Energy Capitalization in the Dutch Rental Market

June 4, 2016

Abstract

Using a large dataset on the Dutch rental market we investigate whether dwellings with high energy efficiency are rented out at a premium. Given the importance of the buildings sector in the energy-related greenhouse gas emissions improving energy efficiency is a key contribution to mitigating the climate change. The energy performance in the residential rental sector is of particular interest since the incentives to undertake efficiency improving investments are distorted. While the landlord has to bear the costs, the tenant benefits from reduced utility expenses. This "split incentives problem" has been put forward to explain discrepancies between energy performances in the rental dwelling stock compared to the owner-occupied dwelling stock. A solution for the landlord to recoup the energy related investments is to raise the rent such that the tenant's overall living expenses remain constant. We employ a hedonic regression approach to assess whether energy efficiency is implicitly priced on top of standard dwelling attributes. The dataset contains observations on rental rates charged in the Netherlands between 2012 and 2015 as well as information on location, age, size, type and general condition of the dwelling. Moreover, energy labels and a continuous measure of energy performance are assigned to each dwelling. This allows us to estimate the rent elasticity with respect to energy performance. Our findings indicate a positive rent premium for dwellings with high energy efficiency. This result implies that tenants are willing to pay for improved energy efficiency. Thus, the split costs and benefits of energy related investments should not hinder landlords from improving energy efficiency of their homes.

1 Introduction

In its strategy to achieve a reduction in greenhouse gas emissions (GHG) the EU Commission identified energy savings as one of the key goals, given that 80% of the EU GHG emissions are related to energy (EU Commission (2012)). Especially the buildings sector plays a central role to reach a substantial GHG reduction. This study will focus on the Dutch buildings sector and ask whether energy efficiency is capitalized into residential rental rates of dwellings. If this is the case, costly investments to improve the energy efficiency of a dwelling can be recovered. Otherwise homeowners may not have the incentive to invest to save energy.

The energy performance in the residential rental sector is of particular interest not only because of its size, but also because the incentives to undertake efficiency improving investments are distorted. While for owner-occupants the costs and benefits of energy efficiency enhancing investments accrue to the same person, in the rental segments the investor (owner) is not the immediate beneficiary (occupant). Krishnamurthy and Kriström (2013) assess the magnitude of what they call the "owner-renter divide" for a cross-section of 11 OECD countries. They find that owners in their sample are more likely to have energy efficient appliances and do efficiency enhancing investments. Moreover, Rehdanz (2007) finds that owners in Germany are comparatively less affected by energy price increases. She hypothesizes that this is because owners might have invested stronger in energy efficient heating and hot water supply systems. Also, Davis (2011) observes that US landlords, who do not pay the utility bill, are less likely to buy appliances with high levels of energy efficiency. The distorted investment incentives are an important barrier to energy efficient housing.

Overall, the literature observes a gap between potential and actual energy efficiency (Allcott and Greenstone, 2012). One of the explanations for this gap is the principal-agent problem between tenant and landlord (Fisher and Rothkopf (1989), Jaffe and Stavins (1994),Gillingham et al. (2009), a.o.) Mostly, rent contracts are specified such that the landlord has to pay for energy saving investments like improved isolation, heating system etc., whereas the savings resulting from these investments accrue to the tenant, who pays the utility bill. Only if tenants value energy efficiency of their home and are sufficiently well informed about it, landlords can recoup their investments by demanding higher rents. This so called "split incentives problem" together with asymmetric information about the investments is one explanation for less energy efficiency in the rental housing stock. Other explanations are based on different lock-in concerns between landlords and owner-occupants, differences in search costs between tenants and owner-occupants and the relative bargaining power of owners and tenants depending on the market structure

(Kholodilin and Michelsen (2014), Fuerst (2015)).

To assess whether buyers or tenants value energy efficiency the most common methodology is to use a hedonic regression approach (Rosen (1974)), relating prices to housing characteristics. Early studies by Laquatra (1986), Gilmer (1989) and Dinan and Miranowski (1989) hinted at a sales price premium for energy efficient houses. More recently, several studies have shown that dwellings labeled as energy efficient achieve higher transaction prices than houses with worse energy efficiency performance. For example Brounen and Kok (2011) showed this for the Netherlands, and Hyland et al. (2013) for Ireland. Moreover, Hyland et al. (2013) compare residential sales and lettings segments in Ireland. Kholodilin and Michelsen (2014) attempt a similar comparison for the Berlin housing market. Both studies find a positive but smaller premium for energy efficient dwellings in the rental compared to the owner market. Additionally, Fuerst (2015) find for Wales that while rental premia are present for energy efficient dwellings, dwellings with below average energy performance face no discounts if they are bought to let. Lastly,Bond and Devine (2014) give evidence for premiums on rents of energy efficient certified multifamily properties in the US.

We contribute to this literature by examining the impact of energy efficiency on rental rates using two different indicators of energy efficiency. Energy labels serve as a discrete indicator of the energy performance of a dwelling. In addition, the EPC index measures the energy efficiency on a continuous scale. Moreover, we investigate structural differences between the regulated and unregulated Dutch residential rental market regarding the capitalization of energy performance into the rental rates. Finally, using Dutch data we expand the regional scope of energy efficiency capitalization studies.

Based on a sample of Dutch rental rates we will examine to what extent energy efficiency is valued by the market. In the Netherlands, the rental sector makes up 44% of the residential housing stock in 2014 (datawonen). The majority of rented out dwellings belong to the regulated (social) rental market, namely around 32% of the overall dwelling stock in the Netherlands (Ministerie van Binnenlandse Zaken en Koninkrijksrelaties (2014)). In the Netherlands, all dwellings rented out below a certain threshold in the beginning of the rent period belong to the regulated sector. In the regulated sector maximum rents are determined based on a point system. The dwelling size, facilities, outside area, heating and energy performance of dwelling are evaluated. More points allow the landlord to set a higher rental rate. Therefore, the regulation does not restrict capitalization of energy saving investments into the rental rate. Only around 10-12% of all dwellings belong to the private, unregulated rental market in the Netherlands. This share distinguishes the Dutch housing market from the neighboring European countries, where the unregulated rental sector comprises a larger or at least equal part of the rental sector compared to the regulated sector (Ministerie van Binnenlandse Zaken en Koninkrijksrelaties (2014)).

We employ a hedonic regression model explaining the rental rate of a dwelling with dwelling characteristics such as the size and location of the dwelling along with an indicator of its energy performance. We use both a continuous and a discrete measure: the Energy Performance Coefficient (EPC) Index and energy labels. Moreover, we investigate structural differences between the regulated and unregulated rental market regarding the capitalization of energy efficiency into rental rates.

We find that a lower EPC Index is associated with a higher rent. Also, energy labels indicating a higher energy efficiency are positively correlated with the rental rate. Both these findings hold once we control for the size, location and quality of the dwelling. Therefore, we conclude that energy efficiency is indeed capitalized into the rental rate. Moreover, we find a structural difference between the regulated and unregulated rental market. While in the regulated market more energy efficient homes are rented out at a premium, energy efficiency seems to play no role in determining unregulated rental rates.

The next section present the data and explains the methodology used. In section 3 the result are presented, while section 4 briefly addresses the differences between the regulated and unregulated rent sector. Section 5 contains a discussion of the implications of our results and section 6 concludes.

2 Data

2.1 Descriptive Analysis

The analysis is based on a sample of the Dutch rental market. The dataset contains information on rental rates observed between 2012 and 2015 and a large variety of housing attributes as provided by the Dutch Realtor Association (NVM). This dataset was enriched with the Energy Performance Certificate (EPC) database managed by RVO. We keep only observations for houses built after 1900 and remove rental rate outliers [1]. The resulting sample contains 14541 observations on rental rates between 2012 and 2015.

The dependent variable is the rental rate of a dwelling. Figure 1 shows the sample distribution of the rental rate. On average, a dwelling is rented for 865 EUR (standard deviation: 260 EUR).

[Figure 1 about here.]

The key explanatory variables of interest are those reflecting the energy efficiency of the home. The first possibility is to use the Energy Performance Index (EPI) which

[1] rates above the 95%-quantile

assesses the total energy consumption of a dwelling relative to its size and heating loss areas (Aydin et al. (2015)). The higher the index, the worse the energy performance. The second possibility is to use energy labels. These range from A to G and are assigned to dwellings based on the EPI. Figure 2 shows the sample distribution of the EPI. On average, the dwellings reach an index value of 1.5, which corresponds to label C. The relationship of the rent and the EPI is depicted in Figure 3. The fitted values line hints at a negative relationship, as expected. Dwellings with lower index values are associated with higher rents.

[Figure 2 about here.]

[Figure 3 about here.]

In the sample, 44% of the dwellings are labeled A or B. Average rental rates per energy label are shown in Figure 4. The figure indicates that dwellings with labels A or B are on average rented out at a premium compared to dwellings with labels C or lower.

[Figure 4 about here.]

The control variables can be grouped into variables on general dwelling characteristics, the dwelling location and the dwelling condition. Dwelling characteristics include information on the age of a house or apartment, the size and type of the home. Figure A.9 in the Appendix shows the sample distribution of dwelling age. The majority of houses were build after 1950. On average, the dwellings in the sample are about 27 years old, approximately 100 m^2 large and have 4 rooms.

Figure A.10 (Appendix) indicates an inverted U-shape relationship between dwelling age and the EPI which would imply that relatively new and relatively old homes have a better energy performance than dwellings of medium age. An explanation could be that maintenance refurbishments of older buildings contribute to enhance the energy performance. To capture location related price effects apart from regional ones we include a set of dummy variables indicating location of the dwelling relative to the city center and relative to a road (quiet or noisy). The latter imposes a difficulty for the interpretation of the energy efficiency effect on rental rates. It is likely that dwellings located at busy streets may be equipped with better windows to protect the residents from street noise. Better windows, however, also improve the energy efficiency of a house. It is therefore possible that for buildings at noisy streets, the coefficient on energy efficiency captures also the effect of better protection from outside noise. We test for this possibility by repeating the analysis using a subsample of dwellings located at quiet roads only. Finally, a dummy distinguishing apartments from houses as well as a categorical variable indicating its general quality (simple, normal, luxury) are included. This helps to disentangle non-energy related from energy-related maintenance.

Our data sample differs substantially from the Dutch rental market because the unregulated rental sector is oversampled here. While 88% of the Dutch rental market belong to the regulated sector (Ministerie van Binnenlandse Zaken en Koninkrijksrelaties, 2014), in our sample only 20% of the rent observations are below the regulatory threshold. Consequently, the average rent level in our sample exceeds the average Dutch rent level, which lies at 480 EUR (Ministerie van Binnenlandse Zaken en Koninkrijksrelaties, 2014), considerably. Another key difference between this sample and the Dutch rental market relates to the energy efficiency in the regulated and unregulated rental market. On average, green labels A to C have a higher share in the regulated than in the unregulated sector (?). In our sample, however, the proportions are exactly the opposite: the share of green labelled dwellings is larger in the unregulated sector than in the regulated one. Finally, dwellings in our sample have on average 20 m^2 more living area than the average Dutch dwelling in the rental sector (Ministerie van Binnenlandse Zaken en Koninkrijksrelaties, 2014).

The next section outlines the estimation strategy. We examine whether the pattern that more energy efficient dwellings are rented out at a premium remains once we control for standard rent determinants such as size, age, and location of the dwelling.

2.2 Estimation strategy

In order to investigate whether residents value energy efficiency of their homes we employ a hedonic regression model based on Rosen (1974). The aim is to relate differences in rental rates to differences in dwelling attributes and energy efficiency levels. The basic regression takes the following form:

$$lnP_i = \beta_0 + \beta_1 X_i + \beta_2 EE_i + \sum_{t=1}^{T} \delta_t T_t + \epsilon_{it} \ ,$$

where P_i is the rental rate of dwelling i. X_i is a vector of control variables such as dwelling age, size, type, the maintenance condition and location variables. The coefficient β_2 captures the change of rental rate depending on the energy efficiency level EE_i. Moreover, δ_t captures any macroeconomic shocks common to all rental rates. The dummy variables T_t equals 1 if a rental rate is observed in year t and 0 otherwise. Finally, ϵ_{it}'s are assumed to be normally distributed with mean 0 and variance σ^2_ϵ.

To assess whether the rental rate of a dwelling implicitly reflects its energy efficiency, we proceed in two steps. First, we estimate a model controlling only for a measure for energy efficiency. In the first specification we will use energy labels as indicators for the energy performance of the dwelling. Alternatively, we use the EPC index as a measure of energy efficiency. Next, we include "standard" control variables such as dwelling size, age and location. If the energy efficiency variable enters with a coefficient significantly different from 0, the rental rate indeed reflects the energy efficiency level. This would imply that the efficiency level is a utility-bearing characteristic for which tenants are willing to pay. Finally, we conduct a heterogeneity analysis by distinguishing the regulated from the unregulated rental sector. To this end, we include an interaction term of the energy efficiency proxy with a dummy variable indicating whether or not an observation forms part of the regulated rental sector.

3 Results

The regression results using energy labels as the efficiency indicator are reported in table 4. All three regression specifications control for transaction year and the province. The dependent variable in all specifications is the logarithmic rental rate. In column (1) we regress the log rental rate only on the seven energy labels, using label G as base category. We find that labels A to C, which indicate high energy efficiency, are associated with a rent increase at the 1% significance level. Also, label D has a statistically significant coefficient at the 10% level. Label A for example raises the rent by about 20%. Based on an average rent of 804 EUR for a dwelling with label G, the baseline category, this implies a 160 EUR rent increase.

In the second column of table 4 we add standard rental rate determinants. In this specification labels A to E are statistically significant. Overall the magnitude of their effect on the rental rate increases for each label between 0.5 and 2% compared to the model without controls. We find that an additional square meter living area raises the rental rate on average by less than 1%, all else equal. However, one more room raises the average rental rate by 2%. Based on the average rent for a label G dwelling, located in a residential area next to a quiet road, a household faces thus approximately 16 EUR more housing expenses per month. Houses are rented out at on average 5% lower rates than apartments. This implies about 39 EUR less rent per month. The age of the dwelling enters non-linear as the coefficient on the squared age variable is statistically significant. The location relative to the city center and relative to roads only partly enter the regression significantly. If the location of the dwelling relative to a road is labeled as "unspecified" or if the apartment is located in the city center, the coefficient is highly significant and positive. Baseline categories are apartments located in a residential area and next to a quiet road.

In column (3) of table 4, we add finally a discrete variable classifying dwellings into simple, normal and luxury apartments or houses. Now we find that labels A to D are significant at 1% respectively 5% level. The magnitude decreased below the levels of the first specification without controls. All else equal, label A raises the average rental rate by 16%, about 96 EUR compared to a simple label G dwelling, located in a residential area next to a quiet road. Label D increases the rent by still 3%, approximately 18 EUR. The categorical variable indicating quality enters the regression equation as well with coefficients different from zero. Thus, it is likely that without controlling for quality the energy labels captured partly the overall qualitative condition of the apartment.

As an alternative measure for energy efficiency we use the EPC index based on which the labels are assigned. Table 5 presents the results. The first column shows a lower EPC index is associated with a higher rental rate. A 10% decrease raises the rental rate by 2% on average, an equivalent of approximately 17EUR. In column 2 of table 5 we again add control variables. The EPC index is still statistically significant at a 1% level. Its magnitude is smaller in absolute terms at 0.9%. The results for the control variables are comparable to those of the label specification (table 4). Finally, in the third column we again add the categorical measure of the dwelling's qualitative state. As before, these controls enter the regression equation with coefficients different from zero. The magnitude of the EPC index coefficient decreases even further to 0.8%. However, it is still significant at the 1% level. The sample average of the EPC index lies at 1.5 points, which corresponds to label C. Investments so as to halve the EPC index and reach label A could be recovered through the rent income: A 50% lower EPC index is associated with an average annual rent increase of 35EUR.

A concern remains whether the effect of energy labels/EPC index on the rental rate derives from omitted variables. As stated in the introduction, homes located next to busy roads may have double-glassing for the windows. This would positively effect the energy efficiency but also keeps the street noise outside. Ideally, we want to disentangle whether the rental rate reflects energy efficiency or a higher living quality due to more quietness. To examine whether energy efficiency impacts the rental rate independently we restrict the sample to those dwelling located next to a quiet road and conduct a similar regression exercise as before. Table 7 presents the results. The EPC enters with a negative coefficient significantly different from zero. Also, labels A to D are associated with a rental premium. Since we cannot directly control for double-glassing we take these results as suggestive evidence for a rent premium for energy efficient dwellings.

4 Heterogeneity analysis

As pointed out in the introduction a relatively large share of the Dutch rental market is regulated compared to other European countries. Whether a dwelling belongs to the regulated or unregulated sector is determined by the rent. If the rent lies below a certain rent threshold (liberalisatiegrens), the dwelling belongs to the regulated sector. The relevant threshold is yearly determined by the Dutch government. In 2012, the threshold lay at 665 EUR and rose to 711 EUR in 2015.

Energy efficiency became an explicit determinant of the regulated rent in 2011. The more energy efficient the dwelling, the higher the rent landlords are allowed to ask in the regulated sector. Thus, landlords are automatically made aware of the fact that higher efficiency standards may yield higher rent income and hence also demand a higher rate. In contrast, landlords in the unregulated market might not yet consider it a source of additional income with which they can cover investment costs.

For a deeper analysis of the price effect of energy labels we divide our observations into regulated and unregulated rents. Every rent observation below the regulatory threshold of the observation year is called "regulated", every observation above "unregulated". This results in 2,727 observations of regulated rents and 10,410 observations of unregulated rents. In our sample 21% of the dwellings therefore belong to the regulated sector. The rent in the regulated sector lies on average at 600 EUR and at 930 EUR in the unregulated sector. Figure A.11 shows the rental rate distribution in the two subsamples. Dwellings in the regulated sector are on average 38 years old, while dwellings in the unregulated sector were built 23 years ago. Figure A.12 in the Appendix depicts the age distribution. Figures 6 and 7 give an impression how the two markets differ in the energy performance. The dwellings in the unregulated sector perform better in terms of energy efficiency than dwellings in the regulated sector.

[Figure 5 about here.]

[Figure 6 about here.]

[Figure 7 about here.]

The two plots in Figure A.13 show the EPI-Rent relation for the two markets. While the left plot shows a slightly negative relation in the regulated rental sector, the right plot suggests there is a non-linear relation between energy performance and rent levels in the unregulated rental sector. We will investigate whether these relations remain once we control for other dwelling characteristics.

Table 6 presents the results when we use the EPC index as a measure of energy efficiency and introduce an interaction term of it with a dummy indicating whether or not the observation belongs to the regulated market. We reduce the sample to observations of 500 to 900 EUR rent per month. If there is an differential effect between the two subsectors, it should play out strongest around the defining rent thresholds. We follow the same estimation strategy as with the full sample starting with measures for energy efficiency and subsequently adding standard price determinants. However, we can no longer meaningful include a quality of dwelling proxy due to too few observations.

In the full specification including all control variables in column 2 we find that the EPC impacts the rental rate only in the regulated and not in the unregulated market as the coefficient on the interaction term is significantly different from zero. For the regulated market we find that a 10% decrease in the EPC index corresponds to a 0.4% increase in the average rental rate. Thus, regulated rents are raised by about 2.50EUR (average rent is 630EUR for the baseline dwelling).

The apparent lack of efficiency capitalization in the unregulated sector requires further investigation. Since dwellings of the unregulated sector most likely vary stronger in their characteristics, unobserved heterogeneity potentially biased our results. To control for this feature panel data would be necessary.

5 Conclusion

In this project we investigated whether energy efficiency is capitalized into rental rates in the Dutch residential rental market. Using a hedonic regression model, we find confirming support for this hypothesis. Dwellings with higher energy efficiency are rented out at higher rates. This result holds even when we control for standard rent determinants such as dwelling size, age, and location.

Moreover, we separately investigated the regulated and unregulated residential rental sector. While we find energy efficiency increases rental rates in the regulated sector, we do not see a similar effect in the unregulated sector. Most likely, this result is driven by the methodology of rent regulation. Energy efficiency directly raises the maximum rent landlords in the regulated rent sector may ask.

A lack of energy efficiency capitalization has important policy implications. If tenants are not willing to pay for higher efficiency levels, landlords will be less willing to incur investment costs. In turn, this impedes reaching the goal of reduced GHG emissions. Therefore, not only landlords of the regulated sector should receive subsidies but landlords renting out above the regulatory rent threshold as well. Furthermore, information asymmetries about the costs and benefits of energy efficiency have to be reduced further. It should become undesirable to live in a home with too high energy consumption.

Two key concerns have to be addressed in future work. First of all, the sample used in this analysis is not representative of the Dutch residential rental market. In our sample the unregulated sector is overrepresented. Consequently, the average rental rate is higher than in the Dutch market. Secondly, we need to investigate whether omitted variables drive the result that higher energy efficiency positively affect the rental rate. To do so, we can conduct a similar analysis using instrumental variable estimation.

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A Appendix

Table 1: Summary statistics

	mean	sd
Rental rate	856.7	254.7
Age	25.9	24.6
Living area (m2)	99.4	27.3
Number of rooms	3.66	1.11
Number of floors	1.59	0.86
Regulated rent sector	0.21	0.41
House	0.66	0.48
EPC Index	1.49	0.58
Energy label A	0.26	0.44
Energy label B	0.19	0.39
Energy label C	0.28	0.45
Energy label D	0.13	0.33
Energy label E	0.072	0.26
Energy label F	0.049	0.22
Energy label G	0.029	0.17
Observations	13137	

Table 2: Summary statistics: Regulated Sector

	mean	sd
Rental rate	594.4	82.7
Age	37.7	20.0
Living area (m2)	76.0	21.1
Number of rooms	3.09	1.03
Number of floors	1.27	0.61
House	0.84	0.37
EPC Index	1.91	0.65
Energy label A	0.061	0.24
Energy label B	0.089	0.28
Energy label C	0.28	0.45
Energy label D	0.23	0.42
Energy label E	0.17	0.37
Energy label F	0.11	0.31
Energy label G	0.069	0.25
Observations	2727	

Table 3: Summary statistics: Unregulated Sector

	mean	sd
Rental rate	925.4	239.5
Age	22.8	24.8
Living area (m2)	105.5	25.4
Number of rooms	3.80	1.08
Number of floors	1.68	0.90
House	0.61	0.49
EPC Index	1.38	0.51
Energy label A	0.31	0.46
Energy label B	0.21	0.41
Energy label C	0.28	0.45
Energy label D	0.099	0.30
Energy label E	0.046	0.21
Energy label F	0.033	0.18
Energy label G	0.018	0.13
Observations	10410	

Figure 1: Sample distribution of rental rates

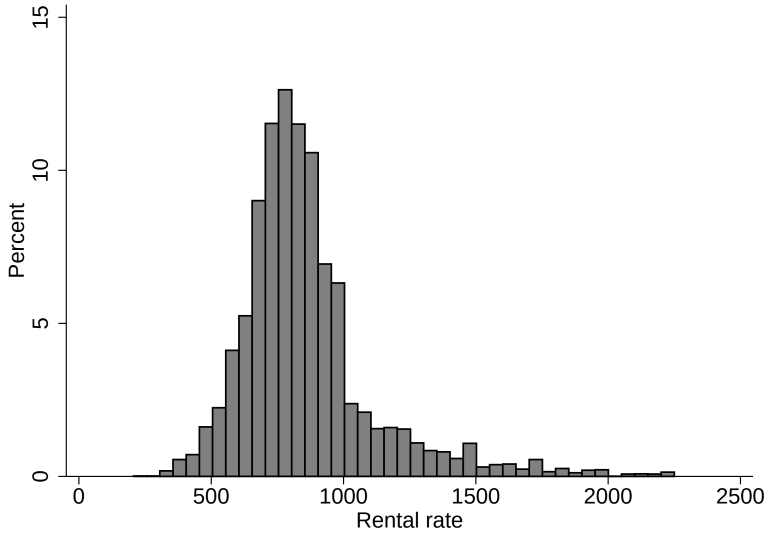


Figure 2: Sample distribution of EPC Index

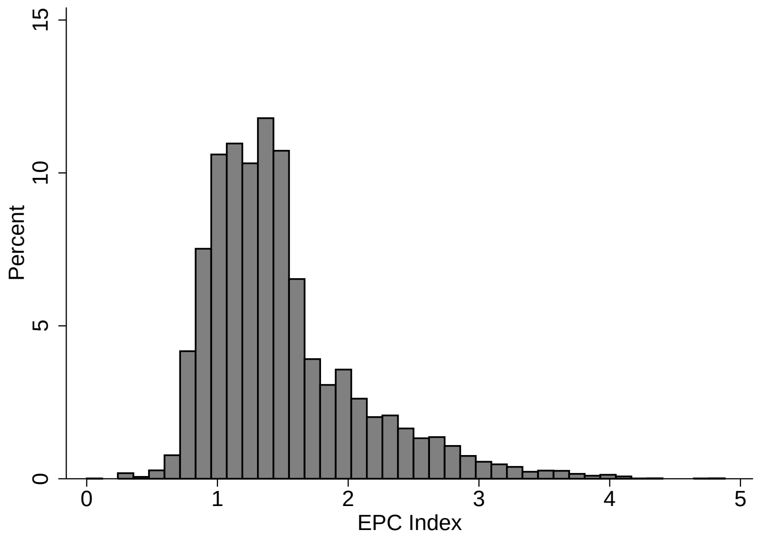
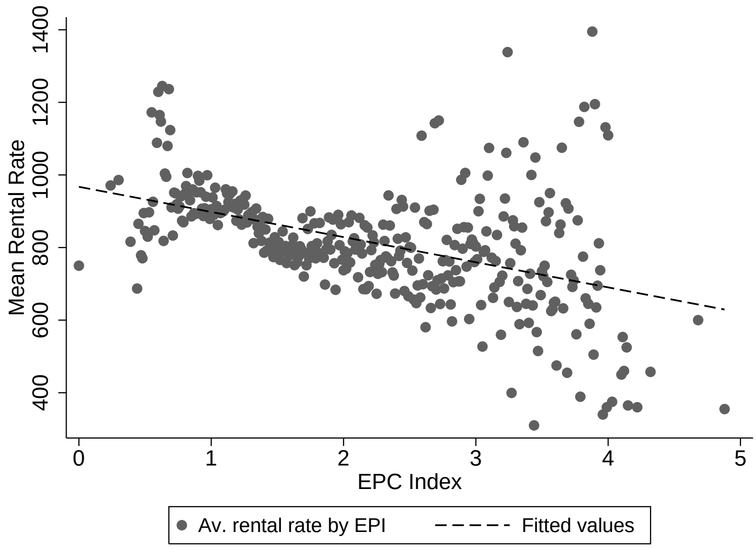
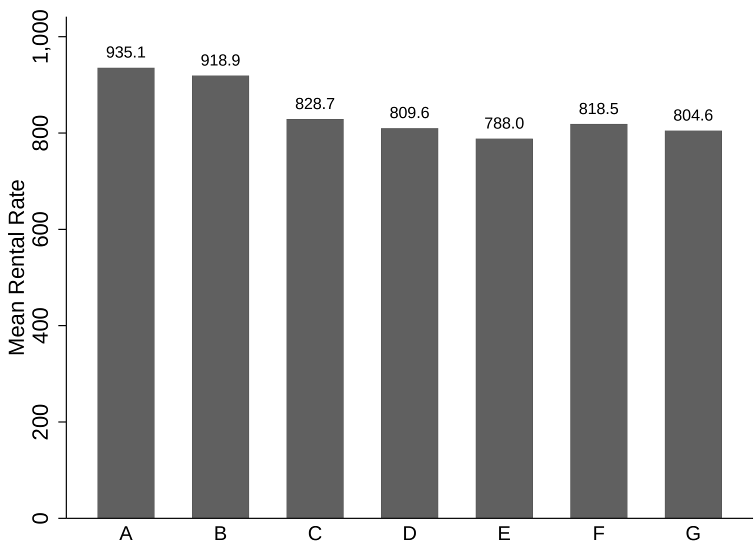


Figure 3: Average rental rate by energy efficiency



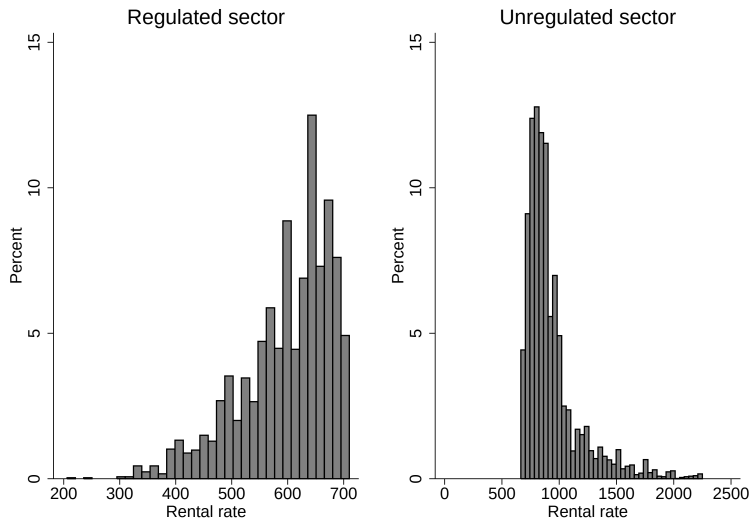
Note: Energy efficiency is measured by the Energy Performance Coefficient. A lower EPI is associated with better energy efficiency.

Figure 4: Average rental rates by energy label



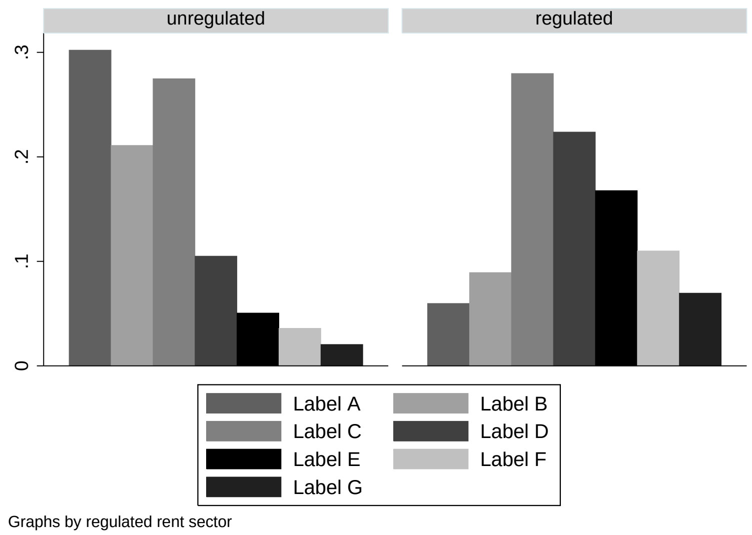
Note: Labels A-G are dummy variables indicating whether or not a dwelling is labeled in the respective class. Label A indicates above average energy efficiency, label G indicates worst energy performance.

Figure 5: Rental rates distribution by sector



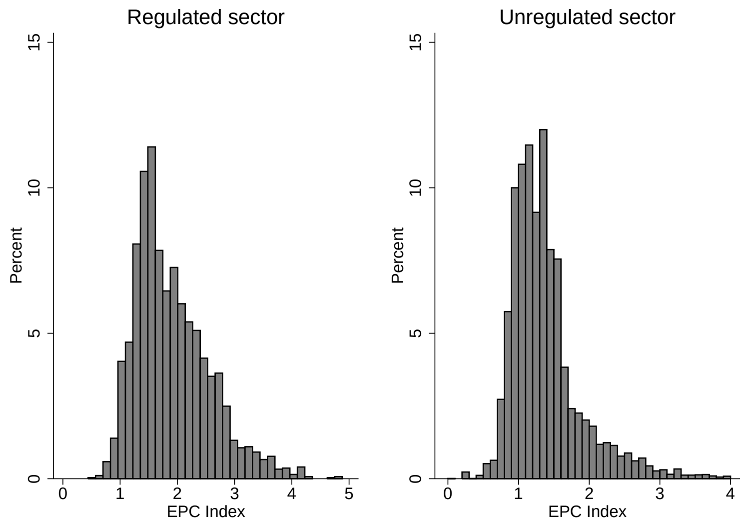
Note: The left (right) plot depicts the sample distribution of the rental rate in the regulated (unregulated) residential rental sector. Dwellings rented out at a rate below the 'liberalisatiegrens' belong to the regulated sector, dwellings rented out at higher rates belong to the unregulated sector.

Figure 6: Energy label share by sector



Note: Regulated and unregulated sector as explained in note to Figure A.11. Labels A-G are dummy variables indicating whether or not a dwelling is labeled in the respective class.

Figure 7: Sample distribution of EPC Index by sector



Note: Regulated and unregulated sector as explained in note to Figure A.11.

Figure A.8: Sample distribution of rental rates by year

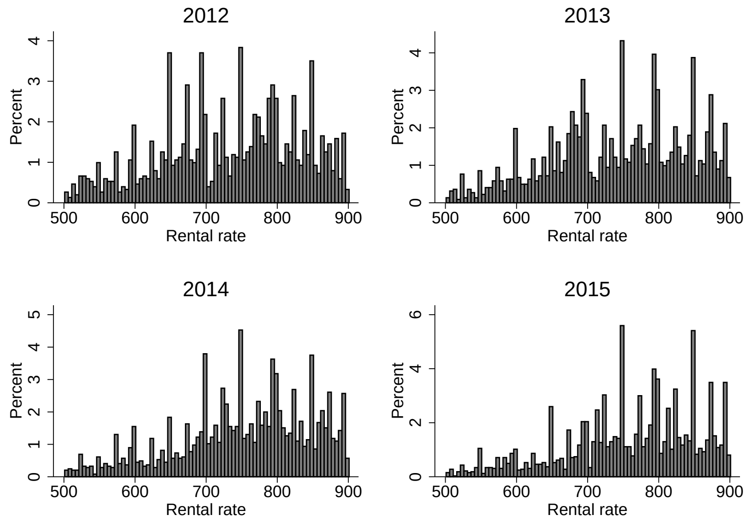


Figure A.9: Sample distribution of construction year

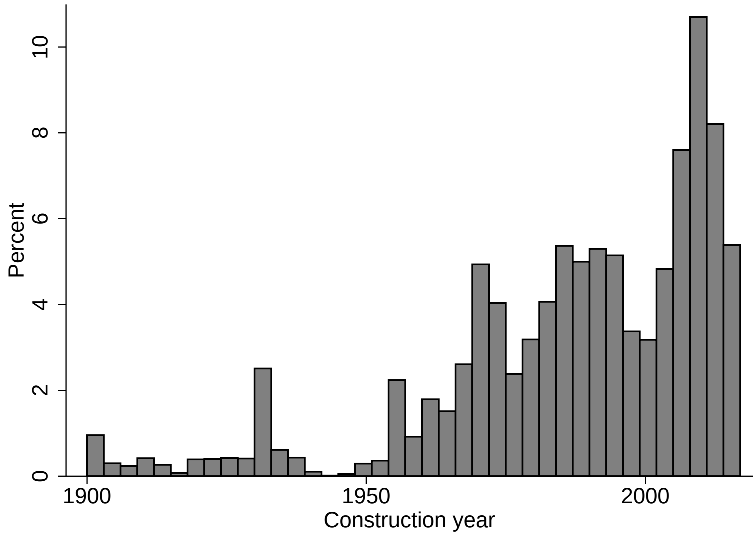
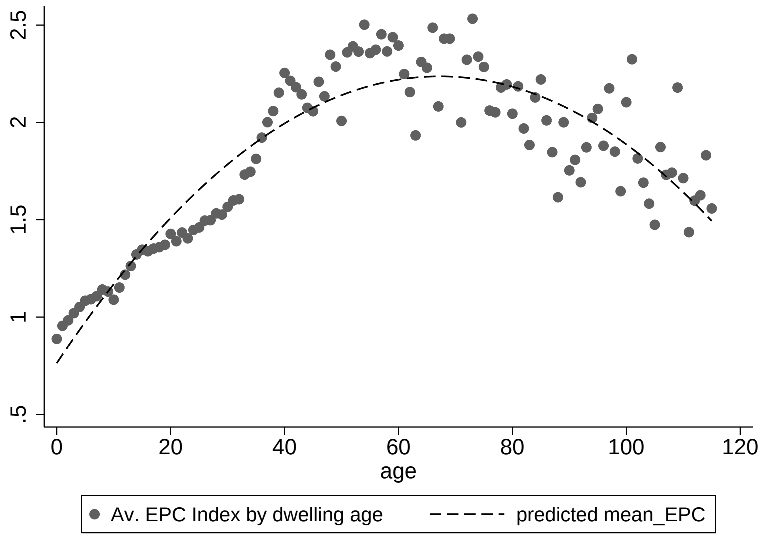
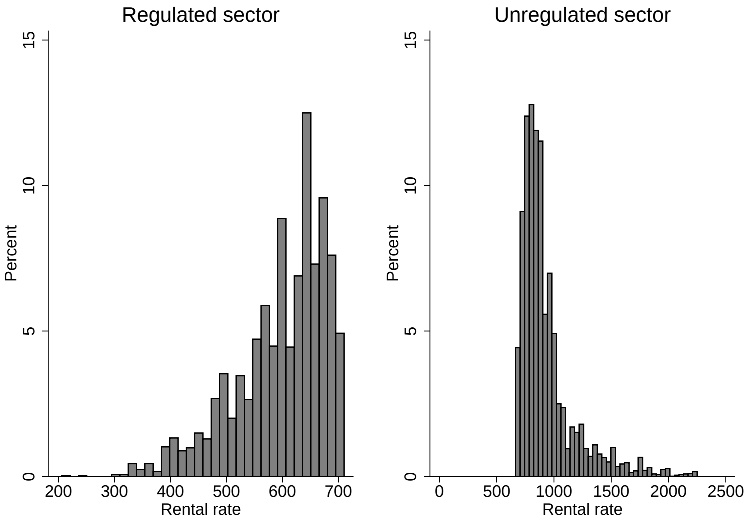


Figure A.10: Energy efficiency by dwelling age



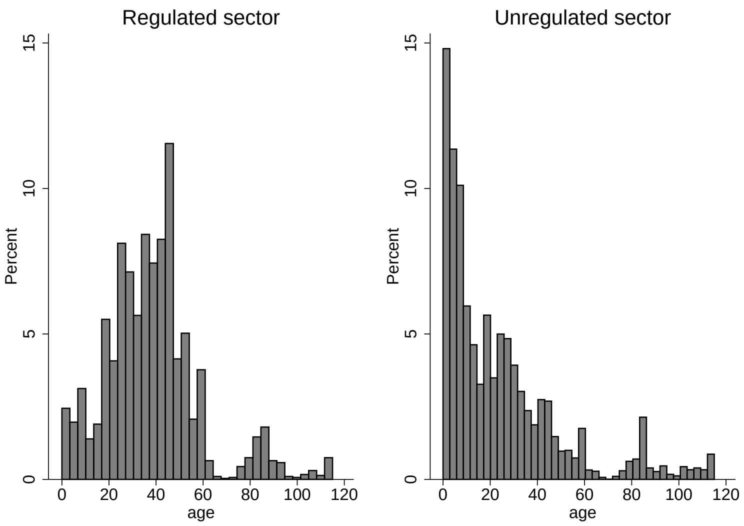
Note: Energy efficiency measured by Energy Performance Coefficient. A lower EPC Index is associated with higher energy efficiency.

Figure A.11: Rental rates distribution by sector



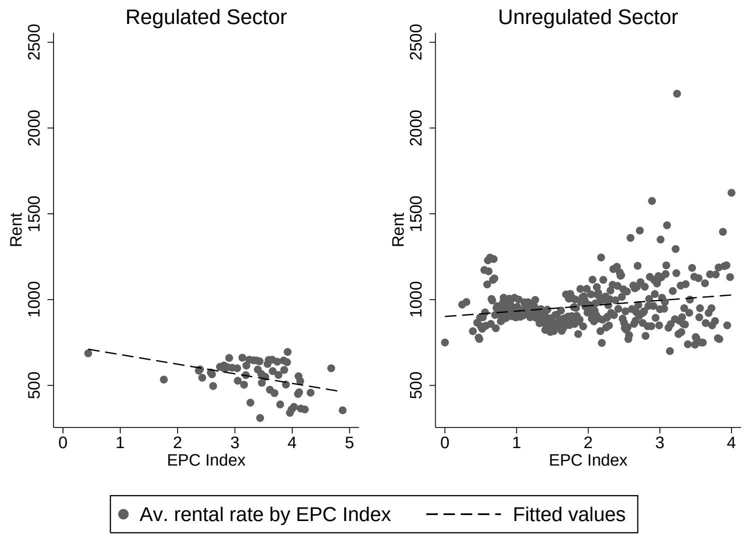
Note: The left (right) plot depicts the sample distribution of the rental rate in the regulated (unregulated) residential rental sector. Dwellings rented out at a rate below the 'liberalisatiegrens' belong to the regulated sector, dwellings rented out at higher rates belong to the unregulated sector.

Figure A.12: Dwelling age distribution by sector



Note: The left (right) plot depicts the sample distribution of the rental rate in the regulated (unregulated) residential rental sector. Dwellings rented out at a rate below the 'liberalisatiegrens' belong to the regulated sector, dwellings rented out at higher rates belong to the unregulated sector.

Figure A.13: Average rental rate by energy efficiency and sector



Note: Regulated and unregulated sector as in note to Figure A.12.

Figure A.14: Parameter estimates: Rent premia per label

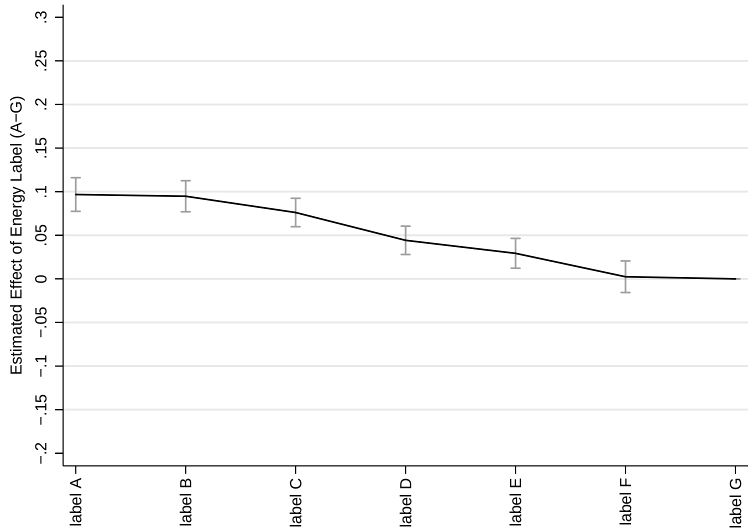


Table 4: Efficiency capitalization in the rental market- Energy labels

VARIABLES	(1) log rental rate	(2) log rental rate	(3) log rental rate
Energy label = 1, A	0.206***	0.115***	0.0967***
	(0.0152)	(0.0149)	(0.0145)
Energy label = 2, B	0.162***	0.118***	0.0948***
	(0.0155)	(0.0140)	(0.0136)
Energy label = 3, C	0.100***	0.0992***	0.0761***
	(0.0153)	(0.0131)	(0.0128)
Energy label = 4, D	0.0305*	0.0621***	0.0442***
	(0.0161)	(0.0133)	(0.0129)
Energy label = 5, E	-0.00291	0.0441***	0.0293**
	(0.0174)	(0.0140)	(0.0135)
Energy label = 6, F	0.0230	0.0151	0.00243
	(0.0185)	(0.0150)	(0.0144)
Living area (m2)		0.00472***	0.00446***
		(0.000111)	(0.000107)
Number of rooms		0.0215***	0.0209***
		(0.00259)	(0.00248)
Number of floors		-0.0299***	-0.0245***
		(0.00330)	(0.00322)
-2 Age		-0.00482***	-0.00360***
		(0.000343)	(0.000340)
Age-squared		6.29e-05***	5.22e-05***
		(3.23e-06)	(3.20e-06)
House		0.0381***	
		(0.00599)	
Constant	6.486***	6.051***	5.917***
	(0.0209)	(0.0245)	(0.0230)
Observations	14,349	14,349	14,349
R-squared	0.282	0.533	0.557
Location rel. to center	NO	YES	YES
Location rel. to road	NO	YES	YES
Quality classification	NO	NO	YES
Year dummies	YES	YES	YES
Province dummies	YES	YES	YES

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Note: Dependent variable is log rental rate. Energy efficiency indicator is the energy label. Baseline categories: Dwelling type (simple) apartment; located in residential area next to quiet road; energy label G; province Groningen; year 2012.

Table 5: Efficiency capitalization in the rental market- EPC Index

VARIABLES	(1) log rental rate	(2) log rental rate	(3) log rental rate
log EPC Index	-0.218***	-0.0908***	-0.0780***
	(0.00630)	(0.00927)	(0.00899)
Living area (m2)		0.00486***	0.00457***
		(0.000102)	(9.89e-05)
Number of rooms		0.0233***	0.0226***
		(0.00271)	(0.00257)
Number of floors		-0.0324***	-0.0265***
		(0.00336)	(0.00328)
Age		-0.00463***	-0.00364***
		(0.000322)	(0.000319)
Age-squared		5.93e-05***	5.09e-05***
		(3.07e-06)	(3.04e-06)
-2 House		0.0399***	
		(0.00610)	
Constant	6.680***	6.147***	6.004***
	(0.0169)	(0.0202)	(0.0200)
Observations	13,132	13,132	13,132
R-squared	0.297	0.547	0.573
Location rel. to center	NO	YES	YES
Location rel. to road	NO	YES	YES
Quality classification	NO	NO	YES
Year dummies	YES	YES	YES
Province dummies	YES	YES	YES

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Note: Dependent variable is log rental rate. Energy efficiency indicator is the Energy Performance Coefficient. Baseline categories: Dwelling type (simple) apartment; located in residential area next to quiet road; energy label G; province Groningen; year 2012.

Table 6: Heterogeneity Analysis- EPC Index

	(1)	(2)
VARIABLES	log rental rate	log rental rate
log EPC Index	-0.0425***	-0.00693
	(0.00303)	(0.00485)
log EPC Index, regulated	-0.0237***	-0.0358***
	(0.00585)	(0.00557)
Regulated rent sector	-0.214***	-0.176***
	(0.00342)	(0.00326)
Living area (m2)		0.00110***
		(4.62e-05)
Number of rooms		0.00708***
		(0.00120)
Number of floors		-0.00757***
		(0.00158)
Age		-0.00189***
		(0.000154)
-2 Age-squared		1.80e-05***
		(1.50e-06)
Constant	6.663***	6.560***
	(0.00722)	(0.00965)
Observations	8,749	8,749
R-squared	0.687	0.731
Location rel. to center	NO	YES
Location rel. to road	NO	YES
Quality classification	NO	NO
Year dummies	YES	YES
Province dummies	YES	YES

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Note: Dependent variable is log rental rate. Energy efficiency indicator is the Energy Performance Coefficient. Baseline categories: Dwelling type (simple) apartment; located in residential area next to quiet road; energy label G; province Groningen; year 2012.

Table 7: Robustness Analysis: Busy road areas

VARIABLES	(1) log rental rate	(2) log rental rate
Energy label = 1, A		0.0946***
		(0.0148)
Energy label = 2, B		0.0934***
		(0.0140)
Energy label = 3, C		0.0733***
		(0.0131)
Energy label = 4, D		0.0417***
		(0.0132)
Energy label = 5, E		0.0272**
		(0.0138)
Energy label = 6, F		0.00178
		(0.0147)
Living area (m2)	0.00454***	0.00444***
	(9.98e-05)	(0.000109)
Number of rooms	0.0231***	0.0213***
	(0.00259)	(0.00249)
Number of floors	-0.0265***	-0.0249***
	(0.00328)	(0.00322)
-2 Age	-0.00359***	-0.00356***
	(0.000327)	(0.000346)
Age-squared	5.03e-05***	5.18e-05***
	(3.13e-06)	(3.27e-06)
log EPC Index	-0.0780***	
	(0.00923)	
Constant	5.982***	5.894***
	(0.0206)	(0.0235)
Observations	12,882	14,058
R-squared	0.572	0.556
Location rel. to center	YES	YES
Quality classification	YES	YES
Year dummies	YES	YES
Province dummies	YES	YES

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Note: Dwellings located at busy roads only. Dependent variable is log rental rate. Baseline categories: Dwelling type simple apartment;located in residential area;energy label G; province Groningen; year 2012.