The impact of sustainable policy on office transaction values

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Abstract

The Dutch government transformed their climate ambitions into proposed targets to strive for a climate-neutral built environment in 2050. The first deadline is the upcoming obligatory requirement for offices larger than 100 square metres (sqm) to have at least an EPC C-label. This study looks at the consequences the upcoming deadline has on the market dynamics by applying a multiple OLS regression analysis on 2,053 office investment transactions, which took place between Q1 2015 and Q2 2022. We found a negative weakly significant divergence of 23.5 per cent in the average transaction value of "2023 proof" and "non-2023 proof" offices seven years before the deadline. Furthermore, the results reveal that three years, and within two years before the deadline, a positive weakly significant diverging trend of respectively 31.9 and 32.7 per cent between the average transaction values of "2023 proof" and "non-2023 proof" offices. Possibly both the Covid-19 pandemic and the approaching deadline contributed to the emergence of this trend. Altogether, this study tried to map the course of the sustainable deadline effect through time. As more Energy Efficiency Obligatory Schemes (EEOS) will be implemented in the future, this paper forms an initial ground for subsequent studies to analyse the effect of sustainability policy deadlines on asset investment market dynamics.

Keywords: Offices; Sustainability; Sustainable policies; Obligatory C-label deadline; transaction values; investment market dynamics; Energy Efficiency Obligation Schemes (EEOS); multiple OLS regression; Hedonic Pricing Method (HPM).

Colophon

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"Master theses are preliminary materials to stimulate discussion and critical comment. The analysis and conclusions set forth are those of the author and do not indicate concurrence by the supervisor or research staff."

Table of contents

1. INTRODUCTION

1.1. Motivation

Climate change is one of the greatest threats humanity faces today (Hoegh-Guldberg et al., 2019). The 2015 Paris climate summit marked the starting point at which society became more aware of the importance of a sustainable transition to protect the earth's living standards (United Nations, 2015). Since then, various countries have tightened their policies to reduce carbon emissions. Nevertheless, the 2021 Glasgow climate conference showed that the world still needs to take steps to limit the rising temperatures by 1.5 degrees Celsius at the end of this century (United Nations, 2021). As the built environment is responsible for 28 per cent of the world's total emissions, there is room to become more energy efficient (Architecture2030, 2018). Especially in Europe, where the built environment contributes to 36 per cent of the energy-related greenhouse gas emissions (European Commission, n.d.). In The Netherlands, the government transformed their climate ambitions into proposed targets to strive for a climate-neutral built environment in 2050 (TNO, 2019).

To create an energy-neutral built environment, the Dutch government established legally bounded targets connected to Energy Efficiency Obligatory Schemes (EEOS). Hence, specific asset groups of real estate need to have a certain degree of energy efficiency before a pre-determined deadline. Therefore, stakeholders use green rating systems to measure real estate energy efficiency and sustainability (Eichholtz et al., 2010). As the Dutch office stock is responsible for 18 per cent of the country's total CO2 emissions, the Dutch government decided that offices need to be the first asset class to become more energy efficient. In the 2000s, the government took the first steps in which it became obligatory on January 1, 2008, to deliver an EPC[1] energy label for offices after a transfer between owners. However, as this policy did not have the desired effect, the "Bouwbesluit 2012[2]" transformed the energy efficiency requirements into legally bound targets (Rijksoverheid, 2012). Therefore, all offices with a surface larger than 100 square metres (sqm) need to have at least an EPC energy label C on January 1, 2023 (Arnoldussen et al., 2016). In 2018 an adjustment was made in the "Bouwbesluit 2012" for objects which have: less than half of their surface for office purposes, have a monumental status, or will be demolished within two years (RVO, 2021). However, objects that do not have these features or do not meet the energy requirement, will lose their office function. Yet, the number of offices with no energy label remains high, at approximately 30 per cent (Somfy Nederland, 2022).

NVM (2021) reported that half of the Dutch office stock, representing 40 million sqm, has an EPC energy rating lower than C. Furthermore, NVM (2021) envisions that a total investment of 680 million euro is needed to meet the energy requirements. Kok and Jennen (2012, p. 496) reveal the

[1] EPC (Energy Performance Certificate) is an indexed green rate label indicating a building's energy efficiency, ranging from A (energy efficient) to G (not energy efficient).

[2] "Bouwbesluit 2012": legally bound building regulations in The Netherlands, starting from January 1, 2012.

consequences as they expect a broader divergence in value between energy-efficient and energy-inefficient office buildings will emerge. Subsequently, it is expected that this distinctive trend will be reflected in the assets' value, rents, absorption time and vacancy rates (Kok & Jennen, 2012; Warren-Myers, 2022). As the deadline for the energy efficiency obligation for offices is approaching, the pressure on owners and investors in office buildings rises. Furthermore, Vastgoedmarkt (2021) asserts that the Covid-19 pandemic delayed the sustainable transition of office buildings, negatively affecting the supply growth of the total sustainable office stock. Consequently, this affects the office market dynamics and asset values (Vastgoedmarkt, 2022). All in all, these developments rise to the attention of governmental organisations, office owners and investors.

1.2 Academic relevance & research problem statement

There are various examples of academic papers researching the relationship between sustainability affecting real estate asset values. For example, Eichholtz et al. (2013) analysed American office buildings to find that the value of "green" real estate is much less volatile during a period of economic downturn than "brown" real estate. Surmann et al. (2015) examined how energy efficiency influenced the market value of German office buildings between 2009 and 2011. More recently, Mangialardo et al. (2018) investigated the green premium realised on newly developed office buildings in Milan. Regarding academic research on the impact of energy efficiency on the value of Dutch office buildings, the amount of studies becomes limited. Generally, it involves papers that analyse the influence of energy efficiency on office rental levels as part of a green premium (Kok & Jennen, 2012). However, these studies took place years before the obligatory energy efficiency deadline. Furthermore, many studies face the limitation of having a small sample size due to a limited amount of available data (Surmann et al., 2015; Manglialardo et al., 2018).

To measure the impact sustainability has on office values, we need to take a closer look at the determinants which play a role. Ciora et al. (2016, p. 60) assert that because of the heterogeneity of European institutions and real estate markets, a variety of hypotheses still need to be tested on this relationship. One of these fields of interest is the role of obligatory energy requirement deadlines on real estate market dynamics. While being recognised by studies like Arnoldussen et al. (2016) and Fawcett et al. (2019) as a prospective impactful exogenous factor, few papers have focused so far on the effect sustainable policies have on asset transaction values. Furthermore, there are almost no familiar studies which focus on the relationship between policy-driven EEOS affecting asset values. More specifically, there are currently no papers analysing the impact of the Dutch 2023 obligatory energy efficiency deadline on office values. However, we can define some factors which will play an important role when the deadline approaches. A meaningful mechanism is captured in the investment perspectives of office owners and investors. Dixit and Pindyck (1994) assert that: high initial costs of sustainable building materials; uncertainty caused by energy costs, public policy, rents and exit yields; and the short-run implications of delaying retrofits, are influential factors which occur when facing investments in real estate sustainability. Subsequently, as the deadline approaches, it is expected that it will affect the office investment market dynamics. To obtain the required 2023 energy efficiency level, office investors and owners should consider investing in energy-efficient buildings, or paying high initial costs in the short term to retain the objects office function after January 1, 2023. Therefore, we would expect an increasing divergence trend in average transaction values between "green" and "brown" offices (Kok & Jennen, 2012). Furthermore, it is expected that EEOS will be implemented more frequently in the upcoming years in European countries (Fawcett et al., 2019). Additionally, Economidou et al. (2020) notice the importance of researching the economic consequences of such policy ambitions on the built environment. Therefore, this study wants to analyse the effect the current 2023 obligatory energy efficiency deadline has on Dutch office transaction prices. More explicitly, this paper will be of added value by analysing the trend effects of the upcoming deadline on the transaction values of "2023 proof [3] " and "non-2023 proof [4] " offices. Altogether, this study meets the demand for more in-depth research to measure the impact of the energy transition on the value of the real estate (Christersson et al., 2015).

The paper uses a multiple Ordinary Least Squares (OLS) regression analysis, in which we examine a dataset of 2,053 Dutch office investment transactions. The research period involves the first quarter of 2015 till the second quarter of 2022. Finally, the dataset should give insight into how investors incorporate a brown discount or a green premium over time, based on the obligatory C-label deadline. Fawcett et al. (2019) recognise that the performance of EEOS depends on policy details, governance, market structure and conditions. Therefore, it is interesting to analyse whether the deadline affected the office transaction values of "2023 proof " and "non-2023 proof" over time. All in all, to get insight into the relationship, this study has the following main research question:

"To what extent were transactions prices of Dutch office buildings over the 2015 to 2022 period affected by the upcoming 2023 obligatory energy C-label deadline?'"

To finally answer the research question, this paper has the following structure. Chapter 2 gives an overview and discusses all the relevant academic literature. Subsequently, the methodology in Chapter 3 provides insight into the way the empirical model is tested by applying a multiple OLS regression analysis. Chapter 4 discusses the descriptive statistics and quality of the used data frame. Chapter 5 presents and discusses the results of the multiple OLS regression analysis extensively. Lastly, in Chapter 6, we draw conclusions from the research results.

[3] "2023 proof" involves offices which have an EPC energy label between A-C at their date of transaction.

[4] "Non-2023 proof" involves offices that have an EPC energy label between D-G at the date of the transaction in which these objects would officially lose their office function after January 1, 2023.

2. THEORATICAL BACKGROUND

This master's thesis aims to analyse the impact obligatory sustainable policy has on the investment transaction prices of offices. Therefore, this chapter consists of an academic literature review that tries to implement appropriate theories and concepts that relate to the research problem statement. Firstly, we will deepen the paper's subject by implementing familiar literature about the impact of sustainability policy on property values and, in particular, offices. Furthermore, this section examines the advantages and limitations of some research methods that tried to capture the effect of sustainability on office transaction values. Lastly, we translate the literature review into a summarising conceptual model.

2.1. The relationship between sustainability, sustainability policies, and office values

Recently, Economidou et al. (2020) wrote a review of 50 years of energy efficiency policies in European countries, where they focused on policy instruments supporting measures on energy efficiency in new and existing buildings. Economidou et al. (2020) assert that in Europe, due to the oil crisis in the 1970s, countries introduced energy efficiency policies for the built environment. Subsequently, Economidou et al. (2020) conclude that within the last 50 years, energy efficiency policies became more dominant in their scope, scale and ambition. Therefore, Economidou et al. (2020) discuss that policymakers should consider both the ecological and economic impact of such energy efficiency policies on the built environment and its sector. In another review study on energy efficiency policies, Fawcett et al. (2019) describe that the rising awareness in society that the built environment causes a large share of the total carbon emissions contributed to the growing application of national EEOS. In their study, they analysed EEOS in different European countries, in which they found successful executed EEOS in Denmark and the United Kingdom. Subsequently, Fawcett et al. (2019) conclude that EEOS, if well designed, can significantly contribute to energy savings. However, the role of institutions and stakeholders needs to be notified, in which the discussion about the cost to bill payers is the most influential factor on EEOS performance.

Besides the presence of EEOS, there is growing interest in energy-efficient buildings to reduce operational costs. In their study, Zhang et al. (2018) reviewed existing studies which analysed the economic feasibility of green properties from the perspective of market participants and the building life cycle of an object. Here, Zhang et al. (2018) notice that although "going green" can be economically beneficial, there are factors which influence the choice of tenants and developers to invest in green properties. According to Zhang et al. (2018, p. 2243), these are: *"(..) overestimates of initial costs, cost-benefit mismatch caused by information asymmetry, split incentives caused by contract structure and energy pricing, and a lack of attention to energy costs."* Altogether, these developments form an initial ground for studies to research the impact of sustainability on property investment values. However, the extent to which sustainability contributes needs to be considered. In their review study, Krause and Bitter (2012) emphasise that the level of income determines the value of commercial real estate.

Subsequently, a higher level of energy efficiency should theoretically form a rent premium incorporated into the asset values (Krause & Bitter, 2012). However, as there are exogenous factors that need to be controlled for, it is challenging to capture the exact contribution of sustainability. When examining this relationship, studies make use of the Hedonic Pricing Method (HPM) which implies a hedonic analysis that controls for building characteristics such as size, height, services and location (Nappi-Choulet et al., 2007; Kok & Jennen, 2012; Carlson & Pressnail, 2018; Seo et al., 2019). Lastly, economic trends and market cycles are significant exogenous factors which affect market dynamics (Barras, 2002; Gaddy & Hart, 2003; Ossokina, 2012; Buitelaar, 2017).

Warren-Myers (2022) performed a review study on the sustainability consideration of property values. According to Warren-Myers (2022), the interest in researching sustainability influencing property values started at the beginning of the 21st century. Studies then focused on the benefits of sustainability associated with cost efficiency, profitability and marketability as a driver for increased rents, reduced operating costs, higher sale prices and lower degrees of vacancy (Warren-Myers, 2022). In the beginning, studies were more cautious when concluding. For example, Myers et al. (2007) researched the limited studies which examined the impact of sustainable factors which would affect the objects' value. Subsequently, they noted the lack of consensus to determine the actual effect of sustainability on the market value of an office due to a lack of market data, empirical data, and market transactions. Simultaneously, Warren-Myers (2022) concludes the existing challenges of researching the impact of sustainability on property values as a consequence of changing sustainability, environmental, social and governance and climate factors.

After the introduction of EEOS in the last couple of years, the demand for generally binding energy ratings for properties increased (Fawcett et al., 2019; Economidou et al., 2020). Subsequently, Warren-Myers (2022) describes that since their introduction, some of these energy rating systems are now globally used, like BREEAM, Energy Star and LEED. On the one hand, Warren-Myers (2022) emphasised the advantage of using energy rating systems as a common language for stakeholders and governments to indicate the property's sustainability requirements. On the other hand, Warren-Myers (2022) admits the challenges as the variety in which energy rating makes use of elements which contribute to the sustainability of a building. Subsequently, this creates confusion for stakeholders. There are still complexities when comparing specific rating systems having a multi-criteria approach (Warren-Myers, 2022). Since 2007, the European Union tried to homogenise the energy efficiency rating of buildings by introducing the EPC for the European market (Li et al., 2019). Still, various energy efficiency ratings are used globally, or even within the European Union.

Two studies which tried to capture the effect of sustainability by analysing how green ratings contribute to the determination of rents are the papers of Eichholtz et al. (2010), and Kok and Jennen (2012). Firstly, Eichholtz et al. (2010) applied a hedonic analysis on rent data of 8,105 American offices provided by the Environmental Protection Agency. Secondly, Kok and Jennen (2012) criticised the large-scale presence of speculations and the shortage of empirical studies that analyse the relationship between sustainability and possible revenues on commercial assets. Therefore they applied a hedonic analysis on the impact of energy labels and accessibility on 1,100 Dutch office lease transactions, which took place between 2005 and 2010. A relevant issue when comparing the results of these studies is the comparability of the applied energy rating systems. Eichholtz et al. (2010) used the American LEED and Energy Star rating systems, while Kok and Jennen (2012) implemented the EPC energy rating. The American LEED score focuses on energy efficiency, but also on how the building contributes to human health, water resources, biodiversity and the green economy (Newsham et al., 2009). The Energy Star rating system only indicates the energy efficiency of a property with a 1 to 100 score. Likewise, EPC is also based on energy efficiency but uses an A till G score with a validity of ten years (Li et al., 2019). Subsequently, Eichholtz et al. (2010, p. 2498) revealed that different energy scores result in different average rental premiums. They found that a higher LEED score represents a 5.2 per cent premium increase, while a higher Energy Star rating increases the premium by 3.3 per cent. Kok and Jennen (2012) analysed real estate transaction data including EPC labels provided by the Dutch Ministry of Economic Affairs. They found that “non-green” office buildings represented a 6.5 per cent lower value on rents than “green” offices. Lastly, Eichholtz et al. (2010) and Kok & Jennen (2012) used distinctive study areas, and different research periods, and controlled for other parameters. All in all, it is doubtful to what extent we can compare the results of such studies.

Another perspective on researching the effect of sustainability on property values is analysing the operational costs, as they can be reduced by pressing down the objects’ energy consumption. Eichholtz et al. (2010, p. 2492) assert that the energy usage of an office building’ is on average equal to 30 per cent of the total operating expenses. Therefore, reducing the property’s operating costs can be attractive for users, owners and investors of office buildings. Subsequently, adjusting energy-saving features in offices can reduce the total energy consumption. Christersson et al. (2015) investigated the financial performance of energy audit investments of existing office buildings. They found a premium for sustainably transformed offices, as the market values represented a 2.5 higher percentage on average. On the one hand, Carlson and Pressnail (2018) claim in their small sample study that retrofitting sustainable elements in office buildings can decrease operating costs, increase tenancy rates and effective rent. Altogether, this will result in an increasing net operating income. On the other hand, Carlson and Pressnail (2018, p. 154) admit that this does not have to apply to each retrofit. Nonetheless, in those places where these advantages emerge, they positively affect office values.

Zhang et al. (2018) notice that, because of their energy efficiency, green buildings beneficially have lower operating costs compared to objects that do not have that advantage. According to Zhang et al. (2018), these benefits are generally capitalised into the market value. Subsequently, Zhang et al. (2018, p. 2239) describe this specific capitalisation as the “green premium.” It refers to the difference in rental or sale prices between “green” and “non-green buildings,” which apart from being marked as “green” have the same physical characteristics. Additionally, Ciora et al. (2016) assert that having a green premium can be of interest to the owner as it results in a significantly higher resale value.

Moreover, this does not only hold in times of economic prosperity and a tight market. Eichholtz et al. (2013) performed a hedonic analysis on American office buildings. They discovered that the value of "green" real estate is much less volatile during a period of economic downturn than "brown" real estate. Earlier, Eichholtz et al. (2010) asserted that sustainable properties have longer economic lives than conventional buildings, because of having less environmental risk and better marketability. Subsequently, it reduces risk premiums, and higher valuations of the properties will follow.

According to the theory of DiPasquale and Wheaton (1992), real estate market dynamics will be affected when a government implement new regulations. Obligatory energy requirements higher the risk of energy-inefficient office buildings becoming unusable. Consequently, as yield captures risk, asset values are affected. Eichholtz et al. (2013) researched the economics of green buildings, by performing a hedonic analysis on 4,451 offices with an Energy Star or LEEDS certificate, offered by the CoStar Group. Additionally, Eichholtz et al. (2013) found that investing in properties which score high on legally bound energy rating classifications might reduce the risk for stakeholders of decreasing asset value when the environmental agenda becomes more relevant, and energy prices increase. Furthermore, Eichholtz et al. (2013) exposed the trend in which real estate investors attach more value to buildings having a lower risk premium because they perform well on the energy classification scores. Eichholtz et al. (2013) speculate that this could also be a consequence of stakeholders assessing energy-efficient buildings as a stable investment when facing rising energy prices in the future. Subsequently, investing in non-energy efficient properties can be marked as riskier. Hüttler et al. (2011) confirm this as they executed a survey involving 40 large German, Suisse, and Austrian real estate firms. They found that 70 per cent of the investors were willing to accept an 8.9 per cent higher average investment cost for sustainable buildings. Furthermore, they revealed that 86 per cent of the tenants were willing to pay a 4.5 per cent higher rent for a sustainable office building.

According to Warren-Myers (2022), zero-emission obligations, rising climate risks, and EEOS will become more of an issue for owners, investors and tenants of real estate, which is in line with the prediction of Eichholtz et al. (2010). They already acknowledged that, on the one hand, stricter policies based on applying energy ratings lead to a diverging effect between energy-efficient and non-energy efficient properties. On the other hand, society will benefit as it will contribute to the fight against climate change. However, Fawcett et al. (2019) emphasize that the success of implemented EEOS depends on the policy design, governance and market structure conditions. Subsequently, it determines how energy efficiency policies affect buildings economically and in terms of energy performance (Economidou et al., 2020). Nevertheless, the legally bounded energy obligations for offices are a harbinger for stricter EEOS which will follow the upcoming decades (Arnoldussen et al., 2016; Fawcett et al., 2019; Economidou et al., 2020). All in all, it can be concluded that, as a consequence of stricter policy regulations, sustainability will become a more dominantly determinator of property asset values (Eichholtz et al., 2010; Arnoldussen et al., 2016; Economidou et al., 2020; Warren-Myers; 2022).

2.2. Conceptual model

Figure 1 shows the conceptual model illustrating the relationships discussed in Paragraph 2.1. The right side displays the relationships of the research aim. As shown in the theoretical framework, various studies from different research angels acknowledge the added value of a higher energy label score on asset rental and transactions values (Eichholtz et al., 2010; Hüttler et al., 2011; Kok & Jennen, 2012; Eichholtz et al., 2013; Christersson et al., 2015; Carlson & Pressnail, 2018; Warren-Myers, 2022). Subsequently, Eichholtz et al. (2010), Arnoldussen et al. (2016), Economidou et al. (2020), and Warren-Myers (2022) expose that over time, sustainability will be more impactful on asset transaction prices. Furthermore, Eichholtz et al. (2010) expect that stricter legally bound sustainability regulations will result in a diverging effect between energy-efficient assets and energy inefficient assets.

At the moment, there still is a debate whether this is a consequence of a "green premium" or a "brown discount". On the one hand, an asset which conforms to the legally bound energy requirements retains its function. Subsequently, office investors will face lower or no initial costs for realising sustainable retrofits in the short run compared to assets that do not meet the energy requirements. Consequently, this advantage could theoretically translate into a green premium in the market value for energy-efficient buildings (Kok & Jennen, 2012; Eichholtz et al., 2013). On the other hand, the absence of sustainability could result in a brown discount for energy-inefficient assets. When offices do not meet the demanded energy requirements, the properties face the risk of becoming unusable (Arnoldussen et al., 2016). Furthermore, sustainability becomes more of an influential weighting factor for asset investments as society's awareness rises (Warren-Myers, 2022). Ultimately, while investing in energy-efficient assets, investors should realise initial investments in the short run, which should theoretically result in a brown discount on the market values of energy-inefficient properties. All in all, we define the research hypothesis as follows:

Main hypothesis: ***"The closer to the obligatory 2023 C-label deadline, the more divergence between the office transaction values of "2023 proof" and "non-2023 proof" offices."***

To measure the "green premium" or "brown discount", the dependent office transaction price variable is controlled by building characteristics and location. The left side of the conceptual model presents the relationship between building and location characteristics on office transaction prices. Various literature asserts that several building characteristics can affect office transaction prices (Nappi-Choulet et al., 2007; Kok & Jennen, 2012; Carlson & Pressnail, 2018; Seo et al., 2019). Furthermore, location is a vital determinator of sale prices (McCann, 2013; Millington 2013; Van Hees et al., 2017). Altogether, by adding these control variables, the intern validity of the study increases (Brooks & Tsolacos, 2010).

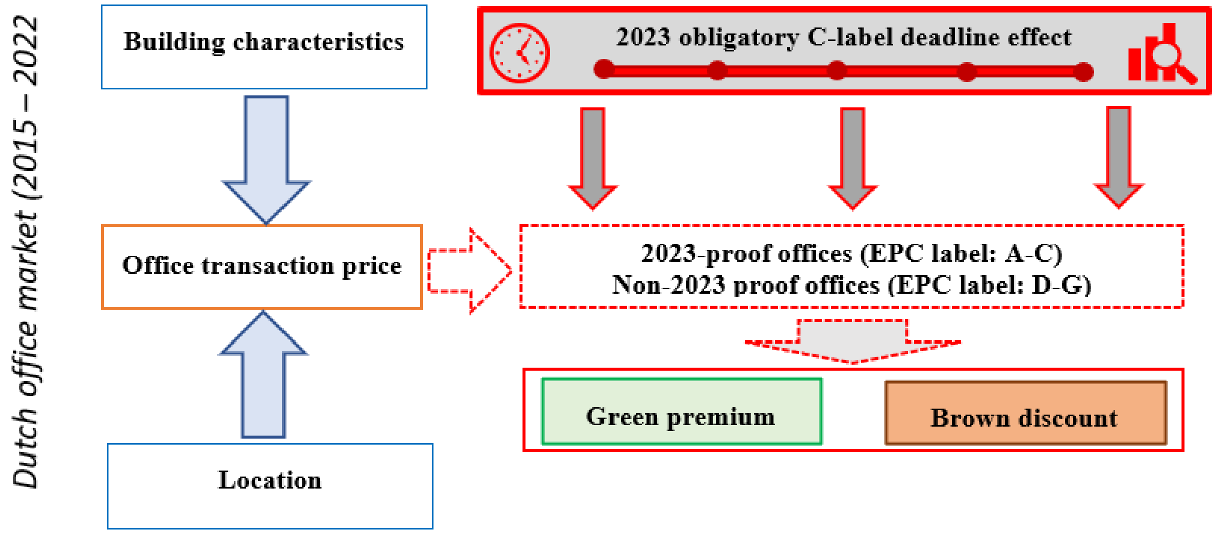

Figure 1) Conceptual model (Author's elaboration, 2022).

3. METHODOLOGY

This third chapter gives insight into the applied method. Firstly, Paragraph 3.1 operationalises and substantiates the applied methodology design to test the proposed hypothetical relationship. Furthermore, this section examines the selected dependent and independent variables for the multiple OLS regression analysis. Subsequently, Paragraph 3.2 explains the study's empirical model.

3.1. Methodology design

As defined in the study's aim, this paper has a primary goal to examine the extent to which sustainability policy influences office transaction values. Therefore, this study uses a quantitative analysis based on cross-sectional data to analyse the degree to which office transaction values were affected over time as the 2023 C-label deadline approaches. As the deadline approaches, we expect that the divergence in office transaction values between "2023 proof" and "non-2023 proof" offices will increase. To research this relationship, the study uses the Hedonic Price Method (HPM), implying a multivariate OLS regression analysis. It represents a common and effective way of researching the relationship between value drivers and real estate prices (Nappi-Choulet, 2007; Kok & Jennen, 2012; Seo et al., 2019; Warren-Myers, 2022).

To be able to indicate the precise deadline effect on office transaction prices, a dependent variable needs to be selected. In the academic field, sqm rental prices are generally used as the endogenous factor when analysing the effect of exogenous value drivers. In their analysis, Kok and Jennen (2012) made use of absolute annual rental prices per sqm. When dealing with a sample containing office transactions that took place in various locations and in different periods, a natural logarithm transformed sqm rental price is a more reliable way of analysing the effect of independent input factors (Brooks & Tsolacos, 2010). As such a diverse sample most likely will result in a left-skewed deviation of rental prices, the natural logarithm ensures that the sample population becomes normally distributed. Subsequently, as normality is one of the key assumptions when working with multiple OLS regression analyses, the transformed variable provides the opportunity to realise reliable generalising statements over the research population (Brooks & Tsolacos, 2010). That is why for example Eichholtz et al. (2010) use the natural logarithm of the rental price per square foot as the dependent variable. On the other hand, Seo et al. (2019) use the natural logarithm for the transaction price, as these are an accurate indicator for indicating actual market values. All in all, this is of relevance when analysing the 2023 C-label deadline effect over the 2015-2022 period. Therefore, this study uses the natural logarithm of the sqm transaction price as the dependent variable.

To examine the relationship of interest, a key independent variable needs to be selected. Firstly, we need to define the offices which are "2023 proof" and "non-2023 proof". Following the EPC label C requirement for office buildings, "2023 proof" refers to offices which had at the day of the transaction an EPC energy label of A, B or C. "non-2023 proof" indicate offices that had an EPC energy label of C, D, E, F or G (Arnoldussen et al., 2016). As this implies a sample deviation, we create a dummy variable for indicating the energy efficiency status of the specific office building. Secondly, the other independent variable refers to the time between the transaction and the actual deadline on January the first, 2023. As we want to research to what extent this potential sustainability deadline effect differs over time, we need to categorise the sample into time categories. Therefore we created transaction year dummies. Subsequently, we interact with both independent variables, which form the key independent variable that will be tested on the dependent variable. Altogether, the key independent variable will contribute to answering the research question as it reveals whether and to what extent transaction values of "2023 proof" and "non-2023 proof" offices significantly differed each year.

Lastly, as shown in Paragraph 2.2, it is proven that there are various factors which significantly affect real estate prices. To increase the explanatory power of the model, we add control variables. The specific added control variables imply location and building characteristics. Firstly, we create categorical municipality dummies to control for location effects. Furthermore, to control for accessibility factors, we add distance variables to the model. These imply the distance between the office building and the nearest train station, transfer station and highway exit, which are proven to contribute positively to the office transaction values (Van Hees, 2017; Seo et al., 2019). Secondly, we add building characteristics to the model to control for physical price-determining factors (Gaddy & Hart, 2003). Therefore, we include building height and size in the model, which are proven to contribute to property values (Nappi-Choulet et al., 2007; Kok & Jennen, 2012; Koster et al., 2014; Carlson & Pressnail, 2018; Seo et al., 2019). Although being frequently used in HPM, building age is not implemented into the analysis as the variable firstly represented a VIF score of 6.83 in which the variable correlated too much with the "2023 proof" dummy variable. Therefore, we excluded this specific variable from the model.

3.2. Empirical model

The methodology design extensively discussed the selected dependent and independent variables. Here, we marked the interaction variable between the "years before deadline" dummies and the "2023 proof" dummy variable as our key independent variable. All in all, we define the study's OLS empirical model that explores the relationship between the sustainable policy deadline effect and office transaction values as follows:

$$Log(sqm\_transaction\_price_i) = \beta_0 + \beta_1(2023\_proof_i) + \beta_2(Years\_before\_deadline_t) + \beta_3(Years\_before\_deadline_i)\ X\ (2023\_proof_i) + \beta_4(Location\_characteristics_k) + \beta_5(Building\_characteristics_i) + e_i$$

Here, we define the dependent variable as the natural logarithm of the transaction price per sqm in an office building *i*. Subsequently, the model implies that the dependent variable is a function of two independent explanatory variables. Firstly, the β_1*2023_proof* dummy variable refers to an office building *i* which has an EPC label between A and C. Secondly, the β_2*Years_before_deadline* dummies imply the number of years between the year of transaction on the time of sale *t* and the obligatory C-label deadline of 2023. The key independent $\beta 3 Years\_before\_deadline_t$ X 2023_proof_i variable stands for the interaction variable, which indicates the relationship between the number of years before the deadline and the transaction on time *t* of a “2023 proof” office building *i*, compared to a transaction of a “non-2023 proof” office building *i* which took place in the same year. Additionally, $\beta_4 Location\_characteristics$ and $\beta_5 Building\_characteristics_i$ refer to the applied control variables consisting of the location characteristics *k* and building characteristics of an office building *i* . Lastly, e_i represents the error term of the OLS empirical model, which indicates the model’s precision of the estimators representing the degree of uncertainty in estimating the values of the coefficients (Brooks & Tsolacos, 2010).

Finally, before running the OLS regressions, we controlled for all the five assumptions of OLS multiple linear regression. These must be checked before drawing conclusions. Brooks & Tsolacos (2010) assert that the OLS assumptions are an appropriate indicator of the model's consistency, efficiency, and unbiasedness. According to Brooks & Tsolacos (2010), OLS analyses should consider the following: (1) the error term has a conditional mean of zero; (2) homoskedasticity, which implies a constant error variance; (3) autocorrelation, which refers to an uncorrelated error over time and/ or across space; (4) endogeneity, which means that regressors are not correlated with the error term; and (5) normally distributed errors. In Appendix 2, we tested all the five OLS assumptions.

4. DATA

Chapter 4 gives insight into the data that we used in the analysis. Paragraph 4.1 provides an overview of the dataset, in which we discuss the data enrichment process and the sample's representativeness. Paragraph 4.2 presents the descriptive statistics in which we examine all included variables individually.

4.1. Dataset overview and representativity

Savills provided excess to the office investment transaction dataset. Before the data cleaning process, it contained 2,093 office transactions accomplished between the first quarter of 2015 and the second quarter of 2022. We selected this time frame as it includes the period after the C-label requirement became legally bound by the “Bouwbesluit 2012.” We started with transactions from 2015 as these were the earliest available cases we could obtain from the data provider. Subsequently, the transactions in the first quarter of 2022 were the most recent transactions we could acquire. Firstly, the dataset included some basic parameters regarding building characteristics. BAG ID numbers gave information about the property’s size, transaction values, EPC energy ratings, building height, and years of construction. Subsequently, the Savills databank provided the opportunity to the extent of the sample with accessibility variables like distances between the office buildings and train stations or main road excesses. To obtain the highest possible number of analysable observations, missing data were filled in by manually entering the BAG ID numbers on the BAG viewer website. Lastly, for research purposes, we enriched the dataset by hand to create the needed *“*2023 proof” dummy variable, “years before deadline*”* dummies, and all the municipality dummies.

Finally, it resulted in an operable dataset of 2,053 cases including a total of 12.4 million sqm of office space, which traded for a cumulative transaction value of approximately 23.7 billion euro. This total amount equalises about 60 per cent of the Dutch office market investment value, which took place between 2015 and the second quarter of 2022. However, it is worth mentioning that the total investment value of the first quarter of 2022 is based on expectations. Within the first quarters of 2022, the predicted total investment value in the Dutch office market represents 2.5 billion euros (Savills, 2022). Nevertheless, over the years, the transactions included in the dataset make up a large part of the total market share. Figure 2 shows the representativity of the dataset by putting the dataset’s yearly investment value against the total annual Dutch office market investment value. Subsequently, Figure 3 illustrates the sample representativeness as a percentage of the total. The transactions years 2016 and 2020 are well represented as the dataset accounts for approximately 80 per cent of the total investment transaction values. Other research years perform well as they correspond to about half of the total yearly transactions. The year 2022 is excluded from Figure 3, as its representativity is based on expected investment values instead of real transaction values. Lastly, Figure 4 displays the spatial distribution of the sample office transactions. As expected from the literature, we can see that the concentration of office transactions that took place between 2015 and 2022 is higher in urban dense areas (Koster, 2013; McCann, 2013).

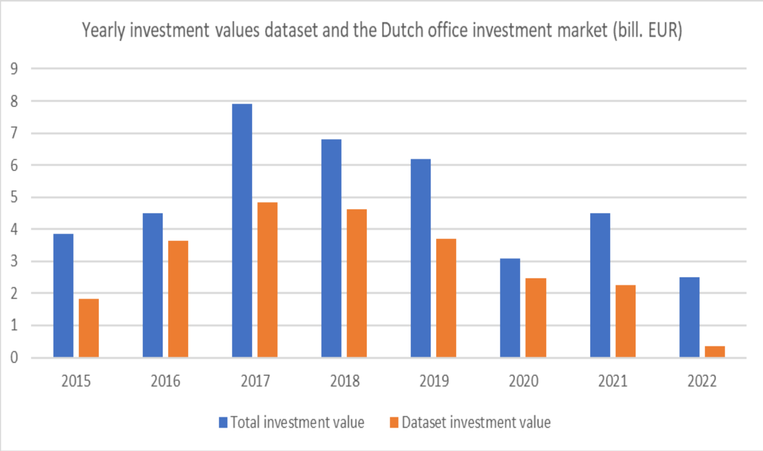

Figure 2) Annual representativity of the sample size to the whole population. (Author's elaboration)

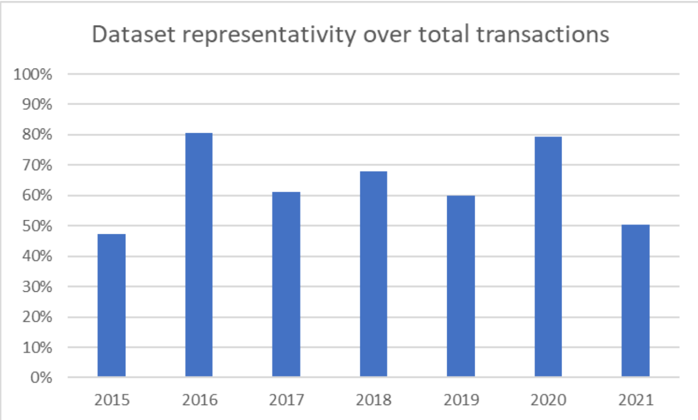

Figure 3) Annual representativity of the sample size displayed as percentage of the total population. (Author's elaboration)

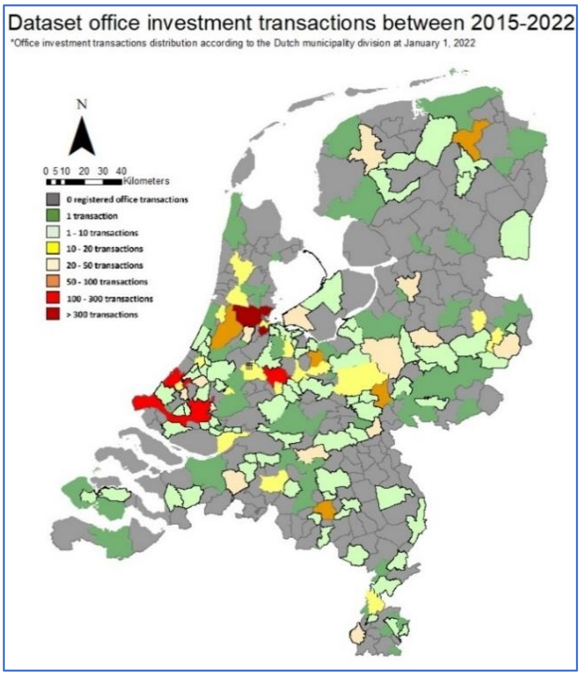

Figure 4) Map displaying the distribution of office transactions in the Netherlands between the first quarter of 2015 and the second quarter of 2022. (Author's elaboration, created with ArcMAP, 2022)

4.2. Descriptive statistics

Table 1 displays the descriptive statistics of all included variables. In the analysis, the dependent variable represents the office transaction value in euros per sqm. It contains a mean value of 1614.78 EUR sqm. This average sqm transaction value differs from Eichholtz et al. (2013), in which they observed an average of 2,633 EUR sqm on American offices. While this sample contains data from different research periods and locations, it is evident that the averages will differ. When creating a histogram of the dependent variable, it reveals that the variable had a left-skewed balance (Appendix 1A). Like other studies that applied a multiple OLS regression analysis, to meet the requirement of a normal distribution, we transformed the variable into a natural logarithm. After completion, the new created *ln_transaction_price* (per sqm) variable demonstrated that the values were now normally distributed (Appendix 1A).

As discussed in the methodology, the research aim is translated into the interaction of two independent variables: the "2023 proof" dummy variable and the "years before deadline" dummies. Over the research period, the sample includes 1,695 offices which were "2023 proof" (EPC label A-C) on the day of the transaction and 357 offices which were "non-2023 proof" (EPC label D-G). The "years before deadline" contains the number of years between the year the transaction took place and the year of the deadline (2023). In that way, the variable should give insight into the changing sqm transaction prices over time. In Appendix 1B, we can see that especially after the pandemic year 2020, the total number of transactions in the dataset has decreased significantly. Though, the proportion of "2023 proof" and "non-2023 proof" office transactions has remained relatively stable as they represented between 15 and 20 per cent of the office transactions each year (Appendix 1B). However, when interpreting the results, the skewed distribution of cases needs to be considered. Consequently, we merged the office investment transactions of 2021 and the first quarters of 2022 to higher the coverage of "non-2023 proof" offices (Appendix 1B).

Besides the dependent and key independent variables, we implemented control variables in the form of building and location characteristics to try as much to reduce the omitted variable bias. As described in the methodology, building characteristics are well-known used parameters when performing these kinds of analyses. Firstly, the office surface variable indicates the total sqm of office space involved in the transaction. Again the data was left-skewed distributed. Therefore, we converted it into a natural logarithm (Appendix 1C). Furthermore, there was the same situation for building height, in which we also changed the variable into a natural logarithm (Appendix 1D).

Lastly, as mentioned in the methodology, this study also controls for locational effects. Therefore we applied distance variables which indicate the quality of offices' accessibility. In the dataset, a train station refers to stations with at least one train connection, while transfer stations refer to larger stations having more than one intercity connection. We can see that the mean distances for train stations (2.7 kilometres) are smaller than transfer station distances (5.1 kilometres). Meanwhile, the mean distance for main road excesses represents a value of 1.9 kilometres. As all the distance indicators were left-skewed, we also transformed these variables into a natural logarithm (Appendices 1D, 1E and 1F). Besides the accessibility parameters, we also implemented urbanity indicators in which municipality dummies control the business location of an office. We choose municipality dummies as these are more precise location indicators for regional and local effects in comparison with alternative province dummies. However, when analysing the dataset, we found that the number of cases was not equally distributed over the different municipality dummies. As McCann (2013) asserts, the number of offices is lower in areas with a lower degree of urban density. Therefore, the number of office transactions in municipalities with a rural character had a low number of transactions. To solve this, we needed to merge some nearby areas to transform them into useful control variables for the analysis. Besides proximity, we also considered the degree of urbanity when merging municipalities. Figure 5 displays the result of the redistribution of the sample cases. Finally, Table 1 presents the absolute deviation and standard deviation of the different municipality dummies.

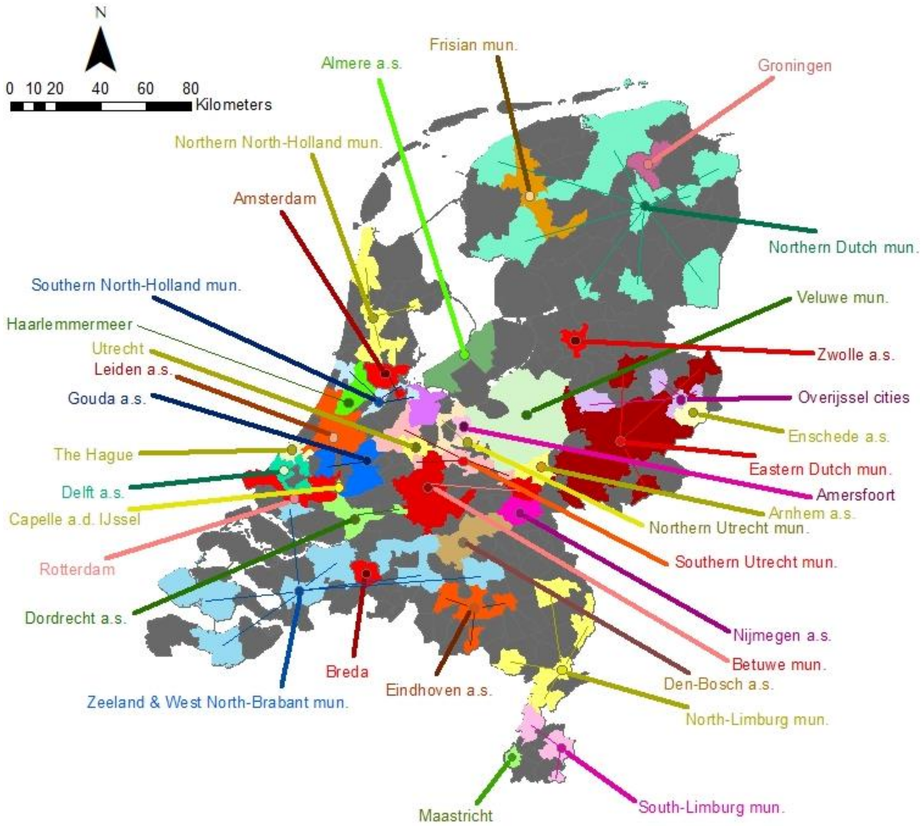

Figure 5) The redistribution of office transactions to meet the requirements of using OLS categorical dummies.

(Author's elaboration, created with ArcMAP, 2022)

Table 1) Overview of the descriptive statistics of all the included office transactions in the dataset.

Variables	Definition	N / %	Mean	Std. Dev.	Min	Max
Transaction variable:	**Dependent variable**					
Transaction price (RATIO)	Square metre transaction prices in euros	2,053	1614.78	1726.12	73.76	23,391.81
Ln transaction price (RATIO)	Natural logarithm of the square metre transaction prices in euros	2,053	7.052	0.799	4.301	10.060
Sustainable policy effect variables:	**Key independent variable**					
2023 proof variable (DUMMY)	"Non-2023 proof" offices (EPC D-G)	17.50%				
	"2023 proof" offices (EPC A-C)	82.50%				
Years before deadline (CAT. DUMMY)	Classes of the number of years between the year the transaction took place and the year of the deadline 2023					
2015: eight years before deadline		10.27%				
2016: seven years before deadline		15.92%				
2017: six years before deadline		20.74%				
2018: five years before deadline		16.60%				
2019: four years before deadline		15.29%				
2020: three years before deadline		11.25%				
2021& 2022: within two years before deadline		9.93%				
Building characteristic variables:	**Control variables**					
Office sqm. Total (RATIO)	Total square metres of leasable office space	2,053	5,892.87	8,289.15	145	122,000
Ln office sqm. total (RATIO)	Natural logarithm of the total square metres of leasable office space	2,053	8.014	1.266	3.807	11.712
Building height (RATIO)	The total building height in metres	2,053	19.15	13.38	3.09	115.37
Ln Building height (RATIO)	Natural logarithm of the total building height in metres	2,053	2.782	0.563	1.128	4.748
Location: accessibility variables:	**Control variables**					
Distance to nearest train station (RATIO)	*Distance in kilometres between an office and the nearest train station*	2,053	2.69	3.41	0.60	39.60
Ln distance to nearest train station (RATIO)	*Natural logarithm of the distance to the nearest train station variable*	2,053	0.675	0.696	-0.511	3.679
Distance to nearest transfer station (RATIO)	*Distance in kilometres between an office and the nearest transfer station*	2,053	5.13	5.47	0.60	44.70
Ln distance to nearest transfer station (RATIO)	Natural logarithm of the nearest transfer station variable	2,053	1.227	0.887	-0.511	3.7999
Distance to the nearest main road entrance (RATIO)	Distance in kilometres between an office and the nearest main road entrance	2,053	1.87	1.34	0.20	19.00
Ln distance to the nearest main road entrance (RATIO)	Natural logarithm of nearest main road entrance variable	2,053	0.494	0.509	-1.609	2.944
Location: municipality dummies:	**Control variables**					
Municipalities (CAT. DUMMY)	Classes of the number transactions that took place between 2015 and 2022 per selected municipality area					
Almere a.s. dummy		1.75%				
Amersfoort dummy		2.44%				
Amsterdam dummy		14.81%				
Arnhem a.s. dummy		3.17%				
Betuwe a.s. dummy		1.61%				
Breda dummy		2.09%				
Capelle aan den IJssel dummy		1.66%				
Delft a.s. dummy		2.78%				
Den-Bosch a.s. dummy		1.80%				
Dordrecht a.s. dummy		1.66%				
Eindhoven a.s. dummy		4.48%				
Enschede dummy		1.41%				
Frisian municipalities		1.46%				
Gooi municipalities		1.51%				
Gouda a.s. municipalities		2.34%				
Groningen dummy		2.68%				
Haarlemmermeer dummy		3.95%				
Leiden a.s. dummy		2.44%				
Limburg North dummy		1.22%				
Maastricht dummy		1.46%				
Eastern Netherlands dummy		1.32%				
North Netherlands dummy		1.27%				
Nijmegen a.s. dummy		1.46%				
North. North-Holland dummy		1.51%				
South. North-Holland dummy		2.73%				
Overijssel cities dummy		2.68%				
Rotterdam dummy		8.38%				
Southern Limburg dummy		1.70%				
The Hague dummy		5.31%				
Utrecht dummy		6.04%				
Utrecht North dummy		1.61%				
Utrecht Southeast dummy		2.24%				
Veluwe dummy		2.58%				
Zeeland and W-Brabant dummy		2.68%				
Zwolle dummy		1.80%				

5. RESULTS

Chapter 5 presents the study's results. Firstly, Table 2 displays the result of the applied multiple OLS regression analysis. Secondly, we reveal the model outcomes, which analyses the log-linear relationship between the sqm transaction prices and the interaction between the "2023 proof" dummy and categorical year dummies. Subsequently, we discuss the model outcomes extensively and try to connect these to earlier literature findings and expectations.

Table 2: result of the multiple OLS regression analysis

Variables	Model 1 Ln transaction price (sqm.)	Int. Model 2 Ln transaction price (sqm.)	Int. Model 3 Ln transaction price (sqm.)	Int. Model 4 Ln transaction price (sqm.)
2016: seven year before deadline	0.1494** (0.0695)	0.5309** (0.1561)	0.4276*** (0.1312)	0.3868*** (0.1227)
2017: six years before deadline	0.1468** (0.0663)	0.3196** (0.1448)	0.3648*** (0.1220)	0.3849*** (0.1142)
2018: five years before deadline	0.3169*** (0.0689)	0.1971 (0.1548)	0.2580** (0.1297)	0.3667*** (0.1218)
2019: four years before deadline	0.4068*** (0.0701)	0.3654** (0.1517)	0.4542*** (0.1275)	0.5178*** (0.1195)
2020: three years before deadline	0.3757*** (0.0750)	0.2244 (0.1655)	0.3076** (0.1391)	0.3319** (0.1303)
2021& 2022: within two years before deadline	0.3716*** (0.0774)	0.1959 (0.1908)	0.3587** (0.1610)	0.3551** (0.1509)
2023 proof dummy	0.0386 (0.0458)	0.0861 (0.1287)	0.0254 (0.1080)	0.0921 (0.1017)
Seven years before deadline X Future proof		-0.4590*** (0.1743)	-0.2965** (0.1461)	-0.2673* (0.1369)
Six years before deadline X Future proof		-0.2127 (0.1627)	-0.1621 (0.1370)	-0.1649 (0.1283)
Five years before deadline X Future proof		0.1391 (0.1728)	0.1701 (0.1450)	0.0655 (0.1360)
Four years before deadline X Future proof		0.0490 (0.1709)	0.0659 (0.1432)	0.0017 (0.1341)
Three years before deadline X Future proof		0.1825 (0.1856)	0.2637* (0.1560)	0.2770* (0.1461)
Within two years before deadline X Future proof		0.1959 (0.2088)	0.2545 (0.1760)	0.2826* (0.1649)
Control variables: municipality dummies*	**NO**	**NO**	**YES**	**YES**
Building & accessibility characteristics	**NO**	**NO**	**NO**	**YES**
Constant	6.7717	6.7350	6.5019	7.007
R-squared	0.0288	0.0400	0.3483	0.4309
Adjusted R-squared	0.0255	0.0338	0.3330	0.4161
N	2,053	2,053	2,053	2,053

Note: the natural logarithm of transaction prices in EUR per square meter is the dependent variable. The parentheses *p <0,10; **p<0,05; ***p<0,01 indicate the significance levels of the regression standard errors of respectively 10, 5 and 1 per cent.

***Regarding the municipality dummies: Haarlemmermeer = reference category (ref cat = 0)**

5.1. Model results

The model outcomes illustrate how the dependent variable, representing the natural logarithm of the EUR sqm transaction price, is associated with the interaction variable representing the "2023 proof" and the "years before deadline" variable. To indicate the model's improvement in explanatory power, we added variables stepwise. Model 1 starts with a basic model with the "2023 proof" dummy variable and categorical "years before deadline" dummy variables. Subsequently, Model 2 contains the interaction variables of the "2023 proof" dummy variable and the "years before deadline" variable. Model 3 adds the categorical municipality dummies. Lastly, Model 4 includes the accessibility variables and building characteristics. Finally, Model 4 achieves an R-squared of 43.4 per cent. As the dependent variable is a natural logarithm, we need to be aware of the log-linear and log-log relationships between the model's dependent and independent variables. When having a significant log-linear relationship, each marginal increase of the independent variable, increases the dependent variable by (expB1 -1 *100) ((ExpB1-1)*100) per cent. When having the "2023 proof" with "years before deadline" interaction variable, we need to be concise when interpreting the result as it represents a growth rate of the regressor to the reference category. Here, the reference category is "non-2023 proof" offices. Subsequently, we need to interpret the interaction variable as the different relationship between one independent variable, depending on the level of another independent variable (Brooks & Tsolacos, 2010).

When examining the results, we first start with Model 1. While we added relatively fewer explanatory variables to Model 1, it reveals a small percentage of explanatory power as the R-squared is 2.83 per cent. When interpreting the model's coefficients, Model 1 indicates that within the first four years after 2015, a general upward trend in the growth rates of the natural sqm transaction prices took place. This upward trend is in line with the expectations based on the literature as the period of economic growth marked an increase in a relatively short-term growth in office space demand, driving up office prices (Barras, 2002; Ossokina, 2012; Buitelaar, 2017). Subsequently, between 2019: the fourth year, and 2020: the third year before the deadline, the growth rate compared to the reference year 2015 decreases from 50.2 per cent to 45,6 per cent. This likely is a consequence of the Covid-19 pandemic, in which such an event causes a short-term demand drop. Simultaneously, it contributes to decreasing average office transaction values (Barras, 2002; Ossokina, 2012). On the other hand, in Model 1, the individual "2023 proof" variable does not contribute to explaining the sqm transaction prices. It means that in Model 1, overall included sample transactions the average sqm transaction prices of "2023 proof" offices do not significantly deviate from "non-2023 proof" offices. The individual "2023 proof" dummy remains insignificant over all models.

In Model 2, we first implemented the key independent variable consisting of the interaction variable between the "2023 proof" dummy and categorical year dummies. The interaction term contributed to the models' explanatory power as the R-Squared increased from 2.83 per cent to 4.49 per cent. We observe in Model 2 that only the interaction variable between 2016: seven years before the deadline dummy, and the "2023 proof" office dummy significantly contributes to explaining the dependent variable. It reveals that given a “2023 proof” office in 2016: six years before the deadline, we find a significant 36.8 per cent decrease in the average sqm office transaction value, compared to a “non-2023 proof” office in the same year. The other interaction variables do not significantly contribute to explaining the dependent variable. In Model 3, we add the location control variables. The municipality dummies contribute to a significant increase in the models' explanatory power, while the R-squared increases from 4,49 per cent to 35,10 per cent. It is in line with McCann (2013) and Koster (2013), as they assert the degree of urbanity is an impactful exogenous factor when analysing the cost prices for office space. Subsequently, we notice that after controlling for the location effects, the interaction term referring to 2020: three years before the deadline, has now become significant. Furthermore, after controlling for location effects, the significance of a given “2023 proof” office in 2016: seven years before the deadline, decreased (from $p<0.10$ to $p<0.05$). Hence, we find a significant 25.7 per cent decrease in the average sqm office transaction value, compared to a “non-2023 proof” office in the same year.

Lastly, in Model 4, we add the last control variables consisting of the accessibility and building characteristics, to the final interaction model. Again it reveals a significant increase in explanatory power while the R-squared increases from 35.1 per cent to 43.2 per cent, which is in line with the results of studies like Nappi-Choulet et al., (2007), Kok & Jennen, (2012), Carlson & Pressnail, (2018), Seo et al., (2019). When interpreting the significant interaction outcomes, it firstly reveals that given a “2023 proof” office in 2016: six years before the deadline, we discovered a significant 23.5 per cent decrease in the average sqm office transaction value, compared to a “non-2023 proof” office in the same year. Again, the interpretation unexpectedly reveals a significantly higher average sqm transaction value for “non-2023 proof” offices in 2016, but the significance level of the interaction term decreased respectively to the previous Model 3: from $p<0.05$ to $p<0.10$. All in all, the sample’s average office transaction values in 2016 seem not to be influenced by the obligatory C-label deadline effect. In the years after 2016 until 2019: four years before the deadline, the average transaction values of “2023 proof” did not significantly deviate from the “non-2023 proof” offices.

Subsequently, when looking at the last three years before the deadline, it reveals that given a “2023 proof” office in 2020: three years before the deadline; we found a significant additional 31.9 per cent increase in the average sqm office transaction value, compared to a “non-2023 proof” office in the same year. Lastly, we can see that in the final Model 4, the interaction variables of 2021-2022: two years before the deadline, have become significant on a significance level of the regression error of 10 per cent ($p<0.10$). Furthermore, given a “2023 proof” office in the sample transactions of 2021 and the first quarter of 2022, another significant additional 32.7 per cent in the average sqm office transaction value is found, compared to a “non-2023 proof” office in the same year. Based on the results, we could say that the transactions in the last three years represent a significant divergent effect between “2023 proof” and “non-2023 proof” offices. Altogether, based on the final OLS regression Model 4, the main hypothesis “***The closer to the obligatory 2023 C-label deadline, the more divergence between the office***

transaction values of "2023 proof" and "non-2023 proof" offices" can not be rejected. On the one hand, the results are in line with the expectations mentioned in the studies of Eichholtz et al., (2010), Arnoldussen et al., (2016), Economidou et al., (2020), and Warren-Myers (2022) that stricter legally bound sustainability regulations will result in a diverging effect between assets which are energy efficient and non-energy efficient. On the other hand, we must acknowledge that the coefficients are weakly significant ($p<0.10$). Therefore, it increases the uncertainty margin of the correctness of the model (Brooks and Tsolacos, 2010). Furthermore, before 2020, there was no visible growing deviant trend in the green premium for "2023 proof" offices compared to "non-2023 proof" offices.

In this study context, the results of the difference between "2023 proof" and "non-2023 proof" offices do not fully confirm whether the growing divergence between "2023 proof" and "non-2023 proof" offices in the last three years before the deadline is mainly caused by the deadline effect. It is especially difficult to validate as the years 2020 and a part of 2021 was affected by the Covid-19 pandemic. Therefore, we try to logically examine the founded relationships by comparing the results to the literature on changing market dynamics. We can speculate that Covid-19 contributed to a constant and relatively growing demand and transaction prices for energy-efficient offices, while transaction prices of energy-inefficient offices decreased significantly. This claim would be in line with Eichholtz et al. (2013) as they assert that as a consequence of increasing investment risks, the value of "green" real estate is much less volatile during a period of economic downturn than "brown" real estate. Subsequently, it can be argued that the combination of the Covid-19 pandemic and the upcoming 2023 C-label deadline caused this diverging trend.

Another interesting result is in the period before 2020, which indicates that in 2016: seven years before the deadline, a significant 23.5 per cent decrease in the average sqm office transaction value is found, compared to a "non-2023 proof" office in the same year. Subsequently, the transactions after 2016 and before 2020 do not show a significant divergence in the average transaction values between "2023 proof" and "non-2023 proof" offices. A possible explanation might be that the generally increasing transaction values during this period of economic growth, combined with the growing demand for offices, resulted in an economically lucrative investment environment for offices with a lower level of energy efficiency (Barras, 2002; Ossokina, 2012; Buitelaar, 2017). Subsequently, the relatively short-term shortage in office space would make it economically reasonable to realise sustainable retrofits, as it preserves the office's future usability and presses down operational costs (Kok & Jennen, 2012; Carlson & Pressnail, 2018; Warren-Myers, 2022). Unfortunately, this literature-related substation falls out of the research's scope as it can not be made up from the quantitative results.

5.2 Results implications: discussion

As the awareness of sustainability is growing in society, the interest in researching the consequences of sustainability issues in real estate increases (Ciora et al., 2016; Warren-Myers, 2022). Still, there are quite some challenges in this research field. At the moment, there is a discussion about the existence of a "green premium" or whether the effectiveness of governmental sustainability policies causes a "brown discount" (Fawcett et al., 2019; Economidou et al., 2020; Warren-Myers, 2022). At first glance, the study's expectations suggested that the closer to the obligatory deadline, the stronger the brown discount on "non-2023 proof" offices. However, the results reveal it is more nuanced. Subsequently, to indicate this we will discuss the results by means of three research limitations. Furthermore, we will implement some research recommendations to improve future studies. Lastly, we appoint the policy implications.

Firstly, we need to consider the quality of the data. As there were some missing values, we enriched the number of cases in the dataset by putting in BAG ID numbers in the BAG viewer. However, when implementing data manually, it increases the risk of mistakes. Furthermore, brokers also manually fill in reported transaction data. We found that they are not always that meticulous. Before performing the analysis, we found some incorrect extreme values, which we removed from the dataset. However, it becomes more difficult to control for wrong values when they are in the bandwidth of the dataset. Altogether, this always needs to be kept in mind when generalising and making statements of the results to avoid making Type I or II mistakes (Brooks and Tsolacos, 2010).

Secondly, due to the data limitations, the case distribution of "2023 proof" and "non-2023 proof" offices in the last two years was too small to make generic statements of a local deadline effect. Subsequently, we could not perform an additional exploratory analysis to control for location effects. Therefore, the results only reveal a deadline effect over all the implemented office transactions in the dataset. As studies like Kok & Jennen (2012) assert the relationship between the level of sustainability and location affecting office values, the data limitation resulted in a missed opportunity to increase the study's general validity. On the other hand, as Myers et al. (2007) acknowledge, due to a lack of market data, empirical data, and market transactions it is sometimes difficult to reach a consensus about the actual impact of sustainability on the market value of an office. Other studies which researched the impact on office values also allocate data limitations as one of the most relevant research limitations (Surmann et al., 2015; Manglialardo et al., 2018). Unfortunately, due to the transparency of real estate markets, analysis of real estate markets remains challenging (Brooks and Tsolacos, 2010). To improve future research, taking a longer research period or manually adding additional transactions could be a solution. Though, to indicate the real deadline effect, we should wait until next year when the transactions of 2022 have taken place. Then it could also be possible to research the statement of Kok & Jennen (2012) to what extent green premiums on places with a lower location premium are affected by the obligatory C-label deadline.

Thirdly, as one of the general limitations of quantitative analysis, the results only reveal relationships between value drivers on sqm transaction values of offices. Subsequently, we tried to substantiate the findings by using relevant literature in addition to the quantitative results. All in all, such speculations are one of the main points of critique added by Kok and Jennen (2012). They criticise the general presence of speculations and the shortage of empirical studies in this research field. Therefore, it would be recommendable for future research to perform additional qualitative analysis when analysing the results. Then, it could be possible to capture the investment motives, which might give a clearer picture of the significant trends over time. Lastly, for Model 4, some of the OLS assumptions were not met. Appendix 4 presents the results of all executed OLS assumption tests.

Finally, it is challenging to connect policy implications to the results of this study. Though, as Economidou et al. (2020) demonstrated in their study, it remains useful to analyse the possible impact of energy efficiency policies on society. Lastly, iterative research in analysing deadline effects and EEOS could contribute to more understanding of the complications of obligatory energy efficiency deadlines on asset market dynamics. Subsequently, it can be of great interest to investors and other stakeholders who are affected by these institutions.

6 CONCLUSION

This study aims to analyse the extent to which the upcoming obligatory 2023 C-label deadline for offices influenced the Dutch office transaction values between 2015 and 2022. The theoretical framework revealed the expectation that energy efficiency policies will increasingly become an important value driver for asset transaction values (Eichholtz et al., 2010; Arnoldussen et al., 2016; Fawcett et al., 2019; Economidou et al., 2020; Warren-Myers, 2022). However, a study which analysis the precise consequences of these deadlines is barely done. Subsequently, it formed the research motivation and aims to answer the following main question: ***"To what extent were transactions prices of Dutch office buildings over the 2015 to 2022 period affected by the upcoming 2023 obligatory energy C-label deadline?***'

Inspired by the Hedonic Pricing Method (HPM), we used a multiple OLS regression to answer the research question. After increasing the model's explanatory power by adding control variables, over the research period 2015 – 2022, we found a negative weakly significant divergence of 23.5 per cent in the average transaction value of "2023 proof" and "non-2023 proof" offices in 2016: seven years before the deadline. Subsequently, three years and within two years before the deadline, the green premium for "2023 proof" offices begins to deviate significantly. Here, we discovered a positive weakly significant diverging trend of respectively 31.9 and 32.7 per cent between the average transaction values of "2023 proof" and "non-2023 proof" offices. On the one hand, the results seem to be in line with the expectations as the divergence between "2023 proof" and "non-2023 proof" offices emerges the closer to the obligatory C-label deadline. On the other hand, we must acknowledge that the coefficients are weakly significant ($p<0.10$). Therefore, it increases the uncertainty margin of the correctness of the model. Furthermore, the outcomes show a dividing trend line in 2020 for the average office transaction values. Therefore, we argued in the discussion of the result that the Covid-19 pandemic could be a possible explanatory exogenous factor on the divergent trend of transaction prices for "2023 proof" and "non-2023 proof" offices. However, we can not validate with certainty. Therefore, it forms one of the most critical limitations of this study. That is why, for future research, we suggest including a qualitative analysis consisting of expert interviews to add more nuance to the results. Other research improvements can be established by reducing the lack of data and increasing the data quality. It would be recommendable to execute this research again over a few years to get a broader view of the transaction developments before and after the 2023 obligatory energy efficiency deadline.

To summarise, this study delivers some proof of a sustainability deadline effect on diverging trends between the transaction prices of "2023 proof" and "non-2023 proof" offices. Although its limitations, this study tried to broaden the research perspective of analysing the consequences of sustainability on asset values, which provides the need for more research (Ciora et al., 2016). As Fawcett et al. (2019) acknowledge, more EEOS will be implemented in the future. Therefore, this study forms an initial ground for future studies to analyse the effect of sustainability policy deadlines on asset transaction values.

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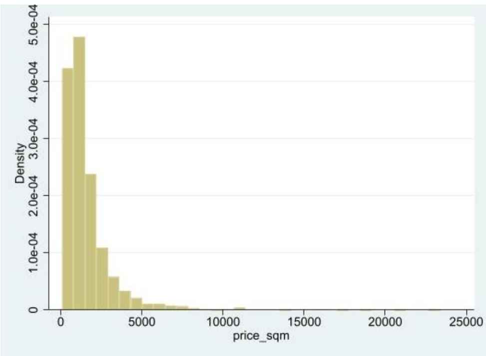
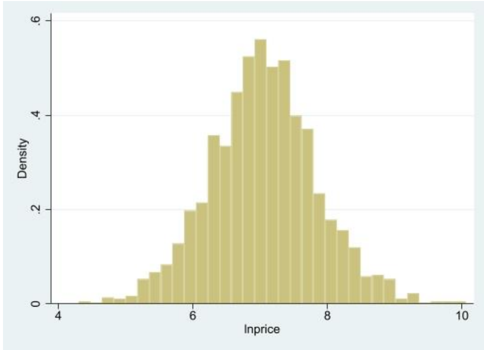
APPENDIX

Appendix 1: descriptive statistics eyeball analysis

1A Dependent variable: Transaction price EUR per sqm (from absolute to natural logarithm).





1B Key independent variables: "2023 proof" dummy & years before deadline

"Years before deadline": case distribution sample:

. tab years_till_deadline

years_till_deadline	Freq.	Percent	Cum.
1	211	10.28	10.28
2	327	15.93	26.21
3	426	20.75	46.96
4	341	16.61	63.57
5	314	15.29	78.86
6	230	11.20	90.06
7	152	7.40	97.47
8	52	2.53	100.00
Total	2,053	100.00	

Deviation of "2023 proof" transactions

year	2023_proof_dummy 0	1	Total
2015	48	163	211
2016	53	274	327
2017	75	351	426
2018	55	286	341
2019	59	254	313
2020	43	188	231
2021	16	136	152
2022	10	42	52
Total	359	1,694	2,053

Unequal distribution of the "2023 proof" and "non-2023 proof" cases in the last two years. Therefore, 2021 and Q1 and Q2 were merged.

New case distribution after merging sample:

tab years_till_deadline

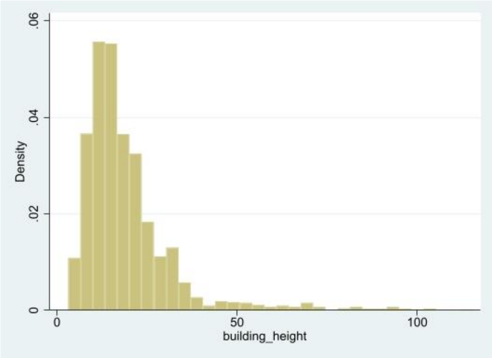
ears_till_deadline	Freq.	Percent	Cum.
1	211	10.28	10.28
2	327	15.93	26.21
3	426	20.75	46.96
4	341	16.61	63.57
5	314	15.29	78.86
6	230	11.20	90.06
7	204	9.94	100.00
Total	2,053	100.00	

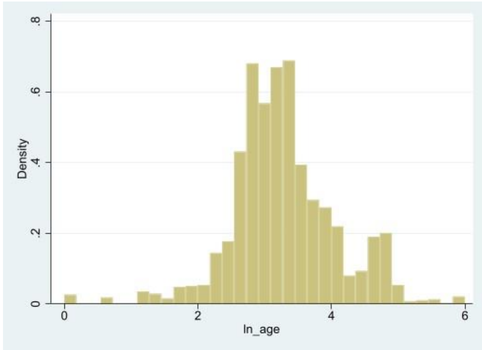
New deviation of "2023 proof" transactions

. tab years_till_deadline future_proof_dummy

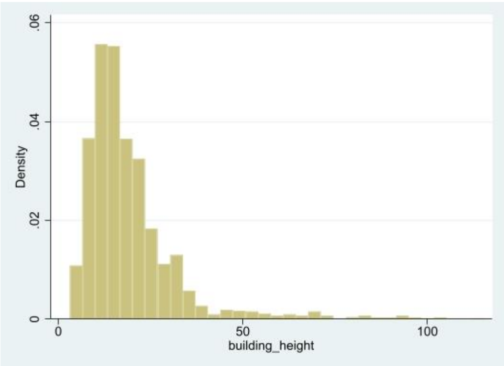
years_till_deadline	2023_proof_dummy 0	1	Total
1	48	163	211
2	53	274	327
3	75	351	426
4	55	286	341
5	60	254	314
6	42	188	230
7	26	178	204
Total	359	1,694	2,053

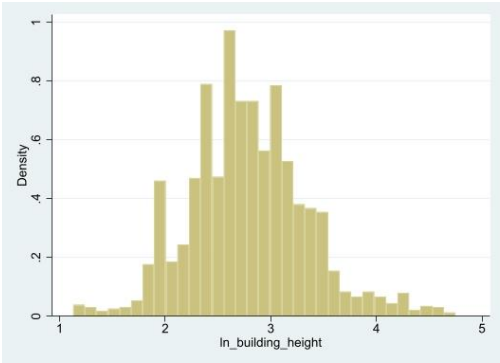
1C: Building characteristics: control variable: building size (from absolute to natural logarithm)



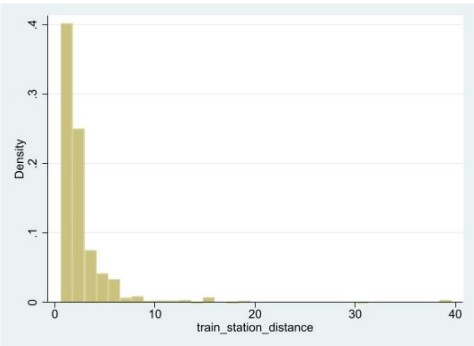


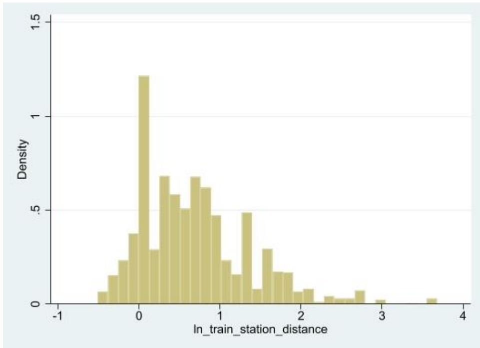
1D: Building characteristics control variable: building height (from absolute to natural logarithm)



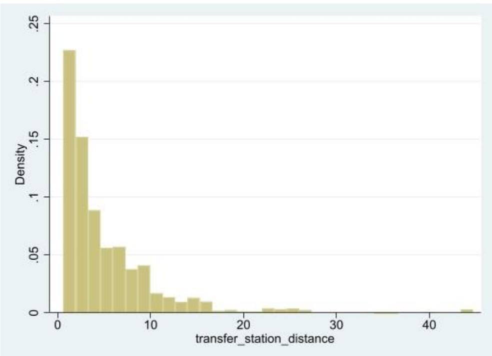


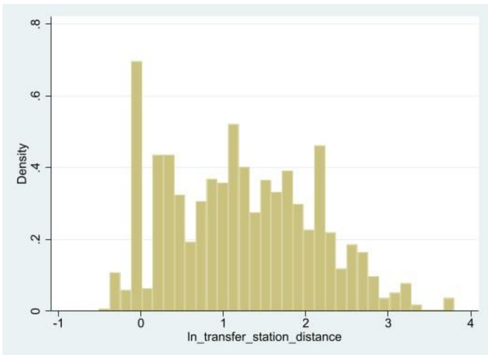
1E: Accessibility control variable: distance to the nearest train station (from absolute to natural logarithm)



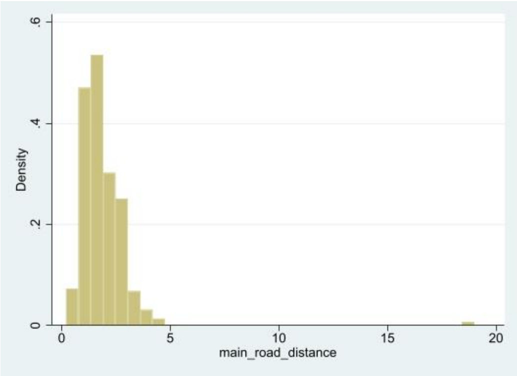


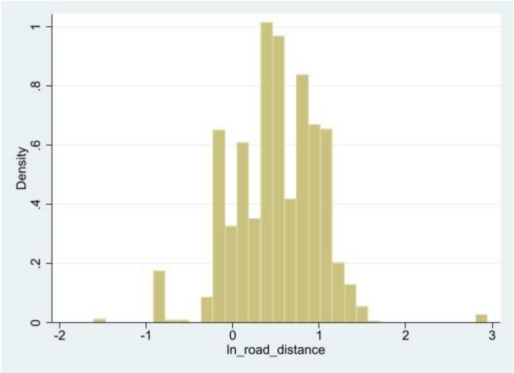
1F: Accessibility control variable: distance to the nearest transfer station (from absolute to natural logarithm)





1G: Accessibility control variable: distance to the nearest main road exit (from absolute to natural logarithm)





Appendix 2: model checks

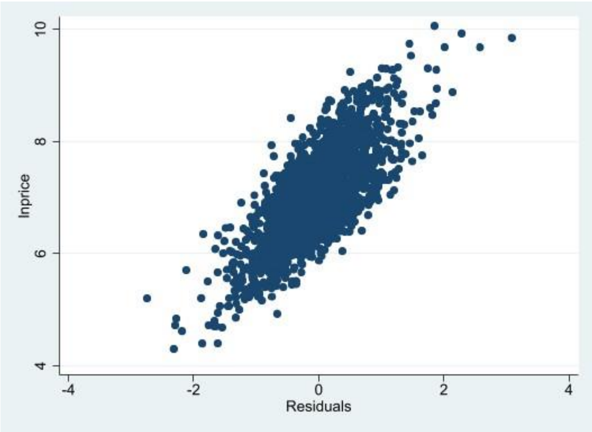
Appendix 2A: correlation matrix

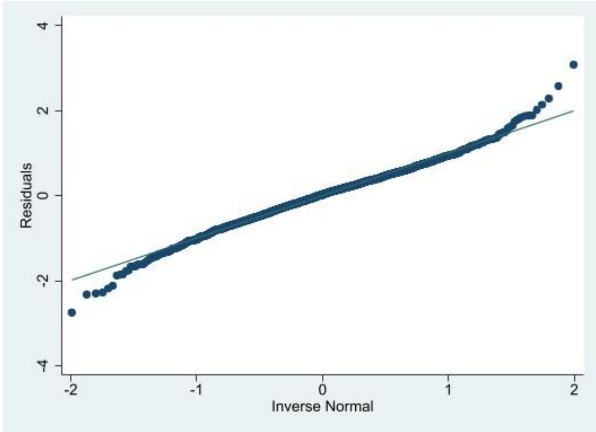
	Ln tr.price	Eight y.b.d	Seven y.b.d	Six y.b.d	Five y.b.d	Four y.b.d	Three y.b.d.	With-two y.b.d.	2023-p. dum	Ln sqm. total	Ln buil.height	Ln train sta dist	Ln trans. sta dist	Ln road dist.
Ln tr.price	1.000													
Eight y.b.d	-0.106	1.000												
Seven y.b.d	-0.054	-0.147	1.000											
Six y.b.d	-0.065	-0.173	-0.223	1.000										
Five y.b.d	0.039	-0.151	-0.194	-0.228	1.000									
Four y.b.d	0.084	-0.144	-0.185	-0.217	-0.190	1.000								
Three y.b.d.	0.057	-0.120	-0.155	-0.182	-0.159	-0.151	1.000							
With-two y.b.d.	0.052	-0.112	-0.145	-0.170	-0.148	-0.141	-0.118	1.000						
2023-p. dum	0.023	-0.047	0.015	-0.002	0.016	-0.018	-0.007	0.042	1.000					
Ln sqm. total	0.025	-0.039	-0.016	0.044	0.088	-0.010	-0.059	-0.038	0.207	1.000				
Ln buil.height	0.286	-0.022	0.034	0.022	0.068	-0.017	-0.075	-0.034	0.154	0.593	1.000			
Ln train sta dist	-0.209	-0.011	-0.030	-0.050	0.004	0.003	0.050	0.056	0.023	-0.124	-0.250	1.000		
Ln trans. sta dist	-0.241	-0.039	-0.031	-0.026	-0.011	0.020	0.030	0.070	0.061	-0.143	-0.245	0.627	1.000	
Ln road dist.	0.081	0.011	0.001	-0.010	0.017	0.007	-0.034	0.007	-0.071	-0.113	-0.022	0.101	0.008	1.000

Appendix 2B: OLS Assumption: Regcheck

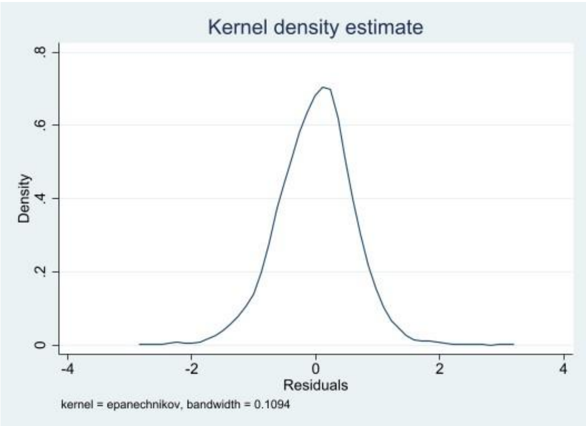
Regression assumptions:	Test:	We seek values
1) no heterokedasticity problem	Breusch-Pagan hettest Chi2(1): 1.728 p-value: 0.189	> 0.05
2) no multicollinearity problem	Variance inflation factor Almere_as_dummy : 1.49 Dordrecht_as_dummy : 1.65 Eindhoven_as_dummy : 4.55 Enschede_dummy : 1.88 Frisian_municipalities_dummy : 1.45 Gooi_municipalities_dummy : 1.65 Gouda_as_dummy : 1.43 Groningen_municipality_dummy : 1.76 Leiden_as_dummy : 1.52 Limburg_North_dummy : 1.48 Maastricht_dummy : 2.22 Amersfoort_dummy : 1.44 Eastern_Netherlands_dummy : 1.48 North_Netherlands_dummy : 1.42 Nijmegen_as_dummy : 1.64 Northern_North_Holland_dummy : 1.77 Southern_North_Holland_dummy : 1.68 Overijssel_cities_dummy : 1.37 Rotterdam_dummy : 1.48 South_Limburg_dummy : 1.39 The_Hague_dummy : 1.34 Utrecht_city_dummy : 1.44 Amsterdam_dummy : 1.44 Utrecht_North_dummy : 1.76 Utrecht_South_East_dummy : 1.84 Veluwe_municipalities_dummy : 3.30 Zeeland_West_Brabant_dummy : 1.49 Zwolle_dummy : 2.55 Veluwe_municipalities_dummy : 3.30 Zeeland_West_Brabant_dummy : 1.49 Zwolle_dummy : 2.55 ln_sqm_total : 2.68 ln_building_height : 1.44 ln_train_station_distance : 1.57 ln_transfer_station_distance : 1.72 ln_road_distance : 1.74 Arnhem_as_dummy : 1.51 1.seven_years_before_deadline : 1.69 1.future_proof_dummy : 1.86 1.seven_years_before_deadline#1.future_proof_dummy : 2.08 1.six_years_before_deadline : 2.37 1.six_years_before_deadline#1.future_proof_dummy : 1.26 1.five_years_before_deadline : 11.16 1.five_years_before_deadline#1.future_proof_dummy : 8.25 1.four_years_before_deadline : 11.99 1.four_years_before_deadline#1.future_proof_dummy : 11.88 1.three_years_before_deadline : 12.90 Betuwe_as_dummy : 11.38 1.three_years_before_deadline#1.future_proof_dummy : 12.28 1.within_two_years_before_deadline : 10.23 1.within_two_years_before_deadline#1.future_proof_dummy : 10.79 Breda_dummy : 9.35 Capelle_aan_den_IJssel_dummy : 9.82 Delft_as_dummy : 11.28 Den_Bosch_as_dummy : 11.91	< 5.00
3) residuals are not normally distributed	Shapiro-Wilk W normality test z: 6.239 p-value: 0.000	> 0.01
4) no specification problem	Linktest t: 1.418 p-value: 0.156	> 0.05
5) functional form problem	Test for appropriate functional form F(3,1994):4.506 p-value: 0.004	> 0.05
6) no influential observations	Cook's distance no distance is above the cutoff	< 1.00

Normality plot for main model 4

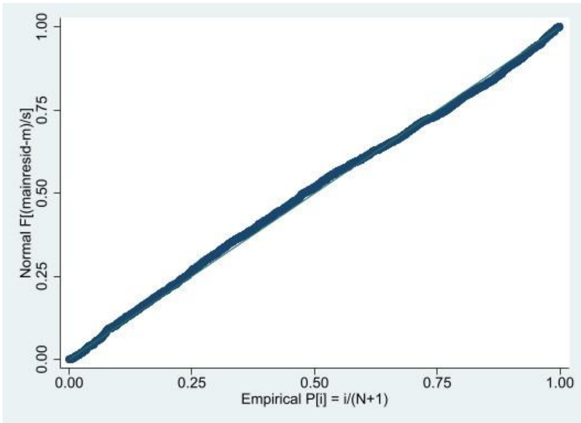




Kernel density graph:



Standardised normal probability plot:



IM White test on main model 4:

```
. estat imtest, white

White's test
H0: Homoskedasticity
Ha: Unrestricted heteroskedasticity

  chi2(644) = 669.52
Prob > chi2 = 0.2356

Cameron & Trivedi's decomposition of IM-test
```

Source	chi2	df	p
Heteroskedasticity	669.52	644	0.2356
Skewness	46.91	52	0.6737
Kurtosis	9.43	1	0.0021
Total	725.87	697	0.2175

OVtest on main model 4:

```
. ovtest

Ramsey RESET test for omitted variables
Omitted: Powers of fitted values of lnprice

H0: Model has no omitted variables

F(3, 1997) =    4.49
  Prob > F = 0.0038
```

Appendix 3: model results

Model 1:

Source	SS	df	MS
Model	37.5856256	7	5.36937509
Residual	1266.12245	2,045	.619130783
Total	1303.70808	2,052	.63533532

Number of obs	=	2,053
F(7, 2045)	=	8.67
Prob > F	=	0.0000
R-squared	=	0.0288
Adj R-squared	=	0.0255
Root MSE	=	.78685

lnprice	Coefficient	Std. err.	t	P>|t|	[95% conf.	interval]
seven_years_before_deadline	.1494072	.0695458	2.15	0.032	.0130193	.2857952
six_years_before_deadline	.1467697	.0662811	2.21	0.027	.0167843	.2767551
five_years_before_deadline	.3169293	.0689862	4.59	0.000	.1816387	.4522199
four_years_before_deadline	.4067635	.0700629	5.81	0.000	.2693615	.5441655
three_years_before_deadline	.375724	.0750358	5.01	0.000	.2285695	.5228785
within_two_years_before_deadline	.3715745	.0773966	4.80	0.000	.2197901	.5233588
future_proof_dummy	.0385686	.0458147	0.84	0.400	-.0512796	.1284169
_cons	6.771693	.0647062	104.65	0.000	6.644796	6.89859

Interaction model 2:

Source	SS	df	MS
Model	52.0965253	13	4.00742502
Residual	1251.61155	2,039	.613835974
Total	1303.70808	2,052	.63533532

Number of obs	=	2,053
F(13, 2039)	=	6.53
Prob > F	=	0.0000
R-squared	=	0.0400
Adj R-squared	=	0.0338
Root MSE	=	.78348

lnprice	Coefficient	Std. err.	t	P>|t|	[95% conf.	interval]
1.seven_years_before_deadline	.5309394	.1561091	3.40	0.001	.2247894	.8370894
1.future_proof_dummy	.0861256	.1286628	0.67	0.503	-.1661986	.3384498
seven_years_before_deadline#future_proof_dummy						
1 1	-.4590445	.1742877	-2.63	0.009	-.8008451	-.117244
1.six_years_before_deadline	.3196037	.1448196	2.21	0.027	.0355938	.6036136
six_years_before_deadline#future_proof_dummy						
1 1	-.2127329	.1627495	-1.31	0.191	-.5319056	.1064398
1.five_years_before_deadline	.1970933	.1547543	1.27	0.203	-.1063997	.5005864
five_years_before_deadline#future_proof_dummy						
1 1	.1391277	.1728035	0.81	0.421	-.1997621	.4780175
1.four_years_before_deadline	.3654148	.1517196	2.41	0.016	.0678731	.6629565
four_years_before_deadline#future_proof_dummy						
1 1	.0489758	.1708841	0.29	0.774	-.2861499	.3841015
1.three_years_before_deadline	.2244003	.1655397	1.36	0.175	-.1002443	.5490448
three_years_before_deadline#future_proof_dummy						
1 1	.1825189	.1855649	0.98	0.325	-.1813977	.5464355
1.within_two_years_before_deadline	.1959124	.1907808	1.03	0.305	-.1782333	.570058
within_two_years_before_deadline#future_proof_dummy						
1 1	.1958683	.2088342	0.94	0.348	-.2136823	.6054188
_cons	6.734955	.1130851	59.56	0.000	6.513181	6.95673

<u>Interaction model 3:</u>

Source	SS	df	MS			
				Number of obs	=	2,053
				F(47, 2005)	=	22.80
Model	454.058904	47	9.66082775	Prob > F	=	0.0000
Residual	849.649173	2,005	.423765173	R-squared	=	0.3483
				Adj R-squared	=	0.3330
Total	1303.70808	2,052	.63533532	Root MSE	=	.65097

lnprice	Coefficient	Std. err.	t	P>|t|	[95% conf.	interval]
1.seven_years_before_deadline	.4276176	.1310663	3.26	0.001	.1705772	.684658
1.future_proof_dummy	.0254336	.1079633	0.24	0.814	-.1862983	.2371656
seven_years_before_deadline#future_proof_dummy						
1 1	-.2965248	.1461484	-2.03	0.043	-.5831434	-.0099063
1.six_years_before_deadline	.3648141	.122027	2.99	0.003	.1255011	.604127
six_years_before_deadline#future_proof_dummy						
1 1	-.1621237	.1370244	-1.18	0.237	-.4308489	.1066014
1.five_years_before_deadline	.2580009	.1297048	1.99	0.047	.0036307	.5123711
five_years_before_deadline#future_proof_dummy						
1 1	.170064	.144975	1.17	0.241	-.1142535	.4543815
1.four_years_before_deadline	.4542313	.1275247	3.56	0.000	.2041365	.704326
four_years_before_deadline#future_proof_dummy						
1 1	.0659057	.1431607	0.46	0.645	-.2148535	.3466649
1.three_years_before_deadline	.307633	.139098	2.21	0.027	.0348413	.5804247
three_years_before_deadline#future_proof_dummy						
1 1	.2636879	.1559583	1.69	0.091	-.0421695	.5695452
1.within_two_years_before_deadline	.3587378	.1609878	2.23	0.026	.0430168	.6744587
within_two_years_before_deadline#future_proof_dummy						
1 1	.2545044	.1759682	1.45	0.148	-.0905952	.599604
Almere_as_dummy	-.2612682	.1307981	-2.00	0.046	-.5177826	-.0047539
Amersfoort_dummy	-.1127037	.1174782	-0.96	0.337	-.3430958	.1176884
Amsterdam_dummy	1.017792	.0817879	12.44	0.000	.8573943	1.178191
Arnhem_as_dummy	-.125732	.1086404	-1.16	0.247	-.338792	.0873279
Betuwe_as_dummy	-.2133579	.1351507	-1.58	0.115	-.4784084	.0516927
Breda_dummy	.103188	.1231549	0.84	0.402	-.138337	.344713
Capelle_aan_den_IJssel_dummy	-.2284446	.1337335	-1.71	0.088	-.4907158	.0338267
Delft_as_dummy	-.1627641	.112989	-1.44	0.150	-.3843523	.0588241
Den_Bosch_as_dummy	.149759	.1300026	1.15	0.249	-.1051953	.4047133
Dordrecht_as_dummy	-.2274624	.1333581	-1.71	0.088	-.4889974	.0340726
Eindhoven_as_dummy	.072441	.0994681	0.73	0.467	-.1226306	.2675127
Enschede_dummy	-.1455413	.1418039	-1.03	0.305	-.4236397	.1325571
Frisian_municipalities_dummy	-.3210676	.1400141	-2.29	0.022	-.5956559	-.0464792
Gooi_municipalities_dummy	.28093	.1379463	2.04	0.042	.0103968	.5514632
Gouda_as_dummy	-.049407	.1189118	-0.42	0.678	-.2826106	.1837965
Groningen_municipality_dummy	.020441	.1143737	0.18	0.858	-.2038626	.2447447
Leiden_as_dummy	.3557014	.1175569	3.03	0.003	.125155	.5862478
Limburg_North_dummy	-.2989511	.1497621	-2.00	0.046	-.5926567	-.0052454
Maastricht_dummy	.0790915	.1394531	0.57	0.571	-.1943966	.3525795
Eastern_Netherlands_dummy	-.2831243	.1450373	-1.95	0.051	-.5675638	.0013152
North_Netherlands_dummy	-.6242542	.1474072	-4.23	0.000	-.9133415	-.3351669
Nijmegen_as_dummy	-.0050028	.1393939	-0.04	0.971	-.2783748	.2683692
Northern_North_Holland_dummy	-.0439302	.1377892	-0.32	0.750	-.3141553	.2262948
Southern_North_Holland_dummy	.3143108	.1140408	2.76	0.006	.0906599	.5379617
Overijssel_cities_dummy	-.4433958	.1139638	-3.89	0.000	-.6668957	-.2198959
Rotterdam_dummy	.4064223	.0880423	4.62	0.000	.2337584	.5790862
South_Limburg_dummy	-.5841333	.1326208	-4.40	0.000	-.8442223	-.3240443
The_Hague_dummy	.5666443	.0957295	5.92	0.000	.3789045	.7543841
Utrecht_city_dummy	.5284736	.0931378	5.67	0.000	.3458166	.7111306
Utrecht_North_dummy	-.1530732	.1345837	-1.14	0.256	-.4170117	.1108653
Utrecht_South_East_dummy	-.1365384	.1203438	-1.13	0.257	-.3725503	.0994736
Veluwe_municipalities_dummy	-.0758008	.1154029	-0.66	0.511	-.3021229	.1505213
Zeeland_West_Brabant_dummy	-.1334204	.1142065	-1.17	0.243	-.3573963	.0905554
Zwolle_dummy	-.147764	.129547	-1.14	0.254	-.4018248	.1062969
_cons	6.501853	.1194994	54.41	0.000	6.267497	6.736209

Interaction model 4:

Source	SS	df	MS			
				Number of obs	=	2,053
				F(52, 2000)	=	29.12
Model	561.733613	52	10.8025695	Prob > F	=	0.0000
Residual	741.974464	2,000	.370987232	R-squared	=	0.4309
				Adj R-squared	=	0.4161
Total	1303.70808	2,052	.63533532	Root MSE	=	.60909

lnprice	Coefficient	Std. err.	t	P>|t|	[95% conf.	interval]
1.seven_years_before_deadline	.3867722	.1227094	3.15	0.002	.1461205	.6274239
1.future_proof_dummy	.0920959	.1016569	0.91	0.365	-.1072686	.2914604
seven_years_before_deadline#future_proof_dummy						
1 1	-.2673115	.1368903	-1.95	0.051	-.535774	.0011509
1.six_years_before_deadline	.3848935	.1142494	3.37	0.001	.1608332	.6089537
six_years_before_deadline#future_proof_dummy						
1 1	-.164908	.1282621	-1.29	0.199	-.4164493	.0866334
1.five_years_before_deadline	.3667123	.1218214	3.01	0.003	.1278021	.6056226
five_years_before_deadline#future_proof_dummy						
1 1	.0654878	.1360392	0.48	0.630	-.2013056	.3322813
1.four_years_before_deadline	.5177613	.1194801	4.33	0.000	.2834428	.7520799
four_years_before_deadline#future_proof_dummy						
1 1	.0016633	.1341167	0.01	0.990	-.2613598	.2646863
1.three_years_before_deadline	.3318873	.1303184	2.55	0.011	.0763134	.5874613
three_years_before_deadline#future_proof_dummy						
1 1	.2770365	.1460575	1.90	0.058	-.0094043	.5634774
1.within_two_years_before_deadline	.3551022	.1509049	2.35	0.019	.059155	.6510494
ithin_two_years_before_deadline#future_proof_dummy						
1 1	.2826087	.1648491	1.71	0.087	-.0406853	.6059026
Almere_as_dummy	-.5166798	.1251379	-4.13	0.000	-.7620942	-.2712654
Amersfoort_dummy	-.3338707	.1121287	-2.98	0.003	-.553772	-.1139693
Amsterdam_dummy	.7035678	.0807361	8.71	0.000	.5452321	.8619035
Arnhem_as_dummy	-.4214069	.105218	-4.01	0.000	-.6277553	-.2150585
Betuwe_as_dummy	-.1888283	.1288445	-1.47	0.143	-.4415118	.0638552
Breda_dummy	-.2345192	.1206084	-1.94	0.052	-.4710504	.002012
Capelle_aan_den_IJssel_dummy	-.385592	.1260125	-3.06	0.002	-.6327216	-.1384625
Delft_as_dummy	-.2210796	.1085307	-2.04	0.042	-.4339247	-.0082345
Den_Bosch_as_dummy	-.0874498	.1247228	-0.70	0.483	-.3320501	.1571506
Dordrecht_as_dummy	-.4096181	.12802	-3.20	0.001	-.6606846	-.1585515
Eindhoven_as_dummy	-.2045098	.0968932	-2.11	0.035	-.3945319	-.0144877
Enschede_dummy	-.4896286	.13683	-3.58	0.000	-.7579728	-.2212844
Frisian_municipalities_dummy	-.6886206	.1363926	-5.05	0.000	-.956107	-.4211342
Gooi_municipalities_dummy	.1368946	.1315699	1.04	0.298	-.1211339	.394923
Gouda_as_dummy	-.2047621	.1137583	-1.80	0.072	-.4278594	.0183351
Groningen_municipality_dummy	-.2574583	.110632	-2.33	0.020	-.4744244	-.0404922
Leiden_as_dummy	.1204229	.1131695	1.06	0.287	-.1015196	.3423654
Limburg_North_dummy	-.5699613	.1432303	-3.98	0.000	-.8508575	-.2890652
Maastricht_dummy	-.1672764	.1364816	-1.23	0.220	-.4349374	.1003846
Eastern_Netherlands_dummy	-.31245	.1391621	-2.25	0.025	-.5853678	-.0395322
North_Netherlands_dummy	-.6774068	.1393194	-4.86	0.000	-.9506332	-.4041804
Nijmegen_as_dummy	-.2980088	.1342005	-2.22	0.026	-.5611962	-.0348214
Northern_North_Holland_dummy	-.3254708	.1322527	-2.46	0.014	-.5848384	-.0661032
Southern_North_Holland_dummy	.0749398	.1093327	0.69	0.493	-.1394781	.2893577
Overijssel_cities_dummy	-.8096863	.1129258	-7.17	0.000	-1.031151	-.5882219
Rotterdam_dummy	.0007866	.0882043	0.01	0.993	-.1721952	.1737685
South_Limburg_dummy	-.7742195	.1266858	-6.11	0.000	-1.022669	-.5257696
The_Hague_dummy	.1366343	.0958044	1.43	0.154	-.0512527	.3245212
Utrecht_city_dummy	.2320843	.0923611	2.51	0.012	.0509502	.4132184
Utrecht_North_dummy	-.2178025	.1282719	-1.70	0.090	-.469363	.0337581
Utrecht_South_East_dummy	-.2127419	.1137077	-1.87	0.061	-.4357398	.010256
Veluwe_municipalities_dummy	-.2733895	.1112013	-2.46	0.014	-.491472	-.0553069
Zeeland_West_Brabant_dummy	-.2844242	.1096719	-2.59	0.010	-.4995073	-.0693411
Zwolle_dummy	-.4131988	.1241069	-3.33	0.001	-.6565911	-.1698064
ln_sqm_total	-.1497079	.0137803	-10.86	0.000	-.1767332	-.1226826
ln_building_height	.3536354	.0326175	10.84	0.000	.2896675	.4176034
ln_train_station_distance	-.0698402	.0278797	-2.51	0.012	-.1245164	-.0151639
ln_transfer_station_distance	-.1180536	.0233571	-5.05	0.000	-.1638603	-.0722468
ln_road_distance	.1740067	.0296395	5.87	0.000	.1158793	.2321342
_cons	7.006982	.156583	44.75	0.000	6.699899	7.314065

Appendix 4: STATA script

```
*Do file master's thesis Friso van der Mark_S4949293*

*In this do file, all procedures are explained stepwise*
clear all
log using "C:\Users\user\OneDrive\Documenten\Master Real Estate Studies 2021-2022\Master Thesis Module.smcl", append
cd"C:\Users\user\OneDrive\Documenten\Master Real Estate Studies 2021-2022\Master Thesis Module\DATA\Data actueel"

*Importing the data csv file*
import delimited "C:\Users\user\OneDrive\Documenten\Master Real Estate Studies 2021-2022\Master Thesis Module\DATA\Data actueel\Savills_office_invest_transactions_bijgewerkt_2", varnames(1) rowrange(2)

*******************************************
*Data check and cleaning process*

*Dependent variable, real transaction price per m2*
*First, an eyeball analysis
replace price_m2 = subinstr( price_m2 , ",", ".", 1)
destring price_m2, generate (price_sqm)
histogram price_sqm
sum price_sqm

*We can see a typical left skewed price deviation. To meet the assumption of normality, we need to take the natural logarithm of this value.
generate lnprice=ln(price_sqm)
*Subsequently, we check whether there now is a normally distributed balance
histogram lnprice
*Check*
codebook lnprice
sum lnprice

*****************************************************************
*Key independent variable*

*the 2023 proof dummy, which includes a dummy variable where:
*0 = Lower than EPC C-label
*1 = Equal or Higher than EPC C-label
rename _proof_dummy future_proof_dummy
codebook future_proof_dummy
sum future_proof_dummy
tab future_proof_dummy

*We can see that the years before deadline variable is a bit confusing as it now says the number of years after 2015, instead of the years untill the obligatory energy efficiency deadline in 2023. Therefore, we define the dummy variables differently.
tab years_till_deadline, gen(year_deadline_dummies)
rename year_deadline_dummies1 eight_years_before_deadline
rename year_deadline_dummies2 seven_years_before_deadline
rename year_deadline_dummies3 six_years_before_deadline
rename year_deadline_dummies4 five_years_before_deadline
rename year_deadline_dummies5 four_years_before_deadline
rename year_deadline_dummies6 three_years_before_deadline
rename year_deadline_dummies7 within_two_years_before_deadline

***************************************************************
*Control Z variables check*
*Total sqm size office building*
histogram sqm_total
sum sqm_total
generate ln_sqm_total=ln(sqm_total)
histogram ln_sqm_total
codebook ln_sqm_total
sum ln_sqm_total

*Age building when transaction was completed*
histogram age_in_years_at_transaction_date
codebook age_in_years_at_transaction_date
sum age_in_years_at_transaction_date
*There is one outlier, probably an incorrect value, we need to drop this one
drop if age_in_years_at_transaction_date>1000
histogram age_in_years_at_transaction_date
*Still the variable is left skewed. We create another natural logarithm of the value.
generate ln_age=ln(age_in_years_at_transaction_date)
histogram ln_age
sum ln_age
drop if ln_age==.
```

```
*Building height variable*
*the height variable need to be destringed
replace property_height = subinstr( property_height , ",", ".", 1)
destring property_height, gen(building_height)
histogram building_height
sum building_height
*building height is a little bit left skewed, lets transform it
generate ln_building_height=ln(building_height)
histogram ln_building_height
sum ln_building_height

****************
*location control variables*
*municipality dummies*
encode own_created_municipalityclass, gen(municipality_dummies)
tab municipality_dummies, gen(municipality_dummy)
rename municipality_dummy1 Almere_as_dummy
rename municipality_dummy2 Amersfoort_dummy
rename municipality_dummy3 Amsterdam_dummy
rename municipality_dummy4 Arnhem_as_dummy
rename municipality_dummy5 Betuwe_as_dummy
rename municipality_dummy6 Breda_dummy
rename municipality_dummy7 Capelle_aan_den_IJssel_dummy
rename municipality_dummy8 Delft_as_dummy
rename municipality_dummy9 Den_Bosch_as_dummy
rename municipality_dummy10 Dordrecht_as_dummy
rename municipality_dummy11 Eindhoven_as_dummy
rename municipality_dummy12 Enschede_dummy
rename municipality_dummy13 Frisian_municipalities_dummy
rename municipality_dummy14 Gooi_municipalities_dummy
rename municipality_dummy15 Gouda_as_dummy
rename municipality_dummy16 Groningen_municipality_dummy
rename municipality_dummy17 Haarlemmermeer_dummy
rename municipality_dummy18 Leiden_as_dummy
rename municipality_dummy19 Limburg_North_dummy
rename municipality_dummy20 Maastricht_dummy
rename municipality_dummy21 Eastern_Netherlands_dummy
rename municipality_dummy22 North_Netherlands_dummy
rename municipality_dummy23 Nijmegen_as_dummy
rename municipality_dummy24 Northern_North_Holland_dummy
rename municipality_dummy25 Southern_North_Holland_dummy
rename municipality_dummy26 Overijssel_cities_dummy
rename municipality_dummy27 Rotterdam_dummy
rename municipality_dummy28 South_Limburg_dummy
rename municipality_dummy29 The_Hague_dummy
rename municipality_dummy30 Utrecht_city_dummy
rename municipality_dummy31 Utrecht_North_dummy
rename municipality_dummy32 Utrecht_South_East_dummy
rename municipality_dummy33 Veluwe_municipalities_dummy
rename municipality_dummy34 Zeeland_West_Brabant_dummy
rename municipality_dummy35 Zwolle_dummy

**********************************************
*Accesibility control variables*
*All the location indicators need to be destringed*
*Road distance variable*
replace distance_to_main_road = subinstr( distance_to_main_road , ",", ".", 1)
destring distance_to_main_road, gen(main_road_distance)
histogram main_road_distance
codebook main_road_distance
sum main_road_distance
tab main_road_distance

*Train station distance variable*
replace distance_to_train_station = subinstr( distance_to_train_station , ",", ".", 1)
destring distance_to_train_station, gen(train_station_distance)
histogram train_station_distance
codebook train_station_distance
sum train_station_distance
tab train_station_distance

*Transfer station distance variable*
replace distance_to_transfer_station = subinstr( distance_to_transfer_station , ",", ".", 1)
destring distance_to_transfer_station, gen(transfer_station_distance)
histogram transfer_station_distance
codebook transfer_station_distance
```

```
sum transfer_station_distance
tab transfer_station_distance

*Check what happens when having ln variables implemented
generate ln_road_distance=ln(main_road_distance)
histogram ln_road_distance
generate ln_train_station_distance=ln(train_station_distance)
histogram ln_train_station_distance
generate ln_transfer_station_distance=ln(transfer_station_distance)
histogram ln_transfer_station_distance
*We are going to use the natural log transformations for the accessibility variables as the show a higher degree of normality.

**************************************************
*****First correlation matrix, before the regression analysis********
corr lnprice eight_years_before_deadline seven_years_before_deadline six_years_before_deadline five_years_before_deadline
four_years_before_deadline three_years_before_deadline within_two_years_before_deadline future_proof_dummy ln_sqm_total
ln_building_height ln_train_station_distance ln_transfer_station_distance ln_road_distance ln_age Almere_as_dummy Amersfoort_dummy
Amsterdam_dummy Arnhem_as_dummy Betuwe_as_dummy Breda_dummy Capelle_aan_den_IJssel_dummy Delft_as_dummy
Den_Bosch_as_dummy Dordrecht_as_dummy Eindhoven_as_dummy Enschede_dummy Frisian_municipalities_dummy
Gooi_municipalities_dummy Gouda_as_dummy Groningen_municipality_dummy Leiden_as_dummy Limburg_North_dummy
Maastricht_dummy Eastern_Netherlands_dummy North_Netherlands_dummy Nijmegen_as_dummy Northern_North_Holland_dummy
Southern_North_Holland_dummy Overijssel_cities_dummy Rotterdam_dummy South_Limburg_dummy The_Hague_dummy
Utrecht_city_dummy Utrecht_North_dummy Utrecht_South_East_dummy Veluwe_municipalities_dummy Zeeland_West_Brabant_dummy
Zwolle_dummy
*lm_age correlates with 2023 proof dummy, exlude from analysis*

*****************************************************************
*Regression models*

*Model 1*
reg lnprice seven_years_before_deadline six_years_before_deadline five_years_before_deadline four_years_before_deadline
three_years_before_deadline within_two_years_before_deadline future_proof_dummy

*Interaction model 2*
reg lnprice i.seven_years_before_deadline##i.future_proof_dummy i.six_years_before_deadline##i.future_proof_dummy
i.five_years_before_deadline##i.future_proof_dummy i.four_years_before_deadline##i.future_proof_dummy
i.three_years_before_deadline##i.future_proof_dummy i.within_two_years_before_deadline##i.future_proof_dummy

*Interaction model 3*
reg lnprice i.seven_years_before_deadline##i.future_proof_dummy i.six_years_before_deadline##i.future_proof_dummy
i.five_years_before_deadline##i.future_proof_dummy i.four_years_before_deadline##i.future_proof_dummy
i.three_years_before_deadline##i.future_proof_dummy i.within_two_years_before_deadline##i.future_proof_dummy Almere_as_dummy
Amersfoort_dummy Amsterdam_dummy Arnhem_as_dummy Betuwe_as_dummy Breda_dummy Capelle_aan_den_IJssel_dummy
Delft_as_dummy Den_Bosch_as_dummy Dordrecht_as_dummy Eindhoven_as_dummy Enschede_dummy Frisian_municipalities_dummy
Gooi_municipalities_dummy Gouda_as_dummy Groningen_municipality_dummy Leiden_as_dummy Limburg_North_dummy
Maastricht_dummy Eastern_Netherlands_dummy North_Netherlands_dummy Nijmegen_as_dummy Northern_North_Holland_dummy
Southern_North_Holland_dummy Overijssel_cities_dummy Rotterdam_dummy South_Limburg_dummy The_Hague_dummy
Utrecht_city_dummy Utrecht_North_dummy Utrecht_South_East_dummy Veluwe_municipalities_dummy Zeeland_West_Brabant_dummy
Zwolle_dummy

*excluded* REF CAT = 0 =Haarlemmermeer_dummy*

*Interaction model 4*
reg lnprice i.seven_years_before_deadline##i.future_proof_dummy i.six_years_before_deadline##i.future_proof_dummy
i.five_years_before_deadline##i.future_proof_dummy i.four_years_before_deadline##i.future_proof_dummy
i.three_years_before_deadline##i.future_proof_dummy i.within_two_years_before_deadline##i.future_proof_dummy Almere_as_dummy
Amersfoort_dummy Amsterdam_dummy Arnhem_as_dummy Betuwe_as_dummy Breda_dummy Capelle_aan_den_IJssel_dummy
Delft_as_dummy Den_Bosch_as_dummy Dordrecht_as_dummy Eindhoven_as_dummy Enschede_dummy Frisian_municipalities_dummy
Gooi_municipalities_dummy Gouda_as_dummy Groningen_municipality_dummy Leiden_as_dummy Limburg_North_dummy
Maastricht_dummy Eastern_Netherlands_dummy North_Netherlands_dummy Nijmegen_as_dummy Northern_North_Holland_dummy
Southern_North_Holland_dummy Overijssel_cities_dummy Rotterdam_dummy South_Limburg_dummy The_Hague_dummy
Utrecht_city_dummy Utrecht_North_dummy Utrecht_South_East_dummy Veluwe_municipalities_dummy Zeeland_West_Brabant_dummy
Zwolle_dummy ln_sqm_total ln_building_height ln_train_station_distance ln_transfer_station_distance ln_road_distance


***********************************************************
*OlS assumptions main model*
reg lnprice Almere_as_dummy Amersfoort_dummy Amsterdam_dummy Arnhem_as_dummy Betuwe_as_dummy Breda_dummy
Capelle_aan_den_IJssel_dummy Delft_as_dummy Den_Bosch_as_dummy Dordrecht_as_dummy Eindhoven_as_dummy Enschede_dummy
Frisian_municipalities_dummy Gooi_municipalities_dummy Gouda_as_dummy Groningen_municipality_dummy Leiden_as_dummy
Limburg_North_dummy Maastricht_dummy Eastern_Netherlands_dummy North_Netherlands_dummy Nijmegen_as_dummy
Northern_North_Holland_dummy Southern_North_Holland_dummy Overijssel_cities_dummy Rotterdam_dummy South_Limburg_dummy
The_Hague_dummy Utrecht_city_dummy Utrecht_North_dummy Utrecht_South_East_dummy Veluwe_municipalities_dummy
Zeeland_West_Brabant_dummy Zwolle_dummy ln_sqm_total ln_building_height ln_train_station_distance ln_transfer_station_distance
ln_road_distance i.seven_years_before_deadline##i.future_proof_dummy i.six_years_before_deadline##i.future_proof_dummy
```

```
i.five_years_before_deadline##i.future_proof_dummy i.four_years_before_deadline##i.future_proof_dummy
i.three_years_before_deadline##i.future_proof_dummy i.within_two_years_before_deadline##i.future_proof_dummy

*OLS assumption checks
regcheck
predict mainresid, resid
scatter lnprice mainresid
qnorm mainresid
kdensity mainresid
pnorm mainresid
estat imtest, white
ovtest

*Correlation matrix for the most important implemented variables*
corr lnprice eight_years_before_deadline seven_years_before_deadline six_years_before_deadline five_years_before_deadline
four_years_before_deadline three_years_before_deadline within_two_years_before_deadline future_proof_dummy ln_sqm_total
ln_building_height ln_train_station_distance ln_transfer_station_distance ln_road_distance

*We close the log and transform to PDF*
log close
translate"C:\Users\user\OneDrive\Documenten\Master Real Estate Studies 2021-2022\Master Thesis Module.smcl"
"Thesis_FrisovanderMark_S4949293.PDF"
```