

Energy efficiency and economic value in affordable housing



Andrea Chegut^a, Piet Eichholtz^{b,*}, Rogier Holtermans^b

^a MIT, Cambridge, MA, United States

^b Maastricht University, The Netherlands

HIGHLIGHTS

- Dutch affordable housing suppliers recoup sustainability investment by selling dwellings.
- Energy-efficient affordable dwellings sell at a premium.
- A-labeled dwellings are 6.3% – 9,300 euros – more valuable than C-labeled ones.
- The combined value effect of refurbishing an affordable housing dwelling, including improving the energy efficiency, of 20% would more than pay for the retrofit.

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ABSTRACT

Strong rental protection in the affordable housing market often prohibits landlords from charging rental premiums for energy-efficient dwellings. This may impede (re)development of energy efficient affordable housing. In the Netherlands, affordable housing institutions regularly sell dwellings from their housing stock to individual households. If they can sell energy efficient dwellings at a premium, this may stimulate investments in the environmental performance of homes.

We analyze the value effects of energy efficiency in the affordable housing market, by using a sample of 17,835 homes sold by Dutch affordable housing institutions in the period between 2008 and 2013. We use Energy Performance Certificates to determine the value of energy efficiency in these transactions. We document that dwellings with high energy efficiency sell for 2.0–6.3% more compared to otherwise similar dwellings with low energy efficiency. This implies a premium of some EUR 3,000 to EUR 9,700 for highly energy efficient affordable housing.

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1. Introduction

Approximately 27% of aggregate energy use in the European Union's member states stems from the residential sector (Bertoldi et al., 2012). In 2010, this resulted in an estimated 225 billion euro energy bill and 630 million tons of CO₂ emissions for the European housing sector.¹

* Correspondence to: Maastricht University, Department of Finance, PO Box 616, 6200 MD Maastricht, The Netherlands.

E-mail addresses: achegut@mit.edu (A. Chegut), p.eichholtz@maastrichtuniversity.nl (P. Eichholtz), r.holtermans@maastrichtuniversity.nl (R. Holtermans).

¹ These estimates are based on the average electricity and gas price statistics for the EU-27 as provided by Eurostat (2013) and the total electricity and gas consumption figures for the residential sector from Bertoldi et al. (2012). The average electricity and gas prices for households in the EU-27 in 2010 were respectively 17.3 and 5.7 Eurocent per kWh. In that year, the residential sector's electricity consumption was 843 billion kWh and its gas consumption 1385 billion kWh. Multiplying these consumption figures with the average prices yields a total energy bill of approximately 225 billion euros in 2010. We convert these consumption statistics to kg of CO₂ emissions using a conversion factor of 0.445 for electricity and 0.184 for natural gas as documented by the Carbon Trust (2013).

This illustrates the economic importance of energy consumption in housing, and the European Union continues to encourage the uptake of energy efficiency measures in the built environment. The Energy Performance of Buildings Directive of 2003, its recast in 2010, the Energy Efficiency Plan of 2011 and the subsequent 80 billion euro Horizon 2020 energy efficiency stimulus package all aim to stimulate the improvement of energy efficiency and a reduction in energy demand from buildings through regulatory directives, energy efficiency measurement initiatives and financial incentives. On top of that, many member states have their own rules and incentives stimulating sustainability in the built environment.

This study looks at the financial outcomes of energy efficiency in an important and hitherto neglected segment of the housing market in the energy policy literature: the affordable housing sector. Affordable or public housing accounts for 17% of all housing in the EU as a whole. In Austria the sector represents 25% of the housing stock, while for Sweden and the U. K. these figures are respectively 20% and 18%. In many countries, it is the dominant

form of rental housing (Whitehead and Scanlon, 2007). Yet, despite its importance, this segment of the housing market has hardly been investigated in the literature studying the economic effects of energy efficiency. Its size alone makes it an important sector in the energy efficiency abatement discussion.

There are a number of studies investigating the impact of energy performance on the economic performance of real estate, as measured by rental value, occupancy, and transaction price. For commercial real estate these studies generally find higher rents and transaction prices for environmentally certified buildings relative to conventional buildings, as well as higher and more stable occupancy rates.²

In the housing market, the studies concentrating on the financial performance of energy efficiency are fewer in number. Generally, these housing studies also document higher transaction prices for energy efficient dwellings, and find that the size of these price differences depend on the level of energy efficiency (Brounen and Kok, 2011; Cerin et al., 2014; Feige et al., 2013; Hyland et al., 2013). However, almost all of these housing studies take the owner-occupied housing sector into account, which is just one component of the housing market.

Affordable or public housing institutions face significant financial constraints in repaying the investments in energy efficiency related building improvements. This is caused by a split-incentive problem, where building owners invest in energy efficiency for buildings and tenants benefit from the resulting lower energy bill. In many countries, affordable housing sector rents are capped or limited in their increases, which makes the repayment of energy efficiency building investments through increased rents very difficult. These split incentives are a large problem also in the Netherlands, where the affordable housing sector's 2.4 million dwellings account for 31% of the total housing stock (Autoriteit Woningcorporaties, 2012) and where rent increases are strongly regulated.

However, Dutch affordable housing institutions also regularly sell dwellings from their stock to individual households, so an alternative method to get compensated for investments in environmental performance is through the realization of a possible increase in the value of their assets as a result of these improvements. To date, however, there is no evidence showing whether or not this is indeed the case, and given the uncertainty regarding this matter, affordable housing institutions may well underinvest in energy efficiency improvements of their dwellings. The main research question of this paper is to shed light on this issue, by investigating whether energy efficiency is priced in affordable dwellings. We do that by examining a large sample of transactions of individual dwellings by Dutch affordable housing institutions.

To identify these improved energy efficient dwellings, we collect a sample of 17,835 transactions of affordable dwellings from the Netherlands' land registry, the Kadaster, in the period from 2008 until mid-2013 and link it to a database of Energy Performance Certificates (EPCs) maintained by the Netherlands Enterprise Agency (NEA).

The Energy Performance of Buildings Directive of 2003 stipulates the mandatory disclosure of the energy performance of buildings across all EU member states as of January 1, 2006. However, member states were granted an additional period of three years to implement the certification procedure. In the Netherlands all homeowners were obliged to provide an EPC upon the sale of their house (older than 10 years) as of January 1, 2008. Nevertheless, due to opposition in the Dutch parliament, homeowners were able to refrain from providing an EPC in case a waiver

by both the selling and buying party was signed. Affordable housing institutions were given an additional year to implement the EPC to their housing portfolios as long as they ensured full labeling of all dwellings.³ So the incidence of transactions of housing with an EPC label went up substantially in 2008, but there were still many sales of unlabeled dwellings as well. As of 2015, Dutch law on this matter changed again, making the EPC label obligatory for all housing sales and rentals, without any exceptions.

We investigate the impact of energy efficiency on the transaction price per square meter in two ways. First, we estimate the value impact of energy labels in general, by comparing the transaction prices of labeled dwellings with those of non-labeled ones. About 64% of the dwellings in our sample have an Energy Performance Certificate, and we use the non-certified dwellings as the control sample.

Second, we study the energy labeled sample separately. This way, we can compare transactions of homes with high energy efficiency – those having an A or B label – with homes that are less energy efficient – having a label C through G, and it allows us to directly study the relationship between the energy performance index – on which the labels are based – and the prices of affordable homes.

In each of these settings, we analyze the relationship between energy efficiency and the transaction prices of affordable housing by employing a standard hedonic pricing model. This way, we control for building quality, location and general housing market conditions, as well as for thermal characteristics such as insulation quality.

We document that affordable dwellings with high-quality energy labels – Energy Performance Certificates of A or B – have higher transaction values than their otherwise comparable peers. Dwellings with an energy label of B or higher transact for 2.6% more compared to housing with label C or lower. Specifically, an A-labeled dwelling sells for 6.3% more, and a B-labeled dwelling for 2% more than an otherwise similar dwelling with a C label. This implies that the average affordable home with a C label in our sample would sell for almost EUR 9,700, more were it to transact as an A-labeled dwelling and for some EUR 3,000 more in case of a B label. These results suggest that although it may be difficult for affordable housing institutions to recover their investments in energy efficiency improvements directly through increased rents or reduced energy costs, they might be able to recover the investment, at least in part, at the time of sale.

In the remainder of this paper, we will first briefly discuss related studies focusing on the impact of energy-efficiency in the residential real estate sector. Thereafter, we will describe the Dutch affordable housing market, discuss the data and data sources we use for the analysis, and provide some sample statistics. The following sections present the method and the empirical results. The paper ends with a conclusion and a discussion of the policy implications of this study.

2. The housing market and the value of energy efficiency

The literature regarding the value of energy efficiency in housing markets in Europe, Asia, and the U. S. generally finds that homes and apartments that are certified as having low primary energy demand have higher transaction prices and/or rents. However, there are variations across the studies in the type of certification studied, the extent of environmental performance

² See, for example, Bonde and Song (2013), Chegut et al. (2014), Eichholtz et al. (2010, 2013), Fuerst and McAllister (2011), Kok and Jennen (2012).

³ See Brounen and Kok (2011) for a more extensive discussion on the measurement of the Energy Performance Certificate.

measures linked to the certification and the magnitude of the premium for energy efficiency.

Early studies by [Laquatra \(1986\)](#), and [Gilmer \(1989\)](#) analyze the financial implications of the Minnesota Housing Finance Agency's Energy Efficient Housing Demonstration Program. Laquatra concludes that energy efficiency, measured by the thermal integrity factor, is capitalized in the transaction price of a demonstration home and Gilmer finds that home energy ratings have positive search benefits, which are larger in more diverse housing markets. [Dinan and Miranowski \(1989\)](#) study a sample of homes in Des Moines, and conclude that an efficiency improvement that would result in a USD 1 decrease in expenditures to maintain the home at 65°F increases the expected transaction price by approximately USD 12.

[Brounen and Kok \(2011\)](#) analyze the impact of Energy Performance Certificates on the transaction prices of Dutch housing, employing a sample of homes sold in 2008 and 2009. Based on thermal quality, these homes are rated from A++ to G, with A++ indicating highest energy efficiency. Dutch homes with an A label sell for 10.2% more than otherwise similar homes with a D label. The premiums for B and C labeled homes are 5.5% and 2.1%, respectively. Dwellings with a label inferior to D trade at a discount.

[Cerin et al. \(2014\)](#) investigate whether the energy efficiency of homes in Sweden contributes to the transaction price. The authors study housing transactions from 2009 and 2010, and find that only the most energy efficient homes command a small price premium. A decrease in energy consumption of 1% for the most energy efficient homes yields a transaction price increase of 0.03%.

[Hyland et al. \(2013\)](#) perform a similar study for the transactions in the Irish housing market, and also include housing rents in their analysis. The authors study the relationship between Ireland's Building Energy Rating (BER) and transaction prices and rental rates for the period from 2008 to 2012. Their transaction price results are comparable to those found by [Brounen and Kok \(2011\)](#), both in direction and in terms of magnitude. Moreover, the authors find that energy efficiency matters more when selling conditions are worse and dwellings are smaller. For rents, the authors document a higher rental value of 1.9% for an A labeled dwelling compared to a D label. Surprisingly, the rental premium for a B labeled dwelling is 4.2%. Rental units with E, F and G labels have rental discounts.

[Feige et al. \(2013\)](#) study the effect of different sustainability attributes on the rental value of Swiss residential units in 2009. They employ a broad range of sustainability criteria, and find that the environmental performance of dwellings is positively related to rent levels. Especially attributes that improve water efficiency, the health and comfort level, and the safety and security of a building contribute positively to the rent level. Interestingly, the energy efficiency of a dwelling is negatively related to rent levels. The authors argue that this may be caused by the common Swiss practice of incorporating the energy costs in the rent.

Recently, [Copiello \(2015\)](#) has performed a case study of one refurbished affordable apartment building in Turin, Italy. The refurbishment has increased the building's environmental performance, improving its insulation, heating systems and other installations. The author finds that rents in the building have gone up substantially, so providing a market-based incentive towards improvements in environmental performance in affordable housing.

In Asia, [Yoshida and Sugiura \(2015\)](#) assess the impact of certification under the Tokyo Green Building Program on the transaction value of residential real estate.⁴ The authors employ a sample

of condominiums sold in the period from 2002 to 2009, and document that new certified units sell at a substantial discount of approximately 11–12% compared to non-certified apartment units. However, certified dwellings do sell at a premium in the secondary market.

[Deng et al. \(2012\)](#) investigate the effect of Green Mark certification on the transaction price of residential housing in Singapore.⁵ The authors find that certified dwellings sell at a 4–6% premium. The observed premium varies significantly across the certification categories, with Platinum rated buildings commanding the highest premium – 14%. The transaction price for buildings with the lowest type of certification does not differ significantly from non-certified buildings.

In China, rating systems for the environmental performance of buildings are not formally adopted. Therefore, a study by [Zheng et al. \(2012\)](#) evaluates the impact of “marketing greenness” on the transaction price of housing in Beijing. The authors construct a Google Green Index based on the search rank of housing complexes with respect to their green features for the period from 2003 to 2008 to test the relationship between the initial asking price and the “greenness” of these properties. The authors document that the greenest building in the sample sells at a 17.7% premium compared to the least green building.

[Dastrup, et al. \(2012\)](#) focus on the impact of solar panels on the transaction prices of owner-occupied homes in California, and find that these are capitalized in the transaction value at a 3.6–4.0% premium, corresponding to a predicted increase in transaction value of about 22,500 dollars. The premium is higher in streets with fewer solar-powered homes.

[Kahn and Kok \(2013\)](#) assess the impact of green home certification on transaction values in California. The authors employ a dataset of homes sold between 2007 and 2012. Homes with a green certificate transact for 2–4% more compared to otherwise similar homes, and energy efficiency is more important for dwellings located in a hotter climate or in districts with higher electricity prices.

The existing findings in Europe, Asia and America suggest that energy efficiency commands a premium in residential sales and rents. However, with the exception of the case study of [Copiello \(2015\)](#), none of these studies involves affordable housing. This implies a void in understanding the role of energy efficiency in the housing stock, especially for Europe, where affordable housing institutions play such a prominent role in the residential sector. Moreover, [Schaffrin and Reibling \(2015\)](#) show that low-income households spend a relatively large share of their income on utility costs, which could imply that possible value effects of investments in the environmental performance in housing are large in affordable housing.

To help fill this gap in the literature, we focus on energy efficient affordable housing. We measure the financial performance of dwelling energy efficiency in the European country with the highest number of affordable dwellings per capita: the Netherlands.

3. The Dutch affordable housing market

In relative terms, the Netherlands has by far the largest affordable housing sector of all the countries in Europe: almost one out of three households live in a dwelling owned by an affordable

(footnote continued)

resource efficiency, use of energy efficient equipment, life span, planting and the mitigation of the heat island phenomenon of a building.

⁵ Singapore's Green Mark program assesses the environmental attributes of buildings. The program evaluates the energy and water efficiency, the quality of the indoor environment and the overall environmental impact of real estate.

⁴ The Tokyo Green Building Program scores various environmental factors of different types of real estate. The score takes into account the energy efficiency,

housing institution (Aedes, 2013a). Another yardstick of prominence is that the 381 Dutch affordable housing institutions together own approximately 2.4 million dwellings (Autoriteit Woningcorporaties, 2013). Together, they dwarf Dutch institutional investors in housing, who own a combined portfolio of only 136,000 dwellings (Finance Ideas, 2014).

Hence, to scale up investments in the environmental performance of homes in the Netherlands, affordable housing institutions are a logical starting point. That holds for other European Union countries as well. The affordable housing sector in other European countries is substantially smaller, but is still approximately 17% of the total housing stock (Whitehead and Scanlon, 2007).⁶

With an affordable housing sector this large, it is inevitable that these institutions also cater to middle- and lower-middle income groups besides their core client base, i.e. families with the lowest incomes. The Dutch affordable housing stock reflects this. With an average value of EUR 149,000 in 2012 (Aedes, 2013b), the dwellings they own are only 36% less valuable than an average owner-occupied home. The average quality of these dwellings is also underlined by the fact that some 42% are single-family homes (Aedes, 2013b), where affordable housing in most other countries is associated with projects, i.e. high rise apartment buildings, often located in the less attractive parts of cities. Only 11% of the Dutch affordable housing stock would fit that description, whereas the remainder consists of multi-family housing with four floors at most (Aedes, 2013b), as well as some senior housing.

In 2012, Dutch affordable housing institutions charged an average rent of EUR 434 per month excluding utility costs (Aedes, 2013b). This is lower than the market rent in most Dutch regions, so households that live in a dwelling owned by an affordable housing landlord tend to stay there, and many affordable housing institutions have waiting lists for their product, especially in the big cities and in the Randstad region in the western part of the country.⁷

Almost all households living in dwellings owned by affordable housing institutions are eligible for rent protection. This implies that the rent of an existing contract can only be increased by a percentage set by the government, usually inflation plus a mark-up. Even when an owner does a major renovation, improving the quality of a dwelling, or when an owner invests in energy efficiency, thereby lowering the utility costs for the tenant, the rent on existing contracts cannot be increased to compensate the owner for the investment expense.⁸ This makes it difficult to recoup an investment in the environmental performance through improved rental cash flows, and it creates a disincentive for the diffusion of energy efficient affordable housing.

However, affordable housing institutions may be able to partly recover these investments if they sell part of their housing stock in the market. Most European countries' affordable housing institutions are not allowed to do that, so the sale of affordable dwellings is quite rare. But in the Netherlands, affordable housing

institutions are allowed and even stimulated to gradually sell dwellings from their stock (Binnenlandse Zaken en Koninkrijksrelaties, 1992). This policy allows affordable housing institutions to sustain a steady cash inflow, which they can reinvest in new construction and in the renovation of their remaining housing stock, thereby realizing their ambitions regarding its quality and environmental performance. The policy also aims to foster private home ownership among low- and middle-income households. This unique regulatory environment in the Netherlands creates an ideal setting to analyze whether consumers in affordable housing value energy efficiency investments.

4. Data and descriptive statistics

4.1. Data

In order to investigate the impact of energy efficiency on the transaction value of affordable housing empirically we combine various data sources. For every year between 2008 and 2013 we retrieve the universe of affordable housing institutions active in the Netherlands from the Autoriteit Woningcorporaties.⁹ Using the affordable housing institutions' original listed name as obtained from the Autoriteit Woningcorporaties, we gather information regarding the housing transactions by each institution in the database of the Dutch land registry, the Kadaster. This database provides the exact location of each transacted dwelling, as well as its transaction price, and a set of dwelling characteristics. This matching exercise leads to the identification of 44,725 transactions by Dutch affordable housing institutions in the period from 2008 up to mid-2013.

The dwelling quality information provided by the Kadaster is rather limited in scope, and in order to get a more comprehensive set of dwelling characteristics we match the Autoriteit Woningcorporaties and Kadaster data with data from the Dutch Realtors Association (NVM). The NVM documents detailed information for every home that is sold by an associated realtor. This enables us to extensively control for the impact of quality differences throughout our analyses. Based on the location of each home – by employing the unique combination of the building's postcode, house number, and house number addition – we combine the information from the NVM database with the set of transactions supplied by the Kadaster. This leads to a total of 25,785 matched transactions.

Further information on the Energy Performance Certificate (EPC) and energy performance index of each home is obtained from the NEA, which is part of the Dutch Ministry of Economic Affairs. This agency facilitates the energy performance certification of existing and new buildings in the Netherlands.

Incomplete information on quality characteristics across transactions limits the sample, and our final sample includes a total of 17,835 transactions.¹⁰ Of these dwellings, 11,411 have an energy label, and the other 6,424 observations serve as the control sample.¹¹

⁶ This number is based on a survey of affordable housing institutions in Austria, Denmark, England, France, Germany, Hungary, Ireland, the Netherlands, and Sweden performed by Scanlon and Whitehead (2007).

⁷ The Randstad is a region in the Netherlands consisting of the nation's four largest cities, Amsterdam, Rotterdam, the Hague and Utrecht, as well as the smaller cities lying between them. In total, some 41% of the total Dutch population lives in this area. Retrieved from: <http://www.cbs.nl/en-GB/menu/methoden/toelichting/alfabet/r/randstad-region.htm>.

⁸ Only if at least 70% of households living in a housing complex agree with a rent increase associated with a refurbishment can the rent be increased for all of the existing tenants in that complex under Dutch law. This number is hard to accomplish in practice, and even if successful, this negotiation process usually does not provide additional rental cash flows that suffice to recoup the investment costs borne by the owner.

⁹ The Autoriteit Woningcorporaties is the supervisory body to which all Dutch affordable housing institutions report. We use the overview of institutions they maintain to ensure complete coverage in the earlier years of our sample period since many Dutch affordable housing institutions merged over the last decade: the affordable housing market consolidated from 430 institutions in 2008–381 institutions in 2012.

¹⁰ Due to non-consistent information on the transaction price between the Kadaster and NVM databases the sample reduces to 22,017 observations. Finally, missing dwelling quality characteristics and ensuring that every postcode area has at least one labeled building further reduces the sample to 17,835 observations.

¹¹ The Dutch Realtors Association (NVM) is better represented in the urban areas of the Netherlands. To ensure that our results do not suffer from selection bias

4.2. Descriptive statistics

Table 1 provides information on the total sample, and on the sub-samples of non-labeled and labeled dwellings, with the latter specified by label quality. The first column of Table 1 shows that the average home in the sample sells for some EUR 1,760 per square meter, with an average size of approximately 90 square meter divided over four rooms. Most of the homes are either apartments or duplexes, and these two types account for about 76% of the total sample. Most of the homes in the full sample have been constructed between 1961 and 1990. The quality of exterior (interior) maintenance is rated as medium or better for 96.1 (93.6) percent of the observations.

Concerning the thermal quality characteristics, almost 90% of the homes use a central heating system.¹² The insulation quality is on average quite poor with 73% of the observations displaying a low insulation quality: less than two types of insulation. Less than 10% of the homes have four or more types of insulation.

Energy performance certificates were initially not completely mandatory in the Netherlands. Due to societal resistance against the EPC label, the initial Dutch legislation pertaining to the matter allowed home buyers to sign a waiver that obviated the seller's obligation to provide an EPC with the home. This explains why we observe both labeled and non-labeled dwellings in our sample.

The remaining columns of Table 1 provide dwelling characteristics across label categories within the labeled sample. Based on the transaction price per square meter the largest difference occurs between label categories A to B and C to G. The average home with energy label B or higher transacts for some EUR 400–500 per square meter more than the average home with label C or lower. The distribution of dwelling types shows that apartments tend to have a higher energy label. Duplexes and semi-duplexes are more strongly represented in the lower quality label categories. Not very surprisingly, homes with a higher quality energy label tend to be constructed more recently.

Comparing dwelling sizes across label quality groups shows no systematic differences when looking at floor surface area, but homes with the best environmental quality have a somewhat lower number of rooms.

As expected, thermal characteristics do differ substantially across label categories. Homes with a higher energy label more often use a central heating system, and have higher insulation quality. On average, more than 55% of the homes with an A label have a high insulation quality while this is the case for some one percent of homes with a G label. The quality of the interior and exterior maintenance further confirms this.

The distribution of the energy label reveals that label C, D, and E are the largest label categories, cumulatively representing some 75% of the sample. Furthermore, less than one percent of the affordable homes sold have an A label compared to a national average of more than three percent.¹³ Given that two thirds of the labeled sample consists of lower quality homes with energy label D or lower there is still a lot to gain from investments in energy efficient retrofits.

Fig. 1 compares the distribution of the label categories in our sample to the national average over the same time period. In

general, comparing the overall label distribution for our affordable housing sample to the national average shows that our sample has a slightly worse average label compared to the national figures.

5. Method

To investigate how energy efficiency influences the transaction price of affordable housing, we employ a standard hedonic real estate valuation framework (Rosen, 1974). We estimate a semi-log hedonic equation, relating the log of the transaction price per dwelling to energy efficiency, building characteristics and location, and time:

$$\log P_i = \alpha + \delta G_i + \beta X_i + \gamma T + \varepsilon_i \quad (1)$$

In our base model in Eq. (1), the dependent variable is the logarithm of the transaction price P per square meter of home i . The variable of interest of the model is G , which is a dummy variable with a value of one if building i has an energy label and zero otherwise. δ is thus the average premium (in percent) estimated for a labeled dwelling relative to non-labeled dwellings. In alternative specifications of the model, G denotes the quality of the energy label or the level of the energy performance index on which the EPC labels are based. X is a vector of hedonic characteristics (e.g. size, age, thermal, and quality characteristics) and location (the four-digit postcode area the home is located in) of home i .¹⁴ We control for macro-economic factors using year-quarter fixed effects T . Last, α , β and γ are estimated coefficients for the control variables, and ε is an error term.

In this model specification we cannot entirely rule out the possibility that unobserved quality differences between the homes in our labeled and non-labeled sample and within the different label categories determine the observed capitalization differences. For example, affordable housing institutions might choose to bundle high energy efficiency with other quality characteristics such as nicer kitchens or bathrooms. Nevertheless, by extensively controlling for quality characteristics on the building level, such as the level of interior and exterior maintenance we reduce this possibility as much as possible.

6. Results

We first assess the value of energy labels in general, distinguishing low-quality from high-quality labels. After measuring the relative value of energy labels in the full sample we further investigate the effect of dwelling energy efficiency by inspecting a subset of labeled dwellings only.

6.1. The value of energy performance certificates in affordable housing

Table 2 displays the results of our regression analysis of the full sample using the base model presented in Eq. (1). All specifications presented in Table 2 use the natural logarithm of the transaction price per square meter as the dependent variable. This dependent variable is related to an extensive set of hedonic and location characteristics, as well as macro-economic factors that serve as control variables in the specification.¹⁵ The models in

(footnote continued)

we have also estimated the results presented in Tables 2 and 3 for the larger sample provided by the Dutch Land Registry (Kadaster), using a reduced set of covariates. The results from these robustness tests are in line with the effects we present in Tables 2 and 3.

¹² The central heating systems in the Netherlands are mostly gas-powered. The gas/coal heating variable in the table indicates the presence of a gas or coal stove that directly heats living spaces.

¹³ The national figures and distribution for all Dutch homes are available from the NEA, www.senternovem.databank.nl.

¹⁴ We also tested different location fixed effects, controlling for location at the municipality level or the six-digit postcode level. The results are consistent and robust. Similar location fixed effects have been employed in previous research by Kok and Jennen (2012).

¹⁵ The strong similarity of the treatment and control samples of labeled and non-labeled homes allows us to compare these samples directly. Nevertheless, we

Table 1
Descriptive statistics.

	Total Sample	Non-Labeled Buildings	A	B	C	D	E	F	G
Transaction price (euro per square meter)	1,762.62 [613.69]	1,853.56 [665.09]	2,083.07 [1035.01]	2,128.67 [815.67]	1,760.13 [552.05]	1,652.66 [538.21]	1,639.97 [524.68]	1,639.07 [521.09]	1,664.56 [524.03]
Dwelling type									
Apartment	38.42	42.43	61.02	63.90	44.60	31.16	31.82	27.98	20.52
Duplex	37.79	36.10	15.25	23.58	36.08	45.73	42.94	33.21	30.78
Semi-duplex	17.48	15.77	16.95	10.01	16.91	18.82	18.02	23.12	25.27
Semi-detached	6.31	5.70	6.78	2.50	2.41	4.29	7.22	15.69	23.43
Period of construction									
Pre 1930	8.40	9.95	32.20	12.78	3.61	4.89	8.87	10.61	20.52
1930–1944	2.98	2.49	0.00	0.53	1.10	2.61	4.97	6.82	7.04
1945–1960	15.57	15.69	1.69	2.90	6.48	11.64	20.97	32.30	41.04
1961–1970	22.67	21.12	11.86	11.59	12.16	25.83	35.49	31.69	22.36
1971–1980	24.39	23.18	13.56	10.67	25.09	33.48	26.57	17.59	8.42
1981–1990	20.81	19.55	0.00	40.18	45.51	20.42	3.08	0.99	0.46
1991–2000	2.95	3.14	1.69	14.36	5.85	1.10	0.05	0.00	0.00
> 2000	2.23	4.87	38.98	6.98	0.20	0.03	0.00	0.00	0.15
Building characteristics									
Dwelling size (square meter)	89.46 [23.70]	89.62 [24.79]	85.66 [27.02]	79.62 [25.49]	87.41 [22.81]	91.81 [23.45]	91.30 [22.15]	90.40 [21.01]	88.65 [21.96]
Number of rooms	3.93 [1.12]	3.87 [1.15]	3.15 [1.06]	3.35 [1.16]	3.75 [1.08]	4.04 [1.11]	4.15 [1.03]	4.21 [0.99]	4.24 [1.11]
Number of stories	2.10 [0.88]	2.04 [0.90]	1.75 [0.88]	1.69 [0.85]	2.01 [0.89]	2.22 [0.86]	2.20 [0.87]	2.23 [0.83]	2.27 [0.80]
Basement	3.43	3.35	1.69	0.26	1.34	1.97	5.01	6.07	14.70
Attic	27.65	25.00	22.03	16.47	25.43	31.91	32.37	33.59	27.11
Garden	62.93	60.46	54.24	43.87	58.84	67.74	67.91	69.83	72.89
Parking	8.09	9.04	27.12	6.32	4.98	8.40	7.49	8.79	12.10
Monument	0.26	0.25	3.39	0.92	0.03	0.14	0.00	0.23	1.84
Ground lease	18.36	22.29	22.03	36.89	23.89	12.77	11.54	7.20	7.35
Partial lot	15.24	15.68	3.39	5.67	13.30	15.15	16.78	18.27	21.29
Thermal and quality characteristics									
Interior maintenance low ^a	4.64	5.09	0.00	1.58	2.64	4.03	5.24	6.82	10.11
Interior maintenance medium ^b	93.57	91.49	77.97	94.47	96.49	95.45	94.34	92.95	89.74
Interior maintenance high ^c	1.79	3.42	22.03	3.95	0.87	0.52	0.41	0.23	0.15
Exterior maintenance low ^a	1.03	1.06	0.00	0.13	0.47	0.75	1.29	1.97	3.06
Exterior maintenance medium ^b	96.05	93.93	71.19	94.33	97.66	98.23	97.29	97.04	96.02
Exterior maintenance high ^c	2.93	5.01	28.81	5.53	1.87	1.01	1.43	0.99	0.92
Insulation quality low ^d	73.41	71.56	27.12	54.55	63.98	72.89	85.06	88.78	93.72
Insulation quality medium ^e	16.67	16.94	16.95	13.04	19.95	21.03	12.87	10.54	5.21
Insulation quality high ^f	9.92	11.50	55.93	32.41	16.07	6.08	2.07	0.68	1.07
Heating information missing	7.45	6.74	1.69	4.74	3.74	7.73	8.60	10.99	22.66
Gas or coal heater	2.64	2.58	0.00	0.53	0.30	1.19	2.21	6.82	17.15
Central heating	89.91	90.68	98.31	94.73	95.96	91.08	89.20	82.18	60.18
Transaction characteristics									
Cost payable by vendor	11.36	9.01	8.47	21.48	15.30	11.12	12.46	8.49	8.27
Time on the market (days)	97.02 [119.78]	90.95 [117.15]	128.41 [148.94]	107.09 [140.94]	97.83 [117.27]	98.43 [112.94]	101.26 [122.72]	102.86 [130.06]	105.08 [127.68]
# of Observations	17,835	6424	59	759	2993	3453	2175	1319	653

Notes: Standard deviations in brackets. All variables in percentages, unless indicated otherwise.

^a Rated 1–4 on a scale of 1–9.

^b Rated 5–7 on a scale of 1–9.

^c Rated 8 or 9 on a scale of 1–9.

^d 0 or 1 type of insulation out of 5.

^e 2 or 3 types of insulation out of 5.

^f 4 or 5 types of insulation out of 5.

Table 2 explain about 90% of the variation in the transaction value of the homes in the sample, which compares favorably to what is typically found in the literature employing hedonic valuation models for housing.

The first column in Table 2 relates the transaction value of the buildings in the sample to the most important building

characteristics, location, and macro-economic factors. The location controls are based on the four-digit zip code; macro-economic trends are controlled for using year-quarter fixed effects.

Results for the control variables are mostly in line with the literature. Our main interest in Column (1) lies in the coefficient for the presence of an EPC label. Interestingly and somewhat surprisingly, an EPC label in general has a negative impact of 0.8% on the transaction price per square meter. This effect may stem from the fact that most of our EPC labeled sample consists of homes with a relatively high primary energy demand, having an EPC label of C or less.

(footnote continued)

also applied propensity score weighting in all the specifications, and the results are robust.

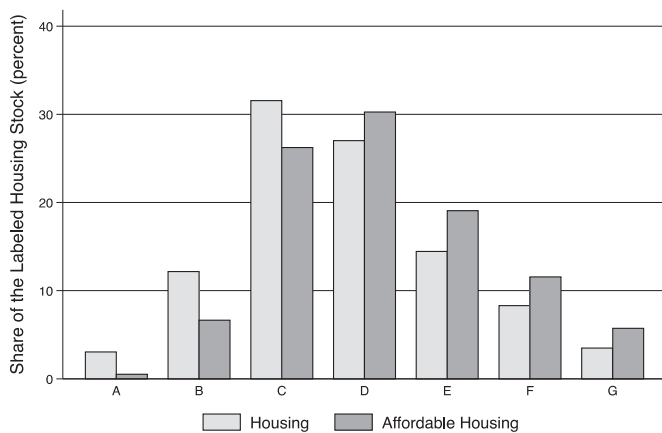


Fig. 1. Distribution of Energy Performance Certificates. *Notes:* The above figure displays the average share of the different energy performance certificates for the Netherlands over the 2009–2013 time period to the distribution of label categories in our sample of sold affordable housing dwellings. The figures for the national distribution are obtained from <http://www.senternovum.databank.nl>.

The second column of Table 2 controls more extensively for the quality characteristics of the homes in our sample and takes the thermal characteristics of the dwelling into account as well. The coefficients of the other control variables, in terms of sign, magnitude and statistical significance, are in line with the previous specification. The negative labeling effect decreases in this more elaborate specification to -0.7% .

The results show that maintenance and thermal characteristics are priced, although the inclusion of these new variables does not push the explanatory power of the model beyond the 0.90 attained in the first specification. Both interior and exterior maintenance are significant determinants of the transaction price, but the former has a much larger effect. Dwellings with the best interior maintenance sell for 12.5% more than the worst, while the effect for best external maintenance is only 3.9%.

The insulation quality of a home also contributes statistically significantly to transaction values. Compared to homes with the lowest insulation quality, homes with two or more types of insulation experience a gradually increasing premium. Relative to homes having low insulation quality, fully insulated homes sell at a premium of 1.7%. When it comes to heating systems, homes with a central heating system transact for approximately 5.7% more as compared to homes with a gas or coal heating system in place.

The third and fourth columns of Table 2 use similar specifications as discussed before, but cluster housing with high energy efficiency, those having labels A or B, versus housing with low energy efficiency, labels C to G, to verify our previous findings. The transaction price for housing with an A or B label is 1.3% higher as compared to non-labeled housing. Conversely, homes with a relatively high primary energy demand, label categories C to G, sell at a discount of 0.8%. Therefore, the negative effect of EPC labels in general as observed in the first and second column of Table 2 stems from dwellings with a label of C or worse.

The fourth column analyzes the value of an EPC label for each label category separately. An affordable dwelling with a low primary energy demand, having an A label, sells for 5.6% more compared to an otherwise similar non-labeled affordable dwelling. This implies that an average dwelling with a low primary energy demand sells for approximately EUR 9,300 more than a non-labeled dwelling. Transaction premiums for homes with an EPC label of B amount to 1.1%. On average, this implies a premium of some EUR 1,800 as compared to similar non-labeled dwellings. On the other hand, homes with a high primary energy demand, those with EPC labels in categories C to G, sell at a discount in the order

of 1.5% compared to homes without a label. For example, an F labeled dwelling on average sells for EUR 2,600 less than a comparable non-labeled dwelling.

6.2. Heterogeneous effects

Having established the baseline results in the previous analysis, we now turn to the EPC labeled set of homes in our sample to further disentangle the observed capitalization of energy labels. The analyses presented in this section employ the same specifications as presented in Table 2, and the results for the control variables are as before, so we omit these from Table 3. However, we do show results for thermal and maintenance quality.

The first column of the table displays the performance of buildings with a low primary energy demand, A and B labeled buildings, relative to buildings with a high primary energy demand, buildings with an EPC label of C or lower. These dwellings command a premium of 2.6% compared to dwellings with a high primary energy demand. This corresponds to an increase of about EUR 3,900 euros in transaction value. Although the categorization employed here is slightly different from the one used by Brounen and Kok (2011), the observed premium is in line with the 3.7% increase they document.

The actual categorization of the energy labels is based on the energy performance index. This index is constituted of a rating that directly relates to the thermal quality of the home and takes the insulation quality, heating installation, (natural) ventilation and indoor air climate, solar systems and built-in-lighting into account. The lowest rating indicates the most energy efficient home. The second column of Table 3 analyzes the direct impact of the level of a home's energy performance index on the transaction value per square meter. We document a non-linear relationship between the energy performance index and transaction values of the dwellings in our sample.

Fig. 2 displays the implicit function of the energy performance index based on the coefficients for the energy performance index in the second column of Table 3. The figure shows a clear non-linear relationship between the energy performance index and the value increment associated with energy efficiency. The value increment is highest for dwellings with a low primary energy demand and decreases quickly for dwellings with a higher primary energy demand.

The paucity of A++ and A+ labeled dwellings in our sample prevents us from observing their economic performance directly, but the graph in Fig. 2 allows us to predict it. The implied premium for a dwelling with an A++ label relative to an otherwise comparable home with a G label is 11.7%. Interestingly, the graph suggests that a major part of that premium can be realized when an A-labeled dwelling is further upgraded to A++: 5.2%, which corresponds to an increase in transaction value of approximately EUR 9,300. Dwellings with an A label command a 6.5% higher transaction price than comparable dwellings with a G label. On average, this implies an increase in transaction value of some EUR 9,600. The difference in the value increment between homes with an E label or lower relative to one with a G label is negligible.

The third column of Table 3 further differentiates across EPC label categories to assess the value of high energy efficiency in affordable housing using the most elaborate set of building and quality controls. With respect to the impact of energy efficiency we investigate the impact of the different EPC labels relative to a dwelling with an EPC label of level C. Dwellings with the lowest primary energy demand, those having an A label, sell for 6.3% more compared to those with a C label, which translates into an increase in transaction value of about EUR 9,700. A dwelling with an EPC label of B sells for 2% more compared to a similar home with a C label. Homes with labels between D and G sell at small

Table 2

Transaction Value and Energy Performance Certificates. (dependent variable: log of transaction value per square meter).

	(1)	(2)	(3)	(4)
Energy label (1=yes)	-0.008*** [0.003]	-0.007*** [0.003]		
Energy label A or B (1=yes)			0.013** [0.006]	
Energy label C to G (1=yes)			-0.008*** [0.003]	
Energy label (1=yes)				
A				0.056*** [0.017]
B				0.011* [0.006]
C				-0.002 [0.003]
D				-0.008*** [0.003]
E				-0.014*** [0.004]
F				-0.016*** [0.005]
G				-0.008 [0.007]
Building characteristics				
Log dwelling size (square meter)	-0.580*** [0.011]	-0.587*** [0.011]	-0.586*** [0.011]	-0.587*** [0.011]
Number of rooms	0.023*** [0.002]	0.024*** [0.002]	0.024*** [0.002]	0.025*** [0.002]
Basement (1=yes)	0.028* [0.015]	0.030** [0.014]	0.031** [0.014]	0.031** [0.014]
Attic (1=yes)	-0.002 [0.004]	-0.002 [0.004]	-0.001 [0.004]	-0.001 [0.004]
Garden (1=yes)	0.031*** [0.004]	0.029*** [0.004]	0.029*** [0.004]	0.029*** [0.004]
Parking (1=yes)	0.055*** [0.005]	0.053*** [0.005]	0.053*** [0.005]	0.053*** [0.005]
Monument (1=yes)	0.137*** [0.041]	0.141*** [0.037]	0.138*** [0.038]	0.137*** [0.037]
Ground lease (1=yes)	-0.007 [0.011]	-0.010 [0.011]	-0.010 [0.011]	-0.010 [0.011]
Partial lot (1=yes)	-0.004 [0.003]	-0.004 [0.003]	-0.004 [0.003]	-0.004 [0.003]
Number of stories ^a (1=yes)				
One story	-0.036** [0.017]	-0.037** [0.017]	-0.037** [0.017]	-0.036** [0.017]
Two stories	-0.006 [0.017]	-0.008 [0.017]	-0.007 [0.017]	-0.007 [0.017]
Three stories	-0.009 [0.017]	-0.014 [0.016]	-0.014 [0.016]	-0.013 [0.016]
Dwelling type ^b (1=yes)				
Apartment	0.071*** [0.009]	0.075*** [0.009]	0.076*** [0.009]	0.076*** [0.009]
Duplex	0.109*** [0.009]	0.113*** [0.009]	0.114*** [0.009]	0.114*** [0.009]
Semi-duplex	0.173*** [0.012]	0.182*** [0.012]	0.182*** [0.012]	0.183*** [0.012]
Thermal and quality characteristics				
Interior maintenance medium ^c		0.039*** [0.005]	0.039*** [0.005]	0.039*** [0.005]
Interior maintenance high ^d		0.125*** [0.014]	0.124*** [0.013]	0.124*** [0.013]
Exterior maintenance medium ^c		0.030** [0.013]	0.030** [0.013]	0.030** [0.013]
Exterior maintenance high ^d		0.039*** [0.016]	0.038*** [0.016]	0.038*** [0.016]
Insulation quality medium ^e		0.007** [0.003]	0.007** [0.003]	0.006* [0.003]
Insulation quality high ^f		0.017*** [0.005]	0.016*** [0.005]	0.015*** [0.005]
Heating information missing ^g (1=yes)		0.030*** [0.007]	0.030*** [0.007]	0.029*** [0.007]
Central heating ^g (1=yes)		0.057*** [0.007]	0.057*** [0.007]	0.056*** [0.007]

Table 2 (continued)

	(1)	(2)	(3)	(4)
Period of construction ^h (1=yes)				
1930–1944	–0.049*** [0.013]	–0.045*** [0.014]	–0.044*** [0.014]	–0.043*** [0.014]
1945–1960	–0.033** [0.014]	–0.027** [0.013]	–0.026** [0.013]	–0.026* [0.013]
1961–1970	–0.037*** [0.012]	–0.034*** [0.012]	–0.033*** [0.011]	–0.033*** [0.011]
1971–1980	–0.022* [0.012]	–0.022** [0.011]	–0.021* [0.011]	–0.022** [0.011]
1981–1990	0.011 [0.011]	0.010 [0.010]	0.010 [0.010]	0.008 [0.010]
1991–2000	0.106*** [0.015]	0.091*** [0.015]	0.090*** [0.015]	0.088*** [0.015]
> 2000	0.217*** [0.017]	0.175*** [0.016]	0.174*** [0.016]	0.173*** [0.016]
Transaction characteristics				
Cost payable by vendor (1=yes)	0.024*** [0.004]	0.023*** [0.004]	0.022*** [0.004]	0.022*** [0.004]
Time on the market (days)	–0.000** [0.000]	–0.000** [0.000]	–0.000** [0.000]	–0.000** [0.000]
Location fixed effects	yes	yes	yes	yes
Year-quarter fixed effects	yes	yes	yes	yes
Constant	9.907*** [0.046]	9.811*** [0.048]	9.808*** [0.048]	9.810*** [0.048]
Observations	17,835	17,835	17,835	17,835
R ²	0.91	0.91	0.91	0.91
Adj. R ²	0.90	0.90	0.90	0.90

Notes: Robust standard errors clustered at the postcode-year level in brackets. Significance at the 0.10, 0.05, and 0.01 level are indicated by *, **, and *** respectively.

^a Default for number of stories is “Four stories”.

^b Default for dwelling type is “Semi-detached”.

^c Rated 5–7 on a scale of 1–9.

^d Rated 8 or 9 on a scale of 1–9.

^e 2 or 3 types of insulation out of 5.

^f 4 or 5 types of insulation out of 5.

^g Default is a gas or coal heater in place.

^h Default for construction period is “Pre 1930”.

discounts, varying between 1% and 2%.

However, these value effects do not paint a complete picture for affordable housing providers who want to improve the sustainability of their housing stock. When existing homes are newly refurbished, increased energy efficiency is just one of the outcomes. Refurbishment will also lead to better interior and exterior maintenance, and the improved label quality will likely be partly driven by investments in better insulation. These latter effects are priced on top of the label effect, and the combined value effect is substantially larger than that of the improved label quality alone. Table 3 underscores this.

Let us take the example of an affordable housing institution that refurbishes dwellings initially labeled E, F, or G, and succeeds in improving their energy efficiency to label A. In the process, it improves both the interior maintenance and the insulation quality level from low to high. In that case, the results in Table 3 predict a total increase in value of 20.5%: 7.8% for the jump in label quality, 11.0% for the increased interior maintenance, and 1.7% for the improved insulation. If we apply that combined value increase to the average square meter value of E, F and G labeled dwellings reported in Table 1, we get a predicted value for an A-labeled building of almost EUR 2,000, which is close to the actual average value reported in Table 1. This combined result indicates that green redevelopment of affordable housing is best conducted as part of a broader renovation.

7. Conclusions and policy implications

The Dutch housing sector spent approximately 11.3 billion euros on energy in 2010, emitting approximately 29,500 tonnes of CO₂. And the cost of energy for the average household is substantial. Thus, for society to apportion less disposable income to household energy expenses in the present and the future, regulators are pushing building owners to abate energy costs through retrofit investments and more stringent and energy-efficient building codes. For the Netherlands, as for other European countries, an important sector in decreasing household energy consumption is the affordable housing sector.

One of the key differences between the owner-occupied residential market and the affordable housing rental market is that affordable housing institutions cannot directly benefit from investments in energy efficiency through lower energy expenses. The tenant pays the reduced energy bill and the building owner undertakes the energy efficiency investment, resulting in a split incentive. Recouping that lower energy bill through higher rents is difficult due to an extensive program of rent protection.

One solution for affordable housing owners would be to sell energy efficient affordable dwellings in the housing market. In principle, this solution is open to affordable housing institutions everywhere, but in many countries, there are legal impediments to doing so. Dutch affordable housing institutions are allowed to sell from their stock, and we use this unique setting in housing policy

Table 3
Transaction Value and Label Quality within the EPC Labeled Sample. (dependent variable: log of transaction value per square meter).

	(1)	(2)	(3)
Energy label A or B (1=yes)	0.026*** [0.007]		
Energy performance index		−0.086*** [0.020]	
Energy performance index ²		0.016*** [0.004]	
Energy label (1=yes)			
A			0.063*** [0.019]
B			0.020*** [0.007]
C			
D			−0.007* [0.003]
E			−0.016*** [0.005]
F			−0.017*** [0.007]
G			−0.013* [0.008]
Thermal and quality characteristics			
Interior maintenance medium ^a	0.040*** [0.007]	0.039*** [0.007]	0.039*** [0.007]
Interior maintenance high ^b	0.110*** [0.017]	0.109*** [0.016]	0.108*** [0.016]
Exterior maintenance medium ^a	0.024 [0.018]	0.023 [0.018]	0.023 [0.018]
Exterior maintenance high ^b	0.032 [0.021]	0.031 [0.021]	0.030 [0.021]
Insulation quality medium ^c	0.004 [0.004]	0.003 [0.004]	0.003 [0.004]
Insulation quality high ^d	0.017*** [0.005]	0.016*** [0.005]	0.015*** [0.005]
Heating information missing ^e (1=yes)	0.025*** [0.009]	0.024*** [0.010]	0.025*** [0.010]
Central heating ^e (1=yes)	0.049*** [0.009]	0.045*** [0.009]	0.047*** [0.009]
Building characteristics	yes	yes	yes
Transaction characteristics	yes	yes	yes
Location fixed effects	yes	yes	yes
Year-quarter fixed effects	yes	yes	yes
Constant	9.865*** [0.059]	9.984*** [0.064]	9.880*** [0.060]
Observations	11,411	11,411	11,411
R ²	0.91	0.91	0.91
Adj. R ²	0.90	0.90	0.90

Notes: Robust standard errors clustered at the postcode-year level in brackets. Significance at the 0.10, 0.05, and 0.01 level are indicated by *, **, and *** respectively.

^a Rated 5–7 on a scale of 1–9.

^b Rated 8 or 9 on a scale of 1–9.

^c 2 or 3 types of insulation out of 5.

^d 4 or 5 types of insulation out of 5.

^e Default is a gas or coal heater in place.

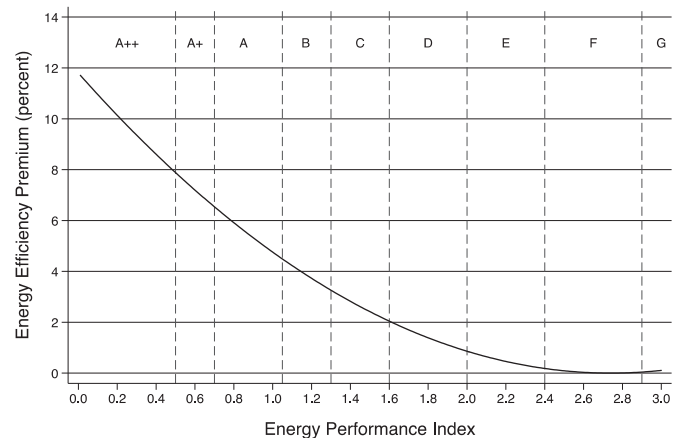


Fig. 2. Transaction Value and Energy Performance Index. Notes: The above figure displays the non-linear relationship between the energy performance index and the incremental transaction value per square meter. The graph has been rebased to zero for ease of interpretation. The vertical dashed lines display the different cut-off values for the energy labels. This categorization has been revised in January 2015; the cut-off values used are the ones applicable at the time of transaction.

2.0% for homes having a B label. This suggests that the average C labeled home in our sample would sell for some EUR 9,700 more were it to trade as an A label. The increase in transaction value for a B label is just over EUR 3,000.

To get a sense of the economic importance of these average transaction premiums we compare them to estimates regarding the costs that affordable housing institutions face when making sustainability retrofits. For example, estimates carried out for the demonstration sites of the Building Energy Efficiency for Massive Market Uptake project as part of the European Union's 7th framework program provide some anecdotal evidence on the costs of energy efficiency retrofitting in the construction market (Chegut and Holtermans, 2014). The estimated costs of energy efficient retrofits for the demonstration sites are approximately EUR 190 per square meter for a typical site. The results documented in Table 3 indicate that renovating a E-G labeled dwelling to achieve an A label would increase the transaction price per square meter by EUR 129. However, this cost-benefit comparison only involves the pure value effect of the label increase, but the results depicted in Table 3 shows that the combined value effects of refurbishments of affordable homes are substantially larger. We find combined premiums of just over 20%, which is equivalent to an increase in price per square meter of EUR 330, which would more than pay for the retrofit.

These rough estimates suggest that the investment in energy efficient retrofits may be partly or fully compensated by an increase in transaction price. However, it is not clear whether the retrofit costs from the demonstration sites are representative for the Dutch affordable housing situation, so we cannot draw firm conclusions on this matter. More research on the costs of a larger sample of energy efficiency retrofits should be conducted in order to draw grounded conclusions regarding the cost-benefit trade-off of such retrofits in affordable housing.

Still, given the economic and statistical significance of the results documented in this study, we find that the affordable housing market values energy efficiency and is willing to pay for it. The Dutch affordable housing sector offers a policy example of how to potentially amortize energy efficiency investments through transaction premiums for energy efficient dwellings. Other countries with affordable housing institutions and split incentive issues may consider the Dutch model as one approach to resolve this disincentive for energy efficiency investments in the affordable housing market. This could foster the proliferation of energy

for our analysis of the value of energy efficiency in affordable housing.

We employ a hedonic pricing model to analyze the impact of energy efficiency on the transaction price per square meter and we separate the sample into EPC labeled and non-labeled dwellings. The results of our EPC labeled sample show that the most energy efficient homes, homes with an energy label of A or B, command a higher transaction price per square meter. We document that a dwelling with an A label commands a 6.3% premium compared to an otherwise similar dwelling with a C label, and this premium is

efficiency in the housing market.

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