Capitalization of Energy Efficiency in the Housing Market

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Abstract

The carbon externality from energy consumption in the residential sector is an important topic of societal debate. Much of the current policy making hinges on the assumption that markets efficiently capitalize home energy performance into transaction prices. However, the existing literature on the topic suffers from omitted variable bias, leading to inaccurate estimates. This study uses an instrumental variable approach on a large sample of dwellings to examine the capitalization of energy efficiency in the housing market. Using the exogenous variation in energy efficiency generated by 1973-74 oil crisis, as well as the evolution of building codes as instruments, we document that a 50 percent increase in energy efficiency leads to an increase in the transaction price of about 11 percent for an average home in the Dutch housing market. Our findings also indicate that the extent of energy efficiency capitalization does not significantly change when information asymmetry is reduced through the presence of Energy Performance Certificates (EPC). These findings are important for public policy regarding investments in home energy efficiency.

JEL Codes: D12, Q51, R21

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1 Introduction

In today's heated debate about climate change, and related, the carbon externality from energy consumption, energy efficiency seems the panacea that is globally embraced by policy makers. For example, the recent Clean Power Plan proposed by the United States Environmental Protection Agency (EPA) allows for investment in energy efficiency as a substitute for cutting carbon emissions from actual power generation. The building stock represents an important target for policy makers, due to its significant potential for efficiency improvements (Perez-Lombard et al., 2008). Across the ocean, the European Union aims for a 20 percent reduction in energy consumption, based solely on "cost effective" measures that are paid back from reductions in energy bills. And China has included energy efficiency as a cornerstone of its current five-year plan, with the ambition to retrofit four million square feet of non-residential space. But of course, the success of such programs depends on the ability of homeowners, developers, and commercial real estate investors to understand efficiency opportunities and their willingness to invest in building upgrades.

Economists have long recognized that market failures can lead to what has been termed the "energy efficiency gap" – the difference between the optimal level of energy efficiency investments and the level actually realized (Allcott and Greenstone, 2012).[1] Upgrading a dwelling to improve its energy efficiency typically involves a significant financial investment, and the uncertainty regarding its financial return may be a reason for households not to undertake seemingly profitable investments in energy efficiency. For instance, from the homeowner's point of view, the expected length of tenure may not be sufficient to offset the cost of investment by the reductions in energy costs. The willingness to invest in energy efficiency may be even lower for institutional investors, as they typically lease out their investment properties, and therefore do not benefit from the reduction in energy bills.

Another potential market barrier that may lead to underinvestment in energy efficiency, is the lack of transparency in the housing market. Homebuyers may be unable to

[1] Starting by Hausman (1979), many studies have shown that the present discounted value of future energy savings exceeds the initial costs of energy efficiency investments.

accurately assess the energy efficiency of a home as some features are not perfectly visible to them. Following Akerlof (1970)'s classic "lemons" model, information asymmetry between seller and buyer is generally accepted as one of the main reasons leading to underinvestment in energy efficiency in the housing market (Gillingham et al., 2009). In the absence of information, buyers are not able to incorporate future energy expenditures into their purchasing decisions, and therefore sellers prefer not to invest in energy efficiency improvements. In recent years, energy labels have been proposed as a remedy to this potential market failure. For instance, in order to provide insight into the relative energy consumption of buildings, EU member states have been required since 2009 to implement energy performance certification (EPC) schemes for residential dwellings. By providing information to market participants about the energy performance of buildings, policy makers expect an increase in the demand for energy efficient dwellings, which in return may lead to higher investment in energy efficiency. The effectiveness of this policy of course hinges on the extent to which buyers are willing to pay for increased energy efficiency. It is important to understand whether investments in energy efficiency are capitalized in real estate prices, so that homeowners and institutional investors can better assess their return on investments. From a policy perspective, it is critical to identify the relevance of energy performance certificate on the capitalization of energy efficiency in home prices.

The academic literature provides some empirical evidence on the relationship between energy efficiency and home prices. Using a sample of dwellings with energy performance certificates, Brounen and Kok (2011) document that consumers pay a four percent premium for green-labeled (labels A, B and C) homes in the Netherlands. Similarly, analyzing the property market in the Republic of Ireland, Hyland et al. (2013) find that transaction prices increase as the energy efficiency rating of a dwelling improves. Kahn and Kok (2014), using transaction data from the California housing market, document that homes labeled with a green label are sold at a small price premium compared to non-labeled homes. As energy labels are not necessarily available in other countries, researchers have also used other approaches to identify the market value of energy efficiency. Thorsnes and Bishop (2013) examine the capitalization of building standards that were introduced in New Zealand in 1978, and find a positive premium for dwellings that were constructed after the legislation.

Laquatra (1986) analyzes a sample of houses constructed through the Energy Efficient Housing Demonstration Program of the Minnesota Housing Finance Agency, and identifies the market values of energy efficiency investments based on a vector of thermal integrity factors. Zheng et al. (2012) document that "green" buildings, which are identified based on an index created using Google search, are sold at a price premium at the pre-sale stage. Comparable to these findings, Dastrup et al. (2012) find that solar panel installations are capitalized into house prices at around a 3.5 percent price premium in California.

While this body of literature is significant and growing, the most common methodological drawback of the evidence provided is the potential bias that may arise from the omission of unobserved dwelling characteristics that are correlated with measures of energy efficiency, as indicated by Zheng et al. (2012), Hyland et al. (2013) and Thorsnes and Bishop (2013). Klier and Linn (2012) document a similar problem analyzing the capitalization of energy efficiency for the automobile sector. Typically, in order to minimize the omitted variable bias, the empirical strategy is to include detailed dwelling characteristics in hedonic model. However, this method does not completely rule out the presence of unobservable factors, and multicollinearity among the observed characteristics often leads to imprecise and implausible estimates of attribute prices. Indeed, Atkinson and Halvorsen (1984) document that the difficulties caused by multicollinearity are more apparent when analyzing energy efficiency, leading to insignificant or theoretically incorrect estimates for the coefficients of energy efficiency.

In this study, using a large representative dataset from the Netherlands, we propose an instrumental variable approach in order to more properly identify the capitalization of energy efficiency in the housing market. The analysis benefits from a continuous measure of energy efficiency provided by energy performance certificates, which enables estimating the elasticity of home prices with respect to their energy efficiency. In addition to including detailed dwelling characteristics in the hedonic model, we use an instrumental variable approach to address the issue of omitted variable bias. We exploit the 1973-74 oil crisis, which creates an exogenous discontinuity in the energy efficiency level of dwellings constructed before and after this date, and the evolution of building codes as instruments for energy efficiency. Our results indicate that the OLS estimates are biased downwards:

using an IV approach, we find that as the level of energy efficiency increases by 50 percent, the market value of the dwelling increases by around 11 percent for an average dwelling in the Dutch housing market.

Furthermore, in order to investigate whether the value of energy efficiency increases when information transparency is higher, we create a common energy efficiency measure for certified and non-certified homes, based on actual energy consumption. We find that the market value of a percentage change in actual gas consumption is close to the value of an energy efficiency change that is estimated based on the energy efficiency indicator provided by energy performance certificate. Our findings do not provide any evidence that suggests a higher capitalization rate for homes that are transacted with energy performance certificate. We also use a regression discontinuity approach to test whether the label classification itself has market value. Our results do not indicate a significant change in the transaction price at the threshold energy efficiency level that is used to assign homes into different label classifications. This finding implies that, after controlling for the continuous energy efficiency level, the EU energy label itself does not lead to a significant change in the buyer's valuation of the energy efficiency of a dwelling.

Finally, in order to examine the time variation in the market value of energy efficiency, we estimate the hedonic model for each year separately, from 2003 to 2011. We document that the value of energy efficiency has doubled from 2003 to 2011, which might be partially related to the increase of energy prices, the relative decrease in house prices after 2008 and the general impact of policies and campaigns indicating the importance of energy efficiency.

Our findings suggest that, regardless of the provision of energy label, energy efficiency is capitalized in the housing market. In addition to the immediate financial benefits from lower energy expenses, energy efficiency improvements lead to higher transaction prices at the time of sale. Contrasting Brounen and Kok (2011), our results do not provide any significant evidence for the intangible effects of energy labels on transaction prices. For policy makers the results of this paper may help in refining energy performance certification programs in a way that underlines the financial benefits of energy efficiency. Furthermore, as discussed by Allcott and Greenstone (2012), information campaigns can play an important role in the diffusion of energy efficiency investments. Therefore, the financial benefits that households and investors can derive from energy efficiency need to be more explicitly highlighted in public awareness campaigns.

The remainder of this paper is organized as follows. The next section describes the data. In section 3, we present the methodology and the results. Section 4 provides a brief conclusion.

2 Data

This paper exploits detailed transaction data provided by the National Association of Realtors (NVM) in the Netherlands. The data contains detailed information on the characteristics of the dwellings transacted between 2003-2011, as well as their transaction price. To analyze the energy efficiency of homes, we match this data set with the energy performance certificate (EPC) database managed by Netherlands Enterprise Agency (RVO) – a governmental body responsible for subsidies and regulations related to energy efficiency and innovation (including renewable energy, patents, etc.).

Following the EU directive 2002/91/EC on the energy performance of buildings, energy performance certification for homes was introduced in the Netherlands in January 2008.[2] The energy performance certificate is issued by a professionally trained expert. The expert visits the dwelling and inspects its physical characteristics such as size, structure, quality of insulation, heating installation, ventilation, solar systems, and built-in lighting. The collected information is then used to predict the total energy consumption of the home through an automated engineering model, which is described in more detail by Aydin et al. (2014). After scaling by the size and the heating loss area of the dwelling, the prediction is transformed into an Energy Performance Index (EPI), which is used to assign the dwelling to a certain label class, ranging from "A++" for exceptionally energy-efficient homes, to "G" for highly inefficient homes. The EPC database includes detailed information on the energy performance of homes, as well as information on some other characteristics of these homes.

[2]Dwellings that have been constructed after 1999, or that are registered as monuments, are exempted from mandatory disclosure of the energy performance certificate. If the buyer of the dwelling signs a waiver, the seller is also exempt from providing the certificate.

As the certification program started in 2008, and we limit our sample to the homes that were transacted between 2008-2011. We also exclude homes that were constructed before 1900 or after 1999, as these are exempt from mandatory disclosure of an EPC. For the sake of simplicity, we restrict our sample to single-family homes, which account for nearly 70 percent of the total transactions.[3] Finally, we eliminate outliers that are detected based on the sample distribution of size, price, and the energy performance index – the upper and lower boundaries for the outliers are set at the first and 99th percentile. This leads to a sample of 30,036 single-family homes that were transacted with an EPC during the 2008-2011 period.

Figure 1 presents the distribution of transaction price, energy performance index and construction year of the dwellings in our sample. A higher energy performance index (EPI) indicates a lower level of energy efficiency. According to this simple graph, most of the homes in the sample have an EPI value between 1-3, were constructed after 1950, and sold at a price ranging from €100,000 to €300,000. Table 1 further documents the summary statistics for some of the main characteristics of the sample, distinguishing between "energy-efficient" (EPI<median) and "inefficient" (EPI>median) homes. According to these statistics, efficient homes are sold at a slightly higher price, have a larger size, and are more recently constructed as compared to the less efficient homes.

[Insert Figure 1 here]

[Insert Table 1 here]

As a first analysis of the relationship between energy efficiency and home prices, Figure 2 plots the observed home price for varying levels of energy efficiency. In Panel A, using unadjusted prices, we obtain a U-shaped relationship between the EPI and the value of the dwelling, which is not fully in line with expectations. This may be due to the omission of the other determinants of home prices, which are correlated with energy efficiency (such as dwelling type, location, construction year, etc.). In panel B, we plot the residuals estimated

[3] Bailey (1966) notes that, compared to single-family dwellings, apartment units may present idiosyncratic difficulties of specification and measurement, and differences in the valuation of attributes between these two types of dwellings may exist. Similarly, Ridker and Henning (1967) and Kahn and Kok (2014) focus on single-family dwellings when analyzing energy efficiency and home prices.

based on a hedonic model that includes all determinants of home prices except the EPI. We observe a more distinct relationship in this graph, indicating that as the energy efficiency of a home is lower, the transaction price decreases.

[Insert Figure 2 here]

3 Methodology and Results

3.1 OLS Estimation

Hedonic models are commonly used in the economics literature to estimate the value of individual product attributes (Rosen, 1974). Analyzing the property market, the size of the estimated coefficient on each variable represents the implicit value of that characteristic. Our basic hedonic model takes the following form:

$$Log(Price_i) = \beta_0 + \beta_1 Log(E_i) + \beta_j X_i + \alpha_n + t_i + \varepsilon_i \tag{1}$$

where the dependent variable, $Price_i$, is the transaction price of dwelling i. E_i is the variable of interest which represents the energy efficiency level of the dwelling, and X_i is a vector of other dwelling characteristics. By using a log-log specification, we estimate the elasticity of home prices with respect to energy efficiency, which is denoted by β_1. To control for unobserved location amenities, we include neighborhood fixed effects (α_n) in our model. t_i is a vector of transaction year dummies, which account for the macroeconomic factors that may influence house prices over time.

We first estimate equation (1) using ordinary least squares (OLS), assuming that the energy performance index (EPI_i), which is used as a measure of energy efficiency (E_i), is independent of the error term (ε_i). The results are presented in Table 2.[4] Including the EPI as the sole regressor (column 1), the estimated impact of a 100 percent increase in the EPI is a 24 percent decrease in the value of the home. The coefficient decreases to 11 percent when including other observable characteristics of the home. In column 3, we also include the construction year of the home, as it is expected to be strongly correlated

[4]Control variables are omitted from the table. Detailed estimation results are in Appendix Table A.1

with the level of energy efficiency. Controlling for all other variables, we document that a 100 percent increase in the energy performance index leads to a five percent decrease in the market value of the home.[5] This result implies that if energy requirement is reduced by half, the market value of that home increases by 2.5 percent, which corresponds to a marginal price increase of €5,000 for the average dwelling in our sample. This result does not show significant variation when we specify the year of construction as dummy variables (column 4) instead of a continuous variable.

[Insert Table 2 here]

Although we use a large, representative sample and control for detailed dwelling characteristics in the OLS estimations, there is a potential bias in the estimated value of energy efficiency. The presence of unobserved determinants of home prices may be correlated with the level of energy efficiency, influencing the estimated coefficient. Depending on the direction of the correlation between these unobserved factors and prices, and between the unobserved factors and the energy efficiency level, this can either be a downward or upward bias. Furthermore, multicollinearity between construction year and the energy performance index may increase the magnitude of a bias when controlling for the construction year in the OLS estimates.[6]

Another econometric issue that may cause a biased estimate is the presence of measurement error in the engineering calculations. It could be the case that the engineering calculations include a measurement error, because of the assumptions made in the

[5] We also examine whether the unobserved determinants of label adoption are correlated with the error term in equation (1), which may lead to biased estimates. In order to test this, we first estimate a probit model to predict the probability of label adoption in our sample of labeled and non-labeled homes. Next, as proposed by Heckman (1979), we include the inverse Mills ratio in our model. The results indicate that there is no significant correlation between the error term of model specified in equation (1) and the error term of the estimated probit model (the p-value of the log-likelihood test is 0.176). Therefore, we conclude that there is no evidence for the sample selection bias.

[6] See Mela and Kopalle (2002) for a theoretical explanation of the relationship between multicollinearity and the magnitude of bias.

calculation method, and the potential mistakes made during the inspection.[7] We assume that the predicted energy efficiency (EPI) is a combination of the true value (EPI^*) and a random error component (e) that has a mean value equal to zero and that is not correlated with the true energy efficiency level. In this case, the OLS assumption that the EPI is independent of the error term may not be valid. The presence of this random measurement error leads to a downward bias in the OLS estimate of β_1.

3.2 Instrumental Variable Approach

In order to overcome the potential bias originating from unobserved factors and measurement error, a common approach is to use an instrumental variable (IV) method. Such IV needs to be correlated with the true energy efficiency level (EPI^*), but has to be independent of both the measurement error (e) and the unobserved determinants of the home price.

Energy prices are one of the main drivers of the energy efficiency investments, as rising prices make thermal comfort more costly for households and decrease the payback period.[8] Appendix Figure A.1 presents the development of real oil prices from 1900 to 2000. The most remarkable increase in oil prices took place in 1974, when prices rose by 260 percent. Therefore, dwellings that were constructed just after the oil crisis may be more energy efficient as compared to previously constructed dwellings. Indeed, Figure 3 shows a clear structural break and discontinuity in the average energy efficiency level of homes constructed after the increase of energy prices.[9] This increased energy efficiency level can be considered a combined result of household demand for more energy efficient

[7]Especially for older dwellings, the engineer has to make assumptions regarding the U-value of outside walls and the rates of ventilation and infiltration. As the engineering models are examined through energy simulation tests and verified by pilot studies (Poel et al., 2007), we do not expect a significant systematic bias in the calculated energy efficiency level. Besides, a simple examination of the data on re-inspection of a sample of labeled dwellings indicates that the inspection error is not systematically and significantly correlated with the true value (Aydin et al., 2014).

[8]See Knittel (2011), Li et al. (2009) and Klier and Linn (2010) for an analysis of how gasoline prices drive fuel efficiency in the automobile sector.

[9]Haas and Schipper (1998) document that after the decrease in residential energy demand following the 1973-74 oil crisis, demand did not rebound in times of declining energy prices (e.g., in 1985). They argue that irreversible efficiency improvements, which took place after the 1973-74 oil crisis, might be an explanation for this observation.

dwellings (and appliances), as well as the revision of building codes after the oil crisis.

[Insert Figure 3 here]

Starting in 1965, the Dutch government introduced minimum legal requirements for the thermal efficiency level of new construction. The legislation sets a maximum allowable U-value for each component (walls, windows, floor and roof) of the dwelling. The U-value is defined as the amount of heat loss through a single square meter of material, for every degree difference in temperature at either side of the material.[10] Appendix Figure A.2 presents the over-time variation in the maximum allowable U-value requirements for external walls of new construction in the Netherlands. In order to reach the goal of zero energy buildings, these requirements have been strengthened over time. Figure 3 confirms that the average efficiency level of constructed dwellings is quite stable until the 1960s, and starts increasing (reflected in a decreasing EPI) at the time of the introduction of the first building code in 1965. After the substantial increase in energy costs in 1973-74, the increasing trend in energy efficiency accelerates, forced by stricter building codes.

In order to identify the impact of energy efficiency on home prices using an IV approach, we first exploit the exogenous change (discontinuity) in energy efficiency that took place in 1974 as an instrument, assuming that unobservable characteristics of constructions do not vary discontinuously in 1974. Based on the year of construction, we assign dwellings constructed after 1974 as the homes that were exposed to significantly higher energy costs during their construction. Our main identifying assumption is that unobserved characteristics vary continuously with the year of construction. Thus, any discontinuity of the conditional distribution of energy efficiency as a function of the year of construction in 1974 can be considered as evidence of a causal effect of the oil crisis. This identifying strategy is comparable to Vollaard and Van Ours (2011), who use a similar approach analyzing the impact of stricter built-in security standards on burglary rates.

To obtain more accurate estimates of the trends in energy efficiency before and after the exogenous shock, and to be able to compare dwellings that have similar characteristics, we

[10] For example, one square meter of a standard single glazed window transmits about 5.6 watts of energy for each degree difference at either side of the window, and thus has a U-Value of 5.6 W/m^2. A double glazed window has a U-value of 2.8 W/m^2.

limit our sample of homes to those that were constructed between 1967-1982. This enables us to identify the discontinuity in energy efficiency by isolating the trend effect that might be correlated with the over-time change in unobserved characteristics of the constructed homes (such as time-variant luxury attributes of homes). Figure 4 ,Panel A presents the discontinuity in energy efficiency of homes in 1974. We benefit from this exogenous change as an instrument for the energy efficiency in our hedonic model. As can be observed in Panel B of Figure 4, there is a clear jump in home prices for the homes that were constructed after 1974.

[Insert Figure 4 here]

Using the discontinuity in energy efficiency as an instrument for the energy performance index (EPI), we are able to disentangle the true (and exogenous) variation in energy efficiency. Thus, the first and second stage regression models of the IV estimation can be written as:

$$Log(EPI_i) = \alpha_0 + \alpha_1 D_i^{1974} + \alpha_2 T_i + \alpha_3 D_i^{1974} T_i + \alpha_j X_i + \tau_i + \eta_n + \epsilon_i \tag{2}$$

$$Log(Price_i) = \delta_0 + \delta_1 \widehat{Log(EPI_i)} + \delta_2 T_i + \delta_3 D_i^{1974} T_i + \delta_j X_i + t_i + \alpha_n + \varepsilon_i \tag{3}$$

where T indicates the construction year of the home and D^{1974} is a dummy variable which is equal to one for the homes that were constructed after 1974 and zero otherwise. By specifying time trends separately before and after 1974, we are able to capture the exogenous variation in energy efficiency.

Table 3 reports the results of the IV estimations, based on different sample specifications. Results of the first stage regression model imply that the average energy requirement of homes constructed after the 1974 oil crisis is about 6-8 percent lower as compared to previously constructed dwellings.[11] The results in column (1), which are based on the sample of homes constructed between 1967 and 1982, indicate that a 100 percent increase in energy performance index leads to a decrease in the market value of the dwelling by about

[11]Detailed first-stage and second-stage estimation results are presented in Appendix Table A.2 and Table A.3, respectively

22 percent. The estimated coefficient does not vary significantly as we further extend the sample by including the homes constructed long before and after the oil shock (columns 2 and 3). Assuming that the change in home energy efficiency in 1974 is exogenous, the IV results provide evidence that the value of energy efficiency is actually *underestimated* in the OLS regressions.

[Insert Table 3 here]

The identifying assumption of using a discontinuity in energy efficiency as an instrument is that the timing of the oil shock does not coincide with a discontinuity in unobserved dwelling characteristics that might also affect the price of the home. Although this assumption cannot be tested directly, we examine the validity of our findings by using an alternative instrument that is specifically targeted at energy efficiency of new buildings and that exhibits more variation (compared to a one-time energy price shock). The over-time variation in the stringency of building codes provides such alternative, using the maximum allowable U-value requirement for outside walls as a proxy for stringency (see Appendix Figure A.2).

Table 4 documents the IV estimation results that are based on the evolution of U-value requirements for external walls of newly constructed homes.[12] The first stage regression results indicate that the U-value requirement is significantly associated with the energy efficiency level of the homes that were constructed under that requirement, which is in line with the findings of Jacobsen and Kotchen (2013). According to the estimated coefficient on the energy performance index (EPI), if the predicted energy requirement of an average home doubles, the market value of that home decreases by around 21 percent, which is

[12]Detailed first-stage and second-stage estimation results are in Appendix Table A.4 and Table A.5, respectively

close the results documented for discontinuity approach.[13] These findings imply that if the energy requirement of a home is reduced by half, its market value increases by around 11 percent, which corresponds to about €23,000 for the average home in our sample.

[Insert Table 4 here]

From the homeowner's perspective, the question of interest is what our findings suggest about the value of energy efficiency relative to its cost. According to the statistics provided by MilieuCentraal (Center for the Environment), a government agency, in order to decrease the energy requirement of the average dwelling in our sample by 50 percent, the required saving measures cost around €15,000.[14] This simple calculation implies that, for the average homeowner in our sample, more than the invested amount is capitalized in the resale stage. An alternative view is to compare the marginal price increase to the reduction in energy expenditures, as households realize lower energy bills as a result of improved energy efficiency. Given that in 2011, the gas consumption of an average home in our sample was 1,650 m^3 and the price of gas was 0.65 cent per m^3, households realize an estimated €535 annual saving as a result of a 50 percent decrease in the required level of energy. Compared to the €23,000 marginal home price increase following a 50 percent reduction in energy cost, this reflects a capitalization rate of about 2.3 percent (assuming perpetuity).

[13] According to the results provided by Brounen and Kok (2011), "green" labeled homes (labels A, B, or C) are sold for a 3.6 percent price premium as compared to the "non-green" (labels D, E, F, or G) homes. Our sample statistics indicate that the average energy performance index of "green" homes is 40 percent lower as compared to the "non-green" homes. Thus, assuming linearity, we can conclude that the results imply an elastcity of about nine percent, which is lower than our estimate. Thorsnes and Bishop (2013) document that the building code legislation that was introduced in 2002 in New Zealand (leading to a 39 percent increase in energy efficiency) led to a 14 percent increase in the market value of dwellings constructed after the legislation. Again assuming linearity, this result implies an elasticity of about 35 percent, which is larger as compared to our estimate. However, it should be noted that the calculated elasticity parameters in both studies fall within the 95-percent confidence interval of our estimates.

[14] According to the information provided by MilieuCentraal, the estimated unit costs of insulating the components of a dwelling are; €40/m^2 for floors, €100/m^2 for outside walls, €60/m^2 for the roof, €160/m^2 for windows and €2,900 for a boiler (see "http://www.milieucentraal.nl/" for detailed information). Given that the average dwelling in our sample has 59 m^2 of floor area, 82 m^2 of roof area, 65 m^2 of external wall area and 25 m^2 of window area, if all saving measures are implemented for the average dwelling in our sample, this leads to a 70 percent reduction in the expected energy use. The total cost of this reurbishment is €20,680. Assuming linearity, a 50 percent reduction in the required energy costs around €15,000. However, it should be noted that the effectiveness of different saving measures might vary based on their simplicity. Our calculation is based on the saving measures that are necessary in order to decrease the energy requirement of an average dwelling by 70 percent.

3.3 The Impact of Information Provision

Information asymmetry is suggested as one of the main reasons why households underinvest in otherwise profitable energy efficiency investment projects (Gillingham et al., 2009). The underlying mechanism is such that if energy efficiency information is not available, consumers are not able to incorporate the operating costs into their purchasing decisions, which in return leads to lower investments in energy efficiency. In order to enhance the transparency of energy efficiency in the real estate market, energy performance certificates have been used as one of the main policy instruments in many EU countries. This provision of information is expected to enable households and investors to take energy efficiency into account in their purchasing and investment decisions, thus leading to a higher capitalization of energy efficiency. Given that our results provide evidence that energy efficiency is capitalized in a sample of certified dwellings, the question remains how the provision of an energy label affects the capitalization rate of energy efficiency in the market for single-family dwellings.

In order to test whether the capitalization of energy efficiency varies with the disclosure of an EPC, we create a common energy efficiency measure for certified and non-certified homes. Since the energy performance index underlying the EPC is not available for non-certified homes, we exploit the variation in actual energy consumption to estimate the model in equation (1). We match the NVM data set with annual gas consumption data provided by Central Bureau of Statistics (CBS) for the years between 2004-2011.[15] We calculate the average annual gas consumption (per m^2) for each home, and use this as a proxy for the energy efficiency level of that dwelling. Figure 5, Panel A shows the relationship between gas consumption per m^2 and the EPI.[16] CBS also provides information on household characteristics, including household composition and income level. We

[15]Since residential electricity consumption in the Netherlands highly depends on the use of household appliances instead of the characteristics of the dwelling, we do not include household electricity consumption as a measure of home energy efficiency in our analysis. According to the statistics provided by the Odyssee database in 2011, nearly 85 percent of residential electricity consumption is used for household appliances in the Netherlands, and the share of electricity used for air cooling is about 0.3 percent.

[16]The gas consumption data is not available for the years 2005 and 2007. In calculating the average gas consumption level for each home, we correct for annual heating degree days and exclude the years of transaction.

calculate the average characteristics of the households that reside in each dwelling between 2004-2011. We include these average household characteristics in the model as control variables, as they might be correlated with gas consumption (Brounen et al., 2012). In order to obtain information on exact year of construction of the non-certified dwellings, we merge our data set with the housing data provided by CBS. Finally, we exclude the outliers detected based on the sample distribution of gas consumption per m^2, transaction price, house size and household income level (the upper and lower boundaries for the outliers are set at the first and 99th percentile). The complete sample includes 103,834 dwellings that transacted, without EPC, between 2008-2011.

[Insert Figure 5 here]

In Table 5, we report some of the descriptive statistics for certified and non-certified dwellings separately. The transaction price for non-certified dwellings is significantly larger compared to certified dwellings. This might be due to the larger fraction of detached and semi-detached homes in the non-certified sample. The efficiency indicator, which is proxied by gas consumption per m^2, is not statistically different for certified and non-certified homes. The average home in our sample is occupied by two people who have an average annual income around €35,000 (€31,000 for certified dwellings). The average annual gas consumption is 1,800 m^3 for non-certified homes and 1,650 m^3 for certified homes. According to these statistics, given that the consumer price of gas was 65 cents per m^3 in 2011, the annual gas expenditure of the average consumer corresponds to nearly four percent of the income of the average household in our sample – a sizable expenditure.

[Insert Table 5 here]

First, we use OLS to estimate the market value of energy efficiency for non-certified homes. The gas consumption per m^2 is used as a proxy for the energy efficiency level of the home. In column (1) of Table 6, we report the results of the estimation of the model without including control variables.[17] According to the estimated coefficient, if the actual gas consumption per m^2 is doubled, the value of the home decreases by about seven

[17]Detailed estimation results are in Appendix Table A.6

percent. However, when including control variables, the sign of the estimated coefficient becomes significantly positive, which is contrary to expectations. According to the results reported in column (4), keeping the dwelling and household characteristics fixed, if the gas expenditure is doubled, the value of the dwelling increases by around ten percent for non-certified dwellings. The estimated coefficient is nearly the same when we estimate the model for the certified dwellings (column 5).[18]

[Insert Table 6 here]

A potential explanation for these findings is that, due to the omission of unobserved factors and the presence of multicollinearity between actual gas consumption and other dwelling characteristics, the OLS estimation leads to a biased result (Atkinson and Halvorsen, 1984; Mela and Kopalle, 2002). Therefore, we again use an IV approach in order to isolate the exogenous variation in actual gas consumption resulting from stricter building codes.[19] We estimate the same model using the maximum U-value requirement for external walls at the time of construction as an instrument for actual gas consumption per m^2. Table 7 documents the results of the IV estimations.[20] Comparing the coefficient estimates of EPI (column 3) and gas consumption per m^2 (column 2) that are based on the same sample of homes, we can conclude that both efficiency indicators lead similar results. The results show that, keeping other dwelling and household characteristics constant, as the actual gas consumption is doubled, the market value of the home decreases by around 24 percent for non-certified dwellings (column 1) and by 20 percent for certified dwellings (column 2), which is in line with our previous findings. The estimated coefficient is not statistically different for certified and non-certified dwellings, which provides some indication that there is limited evidence on the salience of energy efficiency increasing with the adoption of an

[18]Using a similar approach, Cerin et al. (2014) also report a positive price premium for a decreased level of energy efficiency for a sample of homes in Sweden.

[19]Figure 5, Panel B shows the variation in gas consumption per m^2 of homes based on construction year.

[20]Detailed first-stage and second-stage estimation results are provided in Appendix Table B.7 and Table B.8, respectively

EPC.[21]

[Insert Table 7 here]

We also examine directly whether the energy performance certificate has an additional impact on the transaction price. We apply a regression discontinuity (RD) approach based on the rule that is used to assign homes to energy efficiency labels ranging from "A" to "G". The basic idea behind this approach is that assignment to treatment is determined by the value of an observed characteristic being on either side of a cutoff value (Imbens and Lemieux, 2008). The main identifying assumption is that unobserved characteristics vary continuously with the observable characteristic that is used in the assignment rule (Jacob and Lefgren, 2004). We test whether a discontinuity exists in the transaction price of the dwelling around the threshold values of the energy performance index (EPI) for different label categories. Based on fixed threshold values of energy performance index (EPI), homes are assigned to different label categories. Homebuyers can observe the label category on their energy performance certificate, but not the calculated EPI. We focus on a narrow bandwidth (±0.2 EPI) around the threshold values. Figure 6 compares the label categories, plotting the variation in the adjusted transaction price based on the energy performance index around the cutoff points. We do not visually observe a clear discontinuity in transaction prices at the threshold points that are used to assign homes to different label categories.

[Insert Figure 6 here]

In order to formally test the potential labeling effect, we estimate the following model for each threshold level:

$$Log(Price_i) = \phi_0 + \phi_1 Log(EPI_i) + \phi_2 D_i^{L.label} Log(EPI_i) + \phi_3 D_i^{L.label} + \phi_j X_i + \varepsilon_i \quad (4)$$

[21]It is important to note that, as documented by Aydin et al. (2014), the actual energy consumption does not represent the exact efficiency level due to the existence of rebound effect. Therefore, the estimated market value of a decrease in the level of actual gas consumption is expected to be larger than the value of a decrease in the energy performance index (EPI), as it also captures the increased level of thermal comfort. The first stage results also support the rebound effect hypothesis, as the increased U-value has less impact on the actual gas consumption then it has on the energy performance index, although this difference is not statistically significant (Columns 2 and 3). This finding may also explain the larger coefficient we find by using actual gas consumption as compared to using the EPI.

where $D^{L.label}$ is a dummy variable which is equal to one for homes that were assigned to the label indicating lower energy efficiency level, and zero otherwise. X_i is a vector of dwelling characteristics. $Log(EPI_i)$ and $D_i^{L.label} Log(EPI_i)$ control for the continuous effect of the EPI on transaction price within each label category, and thus ϕ_3 represents the impact of label itself on the transaction price, which is our parameter of interest.

Table 8 reports the estimates of ϕ_3 for each threshold value that is used in the assignment to different label categories. For all cutoff points, the estimated change in transaction price that results from the assignment to a lower energy efficiency class is negative, but not statistically significant. Thus, there is not enough evidence to argue that labeling itself has a significant impact on the transaction price.

[Insert Table 8 here]

Finally, we examine whether the estimated value of energy efficiency varies over time. By using the actual gas consumption per m^2 as a proxy for energy efficiency, we are able to estimate the market value of residential energy efficiency for each year from 2003 to 2011. As reported in Table 9, we document that the estimated coefficient increases from 2003 to 2011, although the difference is not statistically significant. This can be explained partly by the decreasing house prices after 2008 and the relative increase in energy costs.

[Insert Table 9 here]

Figure 7 plots the average capitalized value of a 10 percent increase in energy efficiency over time, as well as the change in residential gas prices in the Netherlands. [22] In addition, the introduction of the EPC in 2008 might also have a general influence on the capitalization of energy efficiency (for both certified and non-certified dwellings), as it may change households' perception of the importance of energy efficiency.

[Insert Figure 7 here]

[22] See Kahn (1986), Allcott and Wozny (2014), Busse et al. (2013) for the anlysis of how the market value of fuel economy in the automobile sector is associated to the changes in gasoline prices.

4 Conclusion

Enhancing residential energy efficiency has been a key element of debate among policy makers, investors, and academics. Notwithstanding promising engineering estimates, large-scale diffusion of energy efficiency enhancements in the single-family residential market has been limited. One of the causes of such slow uptake may be that the returns associated with efficiency upgrades have not been properly identified and communicated. Requiring households to make upfront investments for an uncertain return has been further complicated during the recent period of financial liquidity constraints.

In this paper, we investigate how consumers capitalize energy efficiency in the housing market, and how the provision of an energy performance certificate affects this capitalization rate. Most of the literature addressing the capitalization of energy efficiency in the housing market suffers from a common methodological drawback – the potential bias that may arise from the omission of unobserved dwelling characteristics correlated with measures of energy efficiency. This paper contributes to this literature by using an instrumental variable approach to estimate the capitalization of energy efficiency in the residential sector. We also contribute to the literature by examining the impact of information provision, in the form of energy labels, on consumers' valuation of energy efficiency.

We examine a large representative dataset from the Netherlands, exploiting the discontinuity in the energy efficiency levels of homes constructed during the 1973-74 oil crisis, and the stringency of building codes at the time of construction as instruments for energy efficiency. The results indicate that the use of OLS leads to biased estimates of the market value of energy efficiency. Using an IV approach, we document that if the energy requirement of a dwelling is reduced by half, the market price of the dwelling increases by around 11 percent for an average dwelling in the Dutch housing market.

In order to examine whether the capitalization of energy efficiency varies with the disclosure of an EPC, we estimate the same model by using actual energy consumption as a proxy for a common energy efficiency measure for certified and non-certified homes. Our findings do not provide significant evidence suggesting a higher capitalization rate for dwellings that transacted with an energy performance certificate. We also use a regression discontinuity approach to test whether labeling itself has a market value. The results show that there is no significant change in the transaction price at the threshold energy efficiency level that is used to assign the dwellings into different label classes, which implies that labeling itself does not lead to a significant change in buyer's valuation of the dwelling.

Finally, we examine the over-time change in the market value of energy efficiency, and document that the value of energy efficiency has doubled from 2003 to 2011, which might be the result of increasing energy prices, the relative decrease in house prices after 2008 and the general influence of policies and information campaigns stressing the importance of energy efficiency.

Our findings imply that, beyond the direct financial benefits from lower energy expenses, residential energy efficiency improvements lead to higher transaction prices, regardless of the provision of an energy label. From a policy perspective, the results of this paper may be used to enhance the public awareness regarding the financial benefits of energy efficiency investments. In order to facilitate the uptake of energy efficiency measures, the financial benefits that homeowners can derive from energy efficiency improvements need to be emphasized in public information campaigns, and can also be incorporated into the energy performance certification programs. In relation to "energy efficiency gap" literature, our results also raise the question why energy efficiency investments in the housing sector are far below the optimal level, given that the market value of, for example, insulation is so much higher than its cost. The additional costs (such as the nuisance during the retrofit work and the information costs), the risk of undervaluation of the energy efficiency improvement in the market, liquidity constraints and the future discounting behavior might be some of the reasons that lead to this sub-optimal outcome. Thus, more research needs to be done to understand homeowners' investment decisions, and accordingly cost-effective policies need to be designed in a way to deal with these underlying reasons.

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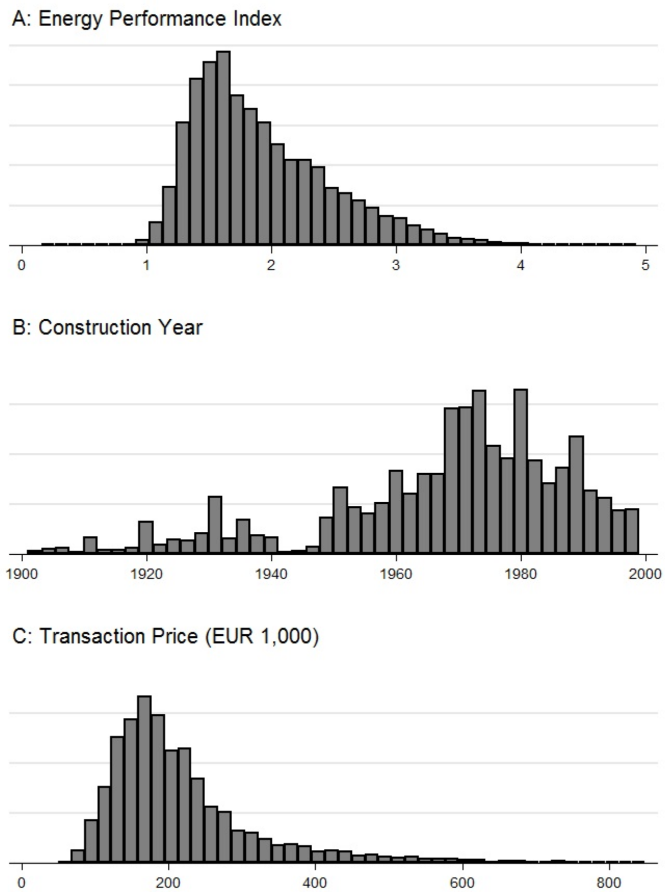
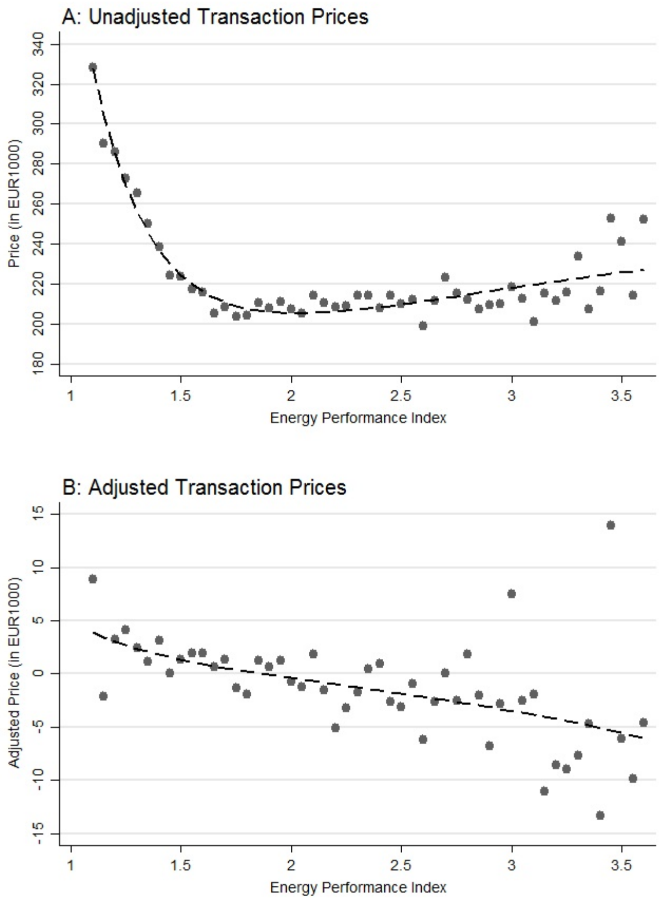
Figure 1: Distribution of Energy Performance Index, Construction Year and Transaction Price



Source: Netherlands Enterprise Agency (RVO), National Association of Realtors (NVM)

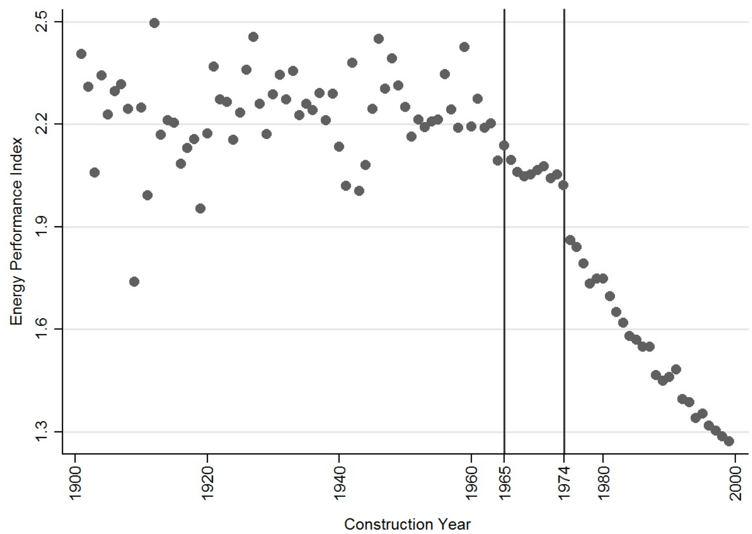
Figure 2: Transaction Prices and the Level of Energy Efficiency



Notes:
Panel A presents a figure relating home prices to the energy performance index (EPI). Panel B Presents a figure relating the residuals of an estimation of the hedonic model controlling for all other observable home characteristics to the energy performance index.

Source: Netherlands Enterprise Agency (RVO), National Association of Realtors (NVM), authors' calculations

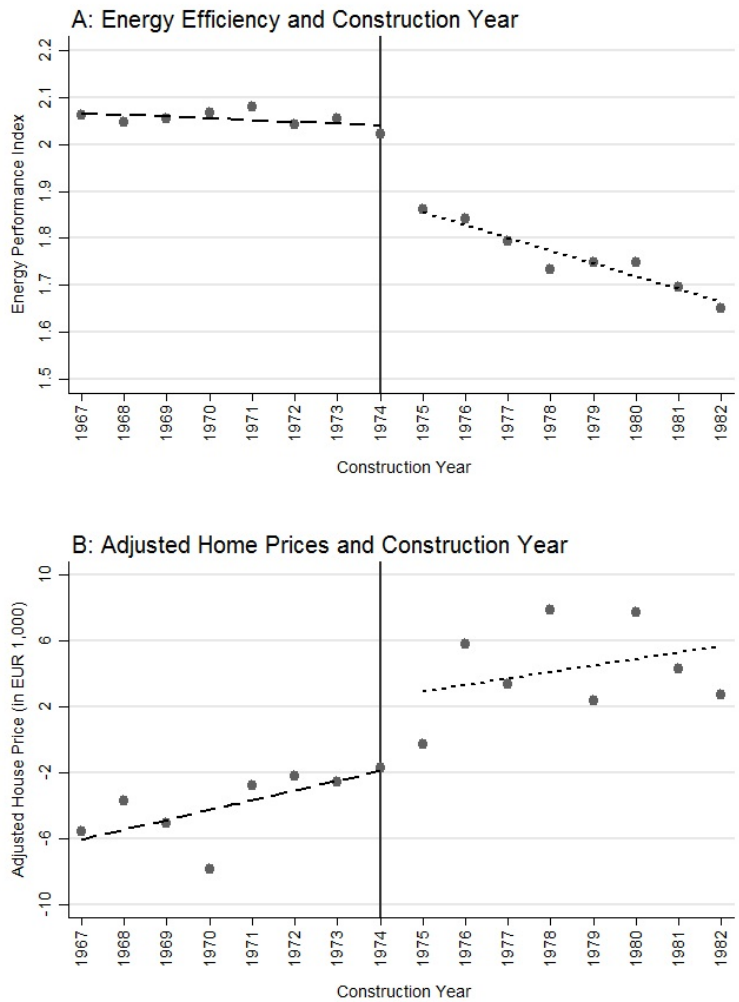
Figure 3: Home Energy Efficiency Levels by Year of Construction



Notes:
This graph presents the average energy performance index of homes for each construction year. The average EPI values are calculated based on the sample of houses that are constructed in each year. The first building code in the Netherlands was introduced in 1965. In 1974, oil prices increased by 260 percent.

Source: Netherlands Enterprise Agency (RVO), authors' calculations

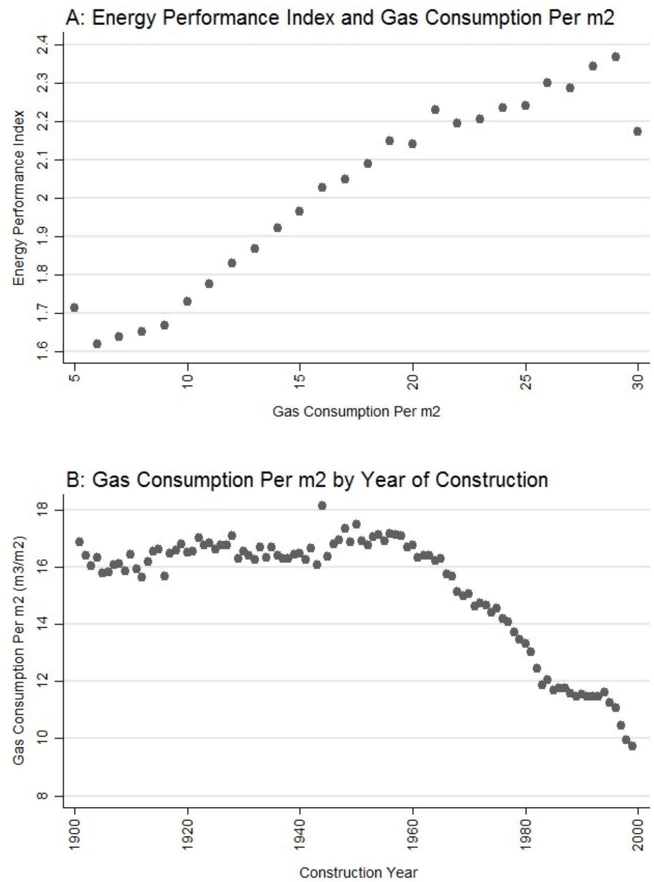
Figure 4: Energy Efficiency and Price of the Homes Constructed Before and After 1974



Notes:
Panel A presents the average energy performance index based on the year of construction before and after 1974 oil crisis. Panel B presents a figure relating the residuals of an estimation of the hedonic model (excluding EPI and construction year variables) to the year of construction.

Source: Netherlands Enterprise Agency (RVO), National Association of Realtors (NVM), authors' calculations

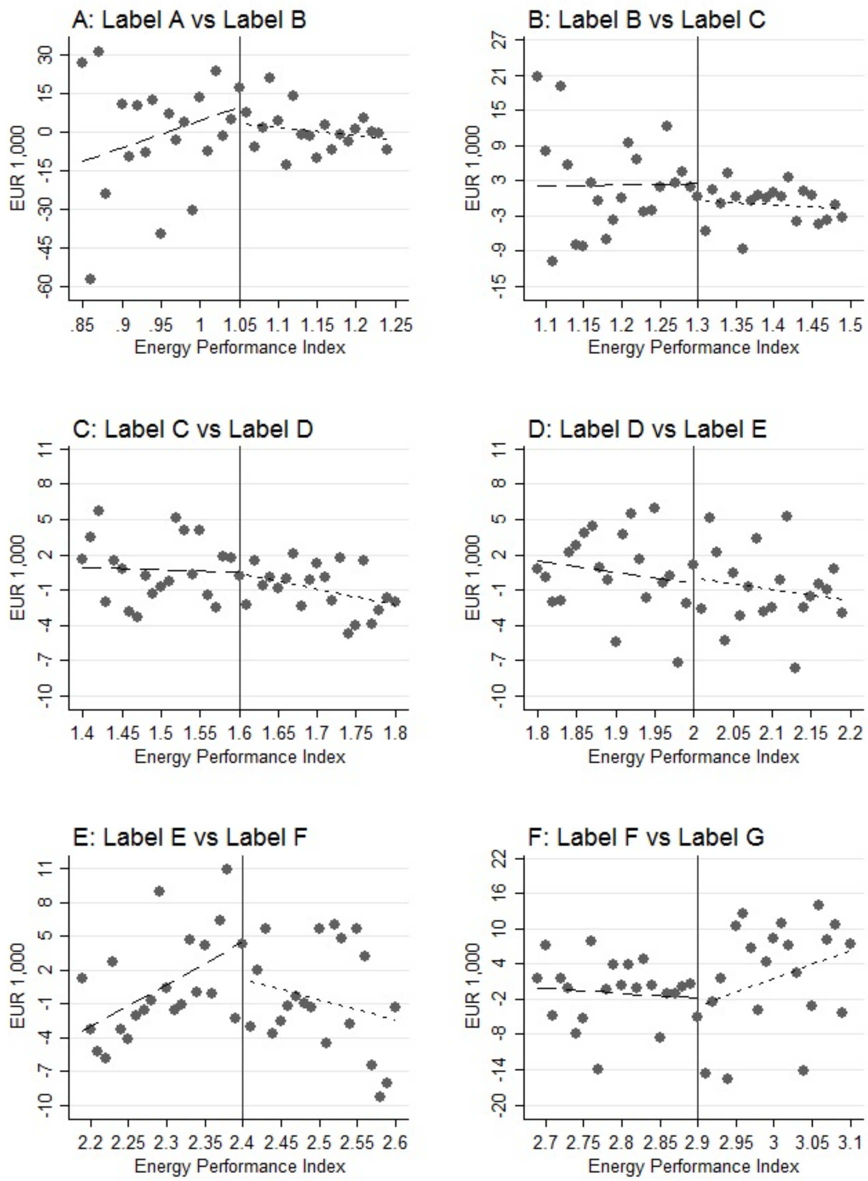
Figure 5: Gas Consumption, Energy Performance Index and Year of Construction



Notes:
Panel A presents the relationship between energy performance index (EPI) and gas consumption per m^2.
Panel B presents the average gas consumption (per m^2) of homes for each construction year. The average gas consumption (per m^2) values are calculated based on the sample of houses that are constructed in each year.

Source: Netherlands Enterprise Agency (RVO), Central Bureau of Statistics (CBS), authors' calculations

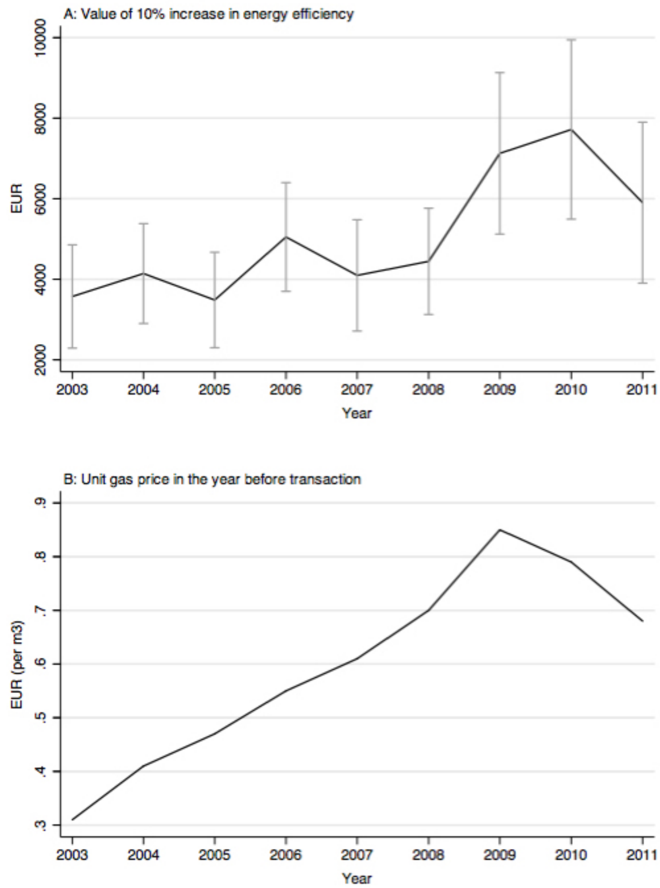
Figure 6: Transaction Prices (Adjusted) by Label Category and Energy Performance Index



Notes:
Threshold values of energy performance index (EPI), which are used to assign label categories (from A to G), are indicated by vertical lines. Each panel presents a figure relating the residuals of an estimation of the hedonic model controlling for all other observable home characteristics (excluding EPI) to the energy performance index.

Source: Netherlands Enterprise Agency (RVO), National Association of Realtors (NVM), authors' calculations

Figure 7: The Value of Energy Efficiency and Residential Gas Prices



Notes:
Panel A presents the estimated value of a 10 percent increase in energy efficiency in the housing market for each transaction year between 2003 and 2011. Vertical gray lines indicate the 95 percent confidence intervals for the point estimates. Panel B presents the one year lagged residential gas prices (€/m^3) for each transaction year.

Source: Central Bureau of Statistics (CBS), International Energy Agency, National Association of Realtors (NVM), authors' calculations

Table 1: Descriptive Statistics for Energy Efficient and Inefficient Dwellings

	Energy-efficient dwellings		Energy-inefficient dwellings	
	EPI≤1.8		*EPI>1.8*	
Number of Observations	*15,170*		*14,866*	
Variables	Mean	Std.Dev.	Mean	Std.Dev.
Transaction Price (€1,000)	229.3	(108.3)	210.8	(109.6)
Energy Performance Index (EPI)	1.507	(0.171)	2.342	(0.417)
Size (m^2)	122.9	(34.2)	116.3	(33.4)
Number of Rooms	4.822	(1.050)	4.835	(1.077)
Number of Floors	2.750	(0.545)	2.750	(0.592)
Year of Construction(Median)	1981		1965	
Type (fraction)				
Corner	0.249		0.257	
Semi-detached	0.103		0.139	
Between or Townhouse	0.552		0.508	
Detached	0.096		0.096	
Transaction Year (fraction)				
2008	0.435		0.425	
2009	0.206		0.218	
2010	0.172		0.176	
2011	0.187		0.181	

Notes:
Median energy performance index (EPI) value for the full sample is 1.8. Summary statistics are provided separately for homes having an energy performance index (EPI) that is smaller (“energy-efficient”) and larger (“energy-inefficient”) than this value.

Table 2: OLS Estimation Results: Home Prices and Energy Efficiency

	(1)	(2)	(3)	(4)
Log(Energy Performance Index)	-0.235***	-0.106***	-0.052***	-0.048***
	[0.019]	[0.007]	[0.007]	[0.007]
Dwelling Characteristics	No	Yes	Yes	Yes
Construction Year	No	No	Yes	Yes
R^2	0.106	0.836	0.843	0.846
Number of observations	30,036	30,036	30,036	30,036

Notes:
Dependent variable is the logarithm of transaction price. Home characteristics include: size, type, quality, number of floors, number of rooms, type of parking place, location of the home relative to city center, road, park, water and forest. Construction year is included as a third order polynomial in column (3). In column (4), dummy variables representing each construction year are included. In all regressions, neighborhood and year of transaction dummies are included. Heteroskedasticity-robust standard errors in parentheses. Standard errors are clustered by neighborhood and transaction year. *P<0.1. ** P<0.05. *** P<0.01

Table 3: IV Estimation Results (Discontinuity in 1974): Home Prices and Energy Efficiency

Construction Period	(1967-1982)	(1959-1990)	(1950-1999)
Log(Energy Performance Index)	-0.227***	-0.185**	-0.198***
	[0.090]	[0.085]	[0.064]
Dwelling Characteristics	Yes	Yes	Yes
Construction Year	Yes	Yes	Yes
R^2	0.852	0.852	0.854
First Stage			
D^{1974}	-0.080***	-0.060***	-0.073***
	[0.009]	[0.007]	[0.006]
F statistic for excluded instrument	74.03	73.20	134.85
Number of observations	12,513	20,270	25,311

Notes:
Dependent variable is the logarithm of transaction price. The energy performance index (EPI) is instrumented by D^{1974}. In all regressions, we include home characteristics, linear construction year variable (before and after 1974), neighborhood and year of transaction dummies as control variables. Home characteristics include: size, type, quality, number of floors, number of rooms, type of parking place, location of the home relative to city center, road, park, water and forest. Heteroskedasticity-robust standard errors in parentheses. Standard errors are clustered by neighborhood and transaction year. * P<0.1. ** P<0.05. *** P<0.01

Table 4: IV Estimation Results (Building Codes): Home Prices and Energy Efficiency

Log(Energy Performance Index)	-0.214***
	[0.074]
Dwelling Characteristics	Yes
Construction Year	Yes
R^2	0.837
First Stage Results	
U-value	0.071***
	[0.006]
F statistic for excluded instrument	138.00
Number of observations	30,036

Notes:
Dependent variable is the logarithm of transaction price. We include home characteristics, construction year variable, neighborhood and year of transaction dummies as control variables in the regression. Home characteristics include: size, type, quality, number of floors, number of rooms, type of parking place, location of the home relative to city center, road, park, water and forest. Heteroskedasticity-robust standard errors in parentheses. Standard errors are clustered by neighborhood and transaction year. * P<0.1. ** P<0.05. *** P<0.01

Table 5: Descriptive Statistics for Non-Certified and Certified Dwellings

	Non-Certified Dwellings		Certified Dwellings	
Number of Observations	*103,834*		*23,187*	
Variables	Mean	Std.Dev.	Mean	Std.Dev.
Transaction Price (€1000)	257.0	(113.3)	214.5	(100.1)
Gas Consumption (m^3)	1,795	(646)	1,647	(581)
Size (m^2)	126.9	(31.1)	117.5	(29.8)
Gas Consumption Intensity (m^3/m^2)	14.44	(4.82)	14.35	(4.67)
Number of Rooms	4.976	(1.073)	4.807	(1.032)
Number of Floors	2.790	(0.556)	2.756	(0.560)
Year of Construction (Median)	1965		1968	
Type (fraction)				
Corner	0.205		0.258	
Semi-Detached	0.164		0.121	
Between or Townhouse	0.490		0.537	
Detached	0.141		0.084	
Transaction Year (fraction)				
2008	0.277		0.434	
2009	0.230		0.205	
2010	0.257		0.173	
2011	0.236		0.188	
Household Characteristics				
Number of Household Members	2.405	(1.011)	2.270	(0.934)
Number of Elderly (Age>65)	0.343	(0.547)	0.332	(0.513)
Number of Children (Age<18)	0.597	(0.774)	0.529	(0.696)
Number of Female Household Members	1.209	(0.625)	1.158	(0.585)
Household Income (€1000)	35.34	(14.74)	31.21	(13.32)

Notes:
Table reports the summary statistics for certified and non-certified homes separately. Average household characteristics and gas consumption are calculated based on the households that reside in each dwelling between 2004-2011 (Gas consumption data is not available for the years 2005 and 2007). In calculating the average gas consumption level for each home, we correct for annual heating degree days and exclude the years of transaction.

Table 6: OLS Estimation Results for Non-Certified and Certified Dwellings

	(1)	(2)	(3)	(4)	(5)
Log(Actual Gas Cons. per m^2)	-0.071***	0.049***	0.112***	0.105***	0.086***
	[0.008]	[0.004]	[0.003]	[0.003]	[0.005]
Dwelling Characteristics	No	Yes	Yes	Yes	Yes
Construction Year	No	No	Yes	Yes	Yes
Household Characteristics	No	No	No	Yes	Yes
R^2	0.010	0.756	0.774	0.794	0.855
Number of Observations	103,834	103,834	103,834	103,834	23,187

Notes:
Dependent variable is the logarithm of transaction price. Home characteristics include: size, type, quality, number of floors, number of rooms, type of parking place, location of the home relative to city center, road, park, water and forest. Household characteristics include: number of household members, number of children (age<18), number of elderly (age>65), number of females and household net income. Construction year is included as a third order polynomial. In column (5), we estimate the same model for the sample of certified homes only. In all regressions, neighborhood and year of transaction dummies are included. Heteroskedasticity-robust standard errors in parentheses. Standard errors are clustered by neighborhood and transaction year. * P<0.1. ** P<0.05. *** P<0.01

Table 7: IV Estimation Results for Non-Certified and Certified Dwellings

	(1) Non-certified	(2) Certified	(3) Certified
Log(Actual Gas Cons. per m^2)	-0.239***	-0.195**	
	[0.052]	[0.090]	
Log(Energy Performance Index)			-0.185***
			[0.080]
Dwelling Characteristics	Yes	Yes	Yes
Construction Year	Yes	Yes	Yes
Household Characteristics	Yes	Yes	Yes
R^2	0.740	0.818	0.844
First Stage Results			
U-value	0.068***	0.065***	0.069***
	[0.004]	[0.009]	[0.006]
F statistic for excluded instrument	307.10	50.07	113.37
Number of Observations	103,834	23,187	23,187

Notes:
Dependent variable is the logarithm of transaction price. In all regressions, we include household characteristics, home characteristics, construction year variable, neighborhood and year of transaction dummies as control variables. Home characteristics include: size, type, quality, number of floors, number of rooms, type of parking place, location of the home relative to city center, road, park, water and forest. Household characteristics include: number of household members, number of children (age<18), number of elderly (age>65), number of females and household net income. Heteroskedasticity-robust standard errors in parentheses. Standard errors are clustered by neighborhood and transaction year. * P<0.1. ** P<0.05. *** P<0.01

Table 8: Regression Discontinuity Estimation Results for Label Effect

	(A-B)	(B-C)	(C-D)	(D-E)	(E-F)	(F-G)
$D^{L.label}$=1	-0.013	-0.012	-0.002	-0.000	- 0.007	-0.015
	[0.029]	[0.008]	[0.007]	[0.008]	[0.011]	[0.018]
Log(EPI)	0.171	-0.011	-0.019	-0.052	0.300**	-0.055
	[0.262]	[0.085]	[0.059]	[0.089]	[0.136]	[0.270]
Log(EPI)*$D^{L.label}$	-0.433	-0.060	-0.088	-0.037	-0.494**	0.530
	[0.312]	[0.107]	[0.093]	[0.152]	[0.224]	[0.464]
Dwelling Characteristics	Yes	Yes	Yes	Yes	Yes	Yes
Construction Year	Yes	Yes	Yes	Yes	Yes	Yes
R^2	0.841	0.863	0.848	0.841	0.843	0.825
Number of Observations	1,461	6,879	11,009	6,899	4,606	2,146

Notes:
Dependent variable is the logarithm of transaction price. We include home characteristics, construction year variable, neighborhood and year of transaction dummies as control variables in the regressions. Home characteristics include: size, type, quality, number of floors, number of rooms, type of parking place, location of the home relative to city center, road, park, water and forest. Heteroskedasticity-robust standard errors in parentheses. Standard errors are clustered by neighborhood and transaction year. * P<0.1. ** P<0.05. *** P<0.01

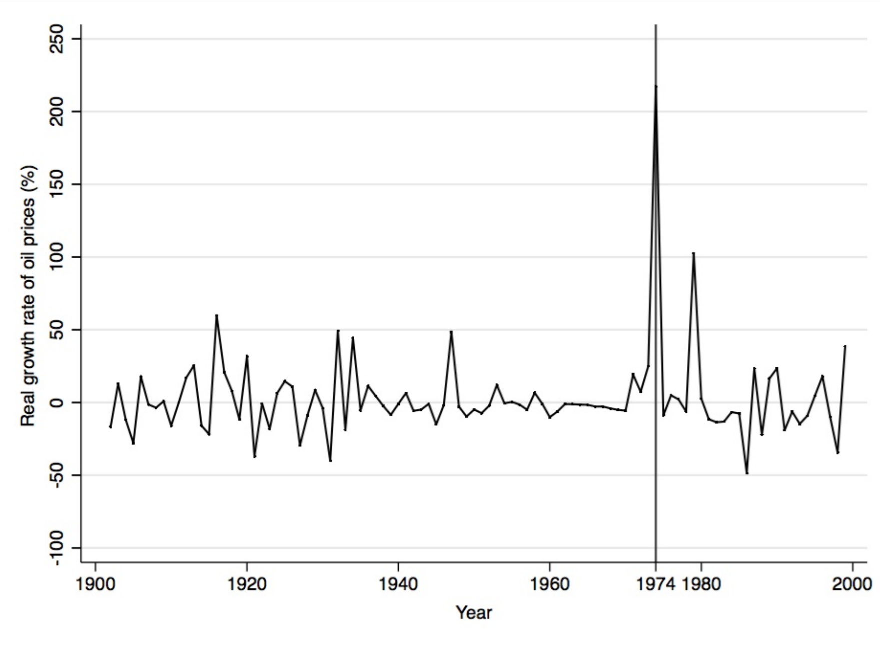
Table 9: The Capitalization of Energy Efficiency Over Time

Year	Log(Gas Cons. per m^2)	N
2003	-0.156***	42,346
	[0.056]	
2004	-0.177***	42,847
	[0.053]	
2005	-0.144***	48,702
	[0.049]	
2006	-0.202***	48,632
	[0.054]	
2007	-0.160***	47,976
	[0.054]	
2008	-0.175***	39,030
	[0.052]	
2009	-0.302***	28,742
	[0.085]	
2010	-0.319***	30,768
	[0.092]	
2011	-0.248***	28,936
	[0.084]	

Notes:
Dependent variable is the logarithm of transaction price. In all regressions, we include household characteristics, home characteristics, construction year variable, and neighborhood dummies as control variables. Home characteristics are: size, type, quality, number of floors, number of rooms, type of parking place, location of the home relative to city center, road, park, water and forest. Household characteristics include: number of household members, number of children (age<18), number of elderly (age>65), number of females and household net income. We include both certified and non-certified homes in the analysis. Heteroskedasticity-robust standard errors in parentheses. Standard errors are clustered by neighborhood. * P<0.1. ** P<0.05. *** P<0.01

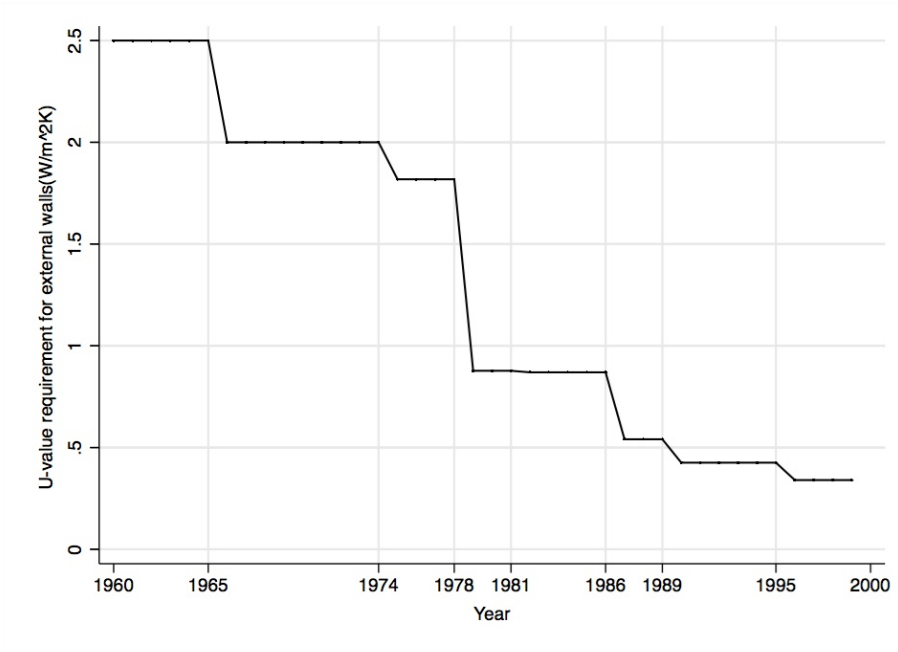
A Appendix

Figure A.1: Development of Oil Prices



Source: International Energy Agency

Figure A.2: Maximum Allowable U-value for External Walls of New Constructions in NL



Source: Netherlands Enterprise Agency (RVO)

Table A.1: OLS Estimation Results: Home Prices and Energy Efficiency

	(1)	(2)	(3)	(4)
Log (Energy performance index)	-0.235***	-0.106***	-0.052***	-0.048***
	(0.019)	(0.007)	(0.007)	(0.007)
Log (House size)		0.673***	0.671***	0.676***
		(0.012)	(0.013)	(0.013)
Number of rooms		0.015***	0.019***	0.019***
		(0.002)	(0.002)	(0.002)
Number of floors		-0.013***	-0.017***	- 0.018***
		(0.004)	(0.003)	(0.003)
Home type=Semi-detached		0.129***	0.112***	0.109***
		(0.005)	(0.005)	(0.005)
Home type=Between or Townhouse		-0.031***	-0.033***	0.033***
		(0.002)	(0.002)	(0.002)
Home type=Detached house		0.318***	0.296***	0.292***
		(0.006)	(0.007)	(0.007)
Parking place		0.055***	0.049***	0.045***
		(0.006)	(0.006)	(0.006)
Only carport		0.072***	0.075***	0.074***
		(0.008)	(0.007)	(0.007)
Only garage		0.147***	0.146***	0.143***
		(0.004)	(0.004)	(0.004)
Garage and carport		0.175***	0.172***	0.171***
		(0.009)	(0.009)	(0.009)
Garage for multiple cars		0.188***	0.192***	0.190***
		(0.009)	(0.009)	(0.009)
Location relative to the center (unspecified)		-0.154***	-0.142***	-0.144***
		(0.016)	(0.016)	(0.016)
Location relative to the center (residential area)		-0.175***	-0.160***	-0.160***
		(0.016)	(0.016)	(0.016)
Location relative to the center (center)		-0.127***	-0.130***	-0.133***
		(0.017)	(0.017)	(0.017)
Near forest		0.116***	0.127***	0.126***
		(0.010)	(0.010)	(0.010)
Near waterside		0.087***	0.078***	0.076***
		(0.006)	(0.006)	(0.006)
Near park		0.043***	0.044***	0.041***
		(0.006)	(0.006)	(0.006)
Clear view		0.027***	0.028***	0.028***
		(0.004)	(0.003)	(0.003)
Location relative to the road (unspecified)		-0.012***	-0.012***	-0.012***
		(0.003)	(0.003)	(0.002)
Location relative to the road (near a busy road)		-0.033***	-0.041***	-0.042***
		(0.009)	(0.009)	(0.009)
Quality==0		-0.058**	-0.055**	-0.046*
		(0.028)	(0.027)	(0.026)
Quality==1		-0.062***	-0.056***	-0.051***
		(0.020)	(0.018)	(0.018)
Quality==2		0.458***	0.450***	0.443***
		(0.097)	(0.097)	(0.103)
Construction year			0.002***	
			(0.000)	
Construction year^2			0.000***	
			(0.000)	
Construction year^3			0.000***	
			(0.000)	
Constant	5.580***	1.851***	1.779***	1.899***
	(0.017)	(0.070)	(0.074)	(0.099)
Observations	30,036	30,036	30,036	30,036
R-squared	0.106	0.836	0.843	0.846

Notes:
Dependent variable is logarithm of the transaction price. The omitted categories are: for ”home type” variable it is ”Corner house”, for ”parking type” variable it is ”no parking place”, for ”location relative to the center” variable it is ”outside the urban area”, for ”view type” variable it is ”not specified”, for ”location relative to the road” variable it is ”near a quite road”, and for ”quality” variable it is ”not specified”.

Table A.2: IV First-stage Estimation Results: Discontinuity in 1974

Construction Period	(1950-1999)	(1959-1990)	(1967-1982)
D^{1974}	-0.073***	-0.060***	-0.080***
	(0.006)	(0.007)	(0.009)
Construction-year (until1974)	-0.004***	-0.006***	-0.001
	(0.001)	(0.001)	(0.002)
Construction-year (after 1974)	-0.012***	-0.011***	-0.013***
	(0.001)	(0.001)	(0.002)
Log of house size(m^2)	-0.064***	-0.064***	-0.066***
	(0.010)	(0.012)	(0.015)
Number of rooms	-0.002	-0.003	-0.002
	(0.002)	(0.002)	(0.003)
Number of floors	0.009**	0.011***	0.014**
	(0.004)	(0.004)	(0.005)
Home type=Semi-detached	0.013**	0.007	0.005
	(0.005)	(0.006)	(0.009)
Home type=Between or Townhouse	-0.014***	-0.013***	-0.020***
	(0.003)	(0.003)	(0.004)
Home type=Detached house	-0.005	0.002	0.020
	(0.008)	(0.009)	(0.013)
Parking place	-0.004	-0.010	-0.015
	(0.006)	(0.007)	(0.010)
Only carport	-0.004	-0.006	-0.006
	(0.007)	(0.008)	(0.010)
Only garage	0.004	0.007	0.005
	(0.004)	(0.005)	(0.006)
Garage and carport	-0.020**	-0.017	-0.027*
	(0.010)	(0.012)	(0.016)
Garage for multiple cars	-0.007	0.002	-0.001
	(0.011)	(0.013)	(0.017)
Location relative to the center (unspecified)	-0.011	0.012	-0.012
	(0.022)	(0.024)	(0.032)
Location relative to the center (residential area)	-0.021	0.004	-0.014
	(0.022)	(0.024)	(0.032)
Location relative to the center (center)	-0.007	0.025	0.017
	(0.024)	(0.027)	(0.035)
Near forest	0.013	0.018	0.014
	(0.012)	(0.014)	(0.017)
Near waterside	-0.004	-0.002	-0.002
	(0.006)	(0.007)	(0.010)
Near park	-0.000	-0.009	-0.009
	(0.007)	(0.008)	(0.010)
Clear view	-0.003	-0.006	-0.016***
	(0.004)	(0.005)	(0.006)
Location relative to the road (unspecified)	-0.001	-0.002	-0.001
	(0.003)	(0.003)	(0.004)
Location relative to the road (near a busy road)	0.008	0.013	0.003
	(0.012)	(0.013)	(0.016)
Quality==0	-0.061**	-0.055**	-0.072**
	(0.026)	(0.026)	(0.032)
Quality==1	-0.006	-0.017	-0.028
	(0.018)	(0.015)	(0.022)
Quality==2	-0.094	-0.105*	-0.093
	(0.065)	(0.060)	(0.100)
Constant	0.988***	0.947***	0.885***
	(0.062)	(0.069)	(0.124)
Observations	25,311	20,270	12,513
R-squared	0.445	0.362	0.258

Notes:
Dependent variable is the logarithm of energy performance index. The omitted categories are: for "home type" variable it is "Corner house", for "parking type" variable it is "no parking place", for "location relative to the center" variable it is "outside the urban area", for "view type" variable it is "not specified", for "location relative to the road" variable it is "near a quite road", and for "quality" variable it is "not specified".

Table A.3: IV Second-stage Estimation Results: Discontinuity in 1974

Construction Period	(1950-1999)	(1959-1990)	(1967-1982)
Log (Energy performance index)	-0.198***	-0.185**	-0.227**
	(0.064)	(0.085)	(0.090)
Log of house size(m^2)	0.613***	0.597***	0.595***
	(0.012)	(0.012)	(0.015)
Number of rooms	0.014***	0.014***	0.014***
	(0.002)	(0.002)	(0.003)
Number of floors	-0.026***	-0.030***	-0.037***
	(0.004)	(0.004)	(0.005)
Home type=Semi-detached	0.110***	0.120***	0.137***
	(0.005)	(0.006)	(0.008)
Home type=Between or Townhouse	-0.037***	-0.035***	- 0.039***
	(0.002)	(0.003)	(0.003)
Home type=Detached house	0.324***	0.342***	0.365***
	(0.007)	(0.008)	(0.011)
Parking place	0.044***	0.039***	0.039***
	(0.006)	(0.006)	(0.009)
Only carport	0.076***	0.070***	0.059***
	(0.007)	(0.007)	(0.008)
Only garage	0.155***	0.154***	0.145***
	(0.004)	(0.004)	(0.005)
Garage and carport	0.172***	0.171***	0.161***
	(0.009)	(0.010)	(0.014)
Garage for multiple cars	0.209***	0.218***	0.223***
	(0.010)	(0.011)	(0.014)
Location relative to the center (unspecified)	-0.176***	-0.153***	-0.144***
	(0.021)	(0.023)	(0.028)
Location relative to the center (residential area)	-0.192***	-0.168***	-0.160***
	(0.020)	(0.023)	(0.028)
Location relative to the center (center)	-0.150***	-0.128***	-0.130***
	(0.022)	(0.025)	(0.032)
Near forest	0.130***	0.133***	0.113***
	(0.010)	(0.011)	(0.013)
Near waterside	0.077***	0.076***	0.067***
	(0.006)	(0.007)	(0.010)
Near park	0.037***	0.038***	0.040***
	(0.006)	(0.006)	(0.008)
Clear view	0.027***	0.023***	0.016***
	(0.003)	(0.004)	(0.005)
Location relative to the road (unspecified)	-0.011***	-0.011***	-0.010***
	(0.002)	(0.003)	(0.003)
Location relative to the road (near a busy road)	-0.026***	-0.028**	-0.035***
	(0.010)	(0.011)	(0.013)
Quality==0	-0.113***	-0.120***	-0.162***
	(0.026)	(0.026)	(0.032)
Quality==1	-0.097***	-0.099***	-0.132***
	(0.018)	(0.020)	(0.028)
Quality==2	0.355**	0.350**	0.464***
	(0.158)	(0.165)	(0.176)
Construction-year (until 1974)	-0.002***	-0.001*	0.005***
	(0.001)	(0.001)	(0.001)
Construction-year (after 1974)	0.006***	0.005***	-0.006**
	(0.001)	(0.001)	(0.002)
Constant	2.295***	2.344***	2.400***
	(0.082)	(0.095)	(0.106)
Observations	25,311	20,270	12,513
R-squared	0.854	0.852	0.852

Notes:
Dependent variable is the logarithm of transaction price. The omitted categories are: for ”home type” variable it is ”Corner house”, for ”parking type” variable it is ”no parking place”, for ”location relative to the center” variable it is ”outside the urban area”, for ”view type” variable it is ”not specified”, for ”location relative to the road” variable it is ”near a quite road”, and for ”quality” variable it is ”not specified”.

Table A.4: IV First-stage Estimation Results: U-value Requirements for Walls

U-value requirement for external walls	0.071***
	(0.006)
Home type=Semi-detached	0.004
	(0.005)
Home type=Between or Townhouse	-0.016***
	(0.003)
Home type=Detached house	-0.014**
	(0.007)
Log of house size(m^2)	-0.059***
	(0.010)
Number of rooms	-0.000
	(0.002)
Number of floors	0.010***
	(0.004)
Parking place	-0.013**
	(0.007)
Only carport	-0.008
	(0.007)
Only garage	0.005
	(0.004)
Garage and carport	-0.020**
	(0.010)
Garage for multiple cars	-0.020*
	(0.010)
Location relative to the center (unspecified)	0.008
	(0.016)
Location relative to the center (residential area)	0.001
	(0.016)
Location relative to the center (center)	0.014
	(0.018)
Near forest	0.003
	(0.012)
Near waterside	-0.005
	(0.006)
Near park	-0.002
	(0.007)
Clear view	0.001
	(0.004)
Location relative to the road (unspecified)	-0.001
	(0.003)
Location relative to the road (near a busy road)	0.018*
	(0.010)
Quality==0	-0.061**
	(0.025)
Quality==1	-0.004
	(0.015)
Quality==2	-0.128***
	(0.044)
Construction-year	-0.008***
	(0.000)
Construction-year^2	-0.000***
	(0.000)
Construction-year^3	-0.000***
	(0.000)
Constant	0.768***
	(0.054)
Observations	30,036
R-squared	0.414

Notes:
Dependent variable is the logarithm of energy performance index. The omitted categories are: for ”home type” variable it is ”Corner house”, for ”parking type” variable it is ”no parking place”, for ”location relative to the center” variable it is ”outside the urban area”, for ”view type” variable it is ”not specified”, for ”location relative to the road” variable it is ”near a quite road”, and for ”quality” variable it is ”not specified”.

Table A.5: IV Second-stage Estimation Results: U-value Requirements for Walls

Log (Energy performance index)	-0.214***
	(0.074)
Home type=Detached house	0.112***
	(0.005)
Home type=Between or Townhouse	-0.035***
	(0.003)
Home type=Detached house	0.294***
	(0.007)
Log of house size(m^2)	0.662***
	(0.014)
Number of rooms	0.019***
	(0.002)
Number of floors	-0.015***
	(0.004)
Parking place	0.047***
	(0.006)
Only carport	0.074***
	(0.007)
Only garage	0.147***
	(0.004)
Garage and carport	0.169***
	(0.009)
Garage for multiple cars	0.188***
	(0.009)
Location relative to the center (unspecified)	-0.140***
	(0.017)
Location relative to the center (residential area)	-0.159***
	(0.016)
Location relative to the center (center)	-0.128***
	(0.018)
Near forest	0.127***
	(0.011)
Near waterside	0.077***
	(0.006)
Near park	0.043***
	(0.006)
Clear view	0.028***
	(0.003)
Location relative to the road (unspecified)	-0.013***
	(0.003)
Location relative to the road (near a busy road)	-0.038***
	(0.009)
Quality==0	-0.065**
	(0.028)
Quality==1	-0.057***
	(0.018)
Quality==2	0.430***
	(0.099)
Construction-year	0 .000
	(0.001)
Construction-year^2	0.000***
	(0.000)
Construction-year^3	0.000***
	(0.000)
Constant	1.920***
	(0.095)
Observations	30,036
R-squared	0.837

Notes:
Dependent variable is the logarithm of transaction price. The omitted categories are: for ”home type” variable it is ”Corner house”, for ”parking type” variable it is ”no parking place”, for ”location relative to the center” variable it is ”outside the urban area”, for ”view type” variable it is ”not specified”, for ”location relative to the road” variable it is ”near a quite road”, and for ”quality” variable it is ”not specified”.

Table A.6: OLS Estimation Results based on Gas Consumption per m^2

	(1)	(2)	(3)	(4)	(5)
Log (Gas consumption per m^2)	-0.071***	0.049***	0.112***	0.105***	0.086***
	(0.008)	(0.004)	(0.003)	(0.003)	(0.005)
Log of house size(m^2)		0.813***	0.802***	0.720***	0.632***
		(0.009)	(0.009)	(0.008)	(0.013)
Number of rooms		0.012***	0.016***	0.013***	0.014***
		(0.001)	(0.001)	(0.001)	(0.002)
Number of floors		-0.016***	-0.017***	-0.020***	-0.014***
		(0.002)	(0.002)	(0.002)	(0.004)
Home type=Detached house		0.103***	0.090***	0.085***	0.101***
		(0.003)	(0.003)	(0.003)	(0.005)
Home type=Between or Townhouse		-0.028***	-0.024***	-0.025***	-0.022***
		(0.002)	(0.002)	(0.002)	(0.002)
Home type=Detached house		0.259***	0.240***	0.239***	0.267***
		(0.004)	(0.004)	(0.004)	(0.007)
Parking place		0.055***	0.044***	0.038***	0.041***
		(0.004)	(0.003)	(0.003)	(0.006)
Only carport		0.070***	0.070***	0.062***	0.063***
		(0.004)	(0.004)	(0.004)	(0.007)
Only garage		0.111***	0.110***	0.104***	0.127***
		(0.002)	(0.002)	(0.002)	(0.004)
Garage and carport		0.142***	0.133***	0.124***	0.149***
		(0.005)	(0.004)	(0.004)	(0.009)
Garage for multiple cars		0.140***	0.146***	0.143***	0.178***
		(0.004)	(0.004)	(0.004)	(0.010)
Location relative to the center (unspecified)		-0.133***	-0.140***	-0.145***	-0.186***
		(0.007)	(0.007)	(0.007)	(0.018)
Location relative to the center (residential area)		-0.149***	-0.163***	-0.171***	-0.205***
		(0.007)	(0.008)	(0.008)	(0.018)
Location relative to the center (center)		-0.149***	-0.158***	-0.161***	-0.176***
		(0.008)	(0.008)	(0.008)	(0.019)
Near forest		0.120***	0.121***	0.112***	0.100***
		(0.006)	(0.006)	(0.006)	(0.011)
Near waterside		0.085***	0.069***	0.066***	0.072***
		(0.004)	(0.004)	(0.004)	(0.007)
Near park		0.034***	0.035***	0.029***	0.035***
		(0.003)	(0.003)	(0.003)	(0.006)
Clear view		0.025***	0.025***	0.025***	0.025***
		(0.002)	(0.002)	(0.002)	(0.004)
Location relative to the road (unspecified)		-0.014***	-0.014***	-0.011***	-0.009***
		(0.002)	(0.002)	(0.002)	(0.003)
Location relative to the road (near a busy road)		-0.066***	-0.068***	-0.057***	-0.037***
		(0.005)	(0.005)	(0.005)	(0.009)
Quality==0		-0.246***	-0.248***	-0.217***	-0.066**
		(0.054)	(0.053)	(0.049)	(0.028)
Quality==1		-0.041**	-0.042**	-0.046**	-0.056***
		(0.020)	(0.019)	(0.018)	(0.020)
Quality==2		0.098	0.082	0.070	0.182**
		(0.081)	(0.080)	(0.072)	(0.081)
Construction-year			0.003***	0.003***	0.003***
			(0.000)	(0.000)	(0.000)
Construction-year^2			0.000***	0.000***	0.000***
			(0.000)	(0.000)	(0.000)
Construction-year^3			0.000***	0.000***	0.000***
			(0.000)	(0.000)	(0.000)
Number of household members				-0.040***	-0.044***
				(0.002)	(0.004)
Number of children (age<18)				0.026***	0.030***
				(0.002)	(0.004)
Number of elderly (age>64)				0.007***	0.014***
				(0.002)	(0.003)
Number of female				0.017***	0.015***
				(0.001)	(0.003)
Log (income)				0.174***	0.158***
				(0.003)	(0.006)
Constant	5.701***	1.049***	0.887***	-0.403***	0.211**
	(0.021)	(0.053)	(0.053)	(0.066)	(0.103)
Observations	103,834	103,834	103,834	103,834	23,187
R-squared	0.010	0.756	0.774	0.794	0.855

Notes:
Dependent variable is the logarithm of transaction price. The omitted categories are: for ”home type” variable it is ”Corner house”, for ”parking type” variable it is ”no parking place”, for ”location relative to the center” variable it is ”outside the urban area”, for ”view type” variable it is ”not specified”, for ”location relative to the road” variable it is ”near a quite road”, and for ”quality” variable it is ”not specified”.

Table A.7: IV Estimation First-stage Results for Non-EPC Sample

	(1)	(2)	(3)
U-value requirement for external walls	0.068***	0.065***	0.069***
	(0.004)	(0.009)	(0.006)
Construction-year	-0.005***	-0.004***	-0.008***
	(0.000)	(0.001)	(0.000)
Construction-year^2	-0.000***	-0.000***	-0.000***
	(0.000)	(0.000)	(0.000)
Construction-year^3	-0.000***	-0.000***	-0.000***
	(0.000)	(0.000)	(0.000)
Log of house size(m^2)	-0.444***	-0.477***	-0.031***
	(0.006)	(0.013)	(0.012)
Number of rooms	0.012***	0.009***	0.005**
	(0.001)	(0.002)	(0.002)
Number of floors	-0.023***	-0.013***	0.014***
	(0.002)	(0.004)	(0.004)
Home type=Detached house	0.018***	0.015**	0.007
	(0.003)	(0.007)	(0.006)
Home type=Between or Townhouse	-0.123***	-0.118***	- 0.017***
	(0.002)	(0.004)	(0.003)
Home type=Detached house	0.093***	0.107***	- 0.023***
	(0.004)	(0.008)	(0.008)
Parking place	0.025***	0.024**	-0.012
	(0.004)	(0.011)	(0.008)
Only carport	0.016***	0.024**	-0.008
	(0.004)	(0.012)	(0.009)
Only garage	0.053***	0.057***	0.007
	(0.002)	(0.005)	(0.005)
Garage and carport	0.046***	0.049***	-0.023**
	(0.005)	(0.015)	(0.012)
Garage for multiple cars	0.036***	0.052***	-0.015
	(0.005)	(0.012)	(0.013)
Location relative to the center (unspecified)	0.054***	-0.008	0.035*
	(0.007)	(0.021)	(0.020)
Location relative to the center (residential area)	0.048***	-0.014	0.032
	(0.007)	(0.021)	(0.020)
Location relative to the center (center)	0.059***	0.016	0.037*
	(0.008)	(0.023)	(0.022)
Near forest	0.030***	0.064***	0.004
	(0.006)	(0.014)	(0.013)
Near waterside	0.013***	0.011	-0.007
	(0.004)	(0.010)	(0.007)
Near park	0.016***	0.015	-0.005
	(0.004)	(0.010)	(0.008)
Clear view	0.002	-0.001	0.003
	(0.002)	(0.006)	(0.005)
Location relative to the road (unspecified)	-0.002	0.000	-0.001
	(0.002)	(0.004)	(0.003)
Location relative to the road (near a busy road)	0.020***	0.031***	0.017
	(0.006)	(0.012)	(0.012)
Quality==0	-0.082**	-0.023	-0.061*
	(0.037)	(0.049)	(0.031)
Quality==1	-0.075***	-0.071**	0.021
	(0.020)	(0.032)	(0.017)
Quality==2	-0.126**	-0.332	-0.073**
	(0.058)	(0.238)	(0.030)
Number of household members	0.013***	0.024***	-0.019***
	(0.002)	(0.005)	(0.004)
Number of children (age<18)	0.003	0.005	0.010**
	(0.003)	(0.006)	(0.004)
Number of elderly (age>64)	0.072***	0.051***	0.023***
	(0.002)	(0.004)	(0.003)
Number of female	0.019***	0.014***	-0.003
	(0.002)	(0.005)	(0.003)
Log (income)	0.036***	0.045***	-0.022***
	(0.003)	(0.007)	(0.005)
Constant	4.179***	4.367***	0.825***
	(0.036)	(0.079)	(0.075)
Observations	103,834	23,187	23,187
R-squared	0.392	0.375	0.417

Notes:
Dependent variable is the logarithm of gas consumption per m^2. The omitted categories are: for "home type" variable it is "Corner house", for "parking type" variable it is "no parking place", for "location relative to the center" variable it is "outside the urban area", for "view type" variable it is "not specified", for "location relative to the road" variable it is "near a quite road", and for "quality" variable it is "not specified".

Table A.8: IV Estimation Second-stage Results for Non-EPC Sample

	(1)	(2)	(3)
Log (Gas consumption per m^2)	-0.239***	-0.195**	
	(0.052)	(0.090)	
Log (Energy performance index)			-0.185**
			(0.080)
Log of house size(m^2)	0.569***	0.500***	0.587***
	(0.022)	(0.044)	(0.013)
Number of rooms	0.018***	0.016***	0.015***
	(0.001)	(0.002)	(0.002)
Number of floors	-0.028***	-0.018***	-0.013***
	(0.002)	(0.004)	(0.004)
Home type=Detached house	0.091***	0.105***	0.104***
	(0.003)	(0.005)	(0.005)
Home type=Between or Townhouse	-0.067***	-0.054***	-0.035***
	(0.007)	(0.011)	(0.003)
Home type=Detached house	0.271***	0.297***	0.272***
	(0.006)	(0.012)	(0.008)
Parking place	0.046***	0.047***	0.040***
	(0.004)	(0.007)	(0.006)
Only carport	0.067***	0.070***	0.064***
	(0.004)	(0.008)	(0.007)
Only garage	0.123***	0.144***	0.134***
	(0.004)	(0.007)	(0.004)
Garage and carport	0.140***	0.163***	0.149***
	(0.005)	(0.011)	(0.010)
Garage for multiple cars	0.155***	0.193***	0.180***
	(0.005)	(0.011)	(0.010)
Location relative to the center (unspecified)	-0.126***	-0.187***	-0.179***
	(0.008)	(0.018)	(0.018)
Location relative to the center (residential area)	-0.154***	-0.208***	-0.199***
	(0.009)	(0.018)	(0.018)
Location relative to the center (center)	-0.140***	-0.171***	-0.168***
	(0.009)	(0.020)	(0.019)
Near forest	0.122***	0.118***	0.106***
	(0.006)	(0.013)	(0.011)
Near waterside	0.070***	0.075***	0.071***
	(0.004)	(0.007)	(0.007)
Near park	0.034***	0.039***	0.035***
	(0.004)	(0.007)	(0.006)
Clear view	0.026***	0.025***	0.026***
	(0.002)	(0.004)	(0.004)
Location relative to the road (unspecified)	-0.012***	-0.009***	-0.009***
	(0.002)	(0.003)	(0.003)
Location relative to the road (near a busy road)	-0.051***	-0.029***	-0.032***
	(0.005)	(0.010)	(0.009)
Quality==0	-0.246***	-0.074**	-0.080***
	(0.051)	(0.033)	(0.031)
Quality==1	-0.073***	-0.077***	-0.059***
	(0.018)	(0.018)	(0.018)
Quality==2	0.026	0.091**	0.142**
	(0.066)	(0.043)	(0.061)
Construction-year	-0.000	0.001	0.000
	(0.001)	(0.001)	(0.001)
Construction-year^2	0.000***	0.000***	0.000***
	(0.000)	(0.000)	(0.000)
Construction-year^{3}Construction-year	0.000***	0.000***	0.000***
	(0.000)	(0.000)	(0.000)
Number of household members	-0.036***	-0.037***	-0.045***
	(0.002)	(0.004)	(0.004)
Number of children (age<18)	0.028***	0.031***	0.032***
	(0.002)	(0.004)	(0.004)
Number of elderly (age>64)	0.033***	0.029***	0.023***
	(0.004)	(0.006)	(0.003)
Number of female	0.024***	0.019***	0.015***
	(0.002)	(0.003)	(0.003)
Log (income)	0.187***	0.170***	0.158***
	(0.004)	(0.007)	(0.006)
Constant	1.073***	1.464***	0.767***
	(0.218)	(0.418)	(0.122)
Observations	103,834	23,187	23,187
R-squared	0.741	0.822	0.848

Notes:
Dependent variable is the logarithm of transaction price. The omitted categories are: for ”home type” variable it is ”Corner house”, for ”parking type” variable it is ”no parking place”, for ”location relative to the center” variable it is ”outside the urban area”, for ”view type” variable it is ”not specified”, for ”location relative to the road” variable it is ”near a quite road”, and for ”quality” variable it is ”not specified”.