"The association between energy efficiency and time on the housing market in Limburg and Hainaut, Belgium"

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ABSTRACT

Higher houses prices lead to longer time on the market. However, the relationship between time on the market and energy efficiency has not been addressed extensively. What is the association between time on the market and energy efficiency? Is there a difference in time on the market between Limburg and Hainaut? This research examines the effect of energy efficiency on time on the market. We use data from 2019-2022Q1 of Limburg and Hainaut, two provinces in Belgium. Time on the market, is the measurement of market liquidity which is the number of days a house stays on the market. We use two measurements of energy efficiency which are, energy label and EPC values. While controlling for other building characteristics, we find that houses with low energy efficiency have a shorter time on the market compared to houses with high energy efficiency. Furthermore, houses built between 1941-1960 have the shortest time on the market compared to other building categories. Both energy label and EPC values have a significant negative effect on the time on the housing market in Belgium.

Keywords: [Energy labels, EPC values, Time on the market, Energy efficiency, Market liquidity]

PREFACE

I would like to thank Yves Vanderveken from Zimmo for providing the data to conduct this research. Furthermore, I would like to thank my promotor, Prof dr. Arno van der Vlist and my assessor, Prof dr. Xiaolong Liu.

1. INTRODUCTION

1.1. Motivation

Energy efficiency improvements in the real estate sector can play an important role in the reduction of global carbon emissions. The Real Estate sector is responsible for 40 percent of final energy consumption in the European Union. This reflects not only the enormous potential to contribute to global change, but also calls for actions and initiatives in order to reduce negative ecological impacts (Cajias and Piazolo, 2013). The heating of buildings and domestic energy use, accounts for almost one fifth of total greenhouse gas emissions in Belgium (Damen, 2019)..

The European Union implemented the Energy Performance of Buildings Directive (EPBD) in January 2003 with the explicit goal of promoting energy efficiency in buildings (Brounen and Kok, 2011). Mandated by EU regulation, all leasing and sales transactions in the housing market of every EU member state need to be accompanied by an energy performance certificate (EPC). Based on an energy index, the energy performance certificates range from "A++" for exceptionally energy-efficient dwellings, to "G" for highly inefficient buildings (Aydin et al., 2017). . In view of European development towards 2050, EPCs aim to reduce the lack of information on energy consumption and raise awareness of their responsible usage. Thus, in the medium run, EPCs force both investors to implement strategies for including energy concerns in portfolio decisions and for homeowners to evaluate the quality of a building more accurately (Cajias and Piazolo, 2013).

The willingness to pay for investors and homeowners to make an energy-efficient investment will depend on the costs and benefits of the investment. The benefits consist primarily of the future energy savings, but also of the potential increase in home value resulting from the investment (Damen, 2019). Imperfect information about the energy efficiency of a home can be a barrier in the decisions that investors and homeowners make, leading to underinvestment in energy efficiency than what would be socially optimal. The purpose of the energy performance certificate (EPC) is to increase transparency so that both, investors and homeowners can better consider the energy efficiency of a home (Damen, 2019). In practice, EPC values can affect the time on the market of houses. For example, a house with a good energy certificate may be sold more quickly.

This research focuses on energy performance certificates in the housing market in Belgium. What impact do these energy performance certificates have on the market liquidity (time on the market)?

1.2 Literature review

In the literature on housing and the role of energy efficiency, research is conducted on house prices and market liquidity.

In 1983, Johnson and Kaserman (1983) find that future savings in energy bills capitalize in housing prices. To this end, they examine the relationship between annual energy bills and house prices. Laquatra, (1986) studies a small sample of newly constructed houses and documents that the Thermal Integrity Factor (TIF), a proxy for energy efficiency, has a positive relation to the transaction price. Dinan and Miranowski (1989) find a similar relation between standardized energy consumption and prices of houses transacted in Des Moines, Iowa. In fact, the documented relation is quite precise: one dollar of energy savings leads to a $11.63 increase in the transaction price. Brounen and Kok (2011) show that energy-efficient homes in the Dutch market transact with a premium of 6.1 percent, all else equal. When observing houses in the highest energy class "A", the willingness to pay more reaches 12.1 percent, whereas buildings in one the lowest class "F" achieve only 1.8 percent (Cajias and Piazolo, 2013). Hyland et al (2013) confirms that buyers and tenants do place a positive and significant value on increased energy efficiency. Hyland et al (2013) find that relative to D-rated properties A rated properties receive a sales price premium of 9% and a rental price premium of just under 2%. However, they were not been able to identify whether this is due to structural differences in demand, tenant search costs or buyer lock-in concerns. These differences in the capitalization rates of energy efficient properties between owners and tenants are similar in magnitude to those estimated by Eichholtz et al (2010) for the commercial property market in the US. The paper of Kahn and Kok (2014) uses detailed data on a large sample of California houses to study whether there is credible evidence of a price premium for energy efficient homes. Comparable to evidence documented for the commercial sector in the U.S., and to the residential sector in Europe, the results in this paper provide the first evidence on the importance of publicly providing information about the energy efficiency and "sustainability" of structures in affecting consumer choice. Green houses transact for significantly higher prices as compared to other recently constructed houses that lack sustainability attributes. ENERGY STAR labelled homes sold for 9% more than non-labelled homes (Kahn and Kok, 2014). The study of Addae-Dapaah and Chieh (2011) set out to determine the premium (if any) commanded by eco-labeling of private apartments in Singapore and above all, to find out if the market understands the different Green Mark (GM) ratings. Furthermore, it is aimed to ascertain the relative profitability of the GM ratings. The objectives were operationalized through the analyses of secondary data of 13,899 private apartment sales data via hedonic model, and primary data from a random survey of 300 people in Singapore. The results clearly show that eco-labeling in Singapore commands a premium. Zheng et al (2012) find that there are two dimensions of "green" real estate. First a housing complex can be built in a city or a neighborhood within a larger district that has especially good local air quality and has access to ample green space. Residential real estate sells for a higher price in the areas that are objectively greener. A second dimension of real estate ‘‘greenness’’ focuses on a building's energy efficiency. A growing literature examines, using data from around the world to test whether such real estate commands a price premium. All else equal, the empirical estimates highlight that these buildings do sell for a price premium at the presale stage. But, they also document that these ‘‘green’’ properties subsequently resell and rent for a price discount (Zheng et al., 2012).

Bloom et al (2011) set out that the use of energy-efficient residential designs has been slow. Of most concern to homebuilders is the perception that the added costs related to increased energy-efficient design and construction will not be recognized when the house is sold (Galuppo and Tu, 2010). The study of Amecke (2012) evaluates the EPCs effectiveness and focusses on its impact on private purchasing decisions for existing dwellings in Germany. The results of this study subsequently suggest that the EPC has only played a limited role in purchasing decisions. The main explanations for this are that (a) the EPC is only viewed and depicted for a minority of dwellings, (b) purchasers understand the information but do not trust it, (c) EPCs do not show the financial implications of energy efficiency well (d) purchasers care significantly less about energy efficiency when they are purchasing a home than about location, selling price, outdoor space, and other factors (Amecke, 2012). Fuerst et al (2015) find no evidence of a relationship between EPCs and rental values in the UK property market. Based on only commercial buildings, their study argues that either tenants do not consider energy efficiency as a relevant factor in transaction deals or underestimate energy expenditures in their investment calculations (Cajias and Piazolo, 2013). Berry et al (2007) find that there is a statistically significant relationship between the house price and the following house characteristics: floor area, block area, distance to CBD, socio- economic advantage, window area, percentage of five-bedroom homes in the local area, whether the house had previously been a government rental property, and the House Energy Ratings (HER). HER is found to be positively associated with house price and has a strongly significant relationship. The association on average for 2005 was 1.23 percent for each 0.5 HER star, and 1.91 percent in 2006, holding all other variables constant. This means while there is a statistically significant relationship between HER and house price, the energy rating explains only a small proportion of the total value of a house. As is to be expected, factors such as block and house size, and location have a greater influence on house price. However, all other things being equal, a house with a high HER will command a higher price than one with a low HER (Berry et al., 2007).

Liquidity in real estate markets can be distinguished between market liquidity and funding liquidity (Brunnermeier and Pedersen et al., 2009). Market liquidity is defined as “the ease with which a property is traded”, funding liquidity of an investment is defined as “the ease with which investors can obtain funding. According to Pivo, (2013), buildings with sustainability features generate more cash flow and value. The value premium, appear to come both the stronger cash flow and lower capitalization rates, suggesting that more sustainable properties are favored in both the space and capital market by renters and investors (Pivo, 2013). Fuerst et al, (2016) argued that the direction of the impact of energy efficiency ratings on time on the market is not straightforward form a theoretical perspective. On the one hand, there may be a larger number of potential buyers for an otherwise similar dwelling that is high energy-rated. On the other hand, many owners of high efficiency units that are about to sell the dwelling, being themselves environmentally aware and oriented, they may expect to get a price premium for their apartments. Houses that are priced higher will have a longer time on the market than houses that are priced lower (Belkin et al, 1976). As most market actors do not pay attention to the energy ratings, it may take a long time for the seller to match with an equally aware buyer, and the seller may eventually need to substantially drop the required green premium. These effects can offset each other therefore the possible liquidity effect is essentially an empirical question (Fuerst et al., 2016). Cajias (2017), describes “the green liquidity premium. The green liquidity premium assumes that the demand for energy efficient assets is significantly higher in comparison to energy inefficient dwelling based on the information from the energy performance certificates. (Cajias, 2017) find that while his results do not confirm in general a liquidity premium for energy efficient assets in the German market, they do confirm that buyers and tenants strongly discriminate energy inefficient assets. Overall, energy inefficient residential object requires more effort as real estate users are increasingly conscious of energetic aspect (Cajias, 2017).

1.3 Research problem statement

The research problem focuses on the relationship between energy certificates and the time on the market of houses for sale in Limburg and Hainaut, Belgium.

Until now, studies on the economic benefit of environmental features have often concentrated on price effects of energy efficiency, verifying price premiums for energy-efficient real estate and confirming the effectiveness of the tool (e.g. Brounen and Kok, 2011; Berry et al., 2007; Fuerst et al., 2015; Amecke, 2012). However, what has not yet been studied is the effect of sustainability on the number of days houses are for sale. This research therefore focuses on the effect of energy efficiency on time on the market. Because everyone focuses on the price effect, a knowledge gap can be observed regarding how many days houses are for sale. The following research question will be answered.

What is the association of energy efficiency and the time on the housing market?

According to Kang and Gardner (1989) real estate markets are often characterized as inefficient and imperfect markets relative to the financial market. This is because buying and selling real estate is a matter of negotiation. If maximizing the present value of the selling price is the only objective, a seller will continue to search for potential buyers until the marginal benefit is equal to the marginal cost of another search. Furthermore, the housing market reacts slowly to new information of other sales because it is costly to obtain. Dipasquale and Wheaton (1996) find the housing market is referred to as completely product-differentiated because each product that is sold in the market is unique. This is in contrast to commodity markets, such as the markets for corn and oil, where uniform goods are traded. The fact that urban land and the housing market are completely differentiated products, makes it difficult to speak about supply and demand dynamics. These constraints make the real estate markets inefficient and imperfect. The degree of market liquidity is most often measured by time on the market (Donald Jud et al., 1996). Previous studies show the importance of time on the market. Belkin et al (1976) show that time on the market is a positive function of the difference between listing price and selling price, which means that there is a trade-off between the ease a property is sold and the price of that same property. Because of the positive function between listing price and selling price, properties that are priced higher have a longer time on the market. The literature on the relationship between energy efficiency and house prices is extensive. Existing studies focus on the Netherlands (Brounen & Kok, 2011), United States (Kahn & Kok, 2014) and Kang & Gardner, 1989), United Kingdom (Fuerst, McAllister, Nanda & Wyatt, 2015), Germany (Cajias & Piazolo, 2013). While all of these studies have examined the importance of prices and time on the market, no one has looked at the relationship between time on the market and energy efficiency. Therefore, sub-question one is stated as: *“What are the drivers of time on the market and what is the role of energy efficiency ?”*

According to van Hoof et al (2017) homes with a poor energy efficiency are difficult to heat or cool. This adds to energy costs (Porto Valente et al., 2022). Given the importance of energy certificates according to Cajias and Piazolo), it will be interesting to see how strong the relationship is between energy efficiency and the number of days houses are for sale. This introduces the second sub-question: *“What is the strength of the relationship between time on the market* *and energy efficiency?"* The second sub-question is answered by using the database of Zimmo. This research uses 29.532 observations of properties for sale & rent in Limburg and Hainaut. With the Zimmo brand, they aggregate more than 120,000 property searches on their site, Zimmo.be and reach more than 6.2 million visitors per month.

Overall, the trend in the housing market has been broadly similar in Flanders and Wallonia. This suggests that there are key common elements in the strong regional trends (KBC, 2021). Yet there are also a number of specific regional differences. For example, the bigger average price rise in Flanders compared with Wallonia is partly due to the relatively stronger increase in Flemish land prices (KBC, 2021). The Covid-19 crisis impacted the number of property transactions in Flanders especially, but also led to a weakening of the upward trend in prices. In Wallonia, prices continued to increase more robustly in 2020 (KBC, 2021). Price differences between Flanders and Wallonia are mostly known and used in previous academic researches. Because of these price differences and different housing characteristics, it is interesting to see what the effect of energy efficiency on time on the market will be, in both regions. Therefore, the third and last sub-question is stated as: *"What is the difference of the effect of energy efficiency on time on the market of houses for sale, between "Limburg" (Flemish province) and "*Hainaut*" (Wallonia province)?"*

This study is divided into 5 chapters. Chapter 1 explained the motivation and research problem. In chapter 2, relevant theories with connection to the topic will be discovered. In chapter 3 the date and methods used will be described. Chapter 4 highlights the results of the regressions and discussions of this study. Lastly, chapter 5 will make an overall conclusion about this study and highlights possible future research.

2. THEORETICAL BACKGROUND

2.1 Market liquidity

Chilka et al (2002) examined the home-buying decision for a couple buying a home. A four-step decision process, that highlights household's behavior is developed. The steps are: 1) specify primary criteria; 2) give weight to the criteria via pairwise comparison; 3) select a slate of candidate houses; and 4) rank the houses via pairwise comparison for each criterion. If two houses are identical and equally priced within a submarket of comparable demand and supply conditions, then the houses should remain on the market for approximately the same duration. If the houses are not identical but are similar in list price, the time on the market of both houses is the same (Belkin et al., 1976). Carrillo et al (2012) find the relationship between market tightness (the ratio of buyers to sellers) and subsequent price appreciation. They argue that the ex-ante sale probability (based on the time on the market) and the sellers' bargaining power respond to changes in the market tightness. According to Van Dijk and Francke (2018) if market tightness defined as a measure of the liquidity in the market increases, agents will gradually adjust their perception regarding market tightness. Sellers set their reservation price based on their perception of the market tightness. Market liquidity responds directly to an increase in market tightness.

Market liquidity or simply time on the market is interpreted differently by different studies. The time a property is on the market is the time elapsing between the establishing of a list price by the seller and the agreement on a transaction price by the buyer and seller. The study of Belkin et al (1976) explains marketing time based on the spread between listing price and selling price. Believing that listing price is the most important variable determining marketing time, Belkin et al (1976) hypothesized that overpriced properties would take longer to sell than property priced comparable houses. Miller (1978) argued that, over time, a rational seller will attempt to obtain a higher nominal selling price in order to maintain a constant real price as marketing time increases. Miller (1978) hypothesized a positive relationship between marketing time and sales price. Kang and Gardner (1989), argued that marketing time is defined as the number of days between a home's listing date and the date on which an offer is accepted. Van Dijk and Francke (2018) uses the number of listed properties as a useful supply indicator. By combining these data on demand and supply, they develop an indicator of market tightness. The advantage of these data is that they provide a detailed panel, both over time and over the cross-section.

A large part of the literature that examines the relationship between house prices and market liquidity uses shocks. These shocks can be either demand or supply shocks (Van Dijk and Francke, 2018). For example, the labor market (Clayton et al., 2010) or the mortgage rate (de Wit et al., 2013) to determine the price volume correlation. According to (Belkin et al (1976), properties remain a short time on the market relative to the time considerations for long run economic equilibrium for an entire metropolitan housing market. Therefore, de demand relevant to time on the market is the number of buyers currently searching in the market area who would seriously consider purchasing a property. The relevant supply is the number of other properties for sale that would appeal to that same group of buyers. The relationship between supply and demand is not peculiar to an individual property but to the collection of properties of which it is an element. For example, if the number of buyers searching for a particular class of property is considerably larger than the number of such properties available, one would expect that the average time on the market for these properties would be short, and the price of these properties would be sustained (Belkin et al., 1976).

The reverse of this assertion follows the same principle, if the number of buyers is considerably smaller than the number of appropriate properties on the market, then the time on the market would be expected to be greater and the price of the properties would fall.

According to Van Dijk and Francke (2021), Clayton et al (2010) and Knight (2002) the relationship between price and time on the market is positive. However, according to Krainer (2001), Residential real estate markets go through "hot" and "cold" periods. In a hot market, liquidity is good and prices tend to be rising, meaning that sellers typically sell their houses fast. In cold markets, prices tend to be declining, liquidity is poor and the volume of sales is low. In other words, when prices are rising the time on the market will be shorter and vice versa.

The interesting puzzle of real estate is the fact that liquidity varies so dramatically over time.

2.2 Determinants explaining time on the market

Market liquidity itself is not directly observable and, therefore, proxies must be created to try and estimate relations between this factor and asset prices (Ametefe et al., 2016). Market microstructure and finance researchers have identified several variables that measure different dimensions of liquidity (Korajczyk and Sadka, 2008). In this paper the following determinants of time on the market are examined: property related, sustainability related and buyers/sellers' motivation related determinants.

2.3 Property related determinants

If pricing decisions were perfect, the initial listing prices of houses with attractive features would be increased. However, market imperfections such as insufficient information and continuously shifting preference functions, may limit the effectiveness of these pricing adjustments. According to Belkin et al (1976) the imperfections described above, can delay a purchase. Buyers have relatively rigid specifications and delay purchase until they find an alternative that meets their criteria. In this case the expected time on the market is influenced by the housing features of specific houses for sale. According to Kang and Gardner, (1989) overpriced homes take longer to sell, regardless of general market conditions or of price subgroup. All else equal, older homes also take longer to sell, although this effect is less important for low-priced homes. The size of a home relative to other in a comparable price group is not important in determining marketing time (Kang and Gardner, 1989). Marks and Waller (1990), envisions the housing market as a continuum of potentials buyers, each searching in one or more potential housing sub-markets comprised of houses with a particular set of attributes or characteristics. Because the number of potential buyers and sellers (and their preferences) in each submarket can differ, the liquidity of houses in each submarket may differ as well. Therefore, as the attribute set changes, the housing liquidity may be affected.

2.4 Sustainability related determinants

The housing industry plays an important role in accelerating the spread of the energy crisis. The housing construction industry must change its view in the way that keeps environmental concerns the centerpiece of its efforts. Furthermore, sustainability in the housing industry needs to reduce the impact on the natural environment and increase the energy efficiency by minimizing the energy consumption Bakar et al (2010), in (Roufechaei et al., 2014). Energy efficiency parameters can play an important role in the energy consumption because the parameters are responsible for environmental issues in both the design and construction phases. The link between energy efficiency and sustainable housing is clear. Sustainability prevents harmful and irreversible effect on the environment. The housing industry needs to use natural and renewable resources to protect the environment (Roufechaei et al., 2014). Increased sustainability in the housing industry leads to higher energy efficiency, which has its effect on time on the housing market. Small increases in energy efficiency can have large effects on the life-cycle energy consumption. Energy efficient houses are promoted in almost every country with energy labels. This is favorable for owners and potential buyers (Deng et al., 2012). Furthermore, energy efficient upgrading produces macro-economic benefits in addition to the sustainable benefits. For example, households fuel bills are cheaper for energy efficient homeowners Goodacre, 2001). These macro-economic benefits have their impact on time on the market.

2.5 Buyers/sellers' motivation related determinants

House prices and their impact on macro-economic equilibrium is one of 11 scoreboard indicators choses as "the most relevant dimensions of macro-economic imbalance and competitiveness losses, according to the European commission (EC, 2012). One of the most effective ways a seller can influence time on the market is through the pricing of his offering. The establishment of an appropriate offering price is complicated by variations in buyer reactions to different combinations of housing attributes (Belkin et al., 1976). The price adjustments are functionally related to time on the market because they depend upon post-listing feedback from the market as the basis for revisions of asking price. But they also determine time on the market as the main control variable in an adaptive selling strategy (Belkin et al., 1976). Clayton et al (2010) indicate that sellers consider different strategies for selling a property. Knight (2002) find that, because of an imperfect competitive housing environment, time is required to match sellers of this heterogenous products with an appropriate buyer. Sellers of houses consider carefully the initial price at which to list their houses on the market. This is because listing prices affects not only the ultimate selling price, but also the length of time the house may remain on the market. The goal of the seller is to sell the house at the highest price possible in the shortest period of time. This objective makes setting the initial listing price very difficult. Pricing the house to high reduces the pool of potential buyers and may extend the market duration of the property. Pricing the house too low may result in a quick sale but at a price lower than might have been achieved with a more selective pool of buyers. According to Wayne Archer et al (2013) Transaction frequency is a key indicator of market liquidity. Wayne Archer et al (2013), studies the market liquidity on the U.S. single-family housing market. He found that an increase in the percentage change in the ratio of the total U.S. sales of single-family homes suggests that market liquidity is increasing. When housing turnover is low, market liquidity declines and the price impact of a transaction will be relatively high.

Lin and Vandell (2007) find that buyers make offers based on information acquired during their search, after an offer, the seller will evaluate the benefits of waiting for a potential better offer. If there is no agreement, the search for each party continues, therefor the price and timing of tis receipt remain uncertain until the transaction process is concluded. Because of the uncertainty and the matter of negotiation in buying and selling real estate, the real estate market is characterized as inefficient and imperfect (Kang and Gardner, 1989).

2.6 Theoretical prediction

Theory helps to understand the association between energy efficiency and market liquidity. According to the literature, there is a possible positive and negative effect on the relationship between energy efficiency and market liquidity. Fuerst et al, (2016) argues that there could be a positive and negative effect because the direction of the impact of energy efficiency rating on time on the market is not straightforward from a theoretical view. Cajias (2017) find no significant liquidity premium but argued that energy inefficient residential object requires more effort to sell. Pivo, (2013) suggests that sustainable properties are favored in the capital market which could imply a shorter market liquidity. Because the little literature that exists on the association between EPC values and time on the market cannot provide clarity, this study formulates two hypotheses:

- Hypothesis 1: High energy efficiency is associated with a shorter time on the market, ceteris paribus.

- Hypothesis 2: The differences in the relationship of time on the market and energy labels between Limburg (Flanders) and Hainaut (Wallonia).

By examining the association between EPC values and time on the market this study will contribute to the observed knowledge gap concerning the association between energy efficiency and time on the market. The main research question is modeled in the conceptual model (figure 1). Setting Time on the market as our dependent variable, energy efficiency as the variable of interest and price, construction year and floor space surface as our control variables.

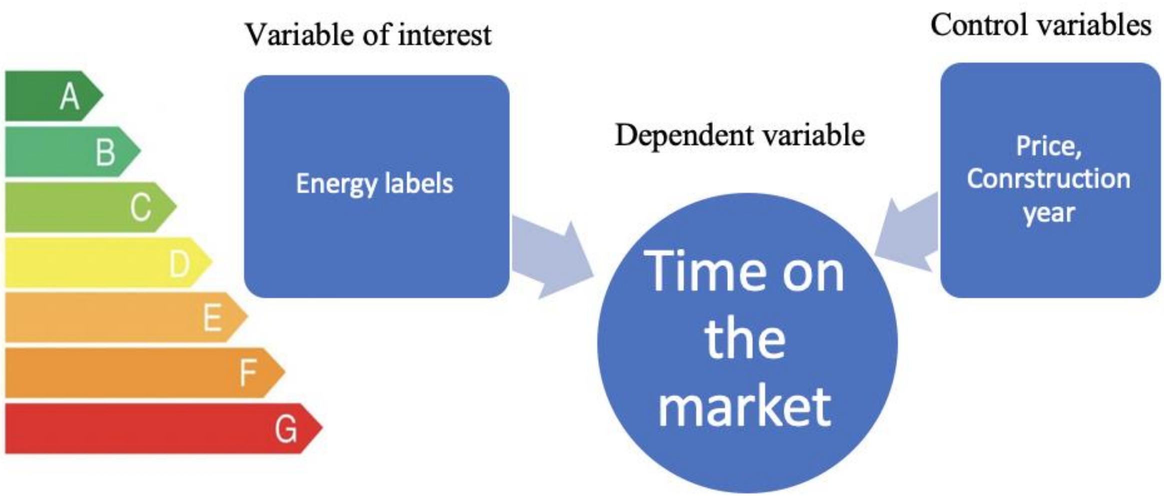

Figure 1 – Conceptual model

3. DATA & METHODS

3.1 The Belgium housing market

Housing stock

In Belgium, about 18 per cent of households occupy a private rented dwelling, 71 per cent of Belgian households own the dwelling they live in, while 11 per cent live in a social dwelling. Belgium has a current housing stock of about 5,631,637 buildings. The Flemish Region registers 29% more dwellings and 16% more buildings, compared to the Brussels-Captial Region. In the Walloon Region, there are 26% more dwellings and 15% more buildings, compared to the Brussels-Capital Region. The age of the buildings varies greatly from region to region. In Flanders, 33% of the buildings were built after 1981, compared to 22% in Wallonia and only 7% in the Brussels-Capital Region (Statbel, 2022). Figure 2 shows that after 2013 the housing stock per 1,000 households increased after a decline for several years in Brussels and a stabilization for Flanders and Wallonia. Broadly speaking, in the last decade, the housing stock per 1,000 households has risen more in Wallonia than in Flanders.

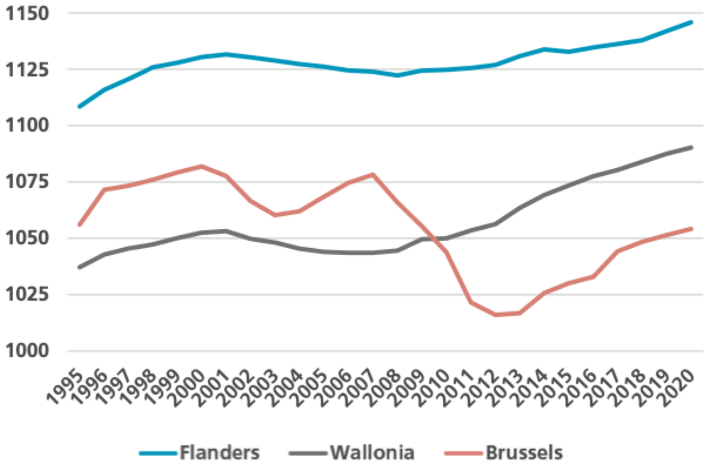

Figure 2[1] – Number of housing units per 1,000 households

Since 2007, the number of permits for the renovation of residential buildings was generally higher than the number of permits for the construction of new residential buildings. From the second quarter of 2018, permits of new buildings rose again. From February 2019 onwards, the number of permits for the renovation of residential buildings is again higher than the number of permits for the construction of new residential buildings (see figure 4). From 2003 onwards, more permits are issued for new apartments than for single family dwellings. During the years 2010-2011,

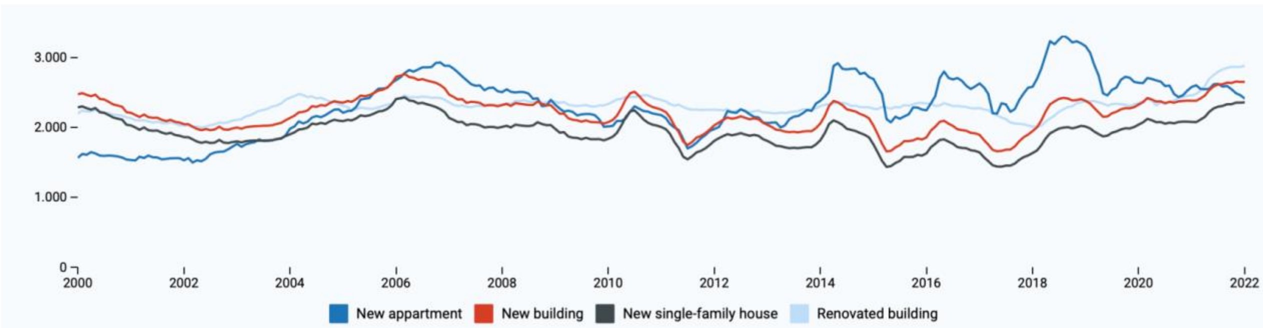

Figure 3[1] – 12 month moving average permits Belgium

[1] *Source: KBC, 2021. The housing market in the three Belgian regions: should we be concerned about overheating?*

both were at approximately the same level. Afterwards, the difference has been increasing again in favor of the apartments. The difference is the greatest in 2018. From 2019 onwards, the gap narrows again.

Prices

Overall, the trend in house prices is broadly similar in Flanders, Wallonia and Brussels. The Belgian median price for an attached or semi-detached house amount to 235,000 euros. A buyer need to pay 337,000 euros for a detached house. The Walloon Region is the cheapest with a median price of 165,000 euros for an attached or semi-detached house, and 273,000 euros for a detached house. In the Flemish Region, the cheapest province is Limburg and the most expensive is Flemish Brabant. In the Walloon Region, the cheapest province is Hainaut and the most expensive is Walloon Brabant (Statbel, 2022). The Brussels-Capital Region is the most expensive region. Attached and semi-detached houses cost there 455,000 euros. The price for a detached house amount to 1,150,000 euros. Outliers in the price spread in recent decades have mainly been caused by Brussels Capital Region, where price trends have been more volatile than in Flanders and Wallonia (KBC, 2021). Figure 3 shows the price evolution in Belgium from the last 10 years.

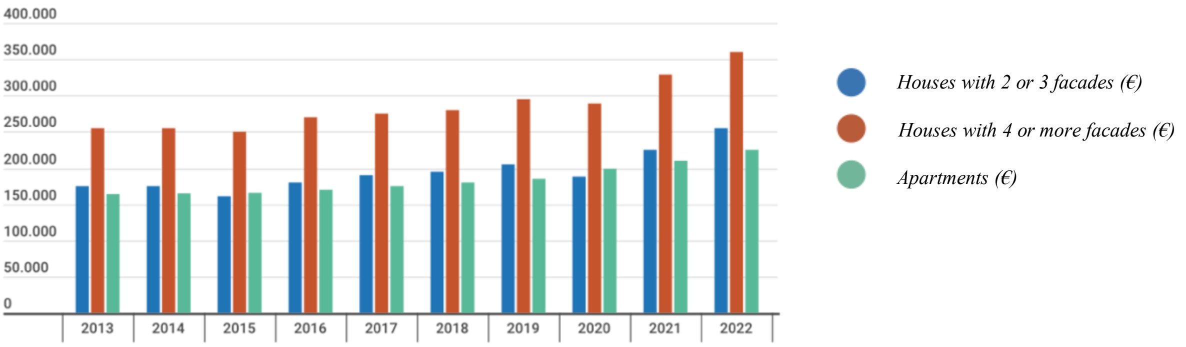

Figure 4[3] – Median house prices of the first quarter for each year

Figure 5 shows the number of houses sold of the three regions in Belgium for 2021. In the Flemish and Brussels region, houses with 2 or 3 facades are the most sold. For the Walloon region, apartments have the most sales and houses with 4 or more facades are negligible.

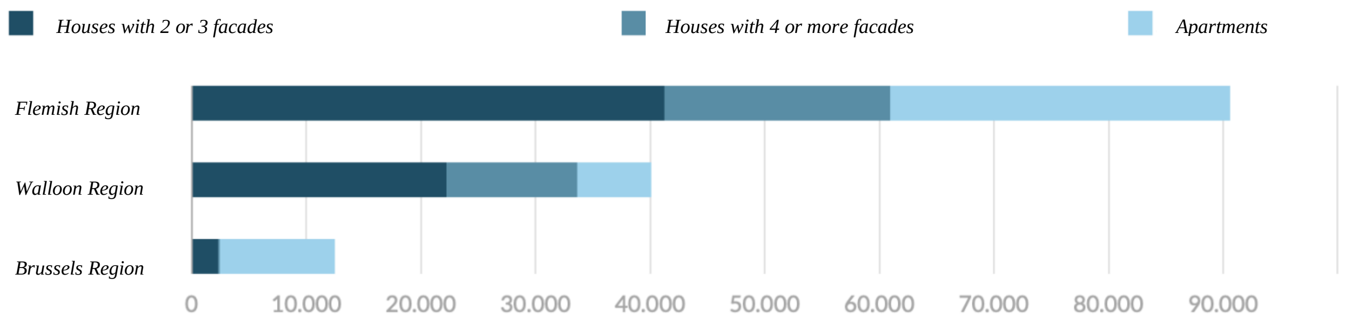

Figure 5[4] – Houses sold in 2021

[3] *Source: Statbel, 2022. House prices – first quarter 2022.*
[4] *Source: Statbel, 2021. Houses sold in Belgium*

Energy efficiency

An important measurement in the Belgium housing market are the EPC certificates. An energy performance certificate (EPC) is a document that shows how energy efficient a building is. The energy score is calculated using data collected by the energy expert during the inspection. During the inspection, the energy expert pays attention to, among other things: the type of house, surface area of the house, year of construction, building materials, type of insulation, heating system and hot water system. After the inspection, all these data are entered into a special software package that is managed by the Flemish Energy Agency. The score is determined by the software using complex calculations. The EPC document has been mandatory since 2008 in Belgium when selling or renting houses and apartments and is valid for 10 years. The energy score stated on the energy performance certificate is a key figure that indicates how much the primary energy consumption per square meter of floor area (kW/m²). The lower the EPC score, the less energy is needed to heat the house. A lower EPC score therefore means a better energy performance. In 2021 the average energy label of dwellings in Belgium was label D (390 kWh). Since 2019, energy efficiency has been represented by a label. This label ranges from G (poor score) to A+ (very good score).

Institutions

As mentioned earlier, Belgium consists of three regions, Flanders, Brussels and Wallonia. Each of the three regions in Belgium has its own housing law. Flanders has the Flemish Housing Codex, Brussels has the "Code Bruxellois du logement" and Wallonia the "Code Wallon du logement". One of the most important steps has been the regionalization of the housing policy as part of the 1980 state reform. Through this, these three legal frameworks were created (Vanneste et al., 2007).

In recent years in Flanders, housing policy has been more explicitly aligned with spatial planning. For example, in the translation of the spatial structure plan for Flanders (RSV) to the provincial and municipal level, there is an increasing focus on infill development. "This means that the new housing needs are to be accommodated as far as possible on undeveloped land within existing cores. Replacement construction also plays an important role. The aim is to create districts and neighbourhoods with a differentiated housing supply and a socio-economic differentiation in terms of occupation (Vanneste et al., 2007).

In Brussels, the "Contracts de quartiers" were launched, establishing a perimeter whereby all of the government's efforts in terms of urban renovation, reconstruction of places that have been cleared, redevelopment of public spaces, strengthening of collective equipment, support for social initiatives, etc. are focused on the area within the perimeter.

For Wallonia, the Z.I.P. (zones d'initiatives privilégiées) should be mentioned. It passes for an original approach compared to the classic instruments of renovation and revitalization by being very inclusive and integrated in character. Here too, government efforts and financial resources are concentrated on zones with more salient social and economic problems (Vanneste et al., 2007).

The folowing examples will show the differences between the housing policies in each region of Belgium. Registration duties (sales taxes) are a major cost. The tax is added to the price of the house and this can be a major factor because the buyer cannot include this cost in the loan from the bank. It will therefore have to come from the savings account of the buyer. The registration fees are for both on building plots and on any existing house. These basic rules apply throughout Belgium, but the rates vary by region (Statbel, 2022).

Flanders:

- 3% for a family home that you will occupy yourself within 2 years
- 1% if you are going to do major energy renovation work within 5 years
- 12% for the purchase of a building plot

Wallonia:

- 12.5% for a large description (CI above 745 euros)
- 6% for a small description (CI below 745 euros)
- Exemption on the first 20,000 euros for your first house, which is a saving of 2,500 euros.

Brussels:

- 12.5% is the standard rate for any home or building plot
- Exemption on your first house for the first 175,000 euros

At first glance, VAT does not seem to have any importance in this study. But in Flanders the VAT is 1% when there is an energy renovation within 5 years. This is significantly less than in Wallonia and Brussels where the VAT is 12,5%, and shows that energy efficiency has a major impact on the VAT rules in Belgium. In the Walloon Region, the registration duties depend on the cadastral income (CI) of your house. The cadastral income (CI) is the average net income estimated by government administration that this property would generate for its owner. Roughly speaking, it comes down to more tax on large houses (Statbel, 2022). The legislation differences show that there are for each region in Belgium different kind of incentives to improve energy efficiency in the housing market. These different legislations make it interesting to see if there is a difference in effect of energy efficiency and time on the market between Limburg and Hainaut.

3.2 Dataset

The data came from Zimmo, a real estate portal website (www.zimmo.be). Zimmo is one of the largest and most popular websites for buying and renting real estate in Belgium. Zimmo has a market coverage of 23 percent. For this research, two datasets are used. A dataset of the province of Hainaut (Wallonia) and a dataset of the province Limburg (Flanders). The data includes time on the market and other building characteristics. The total sample size entails 50.000 observations and contains information about property's building year, EPC value, EPC label, List date, selling date, listing price and floorspace surface. The variable of interest is time on the market which is conducted by subtracting the start and end date from the data sample. Properties with missing EPC values and energy labels were deleted from the sample. After the data cleaning process, the dataset consists of 29.532 observations.

3.3 Operationalization

The study of Kang and Gardner (1989) uses the interpretation of time on the market as the number of days between a home's listing date and the date on which an offer is accepted. This study uses time on the market as the days between a home's listing date and the date the property comes off the market. The dependent variable is time on the market. Time on the market is created by subtracting the sales day and list day to determine time on the market for each property.

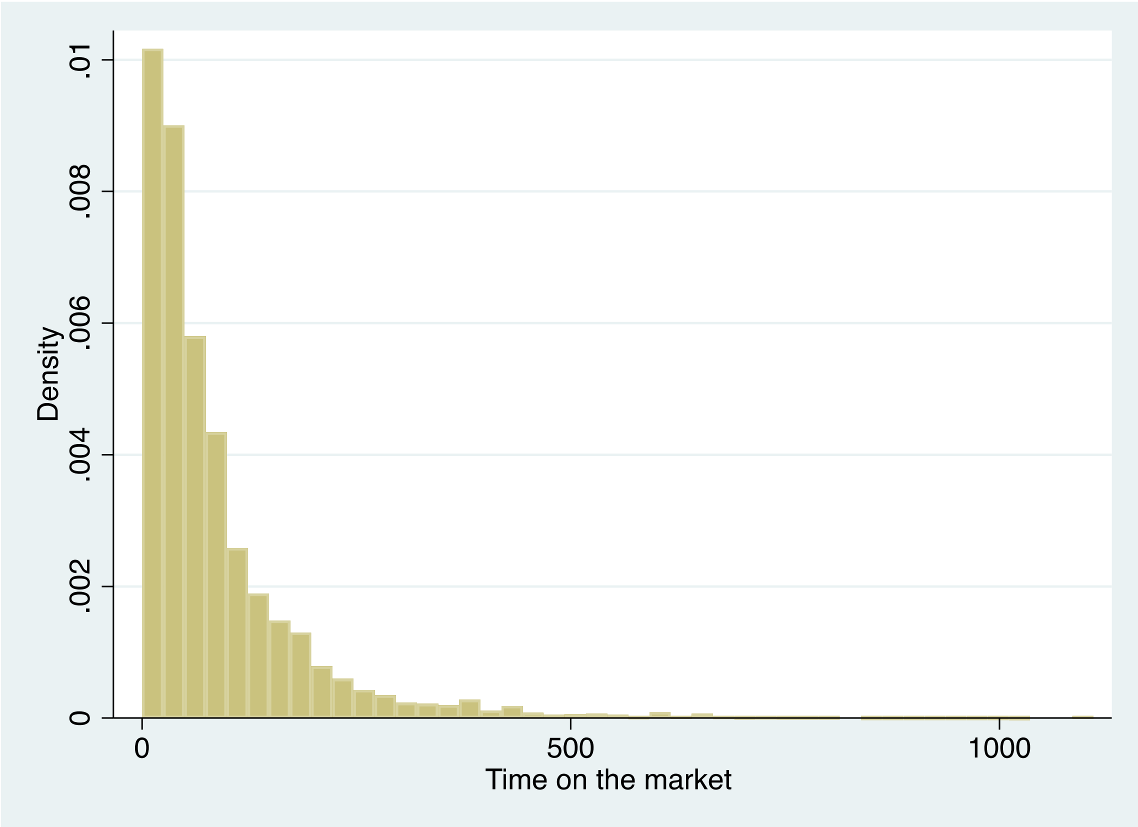

Figure 6 – Graph of the Time on the market distribution in the data set

The key independent variable in this study is energy label. The energy label index measures the energy efficiency level, based on thermal characteristics of the building. The energy labels in the dataset are defined as A+, A, B, C, D, E, F, G and the distribution of the energy labels can be derived from table 1. In this study, the focus is energy label which serves as the main explanatory variable and is therefore detached from other housing characteristic variables.

Table 1 – Overview of energy label distributions

ENERGY LABEL	OBSERVATIONS	MEAN EPC VALUE	STD. DEV.
A PLUS	41	50.89	28.95
A	2,391	72.09	23.91
B	7,229	148.52	30.68
C	6,187	246.02	30.36
D	4,371	342.84	33.95
E	3,386	438.31	38.83
F	5,483	657.99	141.27
G	444	670.00	107.74

In the second model, the key independent variable is EPC, this measures the energy efficiency level and is used as indicator to create the Energy labels. Figure 8 shows that energy labels varies in EPC labels. This is because an energy label is categorized across multiple EPC values.

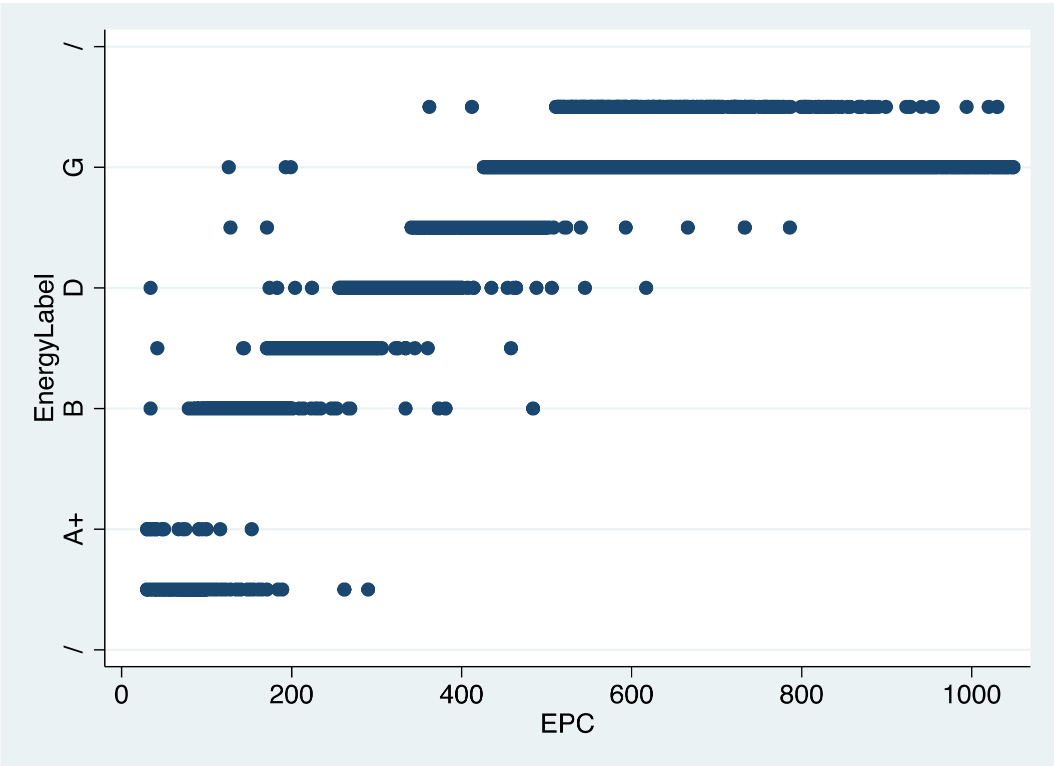

Figure 8 – Scatter of Energy label and EPC

The control variable in this study is Floorspace surface. Missing values of Floorspace surface are deleted in the sample (4.721). In order for the independent variable Floorspace surface to be normally distributed, de variable is transformed using natural logarithm. The variable that controls for the construction is Year, being the year, the properties are build. Year is grouped in seven categories (1820-1900/1901-1920/1921-1940/1941-1960/1961-1980/1981-2000/2001-2022). Properties older than 1820 are omitted from the sample (26). The spatial control variable is ZIP code. This to control for the spatial differences between the province of Hainaut (Wallonia) and the province of

Limburg (Flanders). The sample of this research consists of a dataset with properties that came on the market between 2019-2022 for Limburg and Hainaut which is indicated as Year FE.

3.4 Descriptive Statistics

Table 2 reports the descriptive statistics for all properties that came on the market over the period 2019-2022: Q1. This research uses properties that came on the market in Limburg and Hainaut. The dataset contains all types of houses from detached houses to apartments. Properties older than 1820 were omitted from the sample. Variables end, status, new_obs and project are dropped. Furthermore, properties without information about energy efficiency, floorspace surface and construction year are dropped. Descriptive statistics in column (1) shows the pooled model which contains data of Limburg and Hainaut. Column (2) and (3) show respectively date from Limburg and Hainaut. Limburg has 25,695 observations and Hainaut has 3,837 observations. Total data set contains of 29,532 observations. The mean time on the market in Limburg is 79 days and for Hainaut 102 days. Furthermore, the mean EPC value for Limburg is 391.85 and for Hainaut 287.67.

<u>Descriptive Statistics</u>

Table 2 – Descriptive statistic

	(1) Pooled		(2) Limburg		(3) Hainaut	
	mean	st.dev.	mean	st.dev.	mean	st.dev.
Time on the market (days)	81.89	85.36	79.36	82.35	102.84	103.88
EPC	326.75	206.41	391.85	208.38	287.67	185.27
Energy label						
A plus	0.00		0.00		0.00	
A	0.08		0.09		0.13	
B	0.25		0.22		0.23	
C	0.21		0.29		0.15	
D	0.15		0.197		0.14	
E	0.12		0.149		0.13	
F	0.19		0.263		0.11	
G	0.02		0.00		0.12	
Floorspace surface (m2)	181.41	90.59	185.58	84.75	166.34	96.41
Construction year						
1820-1900	0.03		0.03		0.07	
1901-1920	0.02		0.24		0.05	
1921-1940	0.07		0.08		0.10	
1941-1960	0.15		0.20		0.12	
1961-1980	0.28		0.35		0.15	
1981-2000	0.18		0.18		0.11	
2001-2022	0.26		0.14		0.40	
Province						
Limburg	0,87					
Hainaut	0,13					
Observations	29,532		25,695		3,837	

The table reports summary statistics of property's time on the market and energy labels: column (1) for the full sample, column (2) for Limburg and column (3) for Hainaut. See Appendix for variable definition.

3.5 Methodology

To analyze the relationship between energy labels and time on the market for listed houses between 2019 and 2022 in Belgium, I use an Ordinary Least Squares regression. The regression model describes and evaluates the relationship between a given variable and one or more other variables (Brooks & Tsolacos, 2012). Five assumptions are underlying the classical linear regression model concerning disturbance terms and their interpretation. First, the errors have zero mean. Second, the variance of the errors is constant. Third, the errors are statistically independent of one another. Fourth, there is no relationship between the error and the corresponding variable. Lastly, the error term is normally distributed (Brooks & Tsolacos, 2012). The function of time on the market is a linear function of energy label, floorspace surface, building year, location FE and year FE, or:

$$LN\ (TOM) = \alpha + \beta 1(Elabel) + \beta 2LN(Floorspace) + \beta 3(Buildyear) + \beta 4(LocationFE) + \beta 5(YearFE) + \varepsilon \qquad (1)$$

Where LN (Time on the market) is the number of days a house stays on the market; $\beta 1$ is the measure of energy efficiency; $\beta 2\ and\ \beta 3$ are building characteristics; $\beta 4$ is the location FE; $\beta 5$ is year FE that controls for market liquidity. The last term ε is the stochastic error and is assumed to be i.i.d.

To explore if there is any structural difference between Limburg and Hainaut, a Chow test will be performed. The Chow test is a parameter stability test, for this test the data will be split into two subsamples. The hypothesis for this test is, that there is no difference in the relationship between time on the market and energy efficiency in Limburg and Hainaut.

$$F = \frac{\text{R RSS} - \text{U RSS}}{U\ RSS}\ X\ \frac{(\text{n} - 2\text{k})}{(2k - k)}$$

In the second model, the variable EPC will replace the variable energy label. The third model is to control, if the effect of EPC and energy label is the same, because figure 8 shows that EPC values varies across labels. Furthermore, EPC values are a more precise measurement to analyze the relationship between time on the market and energy efficiency.

4. RESULTS & DISCUSSION

4.1 Energy label

The first model is aimed at controlling for the key independent variable. The results of model (1) are focused on the effect of energy labels and their effect on time on the market. Model (1) does not consider other house characteristics, location or year fixed effects. All the energy labels are statistically significant on a 99 percent significance level, label G is significant on a 95 percent significance level. All energy labels, with label A plus being the reference category, have a negative effect on time on the market. For a property with energy label A, the time on the market decreases with: Exp (-0.395) – 1 * 100% = 32.63 percent or 29 days. A property with energy label G, which is less good than A, the time on the market decreases with: Exp (-0.354) -1 * 100% = 29.81 percent or 26 days. However, it can't be compared with a property that has no energy label, because every seller is obligated to have their house labeled before selling. Energy label A plus is rather rare and hard to find, the effect of the other energy labels is high and negative compared to label A plus. These findings are in line with the findings of Pivo (2013). According to Pivo (2013), sustainable properties are favored in both space and capital markets by renters and investors, which assumes a shorter time on the market. Furthermore, Hyland et al (2013) find that buyers and tenants do place a positive and significant value on increased energy efficiency, which could assume a shorter time on the market for sustainable properties.

The second model controls for the housing character floorspace surface. The coefficient is significant on a 99 percent significance level. When adding Floorspace surface, the impact of label A on time on the market decreases with: 32.63 – {Exp (-0.372) -1 * 100%} = 1.57 percent. This mean that the effect of floorspace surface, decreases the importance of energy label A, which is logic because buyers keep in mind multiple housing characteristics when buying a home.

The third model adds the housing character building year. All the coefficients of building years are significant on a 99 percent significance level, "1901-1920" is significant on a 95 percent significance level. For example, a property that is built between "1961-1980" has a negative effect of: Exp (-0.138) -1 * 100% = 12.89 percent or 11 days on time on the market compared with the reference category of 1820-1900. A property that is built between 2001-2022 has a negative effect of: Exp (-0.106) -1 * 100% = 10.06 percent or 9 days on time on the market. There is not much difference between a property built between "1961-1980" and "2001-2022". When adding more control variables like floorspace surface and building year, older properties with lower energy efficiency, have a shorter time on the market. These findings are in line with Johson and Kaserman (1983) and Laquatra (1986). An increase in energy efficiency lead to an increase in house prices. Houses that are priced higher have a longer time on the market compared to houses with lower prices.

The fourth model controls for year fixed effect. This research used data of houses that came on the market between 2019 and 2022. Adding the year FE has no big influence on the other variables. Energy efficiency is still negatively correlated with time on the market. The effect of building year increases slightly in every building category. The coefficient floorspace surface is still significant. The main findings of this research are in line with Bloom et al (2011) and Galuppo and TU (2010), the use of energy efficient residential design is slow, the added costs related to increased energy efficient buildings will not be recognized when a house is sold.

4.2 Chow test

As described in the methodology, the relationship between two provinces are explored. To test whether there is a different effect of energy labels in Limburg of Hainaut on time on the market, a Chow test is performed on the two subsamples (Limburg and Hainaut). Table 3 shows the regression results of the Chow-test without the variables location FE and year FE of the pooled model, Limburg and Hainaut. Inserting the residuals for the pooled model, Limburg and Hainaut gives the following F-statistic.

$$F = \frac{36460{,}4404 - (30769{,}6882\ +\ 5523{,}49837)}{(30769{,}6882\ +\ 5523{,}49837)}\ X\ \frac{(29532 - 2 * 14)}{(2 * 14 - 14)} = 9{,}71$$

The critical F-value on a 5% significance level is 2.37. The F value of 9,71 is higher than the critical F value which means there is a difference in results between Limburg and Hainaut. This means that the null hypotheses 'no difference between Limburg and Hainaut' can be rejected.

Table 3 – Estimates of OLS

	(1)	(2)	(3)	(4)
ENERGYLABEL A	-0.395***	-0.372**	-0.361***	-0.467***
	(0.147)	(0.145)	(0.136)	(0.129)
ENERGYLABEL B	-0.459***	-0.460***	-0.439***	-0.561***
	(0.146)	(0.144)	(0.135)	(0.127)
ENERGYLABEL C	-0.478***	-0.499***	-0.461***	-0.589***
	(0.146)	(0.144)	(0.136)	(0.128)
ENERGYLABEL D	-0.443***	-0.466***	-0.439***	-0.581***
	(0.146)	(0.145)	(0.136)	(0.129)
ENERGYLABEL E	-0.415***	-0.434***	-0.402***	-0.544***
	(0.147)	(0.145)	(0.137)	(0.129)
ENERGYLABEL F	-0.426***	-0.439***	-0.400***	-0.546***
	(0.146)	(0.144)	(0.136)	(0.129)
ENERGYLABEL G	-0.354**	-0.354**	-0.520***	-0.645***
	(0.157)	(0.155)	(0.151)	(0.144)
LN (Floorspace surface)		0.141***	0.170***	0.157***
		(0.0145)	(0.0150)	(0.0147)
1901-1920			-0.118**	-0.122**
			(0.0538)	(0.0529)
1921-1940			-0.155***	-0.172***
			(0.0427)	(0.0417)
1941-1960			-0.170***	-0.194***
			(0.0386)	(0.0378)
1961-1980			-0.138***	-0.159***
			(0.0371)	(0.0364)
1981-2000			-0.123***	-0.148***
			(0.0389)	(0.0381)
2001-2022			-0.106***	-0.147***
			(0.0405)	(0.0398)
Location FE			YES	YES
Year FE				YES
Observations	29,532	29,532	29,532	29,532
R-squared	0.001	0.004	0.042	0.161

The table shows regression estimates of equation (1). The dependent variable is log Time on the market. The model includes property characteristics as listed in Table 1. Notes; the reference categories, for energy label is A plus, Building year “1820-1900”. The estimation sample is 2019-2022. See Appendix for variable definitions. Robust standard errors in parentheses. *** p<0,01, ** p<0,05, * p<0,1

Chow test

Table – 4 Chow test

VARIABLES	Pooled Model	Limburg	Hainaut
ENERGYLABEL A	-0.371**	-0.284	-1.136**
	(0.175)	(0.184)	(0.541)
ENERGYLABEL B	-0.438**	-0.363**	-1.099**
	(0.174)	(0.183)	(0.539)
ENERGYLABEL C	-0.452***	-0.377**	-1.202**
	(0.175)	(0.184)	(0.542)
ENERGYLABEL D	-0.412**	-0.339*	-1.247**
	(0.176)	(0.185)	(0.543)
ENERGYLABEL E	-0.382**	-0.326*	-1.134**
	(0.176)	(0.185)	(0.544)
ENERGYLABEL F	-0.384**	-0.310*	-1.142**
	(0.176)	(0.185)	(0.545)
ENERGYLABEL G	-0.332*	-1.076	-1.265**
	(0.183)	(0.796)	(0.545)
LN (Floorspace surface)	0.139***	0.157***	0.100**
	(0.0146)	(0.0156)	(0.0432)
1901-1920	-0.115**	-0.121*	-0.0874
	(0.0543)	(0.0625)	(0.113)
1921-1940	-0.184***	-0.137***	-0.311***
	(0.0428)	(0.0487)	(0.0946)
1941-1960	-0.241***	-0.217***	-0.145
	(0.0389)	(0.0442)	(0.0925)
1961-1980	-0.224***	-0.186***	-0.221**
	(0.0374)	(0.0427)	(0.0882)
1981-2000	-0.207***	-0.180***	-0.134
	(0.0391)	(0.0443)	(0.0950)
2001-2022	-0.151***	-0.155***	-0.178*
	(0.0410)	(0.0463)	(0.0989)
Constant	3.784***	3.567***	4.906***
	(0.195)	(0.206)	(0.592)
Observations	29,532	25,695	3,837
R-squared	0.006	0.006	0.009
RSS	36460.4404	30769.6882	5523.49837
K	14	14	14

Notes; the reference categories, for energy label is A plus, Building year "1820-1900". The estimation sample is 2019-2022. See Appendix for variable definitions. Robust standard errors in parentheses. *** p<0,01, ** p<0,05, * p<0,1.

4.3 EPC value

We now measure the effect of EPC values on time on the market, this because the EPC values varies across labels (see fig 8). The regression results in the second model are used to compare the outcome of energy labels and EPC values. The first model is aimed at controlling for the key independent variable, this time, EPC values. Model (1) does not consider other housing characteristics, location or year effects. EPC has a negative effect on time on the market. If EPC value increasing with 1 percent, it will have a negative effect of 0.09 percent on time on the market. However, LN (EPC) is not significant.

The second model controls for the housing character floorspace surface. Floorspace surface is significant on a 99 percent significance level. When adding Floorspace surface, LN (EPC) becomes significant on a 95 percent significance level. An increase of 1 percent in EPC, decrease the time on the market with 2.26 percent. This means when the EPC value increases, which means less energy efficient, the time on the market decreases. This is in line with Belkin et al (2016), higher energy efficiency leads to higher prices and properties that are prices higher have a longer time on the market.

The third model adds the housing character building year. All categories of building year are significant on a 99 percent significance level, "1901-1920" is significant on a 95 percent significance level. Adding building year to the model makes LN (EPC) not significant anymore. For example, a property that is built between "1961-1980" has a negative effect of: Exp (-0.14) -1 * 100% = 13.06 percent or 12 days on time on the market compared to the reference category of 1820-1900. A property that is built between 2001-2022 has a negative effect of: Exp (0.113) -1 * 100% = 10.68 percent or 9 days on time on the market.

The fourth model controls for the year fixed effect. This research used data of houses that came on the market between 2019 and 2022. Adding the year FE makes LN (EPC) significant again on a 95 percent significance level. The effect of building year increases slightly in every building category. For example, the effect of a house built between 1981-2000 increases with: {Exp (-0.171) -1 * 100%} - {Exp (-0.146) -1 * 100%} = 2.13 percent or 1 day after adding the year fixed effect. The coefficient floorspace surface is still significant on a 99 percent significance level.

The main results of the regressions with EPC values are comparable to the regressions with energy label. Both, EPC values and energy labels have a negative effect on time on the market. Floorspace surface is in both cases significant on a 99 percent significance level. A property built between 2001-2022 has a negative effect of: Exp (-0.147) -1 * 100% = 13.67 percent with energy labels compared to: Exp (-0.153) -1 * 100% = 14.19 percent with EPC values. Furthermore, the R-squared of energy label is 16.1% compared to 16% with EPC values. This means that around 16% of the variance of time on the market is explained by energy efficiency. An increase in EPC value causes a decrease on time on the market. An increase of EPC value means that a property becomes less energy efficient, because the higher the EPC value, the lower the energy efficiency. These results are comparable to the regression model with energy labels. The difference in effect between energy label A (high energy efficiency) and energy label G (low energy efficiency) is: {Exp (-0.645) -1 * 100%} - {Exp (-0.467) -1 * 100%} = -10.22 percent. This means that energy label G has a 10.22 percent more negative effect on time on the market than energy label A.

Table 4 – Estimates of OLS Regression

	(1)	(2)	(3)	(4)
LN (EPC)	-0.00905	-0.0226**	-0.0145	-0.0289**
	(0.00947)	(0.00960)	(0.0136)	(0.0134)
LN (Floorspacesurface)		0.135***	0.166***	0.153***
		(0.0144)	(0.0150)	(0.0147)
1901-1920			-0.116**	-0.120**
			(0.0539)	(0.0530)
1921-1940			-0.153***	-0.171***
			(0.0427)	(0.0418)
1941-1960			-0.165***	-0.190***
			(0.0386)	(0.0378)
1961-1980			-0.140***	-0.162***
			(0.0372)	(0.0364)
1981-2000			-0.146***	-0.171***
			(0.0387)	(0.0380)
2001-2022			-0.113***	-0.153***
			(0.0404)	(0.0397)
Location FE			YES	YES
Year FE				YES
Observations	29,532	29,532	29,532	29,532
R-squared	0.000	0.003	0.041	0.160

The table shows regression estimates of equation (3). The dependent variable is log Time on the market. The model includes property characteristics as listed in Table 1. Notes; the reference categories, for energy label is A plus, Building year "1820-1900". The estimation sample is 2019-2022. See Appendix for variable definitions. Robust standard errors in parentheses. *** p<0,01, ** p<0,05, * p<0,1

5. CONCLUSION

The role of energy efficiency and the improvements in the real estate sector are becoming more important in the reduction of global carbon emissions. For reaching the European goal in 2050, action and initiatives are necessary. Therefore, this paper researched the association between energy efficiency and time on the housing market in Limburg and Hainaut, Belgium. Because both, investors and households have to meet certain targets, the adoption of energy efficiency is really important. The relationship between time on the market and prices is well documented in the literature. Higher prices lead to longer time on the market. The contribution of this research is to look at the relationship of time on the market and energy efficiency. Especially for two provinces in Belgium. Properties with low energy efficiency have a shorter time on the market compared to properties with high energy efficiency. This study could not prove the importance of energy efficiency in the housing market. The adoption of energy efficiency is slow, this could be one of the reasons why we found such results. This research uses two measurements of energy efficiency which are energy labels and EPC values. This study finds a negative relationship of 2.85 percent between EPC values and time on the market. Furthermore, it finds a negative relationship of 37.31 percent between a property with energy label A and time on the market and a negative effect of 47.53 percent between a property with energy label G and time on the market. While literature suggest that high energy efficient houses are favored in the capital and space market, this research cannot support in these statements. This research adds to the findings of Fuerst et al (2016), who describes the impact of energy efficiency on time on the market as not straightforward. On the one hand, there may be a large number of potential buyers for an energy efficient property. On the other hand, owners of high energy efficient properties are environmentally aware and expect a price premium which lead to longer time on the market.

Using data from Zimmo, an online website where households can sell their properties. The data sample have more old properties than new properties, this is because the new projects don’t come on the market. This could be a possible limitation where future research could use another data sample that includes more new built properties.

While this study provides evidence of the negative relationship between energy efficiency and time on the market, it does not include selling prices. Prices keep playing an important role in the relationship with time on the market. To strengthen the contribution of this work, future research could use prices and explore if there are any different results.

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6. APPENDICES

Appendix A – Variable Definitions

Table A1 – Variable definitions

Category	Label	Type	Description
Dependent variable	LN (Timeonthemarket)	Continue	The time on the market is derived by subtracting the sales day and list day.
Variable of interest	ENERGYLABEL	Continue	Type of energy label A++, A+, A, B, C, D, E, F, G
	<u>ENERGYLABEL dummies</u>		
	Label A+	Dummy	Indication whether the dwelling is labeled A+, whereas 1 = yes and 0 = no
	Label A	Dummy	Indication whether the dwelling is labeled A, whereas 1 = yes and 0 = no
	Label B	Dummy	Indication whether the dwelling is labeled B, whereas 1 = yes and 0 = no
	Label C	Dummy	Indication whether the dwelling is labeled C, whereas 1 = yes and 0 = no
	Label D	Dummy	Indication whether the dwelling is labeled D, whereas 1 = yes and 0 = no
	Label E	Dummy	Indication whether the dwelling is labeled E, whereas 1 = yes and 0 = no
	Label F	Dummy	Indication whether the dwelling is labeled F, whereas 1 = yes and 0 = no
	Label G	Dummy	Indication whether the dwelling is labeled G, whereas 1 = yes and 0 = no
	EPC	Continue	Indication of the EPC value in kWh/(m2year)
Control Variables	Floorspace surface	Continue	Floorspace surface per m2
	<u>Year dummies</u>		
	1820-1900	Dummy	Indication of the dwelling is constructed between 1820 and 1900, whereas 1 = yes and 0 = no
	1901-1920	Dummy	Indication of the dwelling is constructed between 1901 and 1920, whereas 1 = yes and 0 = no
	1921-1940	Dummy	Indication of the dwelling is constructed between 1921 and 1940, whereas 1 = yes and 0 = no
	1941-1960	Dummy	Indication of the dwelling is constructed between 1941 and 1960, whereas 1 = yes and 0 = no
	1961-1980	Dummy	Indication of the dwelling is constructed between 1961 and 1980, whereas 1 = yes and 0 = no

1981-2000	Dummy	Indication of the dwelling is constructed between 1981 and 2000, whereas 1 = yes and 0 = no
2001-2022	Dummy	Indication of the dwelling is constructed between 1981 and 2000, whereas 1 = yes and 0 = no
PROVINCE	Continue	Indication of the dwelling is located in Limburg or Hainaut, whereas 1 = Limburg and 0 = Hainaut
PROVINCE dummies		
Limburg	Dummy	Indication of the dwelling is located in Limburg whereas 1 = Limburg and 0 = not
Hainaut	Dummy	Indication of the dwelling is located in Hainaut, whereas 1 = Hainaut and 0 = not
Location FE	Continue	ZIP code number
Year FE	Continue	Year the property comes on the market

Appendix B – OLS Assumptions

According to Brooks and Tsolacos (2010), there are four assumptions that are needed to be satisfied in order to make the coefficients the best possible in a linear regression. These are: the consistency of the estimates, the efficiency of the methods, the accuracy of the errors, and the value that is close to the real effect.

Assumption 1: E(ε) = 0

The first assumptions concern the linearity of the residuals and will never be violated when a constant term (β0) is incorporated in the regression model (Brooks and Tsolacos, 2010). Since every model of the analysis includes an intercept term, it is assumed that this assumption is fulfilled.

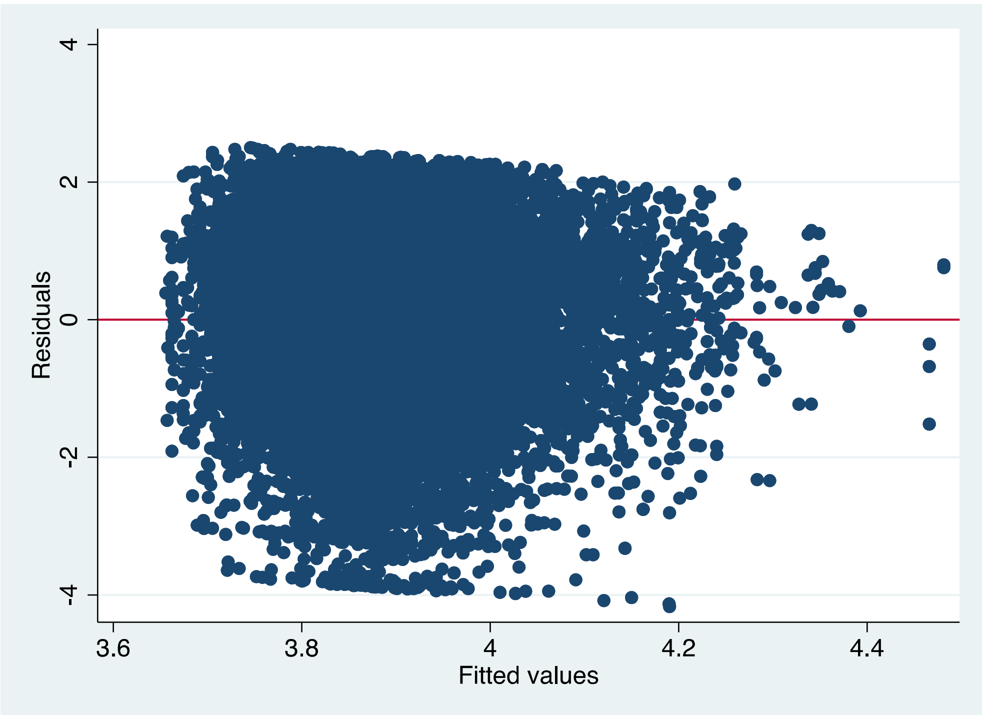
Assumption 2: Var(ε) = σ < ∞

In order to check if the error terms present heteroscedasticity, the Bruesch-Pagan/Cook-Weisberg test is used. The H0 hypothesis of this test is that the residuals' variance is constant. The null hypothesis is rejected at a 5% significance level for all of our models as the p-value is lower than 0.05, indicating that the error terms' variance is not constant. To mitigate the presence of heteroscedasticity, robust standard errors are being used in all of our regression models.

H0: Constant Variance

Chi2 =

Prob > chi2 =

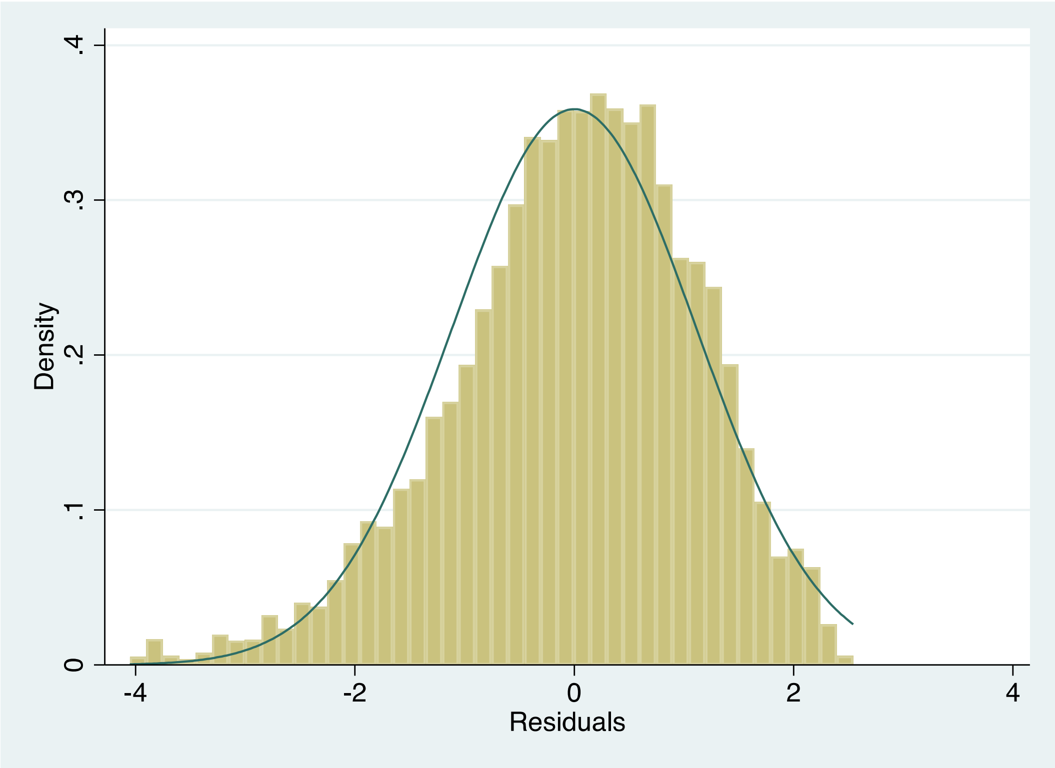


Assumption 3: cov(εi, εj) = 0 for i=j

The third assumption requires that the residuals are uncorrelated with one another. Since the dataset consists of cross-sectional observations, it can be evident that the covariance between the residual is zero and thus, there is no issue of autocorrelation in our sample.

Assumption 4: Normally distributed error terms

The figure below showes that the distribution of the residuals in our models is not normal. However, the normality of the distribution of the error terms is not a major issue. Based on the central limit theorem if the sample exceeds the amount of 30 degrees of freedom, the distribution of residuals can be considered as normal.



Multicollinearity

Multicollinearity is an implicit assumption and refers to the case where the dependent variables must not be correlated with one another (Brooks & Tsolakos, 2010). Multicollinearity issued can occur if the VIF of a variables is higher tan 10. Values greater than 5 indicate possibile multicollinearity. As shown by the table below, all VIF values of the two models used in our analysis are lower than 5, and thus it can be assumed that there are no multicollinearity issues in the models.

Table A3 – Variance inflation factor

	Model (1)	**Model (2)**	**Model (3)**
ENERGYLABEL A plus	1.016	1.016	1.016
ENERGYLABEL B	3.039	3.065	3.286
ENERGYLABEL C	2.836	2.915	3.882
ENERGYLABEL D	2.41	2.475	3.504
ENERGYLABEL E	2.139	2.184	3.095
ENERGYLABEL F	2.682	2.729	4.217
ENERGYLABEL G	1.168	1.17	1.318
LN (Floorspace surface)		1.042	1.068
1820-1900			1.438
1901-1920			1.318
1941-1960			2.706
1961-1980			3.588
1981-2000			3.175
2001-2022			4.729
Mean VIF	2.184	2.074	2.739