that if a property fulfills the popular Minergie-label's requirements (i.e. minimal energy efficiency standard and comfort ventilation), this is not affecting significantly that building's rental rate.
Keywords: Sustainability, Real Estate, Hedonic model

1 Introduction

For real estate investors the relation between a property's financial performance and its sustainability is relevant for several reasons. First, it is important to know whether and to what extent a property which is more sustainable according to certain criteria compared to other properties differs significantly in its financial performance. Second, it is crucial to have an idea which specific sustainability criteria are significantly correlated with a property's financial indicators (e.g. rental rates, sales prices or occupancy rates).

In recent years many authors analyzed the question which criteria of a property have a significant impact on its financial performance. As most papers suffer from of a lack of data, they restrict their analysis to the effect that sustainable or energy-efficient real estate certificates have on the financial performance of a property. The majority of these papers

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found that certified compared to non-certified properties - having otherwise identical characteristics - were sold at significant price premia. This conclusion was found to hold for housing markets of various industrialized countries, including Switzerland (see e.g. Salvi et al. 2008; Wüest and Partner, 2011; Brounen, 2011). One of the few exceptions to these studies are the publications by Müri et al. (2011) and by Fahrländer et al. (2015) studying the impact of location and noise on sales prices of properties, costs and rental rates using Swiss property data. Another exception is a paper by Meins et al. (2012)[7] from the Center for Corporate Responsibility and Sustainability (CCRS). They analysed the relation between the sustainability indicators and the financial performance of properties by means of real estate features of the Economic Sustainability Indicator (ESI)[8] instead of a single sustainable real estate certificate. The ESI-Indicator is a sustainability rating system for Swiss apartment buildings which was developed at the CCRS and consists of an aggregate indicator (i.e. the ESI-Indicator) and its five groups (i.e. the ESI sustainability criteria). To measure the buildings' sustainability impact on the their financial performance, Meins et al. (2012) applied the ESI-Rating to a sample of over 200 Swiss properties of which various financial indicators were available. They estimated the influence of the properties' ESI-Rating on their financial indicators by means of hedonic pricing models and found significant impacts of all of the ESI-Rating's five sustainability criteria on the properties' rental rates in the sample used.

In this paper the main goals are to first verify the robustness and stability of the findings obtained by Meins et al. (2012) by using an updated real estate portfolio consisting of over 400 properties representing a market value of over CHF 6 billion. We thus evaluate the sustainability impact of buildings on rental rates at the aggregate level by using the ESI-Indicator and its five sustainability criteria utilizing hedonic pricing models applied to the housing market. Second, on a disaggregated level the buildings' sustainability criteria are to be investigated and how they relate to their financial indicators using specific sets of the ESI-Rating's 42 sub-indicators.

Organization of the paper

The remainder of this paper is organized as follows: In the next section we present the dataset and its main sources together with descriptive statistics of selected variables. In section 3, we explain in detail how a real estate's sustainability is measured. In section 4 we present and

[7]The paper titled "Nachhaltigkeit und Immobilieninvestitionen" is a projekt documentation written by E. Meins, A. Feige and M. Gaebel in 2012 and is available at the Center for Corporate Responsability and Sustainabiltiy (CCRS) on request.

[8]The ESI-Rating measures a building's sustainability risk from an investor's view, i.e. the risik the building depreciates as a consequence of unfavorable long-term developments.

discuss the estimates of the hedonic pricing models. Finally, this paper's main results are critically appraised in the concluding section.

2 Data description

We use a novel dataset that combines four real estate portfolios of Swiss institutional investors. It contains 435 buildings, all having an ESI-Rating which was collected by the real estate investors themselves during the reference period in 2013-2015 by means of the web-application ESI©web. In total, the four institutional portfolios of the investors represent a market value of CHF 6.5 billion. From these properties 3'100 rental contracts are available, which is equivalent to roughly nine contracts per building. Additionally to the ESI-Indicator, the properties in the aggregate portfolio come with a broad range of real estate features such as age, size, location, or floor number of the building and performance indicators associated such as gross rental income, cashflows, or loss of rental rate[9] The dataset is thus unique as it covers sustainability as well as financial characteristics of properties.

Real estate portfolios with ESI-Rating

Table 1 provides a detailed description of the four real estate portfolios of the institutional investors. Almost 80 per cent of the properties in the dataset are multi-family apartment buildings of which 20 buildings have a mixed use. As 16 out of these 20 properties are mainly used as apartment buildings, they are classified as multi-family properties for the purpose of our analysis.

Institutional Investor	**Type of Use**				**Total**
	Multi-familiy apartment building	**Mixed use**	**Office property**	**Sales property**	
Portfolio1	52	16*	20	3	91
Portfolio2	38	2	5	3	48
Portfolio3	159	2	15	1	178
Portfolio4	50	20	41	7	118
Total	344	41	42	8	435
* of which 9 properties are used mainly as apartment buildings					

Table 1: Swiss properties with ESI-Indicator; Source: CCRS

[9] Most of the property's physical characteristics and financial indicators are obtained by REIDA (Real Estate Investment Data Association) and merged with the property's ESI-Rating data set.

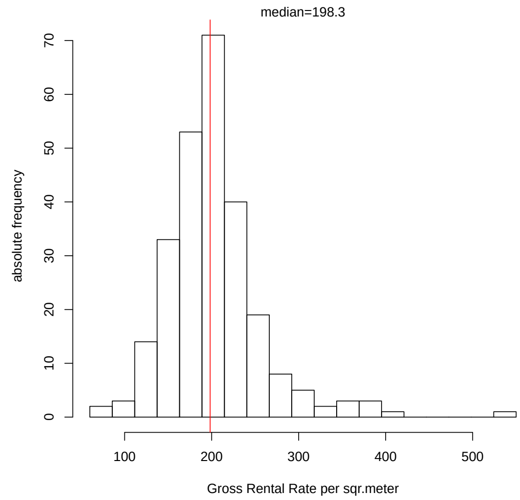
Characteristics of properties and apartments			
Characteristics of properties	**Median**	**Minimum**	**Maximum**
Year of Construction	1972	1893	2014
Market value in CHF Mio.	15	0.238	237
Gross rental income per sqr. meter p.a., in CHF	198.3	61.0	533
Operating cost per sqr. meter p.a., in CHF	41.9	1.1	221.0
Cashflow per sqr. meter p.a. in CHF	157	86.0	524.0
Rental income loss rate, in percent	1.7	-0.8	133.5
Rented Size, sqr. meter	2'711	310	41'750
Characteristics of apartments			
Gross Rental Rate per square meter p.a., CHF	232	97	528
Net Rental Rate per square meter p.a., CHF	195	82	491
Rented Size, square meter	75	10	175
Rental period, days	1'947	-228	21'910

Table 2: Descriptive Statistics of the financial indicators of the aggregate portfolio; Source: REIDA, CCRS

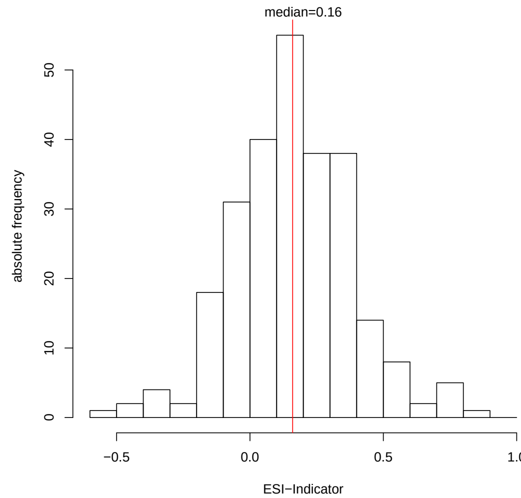
Descriptive Statistics of the aggregate Portfolio

Table 2 shows the descriptive statistics of the main physical characteristics and financial indicators of the aggregate portfolio's properties. The reference period of this dataset is 2014. Financial indicators like such as market value, rental income and cash flow are expressed per unit of rented space and in nominal terms, i.e. in CHF.

In charts 1a – 2b, histograms of two property characteristics - gross rental rate and rented size - are displayed together with a histogram of the buildings' ESI-Indicators and the spatial distribution of the properties' locations. As Meins et al. (2012) have already noted, the properties' characteristics like size are asymmetrically distributed and show several outliers. On the other hand, financial indicators like gross rental rate and the ESI-Indicator are symmetrically distributed and can thus be much more accurately described by a normal distribution. These empirical findings have been already documented very well in the real estate literature by various authors (see e.g. Lisi and Iacobini, 2013). The bivariate correlation between the ESI-Indicator and the gross rental rates of the aggregate portfolio's properties is not significantly different from zero (0.046).

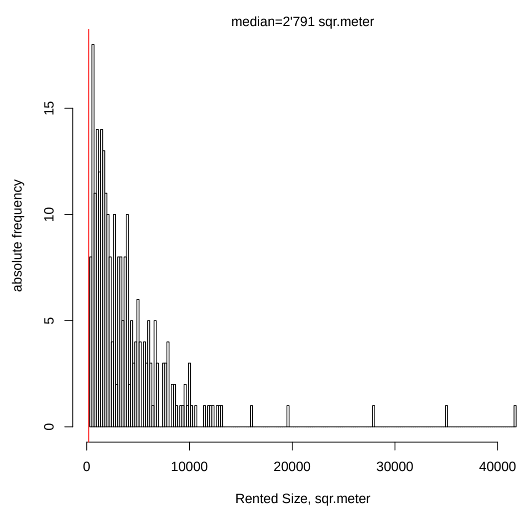


(a) Histogram Gross Rental Rate per sqr. meter

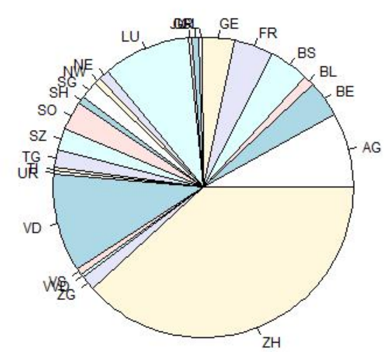


(b) Histogram ESI-Indicator

Figure 1: Histogram of building characteristics of the aggregate portfolio



(a) Histogram of rented Size



(b) Spatial Distribution of Properties

Figure 2: Histogram of building characteristics of the aggregate portfolio

The aggregate portfolio's buildings are identified through their addresses and can thus be assigned to the different cantons in Switzerland. In chart 2b the distribution of the buildings' locations across cantons is displayed documenting that the aggregate portfolio's properties are well distributed across the country.

3 Measuring the sustainability of real estate

Switzerland has guidelines and standards in place on how to build sustainably or on how to certify buildings that comply with sustainability criteria. In this paper we use the ESI-Rating to assess the sustainability of buildings. It defines a sustainable property from the point of view of investors; a property is considered sustainable if it can deal well with the consequences of long-term developments, such as climate change or demographic change, and, therefore has a low risk of depreciation (Meins and Burkhard, 2007, Meins et al., 2010). We operationalized the ESI-Rating by identifying property features with the help of experts (see table 3 for an overview of the 14 selected property features, the so-called ESI-subcriteria). These features were assigned to five groups, i.e. to the ESI-Rating's five sustainability criteria. Additionally, we defined 42 indicators for all of the 14 ESI-subcriteria (referred to as "subindicators") and coded them. The coding took place on a scale from +1 to -1, where +1 corresponds to a favorable outcome in terms of the future long-term development (or "sustainable" from an investor's view). Finally, we aggregated the information on the 42 subindicators to the ESI-Indicator by computing a weighted average of the 42 subindicators.

The ESI Rating's Sustainability Criteria
1. Flexibility and Polyvalence
1 Flexibility to Use
1.2 Adaptability to Users
2. Resource Consumption and Greenhouse Gases
2.1 Energy and Greenhouse Gases
2.2 Water
2.3 Building Material
3. Location and Mobility
3.1 Public Transport
3.2 Non-motorized Traffic
3.3 Location
4. Safety and Security
4.1 Location regarding natural hazards
4.2 Building safety and Security Measures
5. Health and Comfort
5.1 Inside Air Quality
5.2 Noise exposure
5.3 Sufficient natural Light
5.4 Radon (ionizing)
5.5 Construction Materials and inherited Pollution

Table 3: Sustainability criteria used in the ESI Indicator; Source: CCRS

4 Estimation of modified hedonic pricing models

In order to quantify the sustainability impact of a building or apartment (measured with its ESI-Indicator) on its rental rate, hedonic pricing models are specified and estimated. As the aggregate portfolio contains real estate data for buildings and apartments (i.e. contractual data) as well, hedonic pricing models are estimated for multi-family buildings and their apartments separately. To select the variables of the model, this paper relies on Sirmans et al. (2005) who evaluated the control variables which are most commonly used in hedonic studies to explain rental rates or sales prices, respectively. Using these control variables - provided that they are available in the aggregate real estate portfolio - the following two models are specified to explain the aggregate portfolio's gross rental rates:

$$\begin{aligned} GrossRentalRate_i =& FixedEffectUseType + \beta_1 * RentedSpace_i + \beta_2 * BuildingAge_i \\ &+ \beta_3 * MicroLocation_i + \beta_4 * MacroLocation_i \\ &+ \beta_5 * RentalIncomeLossRate_i \\ &+ \beta_6 * DistanceRailwayLine_i + \beta_7 * OperatingCost \\ &+ \beta_8 * ESI - Indicator_i + \epsilon_i \\ & i = 1, ..., N \end{aligned} \tag{1}$$

$$\begin{aligned} log(GrossRentalRate_i) =& FixedEffectUseType + \beta_1 * log(RentedSpace_i) + \\ & \beta_2 * log(BuildingAge_i) + \beta_3 * MicroLocation_i \\ &+ \beta_4 * MacroLocation_i + \beta_5 * RentalIncomeLossRate_i \\ &+ \beta_6 * log(DistanceRailwayLine_i) + \beta_7 * log(OperatingCost_i) \\ &+ \beta_9 * ESI - Indicator_i + \epsilon_i \\ & i = 1, ..., N \end{aligned} \tag{2}$$

where the following definitions are made:

FixedEffectUseType: three types of use (apartment, office, sale)

MicroLocation: ordinal values (1: unfavourable location; 2: average location; 3:favourable location) within region

MacroLocation: ordinal values of regions (1: unfavourable location; 2: average location; 3:favourable location) within country

TaxRanking: Ranking of the property's location canton according to a four-person family's (i.e. 2 adults, 2 children) tax burden

DistanceRailwayLine: distance of property to railway line, in km

N denotes the aggregate portfolio's sample size and ϵ_i represents the hedonic pricing model's error term assumed to be uncorrelated across observations (i.e. properties and apartments, res.). The specifications of the two models are slightly modified (by adding the additional variables NumberRoom, PeriodRent and Floor) when estimated to fit the apartments' rental rates. Additionally, both models are estimated using the ESI-Rating's five sustainability criteria instead of the (aggregate) ESI-Indicator allowing to quantify each sustainability criteria' impact on the property's rental rates separately.

Estimation of hedonic pricing models at an aggregate level

In tables 4 - 7, OLS regression estimates and significance levels of model (1) and (2) are displayed[10]. For the interpretation of the two hedonic pricing models' coefficients, it is useful to focus first on the the estimated coefficients of the properties' physical and locational characteristics and in a second step to interpret the ESI-Indicator's impact on the properties' rental rates.

The signs of the properties' physical and locational coefficients match well other hedonic pricing models of the Swiss housing market. The properties' rented size uniformly have a negative impact on the buildings' and apartments' rental rates, respectively, whereas the properties' location ratings are uniformly positively correlated with their rental income. Consistent with the results of other empirical studies, an increasing rental period has a dampening effect on an appartment's rental rate. This results in the much discussed difference between the existing rent and market rent that widens over time. Rather unexpectedly, the apartments' room numbers' impact on their rental rates are not uniformly negative as widely documented in the literature (see e.g. Brake, 2013). However, the apartments' rental rates are significantly and positively correlated with their floor number.

Focusing on the sustainability criteria's relation with the real estate financial indicators, it must be differentiated between the sustainability's measured influence on the apartment and on the property level. Whereas on the property level, only three sustainability criteria are significantly correlated with the buildings' rental income, on the apartment level additional to the ESI-Indicator as a whole all of the ESI-Indicator's five sustainability criteria significantly impact the apartments' rental rates. Here, the most important results can be summarized as follows. The aggregate ESI-Indicator's influence on an apartment's rental rate is uniformly positive (CHF 48.4 and 18 per cent, respectively) as the ESI-Indicator increases one point. Second, all of the five ESI-Indicator's sustainability criteria with one exception (Flexibility and Polyvalence) have a positive and significant impact on the apartments' rental rates.

[10]In order to correct for potential heteroscedasticity in the hedonic pricing model's error term, the coefficients' standard errors are computed using White's (1980) estimator.

Table 4: Regression of Gross Rental Rate per square meter, properties

	Model (1) with ESI criteria			Model (1) with ESI-Indicator		
	Estimate	t-value*	Pr(>|t|)	Estimate	t-value*	Pr(>|t|)
FixedEffect Apartment	165	11.6	0.0	176	10.8	0.0
FixedEffect Office	158	4.3	0.0	202	5.7	0.0
FixedEffect Sale	189	8.6	0.0	218	11.0	0.0
RentedSize	-0.0009^a	-1.0	0.3	-0.0009^a	-1.0	0.32
BuildingAge	-0.2	-1.6	0.1	-0.1^c	-0.8	0.4
MacroRating_3	34.0^a	5.4	0.0	36.6^a	5.6	0.0
MicroRating_3	4.9^c	1.7	0.09	5.3^c	1.8	0.06
RentalIncomeLossRate	-0.9^a	-3.5	0.0	-0.9^a	-3.9	0.0
DistanceRailwayLine	10.8^a	1.9	0.05	9.1	1.6	0.1
OperatingCost	0.02	0.5	0.6	0.03	0.9	0.4
ESIIndicator	-	-	-	35.9^b	2.5	0.01
Flexibility	-19.3^c	-1.9	0.05			
ResourceConsumption	4.9	0.5	0.6	-	-	-
Location	18.9^a	3.2	0.0	-	-	-
Safety	4.6	0.9	0.4	-	-	-
HealthComfort	33.9^a	3.1	0.0			
R^2	0.96			0.94		
Num. of Obs.	190			195		

Note: a: $Pr < 0.01$, b: $Pr < 0.05$, c: $Pr < 0.1$; *:calculated using White's heteroscedasticity-consistent estimator; Source: CCRS, REIDA

Table 5: Regression of log (Gross Rental Rate per square meter), properties

	Model (2) with ESI criteria			Model (2) with ESI-Indicator		
	Estimate	t-value*	Pr(>|t|)	Estimate	t-value*	Pr(>|t|)
FixedEffectApartment	5.7	0.2	0.0	5.6 28.6	0.0	
FixedEffectOffice	5.6	0.2	0.0	5.7	24.2	0.0
FixedEffectSale	5.8	0.2	0.0	5.8	26.8	0.0
log(RentedSize)	-0.04^b	-2.0	0.04	-0.04^b	-2.0	0.05
log(BuildingAge)	-0.09^a	-3.9	0.0	-0.06	-2.9	0.0
MacroRating_3	0.17^a	6.2	0.0	0.18^c	6.5	0.09
MicroRating_3	0.02	1.5	0.1	0.02^c	1.7	0.09
RentalIncomeLossRate	-0.01^a	-4.8	0.0	-0.006^a	-5.3	0.0
log(DistanceRailwayLine)	0.02^c	1.8	0.08	0.02^c	1.7	0.09
OperatingCost	0.02	1.6	0.12	0.02^b	2.1	0.04
ESIIndicator	-	-	-	0.15^b	2.2	0.03
Flexibility	-0.09^b	-2.0	0.04	-	-	-
ResourceConsumption	0.001	0.02	0.30	-	-	-
Location	0.09^a	3.5	0.0	-	-	-
Safety	0.02	0.7	0.05	-	-	-
HealthComfort	$\mathbf{0.13^a}$	2.7	0.00	-	-	-
R^2	0.98			0.98		
Num. of Obs.	190			195		

Note: a: $Pr < 0.01$, b: $Pr < 0.05$, c: $Pr < 0.1$; *:calculated using White's heteroscedasticity-consistent estimator Source: CCRS, REIDA

Table 6: Regression of Gross Rental Rate per square meter, apartments

	Model (1) with ESI criteria			Model (1) with ESI-Indicator		
	Estimate	t-value*	Pr(>|t|)	Estimate	t-value*	Pr(>|t|
RentedSize	-0.9^a	-17.3	0.0	$--1.0^a$	–17.2	0.0
BuildingAge	-0.5^a	-8.2	0.0	-0.5^a	-17.2	0.0
MicroRating_2	2.0^b	2.4	0.02	3.1	3.6	0.0
MicroRating_3	1.7^b	2.1	0.04	0.9	1.1	0.26
MacroRating_3	9.3^a	14.3	0.0	8.9^a	13.3	0.0
NumberRoom2	-18.8^a	-6.3	0.0	-15.7^a	-5.2	0.0
NumberRoom3	-9.6	-5.9	0.0	-7.4^a	-4.4	0.0
NumberRoom4	-4.8^a	-3.5	0.0	-3.2^a	-2.3	0.0
NumberRoom5	7.0	0.6	0.5	2.4^b	2.0	0.02
NumberRoom6	12.8^b	2.2	0.03	16.4^a	2.7	0.0
Floor	2.6^a	5.4	0.0	2.1^a	4.4	0.0
RentalIncomeLossRate	-0.3^a	-6.6	0.0	-0.08^c	-1.7	0.08
PeriodRent	-0.004	-27.0	0.0	-0.004^a	-26.6	0.0
TaxRanking	-0.6^a	-3.6	0.0	-0.1	0.9	0.37
DistanceRailwayLine	18.5^a	12.0	0.0	12.7^a	8.2	0.0
ESIIndicator	-	-	-	$\mathbf{48.4^a}$	11.6	0.0
Flexibility	$\mathbf{-19.5^a}$	-7.4	0.0	-	-	-
ResourceConsumption	$\mathbf{19.7^a}$	5.2	0.0	-	-	-
Location	$\mathbf{12.7^a}$	7.6	0.0	-	-	-
Safety	$\mathbf{13.4^a}$	9.7	0.0	-	-	-
HealthComfort	$\mathbf{32.6^a}$	13.2	0.0	-	-	-
R^2	0.49			0.98		
Num. of Obs.	2'781			2'785		

Note: a: $Pr < 0.01$, b: $Pr < 0.05$, c: $Pr < 0.1$; Source: CCRS, REIDA

Table 7: Regression of log(Gross Rental Rate per square meter), apartments

	Model (2) with ESI criteria			Model (2) with ESI-Indicator		
	Estimate	t-value*	Pr(>|t|)	Estimate	t-value*	Pr(>|t|
log(RentedSize)	-0.3^a	-19.8	0.0	-0.34^a	-20.0	0.000
log(BuildingAge)	-0.10^a	-14.3	0.0	-0.11^a	-17.3	0.000
MicroRating_2	0.01^a	3.7	0.0	-0.02	4.5	0.0
MicroRating_3	0.002	0.7	0.5	0.00	0.07	0.94
MacroRating_3	0.04^a	14.8	0.0	0.04^a	14.4	0.0
NumberRoom2	0.08^a	5.3	0.0	0.089^a	6.0	0.0
NumberRoom3	0.05^2	5.5	0.0	0.055^a	6.3	0.0
NumberRoom4	0.04^a	5.2	0.0	0.04^a	6.0	0.0
NumberRoom5	0.03	6.2	0.0	0.04^a	7.3	0.0
NumberRoom6	0.07^a	3.0	0.0	0.08^a	3.4	0.0
Floor	0.01^a	4.9	0.0	0.008^a	4.2	0.0
RentalIncomeLossRate	-0.001^a	-5.9	0.0	-0.0005^a	-2.4	0.0
log(PeriodRent)	-0.05^a	-26.2	0.0	-0.053^a	-26.13	0.0
TaxRanking	-0.001^c	1.7	0.09	-0.0001	0.28	0.77
log(DistanceRailwayLine)	0.02^a	7.3	0.0	0.02	5.6	0.0
ESIIndicator	-	-	-	$\mathbf{0.18^a}$	10.6	0.0
Flexibility	$\mathbf{-0.06^a}$	-5.6	0.0	-	-	-
ResourceConsumption	$\mathbf{0.07^a}$	4.7	0.0	-	-	-
Location	$\mathbf{0.043^a}$	6.4	0.0	-	-	-
Safety	$\mathbf{0.035^a}$	6.0	0.0	-	-	-
HealthComfort	$\mathbf{0.11^a}$	10.9	0.0	-	-	-
R^2	0.98			0.48		
Num. of Obs.	2'527			2'531		

Note: a: $Pr < 0.01$, b: $Pr < 0.05$, c: $Pr < 0.1$;Source: CCRS, REIDA

Additionally, the sustainability criteria Health and Comfort uniformly displays the highest positive correlation with the appartments' rental rates, respectively.

Disaggregate analysis of the ESI-criteria "Flexibility and Polyvalence"

The uniformly negative and significant coefficients of the ESI-criteria Flexibility and Polyvalence in tables 4 - 7 are hard to explain as a property's increasing flexibility should make it more worth from investors' and tenants' point of view. Thus the higher a property's ESI-criteria Flexibility and Polyvalence is, the higher should be its gross rental income and consequently its market value as well as the property's rental income loss rate is expected to be lower on average compared to a property having fixed use. In order to analyse more thoroughly the negative correlation between a property's ESI-criteria Flexbility and its gross rental rate, that criteria's impact is analysed on a disaggregated level, i.e. on the level of its two subcriteria.

The ESI-criteria Flexibility and Polyvalence as a weighted average of 12 subindicators consists of the two subcriteria Flexibility of Use and Adaptability to Users. Eight of these 12 subindicators can be assigned to the subcriteria Flexibiltiy of Use. The two subindicators having the biggest weights within the two subcriteria are "Storey height" and "Usability of Outside Space". Using these two subindicators as proxies for the ESI-criteria's two subcriteria, the following modified hedonic pricing models can be spedifed:

$$\begin{aligned} log(GrossRentalRate_i) =& FixedEffectUseType + \beta_1 * log(RentedSpace_i) + \\ & + \beta_2 * log(BuildingAge_i) + \beta_3 * MicroLocation_i \\ & + \beta_4 * MacroLocation_i + \beta_5 * log(OperatingCost_i) \\ & + \beta_6 * RentalIncomeLossRate_i \\ & + \beta_7 * log(DistanceRailwayLine_i) \\ & + \beta_8 * FlexibilityUse_i + \beta_9 * AdaptabilityUsers_i \\ & + \beta_{10} * ResourceConsumption_i + \beta_{11} * Location_i \\ & + \beta_{12} * Safety_i + \beta_{13} * HealthComfort_i + \epsilon_i \\ & i = 1, ..., N \end{aligned} \tag{3}$$

Table 8: Hedonic models (1) and (2) extended with Flexibility subindicators, properties

	disaggregated Model (1)			disaggregated Model (2)		
	Estimate	t-value*	Pr(>|t|)	Estimate	t-value*	Pr(>|t|
log(RentedSize)	-0.0004	-0.32	0.75	-0.03	-1.5	0.15
log(BuildingAge)	-0.22	-1.3	0.21	-0.1	-3.8	0.0
MacroRating_3	28.9^a	3.4	0.0	0.12^a	3.6	0.0
MicroRating_3	3.2	0.6	0.5	0.0	0.01	0.98
RentalIncomeLossRate	-1.1^b	-2.6	0.01	-0.005^a	-3.3	0.0
log(DistanceRailwayLine)	6.8	0.9	0.3	0.03^b	1.954	0.05
log(OperatingCost)	0.2	0.9	0.3	0.11	3.4	0.0
FlexibilityUse	1.3	0.2	0.9	0.02	0.6	0.5
AdaptabilityUser	$\mathbf{-28.1^a}$	-5.3	0.00	$\mathbf{-0.11^a}$	-4.6	0.0
ResourceConsumption	-2.8	-0.3	0.8	-0.05	-1.0	0.3
Location	13.1	1.5	0.13	0.03	1.0	0.3
Safety	-7.8	-1.1	0.28	-0.02	-0.9	0.4
HealthComfort	$\mathbf{64.6^a}$	3.4	0.0	$\mathbf{0.20^a}$	2.6	0.01
R^2	0.97			0.96		
Num. of Obs.	91			91		

Note: a: $Pr < 0.01$, b: $Pr < 0.05$, c: $Pr < 0.1$;*: calculated using White's heteroscedasticity-consistent estimator; Source: CCRS, REIDA

In table 8, it can be seen that the negative impact of the ESI-criteria Flexibility and Polyvalence on rental rates is solely due to its subcriteria Adaptability to Users. This seems to be somewhat surprising as one expects a property's increasing adaptability from the point of view of its tenants to be positively correlated with its rental rate. The reason for the subindicator Adaptability to Users' negative coefficent might be its operationalisation using the subindicator "Usability of Outside Space". As the availability of a real estate's outside space being shared by all of the property's tenants has become less popular, the impact of the subcriteria Adaptability on a real estate's rental rate may well have become negative.

Estimation of Minergie's impact on rental rates using the ESI-Rating's subindicators

As the aggregate portfolio contains a number of buildings fulfilling the requirements of the Minergie[11] label [12], that label's impact on the buildings' rental rates can be quantified using the properties' ESI-Rating. Being more specific, whether a certain building fulfills Minergie's requirements can be detected examining the ESI-Rating's two subindicators "Thermal Heat Usage" and "Inside Air Quality". If these two subindicators are coded as having minimum energy efficiency and a ventilation, respectively, the property can be assumed to fulfill Minergie's requirements.

[11] Minergie is a popular energy efficiency certificate for Swiss residential and administrative buildings and offices. Its main sustainability criteria are energy efficiency and comfort.

[12] Whether the aggregate portfolio's buildings fulfilling the Minergie requirements are actually certificated as Minergie buildings is not known.

Additionally to the ESI-Rating's 42 sustainability subindicators, an indicator variable can thus be defined being zero if the building does not fulfill Minergie's requirements and being one otherwise. The Minergie variable being defined that way can be added to hedonic models consisting of those physical attributes of models (1) and (2) being significant.

Table 9: Hedonic models extended with Minergie indicator variable, properties

	modified Model (1)			modified Model (2)		
	Estimate	t-value*	Pr(>|t|)	Estimate	t-value*	Pr(>|t|)
log(RentedSize)	-0.0004	0.001	0.71	-0.028	-1.25	0.21
log(BuildingAge)	-0.09	-0.57	0.57	-0.08^a	-3.4	0.0
MicroRating_3	3.8	1.03	0.31	0.019	1.2	0.23
MacroRating_3	39.6^a	5.2	0.0	0.20^a	5.9	0.0
RentalIncomeLossRate	-1.2^a	-3.05	0.0	-0.007^a	-4.0	0.0
DistanceRailwayLine	-6.4	0.97	0.33	-0.010	-0.55	0.5815
log(OperatingCost)	-0.03	-0.6	0.33	0.02	1.53	0.13
MinergieIndicator	0.57	0.03	0.98	-0.16	-1.98	0.0508
R^2	0.96			0.98		
Num. of Obs.	149			149		

Note: a: $Pr < 0.01$, b: $Pr < 0.05$; *:calculated using White's heteroscedasticity-consistent estimatorc: $Pr < 0.1$; Source: CCRS, REIDA

Table 9 shows the estimated parameters of the two modified hedonic models (1) and (2) which have been obtained using the aggregate portfolio constisting of 149 properties having the relevant subindicators (Thermal Heat Usage, Inside Air Quality). The two models' parameter estimates confirm by and large the coefficients of the original model specifications (1) and (2) using all of the aggregate portfolio's properties . Surprisingly and contrary to the findings of Salvi et al. (2008), the Minergie variable's coefficients are not significantly different from zero, i.e. a property fulfilling the requirements of the Minergie labels generates the same gross rental rate compared compared to an identical real estate without fulfilling the Minergie requirements. A possible explanation of that rather unexpected result might be that Minergie's requirements do not only decrease a property's energy consumption for heating but are also increasing its maintenance costs due to its more sophisticated technical equipment.

5 Concluding remarks

Using a unique database containing a broad range of financial variables and sustainability criteria of Swiss buildings, this study quantifies the ESI-Indicator's impact on properties' and apartments' rental rates on an aggregate level by using hedonic pricing models. Additionally, on a disaggregated level the impact of the ESI-criteria Flexibility on real estate rental rates is analysed in detail making use of specific subindicators of these two criteria. Finally, the effects of the popular Minergie label on properties' rental income are estimated using an extended hedonic pricing model as well. On the aggregate level, the hedonic models' estimates show a significant and positive impact of the ESI-indicator and all of the ESI-Rating's sustainability criteria on the apartments' rental rates with the exception of the criteria Flexibilty. As the ESI-indicator increases one point, e.g. from -1 to 0, the buildings' rental rates are boosted by a substantial amount as well, i.e. by 15 per cent. On a disaggregated level, it is shown that the negative impact of the ESI-criteria Flexibility on real estate's rental rates is soley due to the subindicator Usability of Outside Space. Finally, the effects of the popular Minergie-label on the properties' rental rates are found to be insigificantly different from zero. This result casts some doubts about the findings of Salvi et al. (2008) who found significant premia on rental rates for Minergie-certified buildings of up to 6.5 per cent in the Canton of Zuerich.

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