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Does energy efficiency matter for prices of tenant-owned apartments?

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Does energy efficiency matter for prices of tenant-owned apartments?

Abstract
This study analyzes the effect on sale prices for tenant-owned apartments from being enclosed in an energy efficient tenant-owned building. Energy efficiency is measured by the Energy Performance Certificates (EPC) mandated by European Union. While there is an extensive literature on how EPCs affects the sales price of single-family houses, none have focused exclusively on tenant-owned apartments. For owners of tenant-owned apartments, heating is for the vast majority included in the monthly fee that they required to pay the tenant-association, which usually does not change on a short-term basis. Hence, any capitalization of energy efficiency on the price of tenant-owned apartments is not likely to reflect potential cost-savings from lower heating costs in the same way as for single-family houses. However, with the introduction of green mortgages, homebuyers in Sweden can get reductions on their mortgage interest rate if acquiring an energy efficient home. This raises the question if homebuyers' incentives for acquiring energy efficient tenant-owned apartments is large enough to be capitalized into the prices. By hedonic models and matching methods we found mix results. In our most optimistic scenarios, tenant-owned apartments enclosed in energy efficient buildings are sold with a premium of approximately 0.8 to 1.5 percent as opposed to apartments in non-efficient buildings. The results in this study are not robust to all model specifications and varies across regions. In comparison with recent studies using data for single-family houses in Sweden, our detected capitalization is smaller. Lastly, we also document a significant difference in capitalization of energy efficiency between sales in postcodes with low versus high incomes. Our results highlight a need for targeted measures if EPC is to be fully capitalized in prices for all type of dwellings.

Keywords: Energy Performance Certificates, Housing Markets, tenant-owned apartments, Sweden

JEL Classifications: D10, Q51, R20

Does energy efficiency matter for prices of tenant-owned apartments?

Introduction

Reducing the speed of climate change has in the recent decade become as a top priority for numerous governments, scientists, and institutions. The EU has set up ambitious GHG emissions targets in a vision for 2050, which could pose one important step-stone for the world to reach below the Paris 2-degree target and, as the union puts it, keep it down to 1.5°C. This will, consequently, but a lot of pressure on the housing sector to abate its considerable large share of CO_2 emissions compared to other sectors. In this context, EU introduced the Energy Performance of Buildings Directive to form a common European approach to energy savings in buildings. The directive includes the Energy Performance Certificates (EPC) to make consumers aware of the energy efficiency of the buildings they want to buy or rent (Brounen and Kolk, 2011; Cerin *et al.*, 2014; EC, 2020). The EPCs aims at decreasing the information asymmetries between owners of properties and prospective buyers and users. Other actors are also benefitting from this increased energy transparency, e.g. mortgage lenders who can offer lower interest rates by issuing green bonds. The EPC includes information on the buildings annual energy consumption in kilowatt-hours per square meter (kWh). If the energy usage is high, then the building's energy performance is complemented with cost-effective recommendations of improvement.

The EPC has gradually been implemented in the EU and was first introduced in Sweden by the mid of 2007, and is monitored by the National Board of Housing, Building and Planning (Boverket). The current Swedish grading scale was introduced in 2014. It spans like in most other EU-member countries, from A-G with grade A being the most efficient buildings and G the least efficient. Prior to 2014, as of 2009 and 2011, Sweden applied an energy usage figure focusing on the property's relative production compared to properties of similar age. Buildings that are newly built, sold or rented are in Sweden required to have an EPC (with a few exceptions) and is set up by independent certified experts (EC, 2020).[1]

The literature on the capitalization in property sales prices starts the year after the EU regulation was implemented. Research on the residential markets, EPCs and housing prices e.g. encompasses data from the Netherlands (Brounen and Kok, 2011), Wales (Fuerst et al, 2016a), Spain (Ayala et al, 2016), Ireland (Hyland et al, 2013), England (Fuerst et al., 2015) and

[1] For more information regarding the EPC in EU, see European Commission (2020). In the Swedish case more information can be found on the website of the National Board of Housing, Building and Planning (*Boverket*, 2019).

Denmark (Jensen et al, 2016). Most studies find at least some significant price premiums for the most energy efficient homes. For the Swedish market, a limited number of studies have been conducted with mixed results. Studies that use data from the early years of EPC implementation, Wahlström (2016) found no effect at all, while Högberg (2016) detected a positive price premium of 4 percent. Cerin et al. (2014) found price premiums for certain prices and age segments of buildings. Recently, Wilhelmsson (2019) used newer recent data and estimated the price premium in the sales price to approximately 3 percent. However, all these studies been conducted on single-family houses and not apartments, condominiums or other tenant-forms in multi-household houses. As pointed out by Fuerst et al (2016b), apartments are in general more homogeneous compared with single-family houses and, therefore, reduces problems connected to the characteristics of the individual homes. International studies, focusing only on apartments when evaluating the capitalization effect of EPCs are, in general, rare. The few studies that exist indicate a small or insignificant price premium in the sales price for more energy efficient homes (see e.g. Fuerst et al., 2016b; Rolanda and Semeraro, 2016; Taltavull et al., 2016, Fuerst et al., 2015).

In Sweden, 48.5 percent of the households live in multi-dwelling units such as an apartment (SCB, 2019). Out of these apartments, 58.4 percent lives in a rental apartment and 41.6 percent in tenant-owned homes (*bostadsrätter*) or housing cooperatives. Figure 1 depicts the numbers of household living in tenant-owned multi-dwelling buildings between 2012-2018.

>> Insert figure 1 here <<

The share of tenant-owned buildings in comparison with rental apartments varies a lot across cities in Sweden. In some areas, such as Stockholm City, more than 55 percent of the multi-dwelling buildings are tenant owned which constitutes a high number for Sweden (SCB, 2020). In Sweden's tenant-owned homes[2] the tenant association is the owner of the properties and residents owns shares in the association in accordance with the size of their 'apartment'. An association can consist of 2 to 300 hundred flats, located in several buildings. A member of the association is not owning the apartment, but they have the right to utilize it. The member is responsible for maintenance in their own apartment. It is the associations and not the resident's responsibility that each building that is owned by the association have a valid EPC. All

[2] The most common type of housing in tenant-owned homes is apartments where only a small fraction consisting of terraced houses or other living spaces. Hence, from the following, we will denote the tenant-owned homes as tenant-owned apartments even though our data also consists of a small share of other type of living spaces that are tenant-owned.

apartments within the same building (or with the same EPC-ID) will have the same energy performance/grade, which is the information the buyers will observe when acquiring a tenant-owned apartment.

Heating is usually included in the fixed monthly fee that residents are required to pay to their tenant-association. The same goes for usage of water and heated water. Even though the fee can change to reflect the cost structure of the association, it does usually not do that on a short-term basis. Decisions on changed fees are almost exclusively made at the annual member meeting of the tenant association. Periods of higher energy for heating and heated water usage, hence, will not be reflected directly in higher energy costs for the residents. Tenants' individual usages of energy for heating as well as water and heated water are generally not measured per apartment and will, hence, not be reflected in the individual fees. High users of energy and water will, thus, not fully pay for their own consumption, but spilling over costs to other members in the tenant association. However, even if the heating for most owners are included in the monthly fee, there might still be some economic incentives for investing in energy efficient tenant-owned homes. Many Swedish banks have recently started to offer "green mortages" to buyers, which gives reductions on the mortgage interest rate if you acquire an energy efficient home, usually graded A or B in the EPC-scale. This means that there might exist economic incentives for buyers of tenant-owned apartments to acquire energy efficient homes, even if many buyers do not benefit from lower heating costs. If the incentive structure is enough to be capitalized in the sales price, is not yet known.

This study investigates the relationship between energy efficiency for tenant association properties and the sales prices of their enclosed tenant-owned apartments. The energy efficiency is measured by the information contained in the EPCs and includes both energy performance for the tenant-owned building and energy grades (for a part of our dataset). We use hedonic price models with data for six Swedish cities spread over the country. To address potential problems stemming from non-randomness in our treatment variable we also use propensity score matching and the novel coarsened exact matching. Our hypothesis that the incentives for investing in energy efficient tenant-owned apartments (i.e. apartments enclosed in energy efficient buildings) are low, is also reflected in our results. Our estimations indicate premiums in the range of approximately 0.8 to 1.5 percent. However, the effect is not robust, and no significant effect is found in some of our estimations. For tenant-owned apartments enclosed in properties with EPC-grades, we found weakly significant effects (in the hedonic estimations) for the top two most energy efficient grades (A or B) compared with less efficient grades (C-

G). However, when classifying labels A-C as the energy efficient grades, no significant effect is found. Measuring the energy efficiency with energy performance instead of EPC-grades, the effect is weakly significant for the full sample but insignificant when estimating subsamples on regions. Furthermore, a small number of studies – e.g. Fuerst *et al.* (2016b) on the Finish market – have used neighborhood income as a control variable in hedonic price models. By including a dummy for postcodes with low incomes and interacting with our variable for energy efficiency, we investigate if the capitalization differs in low versus high income areas. On one hand, buyers in richer areas might afford to care more of the environment and pay more for the labels that signal energy efficiency. On the other, the low-income individuals might have economic incentives to buy energy efficient apartments if it could save them money. Our results indicate higher capitalization in low-income areas.

The paper is structured as follows: In section 2 the previous literature is presented followed by section 3 where data and methodology are depicted while section 4 outlines the results and discussion.

2. Literature review

Our paper can be related to two strands of literature. Firstly, this study is loosely related to the financial literature of sustainable investments or socially responsible investment (SRI). While the financial literature, in general, focuses on portfolio decisions, buying a house or apartment is for many individuals the largest financial decision they will ever make. Their willingness to consider green attributes in the process is therefore relevant even in housing. Studies in this field have investigated the demographic characteristics of the individuals and how they relate to the SRI. Some studies have for instance analyzed the income characteristics of the individuals (see e.g., Beal and Goyen, 1998; Cheah *et al.*, 2011; Pérez-Gladish, Benson and Faff, 2012) or the community size of the individual's home (e.g., Williams, 2007). However, our paper is mainly related to the studies of the connection between EPC – primarily focusing on energy efficiency (i.e. energy performance) – and housing prices. The effect of energy efficiency on property values have been analyzed on different national housing markets with some mixed results. Following, we present the most relevant of this research, based on the emphasis of this paper. Even though the total number of studies are too large to make it exhaustive, more studies can be found in the summary TableA1 in the appendix.

Brounen and Kok (2011) investigated the relationship between energy labeling and the housing prices in the Dutch residential market during 2008 and 2009. Using a hedonic pricing model with controls for neighborhood characteristics such as housing density, they found a price premium for one-family residential buildings with EU based energy labels – EPCs. Buildings with label A, B or C, were associated with price premiums corresponding to 10, 5 and 2 percent respectively compared to houses sold without the EPC label. For labels analogous with lower quality, F and G, were sold for a discount in comparison with non-labeled buildings. Fuerst *et al*. (2016a) investigate the connection between EPCs and residential housing market in Wales and found significant premiums in sales price per square meter for labels A, B and C in comparison with label D. For the EPCs with A/B rating, the effect was as large as 12.8 percent. For lower efficiency labels such as E, F and G the authors found significant discounts in sales prices in comparison with buildings classified with a D-label. These premiums and discounts were found to be conditional on the type of dwelling. For apartments, no significant effect was found between EPCs and sales prices per square meter. For detached dwellings, they found differences in discounts in sales price for lower quality labels depending on dwellings status as urban or rural. A study conducted by De Ayala *et al.* (2016), focusing on the energy efficiency in the Spanish market uses survey data with a sample involving both apartments and detached houses. Using a hedonic price model, they find that homes labeled as A, B, C or D in their EPCs have a price premium of 5,4 percent in comparison with homes labeled as E, F or G. Hyland *et al.* (2013) use data for the Irish residential market with price data for apartments, terraced houses, detached houses, bungalows and single-family houses. Based on their result they conclude there is a 9 percent premium for homes with A-label compared to D-level.

Kahn and Kok (2014) measures the effect of green labeling in the California housing market. Their results suggest a small premium for single-family homes with a green label compared to comparable non-labeled homes. Other studies from the US include Bruegge et al. (2016) that focus on the “Energy Star” certifications of homes. Using data for residential homes in Florida between 1997 and 2009 they find that buyers are willing to pay a premium for newly built houses with an Energy Star certification, but not so on the resale market. Recently, Jensen *et al.* (2016) study EPCs in Denmark and conclude that they had an impact on the residential values of single-family homes, most notably after 2010. The authors estimate the effect to be over 6 percent for the grade A/B in comparison with the grade D. Further, Bio Intelligence Service (2013) investigates the effect of energy efficiency depicted in EPCs on sales prices of houses in Belgium, France, Austria, Ireland, and UK. The study found a positive relationship between the variables in all investigated areas except for one subarea - Oxford, UK. The positive effects were smallest (2.8 percent) in Ireland and the largest in Austria (8 percent). Further, Fuerst *et al.* (2015) investigates the EPC and housing prices in England and founds a positive price premium for energy efficient buildings compared to less efficient. The effect, however, was smaller for flats compared terraced buildings and no effect at all was found for the most energy efficient semi-detached houses and detached houses in dense areas.

Some studies have focused on specific cities rather than broader regions or the national level. Fuerst *et al.* (2016b) investigates how the energy efficiency affects the apartment prices in Helsinki, Finland. Their hedonic price estimates point to a price premium of 3.5 percent for buildings in the high efficiency categories without controlling for neighborhood characteristics and 1.5 percent after control for these attributes. Rolanda and Semeraro (2016) study the impact of EPCs on the residential apartment market in Turin in Italy, focusing on old buildings. Using a hedonic price model, the authors found after controlling for apartment characteristics, that the EPCs had no impact on the apartment prices. Furthermore, Taltavull *et al.* (2016) focused on the apartment market in Bucharest, Romania and investigates if there exists a "green premium". Combined data from EPC with a proprietary database and they find a premium in two out of five investigated areas. The authors also identified that the relationship might be associated with a spatial distribution. Lastly, Marmolejo-Duarte and Chen (2019) studied EPCs and apartment prices in Barcelona and found a premium of 7.8 % for the apartments labeled A compared to rating G. The effect, however, was uneven across price segments with larger effects found in the low-price segments and no effect at all for recently built more expensive apartments.

There are a few studies regarding energy efficiency and housing values in a Swedish context, with mixed evidence. However, all studies have been conducted using data for single-family houses rather than tenant-owned buildings or apartments and in most cases data before or during the initial phase of the EPCs implementation. Högberg (2013) uses data from 2009 for almost 1100 observations of sales transactions of houses in Stockholm to estimate the marginal effect of energy efficiency on the housing price. Based on a hedonic price model, the estimated result indicated that a 1 percent reduction in standard energy consumption would lead to an increased selling price by 0,04 percent. A larger study was conducted by Cerin *et al.* (2014) uses data from 2009 and 2010 from Swedish EPCs, covering all sales of single-family houses taking place in cities and commuting areas. Based on a sample of over 67 500 observations they conclude that energy efficiency did have an effect of the sales prices of residential houses for certain price segments and for dwellings of certain age-classes. For the lower price segment and older buildings (constructed before 1960), the effect was most prominent, but for the highest price segment no effect was found. The study finds, furthermore, that the number of suggestions for energy improvements in EPCs are significantly larger for cheaper single-family houses and the energy usage in these cheaper properties is also significantly higher than for the more expensive properties.

Wahlström (2016) uses a broad dataset with over 75 000 observations for houses sold in Sweden during 2009 and 2010 and concludes that there is no price premium for energy efficient buildings, but rather that higher energy usage increases the selling price. Wilhelmsson (2019) has recently used a large sample of data from residential single-family houses in Sweden between 2013-2018 and tries to correct for biases in the hedonic price model by estimating the relationship between energy efficiency and housing prices with a combination of approaches. Based on robust regressions, quantile regressions and spatial models, the author concludes that having an energy efficient EPC-grade is capitalized by approximately 3 percent in the sales price. In contrast to Cerin *et al.* (2014), the result from the authors quantile regressions did not indicate that the effect varied over different price distributions. However, the effect was stronger (5 percent capitalization) in the northern part of Sweden which belongs to a different climate zone compared to the rest of the country.

Some studies have also been focusing on the commercial markets and the EPC connection to housing prices. Eichholtz *et al.* (2010) used data for over 10,000 office buildings in the US that have been labeled as green by either the LEED or Energy Star and finds out this labeling is capitalized both in higher rents and selling prices. Chegut *et al.* (2014) focused on the London market for green commercial office buildings that have been classified green in accordance with the BREEAM rating scheme. The authors find a green premium of over 19 percent on the rental market and almost 15 percent in the in sales market in comparison with non-certified office buildings in the same neighborhood. Bonde and Song (2013) does not find any evidence that energy efficiency affects the capital values of commercial buildings in Sweden.

3. Estimation and preliminary analysis

3.1 Data, methodology and estimation procedure

In this study we analyze the relationship between the sales prices of tenant-owned apartments and the energy efficiency as stated in their confining buildings EPCs. The data used in this study is gathered from *Svensk Mäklarstatistik* – i.e. the association of Swedish realtors and covers residential sales transactions of tenant-owned apartments during the full period of 2019. Our data consists of observations from six municipalities that all constitute the major city in its region in Sweden: Malmö, Göteborg, Linköping, Stockholm, Luleå and Umeå. Our motivation behind choosing these cities is to get a broad and geographically diversified picture of the relationship between housing prices of tenant-owned apartments and the EPCs of their confining buildings. The sales data is detailed and includes, except for the sales price of each individual apartment, information about the energy performance or energy performance rating of the building (or EPC-ID) to which the apartment belongs to. The data also includes control variables for each apartment such as number of rooms, age, area in square meters, and the rent or fee paid to the tenant-association each month. The latter two will be expressed in logarithmic form. The energy efficiency is expressed as the building's energy performance in kilowatt-hours per square meter (kWh) while the rating system is a grade that ranges from A to G, with grade A being the most energy efficient. In Sweden, the EPCs were introduced in mid of 2007 for commercial and multi-family buildings, but the grading scale was, however, not implemented in Sweden until 2014. As the EPC is valid for ten years, some tenant association-owned buildings only have information of their building's energy performance, but not actual grade. Hence, only a quarter of our observations will have both the energy performance and grade of their confining buildings (as 2014-2019). Therefore, our dataset will consist of a full sample including all apartments and a subsample only including those apartments that is enclosed in a building with a valid EPC-grade (*graded sample*).

For measure the signaling effect of energy efficiency in the former we construct dummy variables for high and low energy efficiency. Apartment enclosed in buildings with a performance equal to or below 75 kWh per square meters are coded as HIGH (i.e. high energy efficiency or low energy usage) and observations above 140 kWh per square meters as LOW (i.e. low energy efficiency and or high energy usage). These boundaries have been chosen to match the energy grades (i.e. approximately 6.5 percent has energy performance below 75 kWh which is almost the same as number of observations with grade A or B, see Table 1)[3]. The dataset has been cleaned from missing data and other outliers and errors stemming from the

[3] From January 1st, 2019, the way the to measure energy performance in Sweden as displayed by the EPC has changed and is now based on a primary energy number instead of primary energy usage. This will impact the level of energy performance for a small part of our sample with new energy declarations, but the information in the EPC is nevertheless displayed as energy performance in kWh/sqm as before. Given that we are using the information from the EPC, we are measuring the signaling effect of energy efficiency on the sales price rather than the actual effect of energy efficiency on the price. Hence, this new way to calculate the performance should not be a problem as the energy performance and grades is still displayed in the same way to the homebuyers as before.

reporting of the data from the realtors. A few apartments in our sample (out of the nearly 22 000 observations) were more than 300 years old and clearly differed from the rest of the sample. We therefore excluded these. We also excluded a few observations stemming from potential errors in the reporting of the energy performance (such as extreme values for the energy performance despite the apartment being relatively young). Given the large dataset and the design of our estimations (with dummies for age and energy performance), this should be a minor issue.

To achieve the aim with our study we start by using the hedonic price model introduced by Rosen (1974). The hedonic price models are common when it comes to explaining variation in housing prices and have been used in most studies regarding EPC (see e.g. Cerin *et al.*, 2014; Wahlström, 2016; Ayala *et al.*, 2016; Fuerst *et al.*, 2016a; Fuerst *et al.*, 2016b). The general form of hedonic price model for determining the effect of energy efficiency on the sales price of tenant-owned apartments can be set up according to Equation (1):

$$\ln(Y) = \propto + \beta * X + \gamma * Z + \varepsilon \qquad \textbf{(1)}$$

where $\ln(Y)$ represents the natural logarithm of the sales price, $\propto$ is a constant, X is a vector of our important energy efficiency variables with their vector of coefficients being β. Our vector of important dwelling specific and locational control variables is Z with γ being the corresponding vector of coefficients, and ε is the residual term. As pointed out by Wilhelmsson (2019), the hedonic price model can be sensitive to certain biases such as spatial dependence, omitted variables and outliers. To control for the spatial dependence, we therefore include postcode dummy variables to control for joint neighborhood attributes. We use the first 4 digits in the postcode if nothing else stated as more detailed controlling could lead to very few observations per postcode. However, running subsamples while also controlling for income (based on 5-digits postcode), we can control for more detailed common neighborhood characteristics. By including a dummy for postcodes with low incomes and interacting with our variable for energy efficiency, we investigate if the capitalization differs in low versus high income areas. To mitigate issues related to outliers or influential outliers we also run the hedonic estimation with robust regression (rreg in Stata) along with our OLS estimations. By robust regression, observations with a Cook's Distance larger than 1 are omitted and observations with a large absolute residual are given less weights in the final estimation procedure (see e.g. Fuerst et al., 2020 for studies using robust regression when analyzing capitalization in energy-efficient dwellings).

Some authors have pointed out that classic hedonic price estimations might suffer from sample selection bias (see e.g. Marmolejo-Duarte and Chen, 2019; Wilhelmsson, 2019) or other methodological drawbacks (Aydin et al., 2020). In our case apartments that are energy efficient (treatment group) might have different characteristics from those that are not energy efficient (control group). Thus, the treatment effect might be distributed non-randomly. For instance, it is more likely that older buildings have lower energy efficiency compared to never ones. Hence, we will have a discrepancy between treated and control group regarding the age of the buildings. Even though we control for the age of the apartments we cannot be certain that are this relationship is modelled completely correct regarding aspects as the functional form of this relationship, such as linear or non-linear (see for instance a discussion on this issue in Black and Smith, 2004). To reduce problems related to this, it is possible to use some matching method. By matching we try to compare energy efficient dwellings with non-efficient dwellings that are more alike regarding other important factors, such as age, level of rent, numbers of rooms, location etc. Thus, we aim to make the treatment and control groups more similar to each other. In this study we will use two different types of matching, the propensity score matching (PS) and the coarsened exact matching (CEM). The propensity score by Rosenbaum and Rubin (1983) is obtained by running a binary regression with the treatment as dependent variable and important covariates as independent variables. The treatment and control groups are then matched based on their estimated probabilities from the binary regression (which is the propensity score). Propensity score have been used in earlier studies related to capitalization of energy efficiency in dwellings (see e.g. Eichholtz et al., 2013; Walls et al., 2017; Wilhelmsson, 2019). We also implement the CEM by Iacus et al. (2012) as an alternative method to address the possible confounding. CEM works by coarsening variables to groups, where the members in a certain group are given the same numerical value. Identical observations (that have identical values in all coarsen groups) are then matched together into a stratum and given a weight, with matched treatments assigned a weight of 1[4]. Stratums without at least one control and treatment observation will be omitted and a weight of 0 is assigned to unmatched units and is, thus, omitted (see e.g. Iacus et al., 2012 and Blackwell et al., 2009 for more details). The weights obtained from the CEM can then be used to weight the hedonic price estimations. To the best of our knowledge, we do not find any authors that have used CEM to investigate the capitalization of energy efficiency in housing prices. It has, however, been applied in related fields – i.e. public green procurement (e.g. Simcoe and Toffel, 2014).

[4] See Iacus et al., (2012) to see how this weight is calculated for the matched observations in the control group.

In our estimations, we start by estimating the hedonic price model in the full sample. We also run subsamples to control if the effect on prices of tenant-owned apartments enclosed in energy efficient tenant-owned buildings (as depicted by energy performance in the EPC) is different between regions. Furthermore, we run subsamples for those observations enclosed in buildings with an energy grade (graded sample). To get a full picture of the relationship between energy efficiency and the sales price, we test different specifications of the base value to which we compare the high and low efficiency grades. We thereafter proceed by running the hedonic estimation while controlling for income by postcode. Lastly, we use propensity score and coarsened exact matching to mitigate issues related to confounding.

3.2 Descriptive statistics

Table 1 depicts the descriptive stats and a frequency table over our included sample. As shown, our typical object is a middle-aged tenant-owned home with 2,4 rooms and on average 64 square meters. The average price of over 3.3 million SEK is quite high compared to the average tenant-owned home in Sweden. This is caused by the fact that a large part of our sample consists of objects in the municipality of Stockholm and Gothenburg that has a higher price level compared to the rest of the country. The distribution of homes with high energy efficiency (HIGH) i.e. energy performance under 75 kWh per/square meter, is rare compared to the full sample which is a natural reflection that apartments in our sample is middle aged rather than young. Comparing the samples with energy grades and full sample with energy performance, we observe that the percentage of observations with A or B in rating is almost as large as the ones denoted as being highly energy efficient (HIGH).

>> insert Table 1 here <<

4. Empirical results and discussion

4.1. Hedonic price estimations

Table 2 depicts the results from the hedonic price estimations for the full sample. In this sample, we use dummy variables for tenant-owned apartments enclosed in energy efficient tenant-owned buildings, as measured by the energy performance of the building's EPC. Such apartments will hereafter be denoted as *energy-efficient apartments*.

>> Insert Table2 here <<

In Model 1 we start by controlling for a small geographical area by the first two digits in the postcode. We observe that all our control variables are significant with most variation in sales price explained by the size of the home (area) and the rent level (monthly fee paid to association). The negative coefficient of the rent level is expected as higher rent decreases the monthly costs for homeowners. The significant dummy variables for the age of the apartments indicate a significant difference in price compared to tenant-owned apartments constructed before 1900. The negative sign is not unexpected as the reference category are expensive apartments mostly located in concentrated regions in the city-center of Stockholm. Further, we find that the area of the tenant-owned homes in our sample is correlated with the number of rooms according to the VIF-values (variance inflation factors). As both are control variables, they are kept in the estimations. The VIF-value for our treatment variable for energy efficient tenant-owned apartments, HIGH, is very low and does not suggest any problems with multicollinearity. Our R-squared over 81 percent is notably high, but common for hedonic price studies on the housing market, especially given that our sample consists of apartments which are more homogeneous compared to houses. As HIGH is insignificant, we do not find any effect of energy efficiency on the sales price of the tenant-owned apartments.

In Model 2, we instead use the 4-digits postcode to control for more detailed locational effects. Our R-squared now increases to 93 percent, which indicates that a more detailed control for location is important in explaining the sales price. Our treatment, HIGH, is now significant and indicates a price premium of approximately 1.1 percent for energy efficient tenant-owned apartments. This can be interpreted as approximately 11 000 SEK more for every 1 million in sales price for the energy efficient homes, ceteris paribus, compared to the reference category (homes with higher energy performance than 75 kwh/sqm). The size of the premium is smaller compared with the findings of Cerin et al. (2014) and Wilhelmsson (2019) that found larger premiums when using data for houses rather than apartments. As emphasized in the introduction, a large share of the homeowners of tenant owned apartments has the heating included in the monthly fee paid to the association each month, which usually does not change on a short-term basis. The fee is not based on the usages per apartment but rather the joint costs for the association. That the premium is quite low might simply reflect low economic incentives for many buyers of tenant-owned apartments. In Model 3, we include our dummy, LOW, for tenant-owned apartments enclosed in tenant-owned buildings with low energy efficiency (hereafter denoted as *low-efficient apartments*). By including dummies for apartments with both high and low energy efficiency the reference category is now apartments in between these two categories (medium energy efficient). The insignificance of LOW indicates that low efficient apartments are not sold with a discount compared to medium efficient homes all else equal. InModels 4 and 5 we try to mitigate issues related to potential outliers by performing the estimations using the robust regression. The effect of high energy efficiency on the sales price is now reduced to a premium of approximately 0.7 percent that now is weakly significant. The effect of low efficiency on prices is still insignificant.

>> Insert Table 3 here <<

In Table 3 we present the result from regional subsamples. The category South consists of the observations from the municipality of Malmö while the Mid category is based on the sales from Gothenburg and Linköping. As only a few observations of the sample from the northern cities Luleå and Umeå does qualify as energy efficient according to our boundaries, we do not run estimation solely based on these observations. As observed, the coefficient for HIGH are largest in the Southern sample followed by the Stockholm. The effect is, however, not statistically significant for any region.

>> Insert Table 4 here <<

Table 3 depicts the hedonic price estimations using the sample of tenant-owned apartments enclosed in a tenant-owned building with an EPC-grade. In Model 1 we classify energy efficient apartments as those enclosed in a building with the grades A or B and the other labels (C-G) as the reference category. Our results indicate that the effect of energy efficiency is positively related to the sales price but only weakly significant. The estimated premium is approximately 1.5 percent, all else equal, which is higher compared with the effect of energy efficiency in the full sample in Table 2. This 1.5 percent premium can be compared with the ten-basis point reduction in mortgage rate that buyers can get by certain banks if they acquire a home with an energy grade of A or B. Assuming an annual mortgage rate of 2 percent on a 4 million SEK loan, a 0.10 percentage points reduction is approximately 4 000 SEK less per year. If not considering the time value of money or any other potential cost-savings from owning an energy efficient home, a 1.5 percent premium is paid off in 15 years based solely on the mortgage rate reduction. Therefore, a 1.5 percent premium is not unreasonable based on these economic incentives. In Table 4Model 2 we instead define the energy efficient labels as A-C and compare it with the less efficient grades (D-G). Even though the coefficient for the energy efficient grades is positive, the effect is not significant. Hence, our results from Models 1 and 2 suggest that the price premium is only present in the most energy efficient labels, A and B. That these two labels also provide the largest interest rate reduction for homebuyers with green loans might perhaps be a part of the explanation. In Model 3 we add dummies for the least energy efficient labels (E-G). Our results from this estimation shows no significant discount compared with the reference category (label D). In Models 4 and 5 we run the estimations using robust regression. Our effect found in Model 4 now suggest a 1 percent premium for label A and B. However, this is not enough to reach statistical significance.

4.2. Controlling for Income

As the first study on Swedish data, we control for the income of the postcode when evaluating the effect of the energy efficiency on the sales price of tenant-owned apartments. This also enables us to analyze if the capitalization effect differs in low versus high income areas. There are a few theoretical reasons that might lead to differences between these groups. For instance, high-income individuals may afford to be more environmentally conscious compared to low-income individuals, and thus pay more for energy efficient labels. However, it could also be that low-income individuals pay more for energy efficient apartments as they care more about their potential cost-saving benefits. In this section, we use the full sample from Table 2 and match the apartments with the incomes in the age group of 30-64 in their corresponding postcode (5-digit). Hence, because we attach an income to all observations based on their postcodes, with observations belonging to the same postcode (5-digit) get the same income value. As recent data on postcode level is not available, we use data from 2009 available on the website of Radio Sweden (2011) but gathered by Statistics Sweden. We argue that the lack of new data is a minor issue as the income status of the postcodes does not change much in relation to each other on a year-to-year basis. In those postcodes where we could not find any income data, we cleaned the sample from observations belonging to these areas. To divide the data into income categories we calculate the income quartiles in the sample based on the incomes attached to each observation. We then create dummy variables for the apartments based on their matched income. Apartments with incomes (in their postcodes) below quartile 1 is denoted by IC1, apartments with incomes equal to or larger than quartile 1 but smaller than quartile 2 is denoted by IC2, and, lastly, apartments with incomes equal to or larger than quartile 2 but smaller than quartile 3 is denoted by IC3. The results from hedonic price estimations when controlling for these variables are presented in Table 5.

>>Insert Table 5 here <<

Because our income variables are invariant between observations belonging to the same 5-digit postcode we cannot include 5-digit postcode fixed effects without these being omitted. However, we do still see some variation in income between observations belonging to the same 4-digit postcode but not to the same 5-digit code. Hence, we therefore include the 4-digit postcode as fixed effects dummies controlling for common neighborhood effects while also including the income dummies to further divide observations by income within these areas. As observed in Model 1, the income dummies (IC 1-3) are all significant with negative coefficients. This means that there is a significant difference in price, all else equal, between observations within our included income categories and our omitted reference group (high incomes above the third quartile). Our energy efficiency variable, HIGH, indicates a price premium of approximately 0.8 percent but is not of statistically significant size. This insignificant effect is not changed by neither using 3-digit postcodes or controlling for outliers using robust regression (see Models 2 and 3). In Models 4 and 5 we include an interaction effect between HIGH and observations belonging to lower than median incomes (LMI), i.e. incomes below the second quartile in our sample. By this, we want to analyze if the effect of energy efficiency on prices is different if the energy efficient apartments are sold in a low versus high income area. The positive and significant interaction in Model 5 indicates that energy efficiency is valued more in low-income areas. One possible explanation might be a larger share of apartments in which the heating is not included in the fee in low versus high income areas. However, we are not able to control for this. Running this regression with OLS and robust standard errors instead of robust regression does not change the statistically significant interaction.

In Table 6 we test if our estimations (in Table 5) vary depending on the boundaries for which we classify the apartments as energy efficient. As observed, the coefficient when narrowing the boundaries (Models 1 and 3) are larger compared with the corresponding estimates in Table 5, but still not significant. This might be a sample size problem with relatively few observations reaching energy efficiency status. If instead increasing the boundaries (model 2 and 4), we observe a significant premium for energy efficient tenant-owned apartments, of approximately 1 percent.

>> Insert Table 6 here <<

4.3. Matching

As described in the data section, ordinary hedonic price estimations might suffer from methodical problems. Using a propensity score method, we can address the issue of differences between the group with high energy efficiency (treatment) versus the non-energy efficient group (control). We will use two different methods of propensity score. First, we estimate the propensity score using a probit model and include the score in the hedonic model as a covariate. The propensity score in the first step is estimated using the treatment variables (HIGH and A/B) as the dependent variable and the dwelling and location specific variables from the hedonic estimations as independent variables. Here, we chose to only include dummies with high energy efficiency and not for low efficiency. In the second method, we match the treatment and control groups based on the estimated propensity score using a nearest neighbor approach. We thereafter run the hedonic regression on this matched sample using weights from the matching process. For a discussion of these methods, see e.g., Stuart et al. (2010).

>> Insert Table 7 here <<

Table 7 shows the means in the sales price and covariates before and after propensity score matching. As suspected, we can observe that the treatment group in the unmatched samples largely differ regarding the age of the tenant-owned apartments. The control groups include older apartments that are both smaller and cheaper on average. However, after the matching procedure these differences has been largely reduced. The balance in the matched samples is tested by t-tests and mean standardized differences, which can be found in the appendix. These tests show that there is no significant difference between the control and treatment groups after matching. Table 8 depicts the results from the propensity score estimations.

>> Insert Table 8 here <<

As we can see from Models 1 and 3, including the propensity score as a covariate largely reduces the effect of high energy efficiency on the sales price of tenant-owned apartments. The coefficient is positive and ranging from a 0.8 to 1.1 percent premium, ceteris paribus, for tenant-owned apartments enclosed in energy efficient tenant-owned buildings compared to non-efficient. While the effect in the full sample is weakly significant, the estimated premium in the graded sample is insignificant. Looking at the matched samples (model 2 and 4), the effect is similar with the coefficient ranging from 1 to 1.2 percent price premium. As before, the estimations based on the full sample is weakly significant but the effect in the graded sample is insignificant.

Lastly, we use an alternative matching method, the coarsened exact matching (CEM) by Iacus et al. (2012). The results of the CEM are dependent on the variables chosen for the matching procedure and the cut points through which these variables are coarsened. We chose to match on the most important control variables age, log rent, log area, and the number of rooms in each tenant-owned apartment. While running the CEM in Stata it provides an algorithm to automatically chose the cut points. However, we chose the cut points by our own to ensure that this is done based on theoretical knowledge[5]. We test different specifications before we end up with the final cut points. The multivariate L1 distance is a measure of global imbalance in the dataset, and the goal is to produce a model with as low distance as possible. The distance our chosen models can be found in Table 5, which are lower compared with the multivariate L1 distance produced by the Stata algorithm. In accordance with the procedure of Blackwell et al. (2009) we add the matched control variables to the hedonic regression to control for the remaining imbalances. We also add the control variables that were not used in the matching. Our results can be found in Table 9.

>> Insert Table 9 here <<

As observed, the results from the CEM are lower compared the estimates produced from the propensity score or hedonic estimation in Tables 2 and 4. Neither the estimated effect for the graded or full sample is statistically significant.

5. Conclusion and policy implications

To obtain the far-reaching goals set up by the policymakers in the Paris-climate agreement it is of great importance to reduce the energy used by the residential sector. If implemented effectively, the Energy Performance Certificates (EPC) can be good instrument in achieving that goal. Because of that, plentiful of research have been conducted trying to evaluate the effect

[5] Our cutpoints are as follows: Age (0 14.5 29.5 44.5 59.5 79.5 99.5 120.5) , lrent (0 7.7 8 8.3 8.45 8.52 8.7 10), larea (0 3.1 3.45 3.8 4 4.2 4.5 4.75 5 6), Rooms (0 2.25 3.75 5.25 10). For the cut points of the variables with a logarithmic transformation (larea and lrent), these are chosen with respect to corresponding values for the non-logged variables (Rent and Area). For instance, the range 0-3.1 for larea corresponds to the range 0 – 22 sqm without any logarithmic transformation.

of EPCs on the price of properties. The literature has, however, in many cases such as in Sweden, focused on single-family houses rather than apartments or tenant-owned homes in multi-family buildings. This despite that both single-family houses and tenant-owned buildings are required to have a valid EPC. Therefore, we studied the effect on the sale prices for tenant-owned apartments from being enclosed in an energy efficient tenant-owned building. To do so, we performed hedonic price estimations and different matching methods with various model specifications. The included dataset consists of over 20 000 observations spread out over six different Swedish cities. The estimations were performed both on a full sample with dummy variables for apartments enclosed in energy efficient buildings (based on the energy performance of the EPCs), but also on a subsample with EPC-grades. Our results indicate that there is a premium for tenant-owned apartments enclosed in buildings that are most energy efficient or has the highest EPC-grades (A or B). The size of the premium spans from approximately 0.8 to 1.5 percent depending on the estimated model. However, our results vary depending on the included controls, sample or method, and no significant premium is found in some of the estimated models. When classifying labels A-C as the energy efficient grades, no significant effect is found. In comparison with recent studies using data for single-family houses in Sweden, our results indicate a lower premium. When controlling for income in the postcode, we found that the capitalization is higher in low-income versus high-income postcodes. Our findings can have important implications for future policy. For instance, legislators need to be aware that the effect of EPC might be heterogeneous and that more actions may be needed to address certain groups if to be fully capitalized into prices. As a result, we detect an opportunity for enhancing the EPC-policy to stimulate energy efficiency improvements in the built environment, enabling the European Union to reach its climate goals.

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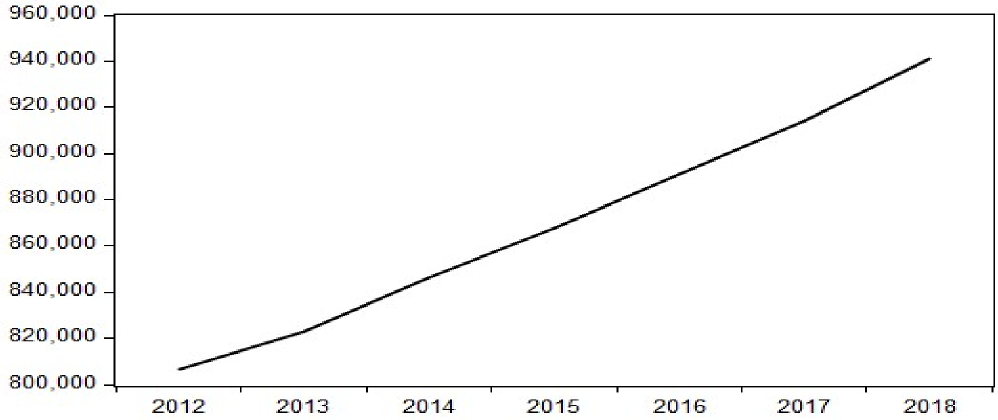
Figures and Tables

Figure 1. Number of households in multi-dwelling tenant-owned buildings



Notes: Number of households in multi-dwelling tenant-owned buildings between 2012-2018. All data collected from SCB (2020)

Table 1. Summary statistics and frequency table

Panel A. Summary statistics

Variable	Obs	Mean	Std. Dev
Price	21,696	3364213	2065931
Area	21,696	64.03	24.84
Room	21,696	2.44	0.99
Age	21,696	63.98	32.84
Rent	21,696	3515.02	1344.48

Panel B. Frequency table

Variable	Frequency	Share of full sample (%)	Share of total grades (%)
HIGH	1397	6.44	
LOW	10,287	47.41	
Grade A	39		0.59
Grade B	385		5.87
Grade C	1040		15.87
Grade D	1353		20.64
Grade E	2266		34.57
Grade F/G	1472		22.46

Notes: This table shows the descriptive stats for our control variables (Panel A) and frequency table (Panel B) of our variables for energy efficiency. Price is the sales price in SEK; Area is the size of the dwelling in sqm; Room is the number of rooms; Age is equal to year 2019 minus the construction year for each dwelling; Rent is the rent or fee paid to the tenant-association each month in SEK; HIGH is a dummy for tenant-owned apartments enclosed in tenant-owned buildings with high energy efficiency ; LOW is a dummy for tenant-owned apartments enclosed in tenant-owned buildings with low energy efficiency; Energy grades are dummy variables equal to 1 if the tenant-owned apartment belongs to a tenant-owned building with the specified EPC-grade/grades.

Table 2. Full sample - Hedonic price estimations

Model 1:	**(1)**	**(2)**	**(3)**	**(4)**	**(5)**
Energy efficiency (EPC)					
HIGH	0.001	0.011**	0.011**	0.007*	0.007*
	(0.19)	(2.39)	(2.31)	(1.71)	(1.67)
LOW			-0.001		-0.001
			(-0.62)		(-0.25)
Dwelling specific controls					
Area	0.862***	0.746***	0.746***	0.750***	0.751***
	(45.07)	(61.76)	(61.29)	(127.10)	(126.45)
Rent	-0.277***	-0.144***	-0.143***	-0.156***	-0.156***
	(-11.91)	(-10.14)	(-10.10)	(-36.60)	(-36.50)
Room	0.049***	0.060***	0.060***	0.058***	0.058
	(13.55)	(25.59)	(25.62)	(30.67)	(30.65)
Building year					
1900–1920	-0.041***	0.002	0.002	0.006	0.001
1921–1940	-0.143***	-0.066***	-0.066***	-0.070***	-0.070***
1941–1960	-0.280***	-0.116***	-0.116***	-0.120***	-0.120***
1961–1975	-0.467***	-0.165***	-0.165***	-0.163***	-0.163***
1976–1990	-0.304***	-0.143***	-0.144***	-0.139***	-0.139***
1991–2004	-0.218***	-0.074***	-0.074***	-0.063***	-0.063***
2005–2019	-0.123***	-0.001	0.002	-0.004	-0.004
Constant	13.48***	13.48***	13.48***	13.54***	13.54***
Time fixed effects	Yes	Yes	Yes	Yes	Yes
Robust regression	No	No	No	Yes	Yes
Postal code fixed effects	(2-digits)	Yes	Yes	Yes	Yes
R^2	0.812	0.933	0.933	0.943	0.943
Obs.	21,696	21,696	21,696	21,695	21,693

Notes: Dependent variable are logarithmic sales price. T-values in parenthesis. Models (1), (2) and (3) are estimated with robust standard errors. Statistical significance is denoted by *** p<0.01, ** p<0.05, * p<0.1. Postcode fixed effects is with 4-digits if nothing else stated. HIGH is a dummy for tenant-owned apartments enclosed in tenant-owned buildings with high energy efficiency; LOW is a dummy for tenant-owned apartments enclosed in tenant-owned buildings with low energy efficiency; Area is the of the size of the dwelling in sqm (log); Room is the number of rooms; Building year (age) is a dummy equal 1 if the apartment were constructed during the given range of years (omitted category is pre 1900). Rent is the rent paid to the tenant-association each month in SEK (log); For the dwelling specific variables, we also include a dummy equal to 1 if the apartment has been significantly renovated or modeled. Results for this variable is available on demand. Models (1), (2) and (3) are ordinary hedonic price estimations while (4) and (5) are robust regressions.

Table 3. Robust regression with regional subsamples from full sample

	Stockholm	South	Mid
HIGH	0.004	0.015	0.001
	(0.65)	(0.85)	(0.15)
Dwelling specific controls	Yes	Yes	Yes
Time fixed effects	Yes	Yes	Yes
Postal code fixed effects	Yes	Yes	Yes
R^2	0.913	0.885	0.912
Obs.	11,468	4,142	5,312

Notes: Dependent variable are logarithmic sales price. T-values in parenthesis. Statistical significance is denoted by *** p<0.01, ** p<0.05, * p<0.1. Postcode fixed effects is based on 4-digits. Robust standard errors are used in the estimations. The mid region contains of dwellings from the municipalities Linköping and Gothenburg and the southern region consists of apartments from Malmö municipality. HIGH is a dummy for tenant-owned apartments enclosed in tenant-owned buildings with high energy efficiency; Dwelling specific variables includes: Area (log), Number of rooms in each apartment, Rent or fee paid to the tenant-association each month (log), dummy for construction year (same as Tables 2 and 3). Lastly, we include a dummy equal to 1 if the apartment has been significantly renovated or modeled since construction.

Table 4. Grade sample - Hedonic price estimations

Model:	**(1)**	**(2)**	**(3)**	**(4)**	**(5)**
Energy grade (EPC)					
A/B	0.015*			0.010	
	(1.70)			(1.34)	
A/B/C		0.001	0.002		-0.001
		(0.13)	(0.32)		(-0.21)
EFG			0.002		-0.002
			(0.42)		(-0.48)
Dwelling specific controls					
Area	0.749***	0.750***	0.750***	0.750***	0.750***
	(32.87)	(33.04)	(33.03)	(63.91)	(63.87)
Rent	-0.164***	-0.165***	-0.165***	-0.170***	-0.170***
	(-6.48)	(-6.55)	(-6.55)	(-19.22)	(-19.19)
Room	0.065***	0.065***	0.065***	0.059***	0.059
	(15.47)	(15.45)	(15.44)	(16.98)	(16.98)
Building year					
1900–1920	0.000	0.000	0.000	0.000	0.001
1921–1940	-0.059***	-0.059***	-0.060***	-0.068***	-0.068***
1941–1960	-0.129***	-0.129***	-0.129***	-0.136***	-0.136***
1961–1975	-0.172***	-0.172***	-0.172***	-0.165***	-0.165***
1976–1990	-0.166***	-0.166***	-0.166***	-0.158***	-0.158***
1991–2004	-0.091***	-0.091***	-0.091***	-0.079***	-0.079***
2005–2019	0.016	0.019	0.019	0.013	0.014
Constant	13.80***	13.80***	13.80***	13.97***	13.97***
Time fixed effects	Yes	Yes	Yes	Yes	Yes
Robust regression	No	No	No	Yes	Yes
Postal code fixed effects	Yes	Yes	Yes	Yes	Yes
R^2	0.936	0.936	0.936	0.944	0.945
Obs.	6555	6555	6555	6551	6553

Table 4. Notes: Dependent variable are logarithmic sales price. T-values in parenthesis. Models (1), (2) and (3) are estimated with robust standard errors. Statistical significance is denoted by *** p<0.01, ** p<0.05, * p<0.1. Postcode fixed effects is based on 4-digits if nothing else stated. Area is the of the size of the dwelling in sqm (log); Room is the number of rooms; Building year (age) is a dummy equal 1 if the apartment were constructed during the given range of years (omitted category is 1900). Rent is the rent paid to the tenant-association each month in SEK (log); Energy grades are dummy variables equal to 1 if the tenant-owned apartment belongs to a tenant-owned building with the specified EPC-grade/grades. In Models (3) and (5), the energy grade D is the omitted category, while grade C-G is omitted in Models(1) and (4) and D-G in (2). For the dwelling specific variables, we also include a dummy equal to 1 if the apartment has been significantly renovated or modeled. Results for this variable is available on demand. Models (1), (2) and (3) are ordinary hedonic price estimations while (4) and (5) are robust regressions.

Table 5. Full sample - Hedonic prices with income controls

	(1)	(2)	(3)	(4)	(5)
HIGH	0.008	0.002	0.004	-0.002	-0.004
	(1.47)	(0.40)	(0.81)	(-0.31)	(-0.73)
Income					
IC1	-0.133***	-0.173***	-0.106***		
IC2	-0.068***	-0.104***	-0.049***		
IC3	-0.051***	-0.070***	-0.040***		
LMI				-0.071***	-0.028***
LMI × HIGH				0.016	0.024**
				(1.53)	(2.59)
Dwelling specific controls	Yes	Yes	Yes	Yes	Yes
Time fixed effects	Yes	Yes	Yes	Yes	Yes
Robust regression	No	Yes	Yes	Yes	Yes
Postal code fixed effects	(4-digits)	(3-digits)	(4-digits)	(3-digits)	(4-digits)
R^2	0.935	0.924	0.944	0.921	0.944
Obs.	20,742	20,740	20,740	20,739	20,740

Table 3. Notes: Dependent variable are logarithmic sales price. T-values in parenthesis. Statistical significance is denoted by *** p<0.01, ** p<0.05, * p<0.1. HIGH is a dummy for tenant-owned apartments enclosed in tenant-owned buildings with high energy efficiency. IC1 is a dummy for observations that belongs to a postcode with low incomes (below first income quartile in our sample), IC2 is a dummy for low to median income postcodes (between first and second quartile) while IC3 is a dummy for median to upper incomes (post code between second and third quartile). LMI is a dummy for observations belonging to below median incomes in our sample (below second quartile). Dwelling specific variables includes: Area (log), Number of rooms in each apartment, Rent or fee paid to the tenant-association each month (log), dummy for construction year (same as Tables 2 and 4). We also include a dummy equal to 1 if the apartment has been significantly renovated or modeled since constructed.

Table 6. Robustness, alternative boundaries for energy efficiency

Model:	**(1)**	**(2)**	**(3)**	**(4)**
HIGH (≤ 50 kWh/sqm)	0.014		0.008	
	(1.10)		(0.73)	
HIGH (≤ 100 kWh/sqm)		0.010***		0.009***
		(2.87)		(2.9)
Income controls	Yes	Yes	Yes	Yes
Dwelling specific controls	Yes	Yes	Yes	Yes
Robust regression	No	No	Yes	Yes
Time fixed effects	Yes	Yes	Yes	Yes
Postal code fixed effects	Yes	Yes	Yes	Yes
R^2	0.935	0.935	0.944	0.944
Obs.	20742	20742	20741	20741

Table 6. This table shows the hedonic price model with income controls. Dependent variable is the logarithmic sales price. Statistical significance is denoted by *** p<0.01, ** p<0.05, * p<0.1.Models (1) and (2) are estimated with robust standard errors. T-values in parenthesis. Postcode fixed effect is with 4-digits if nothing else stated. HIGH is a dummy for tenant-owned apartments enclosed in tenant-owned buildings with high energy efficiency. In this table we define high efficiency as either energy performance below 50 kWh/sqm or 100 kWh/sqm. Income controls includes the same dummy variables as in Table 5. Dwelling specific variables includes: Area (log), Number of rooms in each apartment, Rent or fee paid to the tenant-association each month (log), dummy for construction year (same as Tables 2 and 4). We also include a dummy equal to 1 if the apartment has been significantly renovated or modeled since construction. Postcode fixed effect is with 4-digits.

Table 7. Mean in covariates before and after propensity score matching

	Full sample				Graded sample			
	Unmatched		***Matched***		***Unmatched***		***Matched***	
Variable	Treatment	Control	Treatment	Control	Treatment	Control	Treatment	Control
Price	3742086	3338207	3761089	3704983	3605326	3129489	3697648	359620
Area	70.9	63.6	71.1	71.1	70.2	65.9	70.1	68.3
Age	26.5	66.6	26.8	35.9	19.27	53.6	20.0	27.9
Rent	3800.4	3495.4	3805.1	3894.7	3841.6	3637.1	3839.4	3741.0
Room	2.7	2.4	2.71	2.7	2.7	2.5	2.7	2.6
Obs	1397	20299	1377	921	424	6131	394	256

Table 7. Notes: This table shows the treatment and control group before and after propensity score matching. The treatment in the full sample is the variable HIGH, which is a dummy for tenant-owned apartments enclosed in tenant-owned buildings with high energy efficiency. The treatment for the graded sample is dummy variables equal to 1 if the tenant-owned apartment belongs to a tenant-owned building with the energy grade A or B. The matched full sample is equivalent to the sample used in estimations of Model 2 in Table 8. For the graded matched sample this is equivalent to the data used in estimations of Model 4 in Table 8.

Table 8. Result after propensity score estimations

	Full sample		Graded sample	
Model:	**(1)**	**(2)**	**(3)**	**(4)**
HIGH	0.008*	0.010*		
	(1.77)	(1.88)		
A/B			0.011	0.012
			(1.28)	(1.24)
Dwelling specific controls	Yes	Yes	Yes	Yes
Time fixed effects	Yes	Yes	Yes	Yes
Postal code fixed effects	Yes	Yes	Yes	Yes
Regression on matched sample	No	Yes	No	Yes
Propensity score as control	Yes	No	Yes	No
R^2	0.927	0.919	0.929	0.943
Obs.	16,511	2,754	3,638	788

Notes: This table shows the hedonic price model with estimated propensity score as a covariate (model 1 and 3) as well as on propensity score matched samples (model 2 and 4). Statistical significance is denoted by *** p<0.01, ** p<0.05, * p<0.1. Dependent variable is the logarithmic sales price. T-values in parenthesis. HIGH is a dummy for tenant-owned apartments enclosed in tenant-owned buildings with high energy efficiency. Postcode fixed effects is 4-digits if nothing else stated. The treatment for the graded sample is dummy variables equal to 1 if the tenant-owned apartment belongs to a tenant-owned building with the energy grade A or B. Dwelling specific variables includes: Area (log), Number of rooms in each apartment, Rent or fee paid to the tenant-association each month (log), dummy for construction year (same as Tables 2 and 3). We also include a dummy equal to 1 if the apartment has been significantly renovated or modeled since constructed.

Table 9. Hedonic estimations after Coarsened Exact Matching (CEM)

	Full sample	Graded sample
HIGH	0.005	
	(1.05)	
A/B		0.007
		(0.81)
Dwelling specific controls	Yes	Yes
Time fixed effects	Yes	Yes
Postal code fixed effects	Yes	Yes
R^2	0.931	0.933
Obs.	17,702	4,373

Table 9. Notes: This table shows the results of hedonic price estimations weighted on the matched dataset after CEM. T-values in parentheses. Dependent variable is the logarithmic sales price. HIGH is a dummy for tenant-owned apartments enclosed in tenant-owned buildings with high energy efficiency. Postcode fixed effects is with 4-digits if nothing else stated. The treatment for the graded sample is dummy variables equal to 1 if the tenant-owned apartment belongs to a tenant-owned building with the energy grade A or B. Dwelling specific variables includes: Area (log), Number of rooms in each apartment, Rent or fee paid to the tenant-association each month (log), dummy for construction year (same as Tables 2 and 3). We also include a dummy equal to 1 if the apartment has been significantly renovated or modeled since constructed.