An empirical investigation of the Dutch residential real estate market in the last decade

The impact of energy efficiency on rental prices

Buildings are responsible for approximately 40% of energy consumption and 36% of carbon emissions in the EU (European Commission, 2019). Consequently, it is important to focus on reducing energy consumption and promoting the use of energy from renewable sources in the real estate sector. This study uses a hedonic model to examine the relation between energy labels and rent prices, controlling for building-specific characteristics and economic, social, demographic and locational variables. Proof of this relationship will steer more risk-bearing capital towards sustainable real estate investments and, in turn, help further reduce carbon emissions and energy usage in the building sector.

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Literature overview

Previous studies that have researched the relationship between energy certification and financial performance have found a significant positive relationship. Research in this area has focussed on transaction prices and rental premiums, and the studies differentiate between the residential real estate sector and the office real estate sector. A variety of energy labels are used as a proxy for energy efficiency: EPC, LEED and Energy Star.

Fuerst and McAllister (2008) have examined the price effects of environmental certification on commercial real estate assets in the United States for transaction and rental prices using both LEED and Energy Star certifications. Their findings reveal a significant positive relationship on both transaction price (31-35%) and rental price (6-9.5%). They have found three main drivers for this premium: additional occupier benefits, lower holdings costs and a lower-risk premium. In later work, the authors have found similar results (Fuerst & McAllister, 2011). These results are in line with the findings of Eichholtz, Kok and Quigley (2010), which have determined that buildings with a green rating from either LEED or Energy Star receive a 2.8% to 3.5% higher rent, a 7% to 10% higher effective rent and a 16% to 19% higher transaction price. A later study conducted by the same authors shows similar results (Eichholtz, Kok & Quigley, 2013).

Kok and Jennen (2012) have examined the effects of sustainability on rents realised in the European office market and found that green office buildings receive, on average, a 6.5% higher rent compared to non-green buildings. Kahn and Kok (2014), meanwhile, have examined the relationship between energy efficiency and transaction price by developing a hedonic model for a pricing analysis of all single-family home sales in California between 2007 and 2012. Their results indicate that homes with a green label transact at a small premium (2.1% to 3.9%).

Brounen and Kok's research (2011) is the most similar to the study at hand. The authors have found that energy label adoption rates in the Netherlands were low and declining. Homebuyers paid a 0% to 3% premium for more efficient dwellings; however, energy labels were not entirely mandatory during the sample period. This potentially led to a sample bias: certain homeowners are more likely to obtain an energy label than others. Furthermore, they have argued that regulations should be adjusted to increase the energy label adoption rate. The regulation on energy labels in the residential real estate sector in the Netherlands changed in 2015, making it mandatory for all newly constructed, sold or rented dwellings to provide an energy label.

Research question

Existing literature on the relationship between sustainability factors and real estate return mainly focuses on the United States, particularly the office real estate market. The limited research in the Netherlands focuses on the impact of energy labels on the transaction price of residential real estate (Brounen & Kok, 2011). This study adds to the existing literature by examining the relationship between energy labels and the rental prices of residential real estate in the Netherlands by utilizing a large dataset. A hedonic model is used to examine the relation between energy labels and rent prices, while controlling for building-specific characteristics and economic, social, demographic and locational variables. Proof of a positive relationship between energy labels and rent price indicates the market's ability to capitalise on energy efficiency in investment decisions and inspire increased market demand for energy labels.

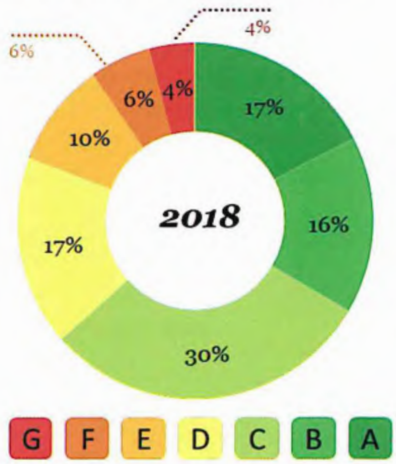
Data

The data used in this study is a combination of public data published by the Rijksdienst voor ondernemend Nederland (RVO) and private data obtained from MVGM. The RVO, formerly known as Agentschap NL, is an agency of the Dutch Ministry of Economic affairs that promotes sustainable innovation and international entrepreneurship. It is responsible for registering Dutch energy performance certificates (EPC) and exercising quality control.

In the Netherlands, the EPC is called 'energielabel'. In general, an energy label identifies how energy efficient a dwelling is. This research utilizes energy labels instead of the actual energy consumption of a dwelling. The benefit of using energy labels is that it is a standardised measure that removes an individual's consumption habits. Homeowners are obligated to provide an energy label to the buyer or renter of a dwelling that states how much energy it consumes. The energy label indicates an energy efficiency level on a scale of seven; the lowest rating is a G for dwellings that are the least energy efficient, and the highest rating is an A for the most efficient dwellings. The energy label provides an overview of a dwelling's characteristics such as dwelling type, insulation, window types and heating system. The Dutch energy label also highlights what measures can be taken to improve efficiency.

In 2018, out of slightly more than 7.9 million dwellings in the Netherlands, almost 3.7 million (46%) residential dwellings had an officially registered energy label. More than half (63.5%) of the rated dwellings received a green rating (a label of C or higher), as can be seen in Figure 1 (RVO, 2018). The energy label database is publicly accessible and provides energy performance labels for all labelled dwellings in the Netherlands, including the date a dwelling received its energy label. In line with Brounen and Kok (2011), dwellings with an energy label of A, B or C are considered 'green' dwellings. This is similar to the colour used for the categories of the actual energy label.

FIGURE 1 ▸ TOTAL DIVISION OF RECORDED ENERGY LABELS IN 2018 (RVO, 2018)



MVGM is the largest property manager in the Netherlands and has over 90,000 rental dwellings.

The dataset contains a majority of dwellings in the free sector (vrije sector) with a rental price above €710 (in 2018). However, robustness tests indicate that the results apply to both the free and social sector dwellings.

The data from MVGM contains just over 215,000 rental transactions from January 2008 until September 2017. The dataset contains various types of characteristics and dwelling attributes, such as physical characteristics; number of rooms, size, property type and thermal characteristics; air conditioning, boiler, insulation, and amenities; garden, garage, air conditioning and locational and neighbourhood characteristics; distance to hospitals, schools and shopping areas; ratings on safety, quality and amenities in the neighbourhood; and socioeconomic factors such as average monthly income per rental transaction. The MVGM dataset utilises data from Dutch Statistics for several of the variables on neighbourhoods and other area-specific characteristics, such as housing density and average income, which is in line with other studies using similar data (Brounen & Kok, 2011). The above-mentioned dwelling characteristics are expected to influence rental prices per square metre. The following section presents the expected relationship between the main variables.

Dwelling-specific characteristics: Dwellings are divided into two main types: single-family homes and multi-family homes. Single-family homes are expected to receive higher rents per square metre than apartments, as they offer more privacy and other benefits. Age is expected to have a convex relationship with rental price. A dwelling's value initially decreases with age, as its quality and newness are reduced compared to newer dwellings; however, very old buildings are considered relatively valuable compared to otherwise similar dwellings, as they are rare and have a certain charm. Size is expected to negatively influence the price per square metre, as economies of scale are involved in developing residential real estate, and this translates into relatively lower rental prices per additional square metre. The quality of the inner and outer maintenance is expected to increase the price per square metre.

Thermal characteristics: These include air conditioning, the type of heating and the quality of insulation. Air conditioning is expected to positively affect price, as it can be seen as a valuable amenity. This relationship, however, is expected to be weaker in the social rent sector, as the energy costs involved in running air conditioning can be a barrier to using it for more financially constrained renters. Moreover, a positive relationship between insulation and rental prices is expected, as insulated houses require less energy for heating and therefore reduce energy expenses. This is in line with the general hypothesis of this research: energy cost-reducing measures are valued and lead to higher rental prices.

Amenities: Amenities are expected to have a positive relation with price per square metre. It is probable that some amenities have a larger effect on the price per square metre in the private sector

FIGURE 2 ▸ ENERGY LABEL BY YEAR OF TRANSACTION, EXCLUDING 2017 (MVGM, 2017)

(i.e., rental prices above €710) compared to the social segment (i.e., rental prices below €710). For example, the presence of a garage or an elevator is anticipated to have a larger effect on rental prices in the private rental sector.

Locational characteristics: The MVGM dataset contains geographical clusters based on the COROP region, province, municipality, district and neighbourhood. From the first to the last, these have decreased in size and increased in homogeneity in terms of locational characteristics. Neighbourhood clusters control for the majority of locational variations, such as distance to the Central Business District (CBD), hospitals and schools. Moreover, it controls for the quality and safety of a neighbourhood. This research used the neighbourhood code to control for locational fixed effects.

Socio economic factors: Housing density and population are expected to have a positive effect on rental prices. In general, rental prices are higher in more populated areas and in larger cities. The average household income in a neighbourhood is also expected to be positively related to rental prices. Richer households usually spend more on their housing and are generally located in similar areas.

The MVGM dataset has been matched with the RVO database to include the energy labels of the transacted dwellings. The initial combined dataset contained 215,000 observations from January 2008 until September 2017. After controlling for outliers and missing variables, 201,804 observations remained. The remaining observations contained 142,454 transactions of dwellings without and 59,350 transactions of dwellings with an energy label. Appendix 1 presents descriptive statistics on dwelling characteristics sorted by labelled and non-labelled dwellings.

The number of yearly transactions has increased over time, from a minimum of 7,834 transactions in 2008 to a maximum of 29,149 in 2015, as can be seen in Figure 2. Similarly, the adoption rate is not evenly distributed and has increased linearly over time, with a minimum adoption rate as low as 3% in 2008 to a maximum adoption rate of 57% in 2016. The share of dwellings with a green label has also steadily increased. In 2008, only 1% of the rental transactions involved a dwelling with a green label, while in 2016, 39% of the rental transactions involved dwellings with a green label.

Methodology

A hedonic model has been used to estimate the relationship between energy labels and rental prices. A dwelling consists of many characteristics, all of which may affect its value. By collecting data on multiple characteristics of many dwellings, a hedonic model can be used to determine the relationship of each characteristic to determine its value.

A regression analyses reveals the characteristics that add to or subtract from a dwelling's value. Haas first used the hedonic model in 1922 to value farmland. Thereafter, scholars around the world have widely adopted this technique for property price appraisals (Abidoye and Chan, 2017). Hedonic models can be used to construct a price index, perform a time series analysis, predict dwelling prices or estimate the intrinsic value of specific attributes. Hedonic regression analysis is frequently used to estimate the marginal contribution of individual characteristics, such as a dwelling's energy label. The most basic hedonic model takes the following form (Sirmans, Macpherson & Zietz, 2005):

$$\textit{Price} = f\,(\textit{Physical Characteristics, Other Factors})$$

This model states that the rent price of a dwelling is a function of its specific physical characteristics (size, number of rooms, age, amenities and others) and other aspects such as location, neighbourhood and external factors. The value of each of the characteristics is given by the regression estimates. Adding energy labels to this equation enables a determination of the implicit value of these labels; however, the values attached to different characteristics are likely unequal for dwellings' differential price ranges. For example, the additional value of an extra bathroom might be greater for a rental unit of €1,500 a month than for a rental unit of €700 a month. To account for this, the hedonic estimations in this research were realised using a semi-logarithmic model.

The semi-logarithmic model has various benefits. First, the log-linear model is easy to interpret: the resulting coefficients of the independent variables can be interpreted as the percentage change in rent. Second, the semi-logarithmic model mitigates heteroscedasticity. Finally, as previously explained, a major benefit of the semi-logarithmic function is that it permits the value of a certain characteristic to vary proportionately with the value of other characteristics. This contrasts with linear models, which value each characteristic equally independent of other characteristics. When using a linear model, an additional bedroom has the same value for a dwelling with a living area of 40 square metres as it does for a dwelling with a living area of 80 square metres. The log-linear model used in this research is the following:

$$\ln(R_i) = \alpha + \beta_1 E_i + \beta_2 P_i + \beta_3 T_i + \beta_4 A_i + \beta_5 L_n + \beta_6 S_n + \beta_7 t_i$$

Where $\ln(R_i)$ is the natural log of the monthly contract rent per square metre of dwelling *i*. *E*, *P*, *T*, *A* and *t* are, respectively, energy label, physical and thermal characteristics, amenities of size characteristics and the transaction year of rental dwelling *i*. Amenities and thermal characteristics such as a garden, shed, garage, air conditioning, boiler and insulation are all dummy variables that receive the value of one if present. The default mode for type of dwelling is a single-family dwelling. *L* and *S* are, respectively, the locational and socioeconomic characteristics conditional to the neighbourhood cluster *n* in which dwelling *i* is located. The sample consists of 7,262 different neighbourhood clusters. Ei is a dummy variable with the value of one if dwelling *i* has an energy label of C, B or A. Obtaining an energy label of C or higher indicates that a dwelling is considered green with regard to energy consumption. Alternatively, E_i indicates the energy label of dwelling *i*, which ranges from A to G. Energy label D serves as the reference group.

The results are presented for ordinary least squares regression models. The models include time-fixed effect, neighbourhood-fixed effect and controls for the period of construction. The construction period has been controlled for using the following brackets: before 1930, 1930-1945, 1945-1960, 1960-1970, 1970-1980, 1980-1990, 1990-2000, 2000-2010 and after 2000, in line with Brounen and Kok (2011).

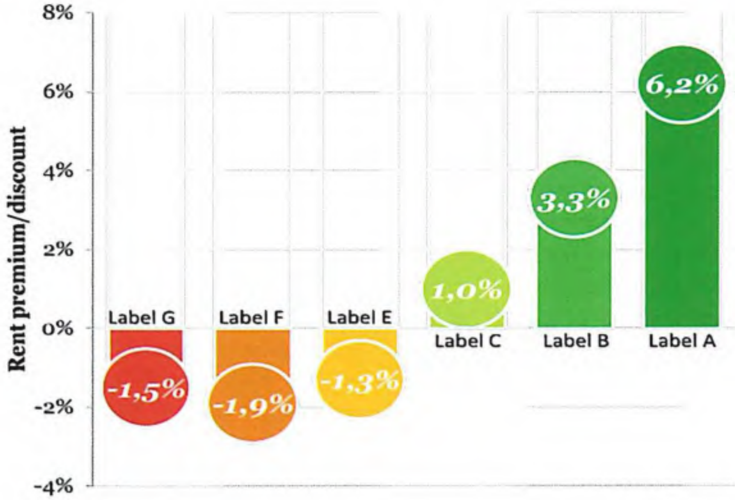
Results

Appendix 2 presents the financial impact of energy labels on rental prices per square metre. The independent variables explain 84% of the variation in the natural log of rental prices per square metre based on the 59,350 observations in Column 1. Multi-family dwellings rent at a 1.2% discount relative to single-family dwellings. A dwelling with a shed or garage rents at a premium of 1.5% and 3.2%, respectively. A one-unit increase in inside maintenance quality (on a scale of one to nine, where nine is excellent) increases rental prices by 3.5%. Moreover, the results on dwelling size are highly significant and suggest that a 1% increase in dwelling size reduces rental prices per square metre by 0.53%.

It is important to note that the variable of interest, 'green rating', is positive and highly significant. Rental prices for dwellings with a green label are 2.7% higher per square metre, ceteris paribus. These findings provide evidence for a positive relationship between rental price and sustainability. Tenants value energy efficiency and pay more for energy-efficient dwellings.

Column 2 of Appendix 2 presents evidence of individual energy label scores, where label D serves as a reference group. Control variables have the same direction and size as in Column 1. As expected, dwellings with higher energy labels receive higher rents compared to the reference group. Dwellings with lower energy labels than the reference group receive a discount. Dwellings with a label of A, B or C receive a premium that is both statistically

FIGURE 3 ▸ ENERGY EFFICIENCY ON RENT PRICE (DEFAULT FOR ENERGY LABEL IS LABEL D)



and economically significant. The premiums are, respectively, 6.2%, 3.3% and 1.0%. This evidence continues to support the positive relationship between energy efficiency and rent price. This indicates that tenants pay more for energy-efficient dwellings. The findings on energy efficiency for individual labels are summarized in *Figure 3*.

Part of the 'green' premium might be explained by the better building quality of homes with an A, B or C label. Therefore, dwellings' thermal characteristics are included in Columns 3 and 4. The control variables maintain the same direction and significance and change only marginally in size. The added thermal characteristics, however, are all highly significant. Dwellings that are equipped with an air-conditioning unit, a boiler or insulation have, respectively, 9.6%, 0.5% and 1.1% higher rental prices per square metre, ceteris paribus. However, adding the thermal characteristics only slightly adjusts the variables of interest 'green rating' and 'energy label'. Both remain highly significant and positive, supporting the evidence of a positive relationship between energy efficiency and rent price.

Appendix 2 presents a significant premium for energy efficiency in dwellings with a label. It should be noted that this premium increases with better energy labels. Previous literature on sustainable products has found evidence that consumers only pay for a minimum level of sustainability (Pelsmacker, Driesen & Rayp, 2005) (Cotte & Trudel, 2009), but Table 2 proves that this is not the case for energy efficiency. If renters were only interested in paying for a minimum level of sustainability, similar premiums would be found for dwellings rated with labels A, B and C.

Robustness

Due to urbanisation, the demand for housing has increased significantly in large cities in the Netherlands, where built-up areas have continuously increased. In 2002, the number of people living in an urban environment outnumbered the population living in a rural environment (Leeuwen, 2014). The robustness of the results is tested by evaluating whether the energy efficiency relationship previously found is solely driven by demand in urban areas. The results obtained are actually stronger in large cities; however, they are also highly significant in the sample that excludes the 30 largest cities in the Netherlands. This provides evidence that these results are robust and are not solely driven by dwellings in large cities, as can be seen in Appendix 3.

Furthermore, the robustness of these results was tested using an alternative definition of homes

with a green label. The findings reveal that the definitions used in this research are robust, and the results are evidence of tenants valuing energy efficiency, as presented in Appendix 4.
In addition, an alternative energy label, the energy index, was used to determine if these results are robust when using a different energy consumption metric. The energy index is a voluntary instrument that uses a more accurate determination of a dwelling's energy performance than the method used to determine an energy label. Similar results were found using this alternative energy label, as Appendix 5 shows.

Furthermore, tests were performed to determine if these results were driven by dwellings in the social sector, where the legal maximum amount of rent is linked to energy performance. Both the free and the social sectors receive a highly positive and statistically significant green premium, which demonstrates that these findings are not solely driven by the social sector, as can be seen in Appendix 6.

Conclusion

This research aimed to investigate the relationship between energy labels and the rental prices of residential real estate in the Netherlands. To research the implications of green labels in residential real estate on rental prices, a hedonic pricing model was developed based on a dataset of just over 200,000 observations in the Netherlands from January of 2008 until September of 2017. Evidence has been presented on label adoption and its financial impact on rental prices.

The evidence revealed that there is a statistically significant premium for dwellings with better energy labels. Dwellings considered 'green' (labels A, B or C) receive 2.6% higher rents. Moreover, the evidence regarding individual dwellings demonstrated that dwellings with a label of A, B and C receive significantly higher rents relative to the reference group (label D), i.e., 6.2%, 3.2% and 1.0%, respectively. On the contrary, the evidence revealed there are significant discounts in rental prices for dwellings with energy labels E, F and G, namely, -1.2%, -1.8% and 1.4%, respectively. This demonstrates that renters are willing to pay a premium for homes that have been labelled as more energy efficient, or 'green'. Our results show that this price premium varies with the energy performance and is robust to variations in the type of energy rating, level of urbanisation and rental segment.

These findings contain some important lessons for investors. When improving the energy efficiency of a dwelling, the increased energy efficiency is recognized at the time of a new rental transaction, which leads to a higher rental price. However, future research should examine to what extent the premium found covers the costs of upgrading a dwelling to a better energy label.

Future research can further investigate which types of dwellings receive the largest premium and, more specifically, the types of renters who are willing to pay this premium. What motivates renters to rent green, and the question of whether energy savings and therefore reduced energy expenditure or environmental concerns drive the trend towards green, should be examined. This research has presented evidence on the relation between energy efficiency and rental prices in the residential sector in the Netherlands. Future research should examine if this positive relationship between energy performance and rent price is also present in the commercial sector in the Netherlands. Moreover, future research should examine if this relation is similar in other EU member states.

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Steve Goossens MSc won the Capital Value Thesis Award for his research on the impact of energy efficiency on rental prices that he performed at Hartelt Fund Management. With this research, Goossens completed his combined MSc Sustainable Finance and his MSc Corporate Strategic Finance at Maastricht University in 2018. Goossens works as a Junior Asset Management Professional at APG Asset Management.

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LITERATURE

- Abidoye, R. and Chan, A. (2017). Critical review of hedonic pricing model application in property price appraisal: A case of Nigeria. International Journal of Sustainable Built Environment, 6(1), pp.250-259.
- Andaloro, A., Salomone, R., Ioppolo, G. and Andaloro, L. (2010). Energy certification of buildings: A comparative analysis of progress towards implementation in European countries. *Energy Policy*, 38(10), pp.5840-5866.
- Brounen, D. and Kok, N. (2011). On the economics of energy labels in the housing market. Journal of Environmental Economics and Management, 62(2), pp.166-179.
- Cadman, D. (2000). The vicious circle of blame. *Upstream*.
- Cotte, J. and R. Trudel (2009), "Does it pay to be good?" MIT Sloan Management Re-view, vol. 50(2).
- De Pelsmacker, P., L. Driesen and G. Rayp (2005), "Do Consumers Care about Ethics? Willingness to Pay for Fair-Trade Coffee", Journal of consumer Affairs, vol. 39(2), pp. 363-285
- DESA (2016), *The Sustainable Development Goals Report 2016*, UN, New York.
- DiPasquale, D., & Wheaton, W. C. (1992). The markets for real estate assets and space: a conceptual framework. *Real Estate Economics*, 20(2), 181-198
- Eichholtz, P., Kok, N. and Quigley, J. (2013). The Economics of Green Building. *Review of Economics and Statistics*, 95(1), pp.50-63.
- Fuerst, F., & McAllister, P. (2011c). The impact of Energy Performance Certificates on the rental and capital values of commercial property assets. *Energy Policy*, 39(10), 6608-6614.
- Kahn, M. and Kok, N. (2014). The capitalization of green labels in the California housing market. *Regional Science and Urban Economics*, 47, pp.25-34.
- Kain, J.F. and Quigley, J.M. (1970). Measuring the Value of Housing Quality, *Journal of the American Statistical Association*, Vol. 65, No. 330, pp. 532-548.
- Kok, N. and Jennen, M. (2012). The impact of energy labels and accessibility on office rents. *Energy Policy*, 46, pp.489-497.
- Majcen, D., Itard, L. and Visscher, H. (2013). Theoretical vs. actual energy consumption of labelled dwellings in the Netherlands: Discrepancies and policy implications. Energy Policy, 54, pp.125-136.
- Pivo, G. and Fisher, J. (2009). Effects of Walkability on Property Values and Investment Returns, Benecki Center for Real Estate Studies, Indiana University. Working paper.
- SER (2013). *Energieakkoord voor duurzame groei*. Sociaal-Economische Raad, Den Haag.
- Sirmans, G.S., Macpherson, D.A. and Zietz, E.N. (2005). The Composition of Hedonic Pricing Models, *Journal of Real Estate Literature*, Vol. 13, No. 1, pp. 3-43.
- Sirmans, G.S., Sirmans, C.F. and Benjamin, J.D. (1989). Determining Apartment Rent: The Value of Amenities, Services and External Factors, *Journal of Real Estate Research*, Vol. 4, No. 2, pp. 33-43.

APPENDIX 1 ▸ SUMMARY STATISTICS COMPARISON LABELED AND NON-LABELED DWELLINGS (2008-2017)

Sample size	No Label: 142454 Mean	St.Dev.	Label: 59350 Mean	St.Dev.
Rent Price (€)	986,77	474,14	891,56	338,95
Rent Price (€/m²)	10,99	4,44	10,26	4,00
Dwelling time (percent)				
Single-Family House	0,66	0,47	0,70	0,46
Multi-Family House	0,34	0,47	0,30	0,46
Dwelling characteristics				
Quality inside (9 = "excellent")	7,39	0,99	7,33	0,92
Quality outside (9 = "excellent")	7,36	0,91	7,36	0,85
Dwelling size (square meters)	97,92	41,95	93,38	31,79
Number of rooms	3,59	1,48	3,50	1,21
Number of bedrooms	2,23	1,26	2,29	1,05
Number of stories	1,70	0,91	1,56	0,86
Age (years)	55,42	50,84	36,56	35,03
Period of construction (percent)				
Pre-1930	0,22	0,41	0,08	0,27
1930-1944	0,10	0,30	0,04	0,19
1945-1960	0,07	0,25	0,04	0,19
1960-1970	0,09	0,28	0,08	0,27
1970-1980	0,09	0,28	0,11	0,32
1980-1990	0,08	0,28	0,16	0,37
1990-2000	0,09	0,29	0,16	0,37
2000-2010	0,17	0,38	0,20	0,40
>2010	0,09	0,29	0,12	0,33
Thermal and quality characteristics				
Boiler (1=yes)	0,61	0,49	0,52	0,50
Insulation (1=yes)	0,56	0,50	0,43	0,49
Air conditioning (1=yes)	0,01	0,10	0,00	0,06
Neighbourhood characteristics				
Housing density (dwellings in 1km radius)	2574,30	1827,76	2464,64	1678,64
Population	4088,71	3363,26	4265,24	3534,93
Total rent units in neighbourhood	44,72	18,62	47,95	18,53
Average annual household income (in thousands €)	26,10	6,93	24,89	6,06
Period of transaction (percent)				
2008	0,05	0,22	0,00	0,06
2009	0,07	0,26	0,01	0,09
2010	0,08	0,26	0,02	0,14
2011	0,10	0,29	0,03	0,16
2012	0,14	0,35	0,05	0,23
2013	0,16	0,37	0,10	0,30
2014	0,15	0,35	0,14	0,34
2015	0,12	0,32	0,20	0,40
2016	0,09	0,28	0,28	0,45
2017	0,05	0,21	0,17	0,38
Energy label (percent)				
Green	0	0	0,67	0,47
A	0	0	0,19	0,39
B	0	0	0,19	0,39
C	0	0	0,29	0,45
D	0	0	0,14	0,35
E	0	0	0,09	0,28
F	0	0	0,06	0,24
G	0	0	0,04	0,20

APPENDIX 2 ▸ RELATION BETWEEN ENERGY EFFICIENCY ON RENT PRICE

	(1)	(2)	(3)	(4)
Green rating (1=yes)	0.027*** (13.28)		0.026*** (13.13)	
Label A (1=yes)		0.062*** (19.03)		0.062*** (19.03)
Label B (1=yes)		0.033*** (11.67)		0.032*** (11.62)
Label C (1=yes)		0.010*** (4.08)		0.010*** (4.14)
Label E (1=yes)		-0.013*** (-4.64)		-0.012*** (-4.47)
Label F (1=yes)		-0.019*** (-5.89)		-0.018*** (-5.59)
Label G (1=yes)		-0.015*** (-4.00)		-0.014*** (-3.77)
Type of Dwelling 1 = Apartment	-0.012*** (-3.66)	-0.012*** (-3.46)	-0.014*** (-4.29)	-0.013*** (-4.04)
Number of rooms	0.011*** (8.43)	0.011*** (8.72)	0.011*** (8.48)	0.011*** (8.77)
Number of bedrooms	0.006*** (4.79)	0.006*** (4.78)	0.006*** (4.78)	0.006*** (4.78)
Number of floors	0.004** (2.68)	0.003* (2.42)	0.003 (1.90)	0.002 (1.69)
Dwelling size (log)	-0.530*** (-184.15)	-0.530*** (-184.90)	-0.531*** (-184.75)	-0.532*** (-185.47)
Quality (inside)	0.035*** (26.89)	0.035*** (26.84)	0.034*** (26.50)	0.034*** (26.48)
Quality (outside)	-0.004** (-2.95)	-0.005*** (-3.35)	-0.004** (-3.00)	-0.005*** (-3.40)
Garden (1=yes)	0.003 (1.08)	0.004 (1.34)	0.001 (0.53)	0.002 (0.85)
Shed (1=yes)	0.015*** (10.50)	0.015*** (9.94)	0.010*** (6.15)	0.009*** (5.88)
Garage (1=yes)	0.032*** (19.05)	0.032*** (18.86)	0.031*** (18.49)	0.031*** (18.33)
Air conditioning (1=yes)			0.096*** (8.75)	0.098*** (9.05)
Boiler (1=yes)			0.005*** (3.41)	0.005** (2.99)
Insulation (1=yes)			0.012*** (7.54)	0.011*** (7.14)
Constant	4.449*** (315.59)	4.419*** (307.11)	4.457*** (316.28)	4.427*** (307.78)
Sample size	59350	59350	59350	59350
R-sq	0.853	0.854	0.853	0.854
adj. R-sq	0.842	0.843	0.842	0.843

Notes: Regression results dependent variable is ln(Rent Price per square meter). Green rating is a dummy variable that takes the value 1 for dwellings with an energy label A, B or C. Models included time-fixed effects, neighbourhood-fixed effect and period of construction controls. Each regression also includes 7262 dummy variables, one for each neighbourhood cluster. Default for energy label is label D, default for dwelling type is single family dwelling. *t* statistics in parentheses * p<0.05, ** p<0.01, *** p<0.001.

APPENDIX 3 ▶ ROBUSTNESS - CITY DRIVEN?

	Excluding top 30 Cities		Top 30 Cities	
	(1)	(2)	(3)	(4)
Green rating (1=yes)	0.016*** (6.23)		0.040*** (12.47)	
Label A (1=yes)		0.043*** (10.19)		0.083*** (16.04)
Label B (1=yes)		0.029*** (8.36)		0.037*** (8.33)
Label C (1=yes)		0.000 (0.10)		0.023*** (6.00)
Label E (1=yes)		-0.009* (-2.49)		-0.014** (-3.27)
Label F (1=yes)		-0.023*** (-5.39)		-0.012* (-2.53)
Label G (1=yes)		-0.016** (-3.07)		-0.011 (-1.93)
Type of Dwelling 1 = Apartment	-0.028*** (-6.89)	-0.028*** (-6.97)	-0.001 (-0.09)	0.002 (0.39)
Number of rooms	0.011*** (6.96)	0.011*** (7.29)	0.012*** (5.22)	0.012*** (5.18)
Number of bedrooms	0.004** (2.76)	0.004** (2.79)	0.008*** (3.49)	0.008*** (3.58)
Number of floors	-0.001 (-0.65)	-0.001 (-0.76)	0.010*** (4.20)	0.010*** (4.04)
Dwelling size (log)	-0.541*** (-149.98)	-0.542*** (-150.57)	-0.523*** (-113.34)	-0.523*** (-113.65)
Quality (inside)	0.034*** (19.78)	0.034*** (19.76)	0.034*** (17.38)	0.034*** (17.36)
Quality (outside)	-0.008*** (-4.52)	-0.008*** (-4.58)	0.001 (0.47)	-0.000 (-0.02)
Garden (1=yes)	-0.004 (-1.32)	-0.004 (-1.11)	0.008 (1.84)	0.009* (2.06)
Shed (1=yes)	0.007*** (3.54)	0.007*** (3.46)	0.013*** (5.07)	0.013*** (4.79)
Garage (1=yes)	0.032*** (15.96)	0.032*** (15.92)	0.031*** (10.67)	0.030*** (10.48)
Air conditioning (1=yes)	0.079*** (6.09)	0.080*** (6.20)	0.115*** (6.23)	0.120*** (6.50)
Boiler (1=yes)	0.002 (0.79)	0.001 (0.39)	0.011*** (4.52)	0.011*** (4.21)
Insulation (1=yes)	0.012*** (6.14)	0.011*** (5.78)	0.010*** (4.09)	0.010*** (3.90)
Constant	4.501*** (252.75)	4.473*** (244.61)	4.426*** (197.53)	4.398*** (193.29)
Sample size	33683	33683	25667	25667
R-sq	0.870	0.871	0.823	0.824
adj. R-sq	0.857	0.858	0.814	0.815

Notes: Regression results dependent variable is Log(Rent Price per square meter). Models included time-fixed effects, Neighbourhood-fixed effect, and period of construction controls. Each regression also includes 7262 dummy variables, one for each neighbourhood cluster. Default for energy label is label D. Default for dwelling type is house. *t* statistics in parentheses * $p<0.05$, ** $p<0.01$, *** $p<0.001$.

APPENDIX 4 ▸ ROBUSTNESS – "GREEN" RATING

	(1)	(2)	(3)
Green rating (Label A, B & C) (1=yes)	0.026*** (13.13)		
Green rating (Label A & B) (1=yes)		0.036*** (17.65)	
Green rating (Label A, B, C & D) (1=yes)			0.025*** (11.87)
Type of Dwelling 1 = Apartment	-0.014*** (-4.29)	-0.015*** (-4.58)	-0.015*** (-4.50)
Number of rooms	0.011*** (8.48)	0.011*** (8.40)	0.011*** (8.56)
Number of bedrooms	0.006*** (4.78)	0.007*** (5.03)	0.006*** (4.92)
Number of floors	0.003 (1.90)	0.002 (1.63)	0.003 (1.87)
Dwelling size (log)	-0.531*** (-184.75)	-0.531*** (-184.96)	-0.531*** (-184.70)
Quality (inside)	0.034*** (26.50)	0.035*** (26.67)	0.035*** (26.56)
Quality (outside)	-0.004** (-3.00)	-0.004** (-3.10)	-0.004** (-2.96)
Garden (1=yes)	0.001 (0.53)	0.002 (0.72)	0.001 (0.20)
Shed (1=yes)	0.010*** (6.15)	0.009*** (5.89)	0.010*** (6.21)
Garage (1=yes)	0.031*** (18.49)	0.031*** (18.43)	0.031*** (18.50)
Air conditioning (1=yes)	0.096*** (8.75)	0.097*** (8.90)	0.095*** (8.70)
Boiler (1=yes)	0.005*** (3.41)	0.005*** (3.37)	0.005*** (3.33)
Insulation (1=yes)	0.012*** (7.54)	0.011*** (7.28)	0.012*** (7.40)
Constant	4.457*** (316.28)	4.452*** (316.49)	4.457*** (315.82)
Sample size	59350	59350	59350
R-sq	0.853	0.854	0.853
adj. R-sq	0.842	0.842	0.842

Notes: Regression results dependent variable is Log(Rent Price per square meter). Models included time-fixed effects, Neighbourhood-fixed effect, and period of construction controls. Each regression also includes 7262 dummy variables, one for each neighbourhood cluster. Default for energy label is label D. Default for dwelling type is house. *t* statistics in parentheses * $p<0.05$, ** $p<0.01$, *** $p<0.001$.

APPENDIX 5 ▸ ROBUSTNESS - ALTERNATIVE ENERGY LABEL

	(1)	(2)
Energy performance Index	-0.035*** (-19.42)	-0.035*** (-19.11)
Type of Dwelling 1 = Apartment	-0.008* (-2.18)	-0.010** (-2.75)
Number of rooms	0.011*** (7.59)	0.011*** (7.68)
Number of bedrooms	0.007*** (5.02)	0.007*** (4.92)
Number of floors	0.006*** (4.20)	0.005*** (3.50)
Dwelling size (log)	-0.544*** (-173.85)	-0.544*** (-174.14)
Quality (inside)	0.029*** (21.16)	0.029*** (20.95)
Quality (outside)	-0.003 (-1.94)	-0.003* (-2.09)
Garden (1=yes)	0.001 (0.45)	-0.000 (-0.07)
Shed (1=yes)	0.012*** (7.26)	0.006*** (3.60)
Garage (1=yes)	0.034*** (19.21)	0.033*** (18.88)
Air conditioning (1=yes)		0.093*** (6.22)
Boiler (1=yes)		0.005** (2.78)
Insulation (1=yes)		0.011*** (6.71)
Constant	4.571*** (293.37)	4.576*** (293.81)
Sample size	47923	47923
R-sq	0.861	0.861
adj. R-sq	0.850	0.851

Notes: Regression results dependent variable is Log(Rent Price per square meter). Models included time-fixed effects, Neighbourhood-fixed effect, and period of construction controls. Each regression also includes 7262 dummy variables, one for each neighbourhood cluster. Default for energy label is label D. Default for dwelling type is house. *t* statistics in parentheses * $p<0.05$, ** $p<0.01$, *** $p<0.001$..

APPENDIX 6 ▸ SOCIAL RENT SEGMENT

	Free sector (1)	Social sector (2)	Free sector (3)	Social sector (4)	Free sector (5)	Social sector (6)
Green rating (1=yes)	0.011*** (4.79)	0.039*** (13.40)				
Label A (1=yes)			0.049*** (13.53)	0.067*** (10.16)		
Label B (1=yes)			0.021*** (6.79)	0.044*** (9.91)		
Label C (1=yes)			0.002 (0.76)	0.023*** (6.72)		
Label E (1=yes)			0.001 (0.21)	-0.017*** (-4.77)		
Label F (1=yes)			-0.002 (-0.51)	-0.025*** (-5.64)		
Label G (1=yes)			0.004 (0.86)	-0.025*** (-4.80)		
Energy performance INDEX					-0.013*** (-5.75)	-0.036*** (-14.58)
Type of Dwelling 1 = Apartment	-0.013*** (-3.59)	-0.006 (-1.06)	-0.012*** (-3.36)	-0.007 (-1.20)	-0.011** (-2.78)	0.002 (0.36)
Number of rooms	0.010*** (7.14)	0.016*** (6.91)	0.010*** (7.25)	0.016*** (6.95)	0.009*** (5.84)	0.018*** (7.45)
Number of bedrooms	0.008*** (6.00)	0.001 (0.23)	0.008*** (5.92)	0.002 (0.66)	0.007*** (4.90)	0.006* (2.57)
Number of floors	-0.001 (-0.86)	0.001 (0.53)	-0.002 (-0.99)	0.001 (0.38)	0.001 (0.76)	0.001 (0.47)
Dwelling size (log)	-0.549*** (-152.08)	-0.730*** (-156.80)	-0.550*** (-152.66)	-0.728*** (-156.70)	-0.561*** (-143.42)	-0.737*** (-149.87)
Quality (inside)	0.030*** (19.77)	0.017*** (8.84)	0.030*** (19.82)	0.016*** (8.59)	0.024*** (14.85)	0.014*** (7.38)
Quality (outside)	-0.002 (-1.44)	-0.006** (-2.68)	-0.003 (-1.88)	-0.006* (-2.46)	-0.000 (-0.10)	-0.005* (-2.31)
Garden (1=yes)	0.004 (1.51)	-0.010* (-2.16)	0.005 (1.80)	-0.009* (-1.98)	0.002 (0.68)	-0.004 (-0.87)
Shed (1=yes)	0.007*** (3.83)	0.012*** (4.47)	0.006*** (3.61)	0.012*** (4.67)	0.004 (1.87)	0.009** (3.04)
Garage (1=yes)	0.028*** (15.86)	0.008* (2.19)	0.028*** (15.74)	0.009* (2.47)	0.029*** (16.03)	0.008* (2.06)
Air conditioning (1=yes)	0.103*** (9.35)	0.036 (1.31)	0.106*** (9.70)	0.028 (1.03)	0.089*** (5.93)	0.040 (1.12)
Boiler (1=yes)	-0.000 (-0.22)	0.013*** (5.06)	-0.001 (-0.34)	0.011*** (4.35)	0.000 (0.11)	0.010*** (3.70)
Insulation (1=yes)	0.009*** (5.42)	0.011*** (4.23)	0.009*** (5.24)	0.010*** (3.85)	0.009*** (4.94)	0.008** (2.94)
Constant	4.614*** (267.53)	5.189*** (213.86)	4.596*** (265.75)	5.178*** (211.74)	4.687*** (248.07)	5.325*** (204.02)
Sample size	45365	13985	45365	13985	35965	11958
R-sq	0.866	0.935	0.867	0.936	0.874	0.941
adj. R-sq	0.854	0.925	0.854	0.926	0.863	0.932

Notes: Regression results dependent variable is Log(Rent Price per square meter). Models included time-fixed effects, Neighbourhood-fixed effect, and period of construction controls. Each regression also includes 7262 dummy variables, one for each neighbourhood cluster. Default for energy label is label D. Default for dwelling type is house. *t* statistics in parentheses * $p<0.05$, ** $p<0.01$, *** $p<0.001$.