Effects of retail accessibility on commercial rental dwellings in the Netherlands

ABSTRACT

The commercial residential rental market is growing and (institutional) investors are curious how rental values can be optimized. This study investigates the influence of accessibility towards retail facilities on commercial residential rent. This revealed preference study applies a sample of 112,000 retail facilities and 44,160 commercial residential rent transactions. A network dataset measures actual travel distances between these two types of real estate using a Geographic Information System. Categorized retail facilities are used in a hedonic regression model, which result in residential rent discounts and rent premiums per retail category. This translates in attraction and repulsion effects from retail accessibility on residential rent. The most important finding of this study is that dwelling should result in a rent premium if a dwelling located near the fashion facilities, electronic stores supermarkets, media, department stores. Some facilities can result in rent premiums if they are accessible, but result in discounts if they are situated too proximate. This can be concluded for DIY stores.

KEYWORDS

Gravity model, accessibility, retail facilities, commercial residential rent, hedonic pricing model, GIS.

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“Everything is related to everything else, but near things are more related than distant things."

- Tobler’s ´first rule of geography´ (1970) -

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1. Introduction

1.1 Context

The Netherlands approximately counts three million rental dwellings. Around 90% of these houses are regulated dwellings (or social housing) where access is granted based on an income limit (Government, 2015). The remaining part belongs to the non-regulated market where tenants pay so-called *commercial residential rent*. Prices can be set freely within this market and there are no access criteria. Demand in the rental market as a whole has increased since the economic crisis around 2008, and the most profound increase can be perceived in the non-regulated market. The non-regulated rental market supply has traditionally been quite small due to a number of circumstances. Fiscal incentives, such as mortgage interest reduction, promote owner-occupying housing, and access to a mortgage was relatively easy. In addition, the income limit to let a social dwelling is only tested at the start of the letting period, which causes so-called ´scheefwonen`, which literally can be translated as *skewed housing*[1].

However, the circumstances to maintain a relatively small non-regulated rental market are changing (Ministry of Interior and Kingdom Relations, 2014). Dutch government policy reforms aim to diminish ´skewed housing` by enhancing the potential to increase rent (during the letting period) based on income. The fiscal incentive for owner-occupiers is still valid, but obtaining a mortgage will be harder as financing rules become more strict (Outlook Syntrus Achmea Real Estate & Finance, 2015). Consequently, forecasted demand for the non-regulated rental market rises, which is catalysed by long–term socio-economic trends. The forecasted population grows at least till 2044 (Duin & Stoeldraaijer, 2014), and the number of households increases due to smaller households and an ageing society. Flexible and temporary employment is on the rise in the labour market which contributes to an increased demand for a more flexible form of housing (Ministry of Interior and Kingdom Relations, 2014). Altogether, the non-regulated rental market supply is unable to absorb all (forecasted) demand, which initiates the investment market to anticipate (Outlook Syntrus Achmea Real Estate & Finance, 2015).

According to a Dutch institutional investors association (IVBN), investment demand in the non-regulated residential sector is high, financial resources are abundant, and locations for development need to be found (IVBN, July 2015). In order to satisfy demand, the consumers preference needs to be revealed and conferring rental prices need to be set. The *revealed preference* determines what a consumer is willing to pay for a certain characteristic, which is accomplished by analysing rented dwellings and their surroundings. Dwellings can be compared along their structural characteristics, and neighbourhood characteristics which can be achieved with a measurement coined as *accessibility*. Accessibility defines the *potential of opportunities for interaction* a consumer can accomplish by reaching various points of interest (Andersson et al., 2010; Hansen, 1959). Traditionally these opportunities relate to factors such as land, labour, and capital. These factors have been impacted by post-industrial and globalizing trends. Industrial impacts have left the city, and consumption has increasingly become more important than production (Lloyd & Clark, 2001). The role of facilitating consumption is extremely important for the success of cities and understudied (Glaser, Kolk & Saiz, 2001). Retail activities are important in modern urban life, since they influence social activities and

[1] If income increases, after access is granted based on initial income, and exceeds the income limit during the rental period, the household does not have to vacate the regulated rental dwelling. As a consequence, a fair share of households in regulated rental homes actually have an income above the income limit (Government, 2014).

physical and environmental structures (Jang & Kang, 2015). Location efficient development, or new urbanism, shows that residential and retail facilities should be located in proximity to each other (Song & Sohn, 2007). This ultimately leads towards a greater sense of community, which attracts more residents (American planning association, 1998). Outcomes of previous research shows that easy access to retail stores results in a premium and raises property value by 5% of the mean property value in Florida (Des Rosiers, 1996). A retail accessibility study in Seoul concluded that some retail centers positively influenced residential attractiveness and some exerted negative influence, by distinguishing five different types of shopping centers based on their size, depending on their proximity (Jang & Kang, 2015). Accessibility towards various forms of transport in the Netherlands has been proven significant when explaining residential location choice (Zondag & Pieters, 2005), but effects of accessibility towards (retail) facilities on commercial residential rent are unknown within the Dutch real estate market. Current literature is opulent with information concerning residential values, i.e. owner-occupier prices and various forms of accessibility (Ottensmann et al., 2008). Even in the Dutch context several accessibility studies could be found (e.g. Geurs, 2004; Muhammed et al., 2008; van Wee et al., 2001), however all these studies focus on job-accessibility and none focus on retail accessibility. This seems odd since the classic accessibility paper of Hansen (1959) studied accessibility along job- opportunities and shopping opportunities. Another remarkable appearance within accessibility studies is the fact that the dependent variable mostly is expressed as the value of property, owner-occupier price or transaction price. In fact, hedonic pricing technique studies with rent as a dependent variable are studies much less, especially concerning the private non-regulated sector. Hoesli et al. (1997) were aware of this occurrence and their paper showed that the hedonic pricing technique could be applied to reveal the rental value within the private rental sector. However, they seemed focused on structural characteristics, and analysis of external effects was roughly executed.

Currently, accessibility studies are reviewed using a broad range of criteria and within different scientific fields which makes it a multifaceted concept. This often leads to poorly executed accessibility studies where accessibility is often misunderstood (Geurs, 2004). According to Geurs (2015) four basic perspectives can be distinguished: "(i) infrastructure-based measures, analysing the performance or service level of transport infrastructure, (ii) location-based measures, analysing accessibility of spatially distributed activities, typically on an aggregate level, (iii) person-based measures, founded in the space–time geography, analysing accessibility at the level of the individual level, and (iv) utility-based measures, analysing the welfare benefits that people derive from levels of access to the spatially distributed activities". In order to demarcate and categorize the perspective according to Geurs (2015), this study applies location-based measures with a gravity-based accessibility model. Subsequently, a hedonic price method links residential rent to the presence of retail facilities in vicinity and interprets the marginal prices as willingness to pay for this amenity.

An attempted contribution to current literature is made by analysing accessibility towards retail amenities with residential rent as a dependent variable. In order to analyse the willingness to pay, the housing market needs to be free of rent control and nonmarket allocation (Van Ommerren & Van der Vlist, 2016), therefore social rent will be ignored. Focus is on retail accessibility on a national level and this study tries to determine if accessibility is influential on the commercialized residential rent. The area of interest will be, in contrast to aforementioned studies who focus on a concentrated region, applied in the Dutch context and tries to extend knowledge of the non-regulated residential rent market. This study applies a *location-based* and *utility-based* perspective of accessibility towards retail and several control variables, i.e. non-retail facilities. Myriad factors that determine residential rent will be summarized into structural, external (neighbourhood characteristics) and accessibility components on the basis of previous residential accessibility studies. An accessibility score will be determined on individual basis by analysing surrounding amenities per dwelling. This information will be aggregated with rent level and considering the assumption that a consumer strives for utility maximization, the revealed preference will be studied (utility-based perspective). Control variables and cluster error regression will be implemented to account for neighbouring influences. These variables include other distance influential facilities, e.g. CBD, schools, hospitals, highway ramps, train stations and restaurants. Commercial residential rent premiums and discounts will be revealed and the most influential retail facilities on rent will be determined. This results in a clear illustration of relevant rent determinants and will aid real estate investors in setting rent levels.

1.2 Research questions

The objective of this study is to explore the effects of accessibility towards amenities on commercial residential rental prices. This is conducted according the willingness to pay for the proximity of amenities, with the influence of accessibility. The situation as drafted in the previous paragraph and objective of the research define the following central question:

- *What is the willingness to pay for retail facilities in commercial rental markets and to which extent is accessibility towards facilities influential?*

The main research question will be answered through the following research questions (RQ):

- *RQ1. What are determinants of commercial residential rent?*

Learning from earlier studies, the determinants of commercial residential rent will be investigated with a focus on accessibility. The applied structure will be a top down approach and key articles will shortly be discussed. A short, but broad view on urban land economics will be evaluated including Von Thunen (1826), Oates (1969), Muth (1969), and Alonso (1964) to underpin the importance of the central business district (CBD). Brueckner et al. (1999) summarize the insights of urban land economics and add the influence of amenities. The influence of amenities is an important factor of housing value and this matter is elaborated along the articles of Cheshire & Sheppard (1995), Small & Steimetz (2012), Kain and Quigley (1970) and Kauko (2003). When variables of previous studies are summarized, an analysis follows to underline the importance of external factors and accessibility (Hansen, 1959; Adair et al., 2000; Song & Sohn, 2007; Franklin and Waddell, 2003). An overview of previously applied accessibility measures will be established in order to select the most appropriate method. This chapter will present the literature review of this study and ends with a theoretical framework which contributes to the answer of the first research question, i.e.: commercial rent determinants.

- *RQ2. How to model accessibility?*

Previous chapter outlines the theoretical framework of the commercial residential rental market. The relation between amenities, accessibility and housing values has been studied before and findings of Andersson et al. (2010), Hewitt & Hewitt (2002) Martínez & Viegas (2009) and Franklin & Waddell (2003) are taken into account. To gain insights of the Dutch context, the study by Debrezion et al. (2006) will be described. Shortcomings and research methods of mentioned studies will be exemplified in order to apply an optimal model.

The applied perspective in this chapter will be *location-based accessibility*. There are several approaches to measure this type of accessibility: (i) the gravity-based model, (ii) the time approach,

and (iii) the distance approach. Analysis of mentioned approaches will determine how this study implements the effects of spatial accessibility and proximity to retail on residential rent. The *gravity based model* is the most advanced approach and analyses the interaction between housing and amenities. This is executed using the amount of retail and floor space. This method is derived from Newton´s law of gravity which depicts the degree of interaction between two places with the influence of *distance decay*[2]. This approach delivers an accessibility index per dwelling, and has been applied within various accessibility studies (Weibull, 1976; Joseph & Bantock, 1982; Luo and Wang, 2003;). This chapter explains which factors influence rent values and tries to explain how a spatial accessibility index can be established.
Distances between dwellings and retail points will be measured with the appliance of shortest network routes with OpenStreetMaps (OSM) in combination with the network analyst function of a Geographic Information System (GIS)[3]. This approach accomplishes better estimates than Euclidean distance measures, and offers reliable and accurate results (Mikelbank, 2004). Different retail types (from fun shopping to daily shopping) will be distinguished along the categorization of Locatus. Locatus broadly categorizes three types of shopping: (i) daily shopping (ii) targeted shopping and (iii) comparative shopping, and each shopping type has their own catchment area. Accessibility will be measured as an index, based on an average of the different retail types, in terms of demand and supply according the gravity model (Hansen, 1959; Jang & Kang, 2015). To estimate demand, the shortest network route between each centroid of the catchment area (based on 15 minutes travel time) and each type of retail store will be measured and weighted by the number of households in each catchment area. As a result, an accessibility index will be estimated per household.

This chapter represents the operation of GIS-based analysis and ends with descriptive analysis of commercial rent determinants and an overview of accessibility scores per retail type.

- *RQ3. What is the impact of accessibility on commercial residential rent?*

The location-based perspective which been applied in previous chapter, delivered an accessibility score per dwelling (A_i) and ensures an economic analysis from the *utility-based* perspective within this chapter. Hedonic regression will deliver the coefficients for the control variables and variables of interest.

The consumers preference will be revealed by their renting habits, and the choice made by consumers to settle on a specific location is assumed to maximize their utility. The basic theory behind this approach is that demand curves of households trace out how much a consumer is willing to pay extra for the addition of one unit of housing service, in this case ´one extra unit of accessibility´. The implicit price of such an attribute, represents the marginal valuation to consumers (Rosen, 1974). The *average willingness to pay* from a consumer point of view will be estimated using commercial residential rent within the Netherlands via the hedonic regression approach based on Rosen (1974).

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[2] The further apart residential and amenities are from each other, the less movement between them will occur. However, a larger retail store which is further away than a smaller retail store which is more proximate, will be preferred.
[3] ArcMap

1.3 Overview

This study starts with a review of existing literature on house rent determinants, focusing on the impact of accessibility studies. This section starts with urban land economics in order to underline the importance the CBD and amenities in the context of rent and accessibility. Various accessibility indexes will be evaluated and an overview will be given of the most used variables in order to determine commercial rent determinants. The influence of accessibility will be measured using a GIS platform in order to determine the location based accessibility index per dwelling. Subsequently, descriptive statistics and an informed choice apply the most used rent determinants, combined with an individual accessibility to economic analysis. The utility based perspective determines the willingness to pay of accessibility. Main findings, conclusions and implications for real estate investors will be discussed in the final chapter.

2. Theoretical framework

Houses are differentiated and heterogeneous products and consist of a bundle of legal rights, structural characteristics and geographic characteristics. Consumers pay rent in order to receive utility. Lancaster (1966) determined that not the product itself creates utility, but its individual characteristics. Rosen (1974) used this “consumer behaviour theory” as a framework for his hedonic price modelling and stated that the value (or rent) is a composite value with underlying characteristics. The hedonic pricing model technique attempts to define the value of a certain characteristic. The hedonic model assumes that price (i.e. rent) embodies various characteristics and each characteristic is determined by an implicit price. Hedonic regression estimates coefficients which represent an implicit price per characteristic. This method results in the willingness to pay per determinant. This chapter attempts to define rent determinants based on existing literature, starting with basic urban land economics and analyses a variety of applied accessibility indexes within real estate context.

2.1 Urban land economics

The relationship between accessibility and housing value has been recognized by various key researchers within the scientific field of real estate. The first well-known research was performed by Von Thünen (1826), who described the trade-off between high rent, along with high accessibility and low transport costs, versus low rent with low accessibility and high transport costs. The central business district (CBD) forms the highly accessible center of a monocentric city, with negligible distance towards amenities. The further a house is situated from the CBD, the less rent is paid because of rising transport costs to reach the CBD (with abundance of amenities). This theory is termed as agricultural land-use and is hereafter extended with functions of zoning by Alonso (1964). Alonso claimed that retail, office or residential functions all compete (in the form of bidding) for the most accessible land. This translates in high floor space ratios in areas where amenities are abundant. Space for agriculture, which has the lowest bid-rent, determines the outskirt of the city.

Oates (1969) projected that, since the primary source of employment lies downtown, individuals prefer living close to the city center to optimize travel- or commuting time and corresponding costs. Therefore it is expected that property values vary inversely with distance from the CBD, ceteris paribus. Muth (1969) developed a different empirical model, which focused on income and locational preference. He argued that the locational preference of more rich residents would be on the outskirts of the city, since they could afford the corresponding travel costs, and property values are higher in suburbs. The model of Oates (1969) is built on the same principle as Von Thünen (1826) as is referred to as the “bid-price function”. The model of Muth (1969) shows more similarity with Alonso (1964) and is referred to as the “standard model”. These theories contradict each other, but both are empirically validated significant. Brueckner et al. (1999) incorporated both insights and showed with an amenity-based theory that when the center has a strong amenity advantage over the suburbs, the rich are likely to live at central locations. When the amenity advantage of the center is weak or negative, the rich are likely to live in the suburbs. It could be stated that urban land economics is the traditional approach to understand the spatial distribution, with traditional factors like labour, transport costs and capital.

Although these traditional models can easily be criticized, due to the simplistic idea that housing prices decline with distance from the city, it holds an element of truth to this day (Ahlfeldt, 2011). However, several factors are less realistic in practice. An example is transport costs, which are assumed to be constant (per unit per kilometre) and location independent. In more recent time the influence of transport has been studied more often, and is generally studied along the lines of *accessibility*.

2.2 Rent determinants

The complex real estate market can be challenging to understand, since each (piece of) property is unique. Because of this heterogeneous character it is difficult to designate all variables that explain residential rent. Determinants of rent are extensive and inconclusive when tested. That is why Rosen (1974) associated observed prices as a set of implicit prices. Although many characteristics can be distinguished, a rough division can be made between structural characteristics and external characteristics in the owner-occupier market (Palmquist, 1984). Or more detailed characteristics like physical characteristics, location characteristics, amenities surrounding the dwelling, certain services and neighbourhood characteristics (Sirmans, 1989). When this study is put in context of the current time, and culture, not all variables seem relevant since maid service or security guards for example are the exception rather than the rule in the Dutch rental market. Therefore, a study which is performed closer to home could be more relevant. Although a Dutch study could not be found which was specifically aimed at rent determinants, a study performed in France showed a clear distinction between structural characteristics and external characteristics (Hoesli et al, 1997). This study showed that the most influential structural determinant on rent is floor space (when floor space increased with 1 m2, ceteris paribus, the rent increases on average by 30,71 Francs in Bordeaux). The most influential external characteristic on rent is the variable ´quality of neighbourhood´.

Table 1 shows the most applied determinants of nine selected studies concerning dwellings and accessibility, a more detailed presentation can be found in appendix I. Since determinants of owner-occupied housing appear comparable with rental dwellings (Malpezzi, 2003; Hoesli et al., 1997), both perspectives have been analysed.

Table 1. Value and rent determinants according to a selected number of (accessibility) studies

		A	B	C	D	E	F	G	H	I
Structural characteristics (Xb_1)	Age		✓	✓	✓	✓		✓		✓
	Floor-space	✓	✓	✓		✓	✓	✓	✓	✓
	Bath- or bedrooms (#)				✓	✓	✓	✓		✓
	Parking/Garage				✓	✓	✓	✓		✓
	Garden						✓	✓		
External characteristics (Xb_2)	Education in district			✓		✓	✓			
	Distance to CBD	✓	✓	✓	✓	✓	✓			
	Distance to park	✓	✓		✓					
	Population density		✓		✓		✓	✓	✓	
	Income				✓	✓	✓	✓	✓	✓
Study Area		ASIA	ASIA	USA	USA	USA	EU	EU	EU	EU

A: *Andersson et al., (2010)* **B**: *Jang & Kang (2015)* **C**: *Song & Sohn (2007)* **D**: *Hewitt & Hewitt (2002)* **E**: *Ottensmann et al. (2008)* **F**: *Dorantes et al. (2011)* **G**: *Debrizion et al. (2006)* **H**: *Öner (2013)* **I**: *Adair et al. (1999)*

From analysis of table 1, and appendix I, it could be stated that there is no clear delineation of rent characteristics. This can be caused due to a number of reasons. First of all, from the detailed presentation in appendix I, some geographical differences appear. Hot climates include air-conditioning in their OLS regression, while colder climates include central heating. Cultural differences can also be seen, since two out of three studies performed in the United States included the percentage of black people as external (neighbourhood) characteristic, where other studies completely neglect this topic. Another difference is that structural- and external characteristics are mostly applied as control variables within accessibility studies, and not its underlying characteristics. Although differences in explaining variables across studies are demonstrated, similarities can be observed as well. Overall, the studies applied a hedonic price technique with OLS. Floor-space seems the most applied, influential and significant, structural characteristic when explaining residential rent. Secondary is distance towards the CBD. When focusing on the European context, floor-space is implemented persistently, the number of rooms and whether a parking facility is incorporated also seems relevant. Distance towards the CBD seems less applied within the European context, which seems extraordinary given the insight of Ahfleldt (2011) as mentioned in paragraph 2.1.[4] Multiple studies proved significant results with different characteristics included in their final best performing model. A somewhat disappointing conclusion from this analysis could be that there is no universal approach or clear demarcation of which residential variables should be used, or applied. Another remarkable case is the absence of energy consumption of a dwelling. According to Santin et al. (2009) energy labels form an important structural determinant within the Dutch residential sector, since energy-consumption of a dwelling can be explained for 42% by building characteristics. Although this variable is neglected thus far in the accessibility literature, it could be an important variable to include in the hedonic regression. Energy labels intuitively influence rent, since more energy efficient

[4] An explanation for this occurrence is when a researcher includes distance to CBD as an explanatory variable, the underlying assumption is that the city is monocentric (Dubin, 1992). The large European cities in which the study has been performed could be typified as more polycentric, for which distance to CBD is less appropriate, than monocentric.

dwellings yield less monthly costs for utilities. This could be an important determinant on rent to implement in the hedonic regression within this thesis.

2.3 Retail facilities

The geographic location of dwellings are measured towards retail facilities. Retail facilities, or shopping amenities, simultaneously exert attraction as well as repulsion effects which impact the value of dwellings and location choice for households´ (Des Rosiers et al., 1996). Convenience gained from retail amenities is the ease of access with associated low cost of travel, and negativity arises from noise or congestion issues which a too great proximity towards retail center generates (Des Rosiers et al., 1996; Kholdy et al., 2014). As mentioned in the first paragraph of this chapter, the price of housing decreases the further one is situated from the CBD (Ahlfeldt, 2001). This traditional approach is applied in many hedonic studies as a distance measure in the baseline model. In short, three types of location-based accessibility perspectives can be distinguished: (i) the distance approach, (ii) the time approach, (iii) the gravity-based model (see table 2). The relatively complicated spatial pattern, of retail and housing, can thus be analysed in various ways. The distance approach can be typified as the most simply method. This method expresses distance between two points as a straight line and neglects infrastructural influences. This type of measurement is often applied in studies which attempt to measure proximity. The time approach is often applied within transport studies and accounts for infrastructural influences, and often congestion. The gravity model is usually applied within real estate studies, since it accounts for demand and supply. An important feature of the gravity model is the implementation of floor space which influences attractiveness. Attractiveness of a retail facility rises along with floor space. The larger the shopping center, the further a consumer is willing to travel for this opportunity and thus a larger catchment area arises (Reilly, 1929). Larger catchment areas are subsequently associated to be more accessible for households´ according the gravity model methodology (Lou & Qi, 2009).

2.4 Accessibility

Before accessibility will be analysed, the quote of a famous geographer seems appropriate to mention: "*Accessibility is a slippery notion…one of those common terms that everyone uses until faced with the problem of defining and measuring it*" (Peter Gould, 1969). Therefore, a short clarification of this concept seems in place. Hansen (1959) described accessibility in his ground-breaking study as the "*potential of opportunities for interaction".* Dalvi & Martin (1976) described accessibility as the "*ease with which any land-use activity can be reached from a location using a particular transport system*". Or "*the freedom of individuals to decide whether or not to participate in different activities*" (Burns, 1979). Geurs & van Wee (2004) describe accessibility in their well-cited study as: "*accessibility measures are seen as indicators for the impact of land-use and transport developments and policy plans on the functioning of the society in general*". In this (retail) accessibility study, accessibility will be described as the "potential of opportunities for interaction a consumer can accomplish by reaching various retail facilities". Accessibility studies have been applied within many scientific fields, such as urban geography, spatial economics and transport engineering. As a consequence, different approaches with different structures or different distance decay parameters can lead to very different conclusions regarding the same study area (Geurs, 2015). The perspective of a study, just as the description of the term accessibility, needs to be clear. Four perspectives within accessibility can be distinguished: (i) infrastructure-based measures, analysing the performance or service level of transport infrastructure, (ii) location-based measures, analysing accessibility of spatially distributed activities, typically on an aggregate level, (iii) person-based measures, founded in the space–time geography, analysing accessibility at the level of the individual level, and (iv) utility-based measures, analysing the welfare benefits that people derive from levels of access to the spatially distributed activities (Geurs & van Wee, 2004). This thesis focusses on location-based measures, where accessibility will be expressed as an index per dwelling in relation to retail facilities.

Table 2. Accessibility measures (location-based)

Accessibility as	Measurement	What is measured?	Observation
Distance	Straight line proximity measurement [D,E,G]	Distance between dwelling and amenity	Does not distinguish the size of retail facilities
	Proximity measurement with shortest route [A]	Distance between dwelling and amenity using 'shortest network route'	Does not distinguish the size of retail facilities
	Gravity model including demand [H,G,I,]	Distance and size of store determine demand and supply	Does not incorporate travel time
	Mixed Geographically weighted regression [B]	Measurement how relationships vary locally in relation to global relationship (which is performed with OLS)	Advanced and complicated technique, but only the global relationship was significant
Time	Gravity model [F]	Interaction over distance and size	Accounts for spill-over effects, and is aimed at one type of transport
Distance & Time	Straight line proximity measurement compared with time measurement in minutes [C]	Comparison which parameter performs better	City is observed as monocentric model, where amenities only are situated In CBD

A: *Andersson et al., (2010)* **B**: *Hewitt & Hewitt (2002)* **C**: *Ottensmann et al. (2008)* **D**: *Dorantes et al. (2011)* **E**: *Debrizion et al. (2006)* **F**: *Öner (2013)* **G**: *Jang & Kang (2015)* **H**: van Eck & De Jong (1999) **G**: Adair et al. (1999) **I**: Song & Sohn (2007)

A baseline gravity model expresses demand for activities, with linear distance decay, and interprets supply based on size of the activity (in this study floor space of retail facilities). This approach reflects a trade-off between distance and size, and has no straightforward interpretation since size and distance are assumed substitutes. In order to improve this feature of the model, the influence of travel cost can be added. The declining cost function of travel can be expressed in distance or time (Ottensmann et al., 2008). This approach expresses households' demand as an economic indicator and assumes a linear relationship. However, demand can also be observed as non-linear, i.e. the demand drops exponentially when travel distance increases. This contribution is expressed as ´beta´ (β) and is sometimes empirically determined, since this coefficient cannot be estimated with OLS regression of the hedonic model, or simply set to 1 and/or 2 (Jang & Kang, 2015). This approach assumes that locations are equally attractive, since the influence of different submarkets is neglected. If residential submarkets are taken into account within accessibility measurement, the variables vary enormously between spatial areas (Adair et al., 1999). This results in spatial fragmentation with localized effects, in the context of the study performed by Adair et al. (1999), for the job-market. Models with spatial submarkets demonstrate that location-based accessibility has an influence on housing prices. An issue, when attempting to apply this method, is that the deterrence function cannot not be empirically determined, and it is estimated based on non-proprietary traffic data. In addition, travel cost determination is based on modal split technique derived from a transport study in the same study area. Although this measure seems accurate it is also time-consuming, especially when national effects are analysed, and is dependent of traffic data.

Analysis from the literature shows that the submarkets in the dependent variable, residential sector, are often implemented. However submarkets in independent variables, retail facilities, are neglected. This proposition assumes that consumers are willing to travel the same distance for daily shopping, as non-daily shopping. An improvement could be the implementation of individual distance decay parameters per submarket. A contribution from this thesis could be implementing a retail accessibility model by measuring accessibility towards different types of retail facilities. This contribution is based on the job-accessibility study by Adair et al. (2009). When submarkets are distinguished in the dependent variable, and distinction is made in independent variable, outcomes vary highly (Franklin & Waddell, 2003). A way of improving this model further is to measure the size effect of the independent variable, i.e. the size of a retail store functions as a proxy for retail attractiveness (Song & Sonh, 2007). This type of proxy for attractiveness has been applied by several researchers before (Weibull, 1976; Joseph & Bantock, 1982; Shen 1998; Luo & Wang, 2003; Lou & Wang, 2003). This measure accounts for supply and demand of retail facilities. Demand is measured based on the distance from retail facility towards other households, and weighted by the distance from each retail store. Attractiveness however is not only influenced on the supply side, but also on the demand side. The demand side is determined by households which are likely to shop at a certain retail facility. The likelihood to shop at such a facility is determined by the distance between the dwelling and type of retail facility. The Dutch retail market can be distinguished in six main branches: (i) daily shopping, (ii) fashion & Luxury, (iii) entertainment, (iv) transport & fuel, (v) leisure, and (vi) services (Locatus, 2015). Daily shopping could be equipped with a higher beta than retail within the fashion & luxury category, since consumers are more inclined to purchase groceries in less distant retail facilities. Ideally, the value of beta´s should be estimated empirically, rather than ex-ante, using a trial-and-error approach (Sohn & Song, 2007).

2.5 Conceptual framework

The aim of this thesis is to determine the willingness to pay for retail amenities in the commercial residential rent market. The first step in order to execute the spatial model is to construct a research method, and this is visualized as step (1) in figure 1. The characteristics of rent can globally be categorized into structural- (b_1X_s) and external characteristics (b_2X_E). This categorization can be determined more specifically, as analysis shows from paragraph 2.2., but for simplicity reasons this division remains. Variables have been assigned along this categorization. Although no universal method could be found to determine commercial residential rent variables, the most applied variables of commercial rent, or derivatives, have been summarized (table 1). In step (2) of figure 1, at least floor-space, energy label and age seem appropriate to incorporate. As external characteristics distance towards CBD and other non-retail facilities seem appropriate variables to include in the hedonic regression. In step (3), the accessibility index of choice will be a gravity model, including supply and demand, with shortest network routes between retail and dwellings. Distance decay parameters should be different per retail category, which distinguish submarkets.

The dependent variable is commercial residential rent and it should be checked whether accessibility has a significant effect on residential rent. If a significant relationship can be determined, the next step (4) is to measure the willingness to pay for accessible dwellings. The hypothesis which will be tested is that retail accessibility has a positive effect on rent, i.e. higher accessibility scores contribute to higher rents. For this hypothesis structural and external characteristics are included along with the accessibility index. When results are estimated, the willingness to pay for accessible retail amenities can be determined. The conceptual framework is visualized in figure 1.

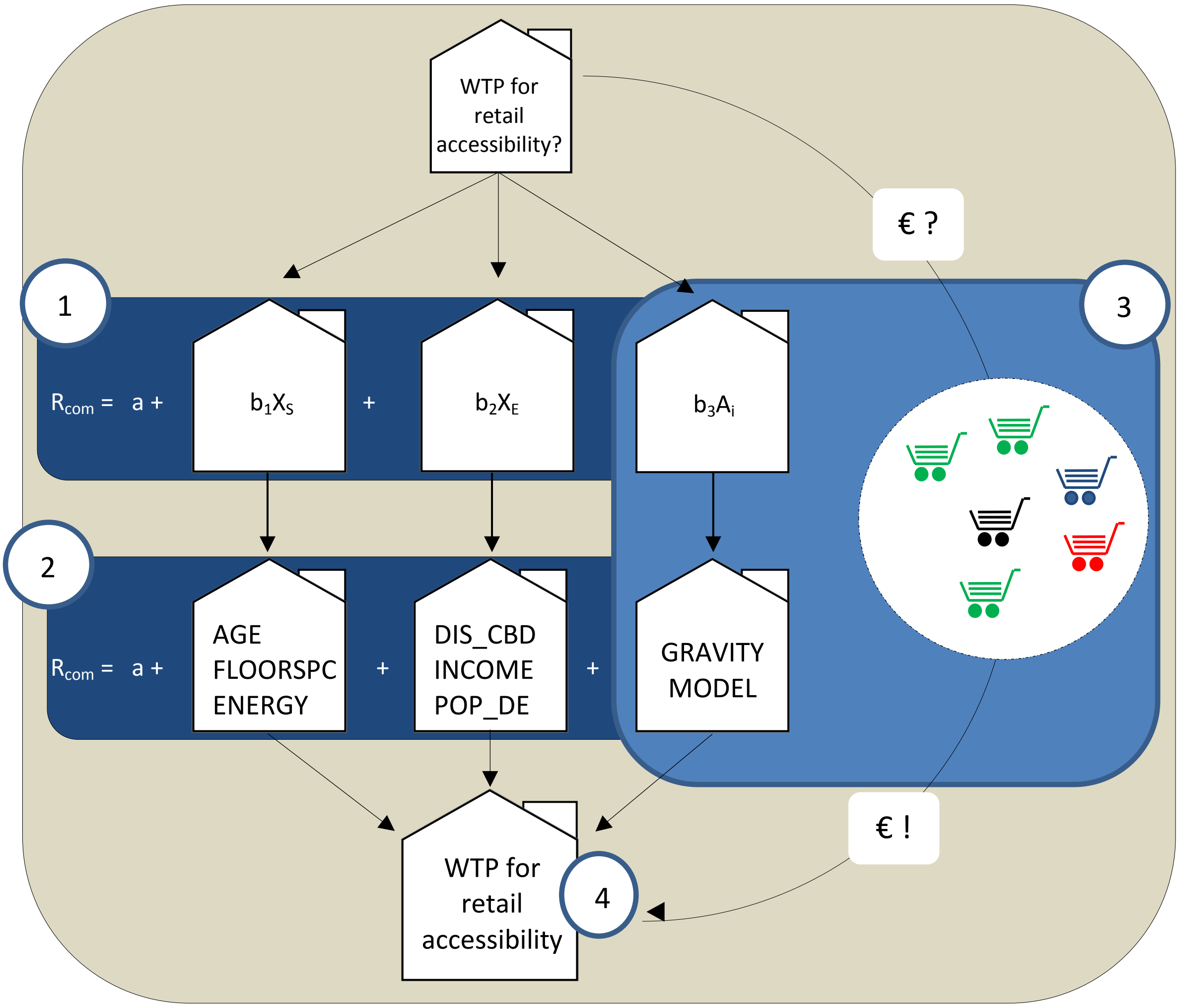

Figure 1. Conceptual model of research methodology

3. Data & Methodology

3.1 Description of data

This study focusses on the Netherlands. The cross-sectional data of commercial rent is provided by Syntrus Achmea Real Estate & Finance (further: SAREF). This dataset initially contains roughly 70,000 rental transactions between 2008 and 2015(Q1) gathered from several institutional Dutch investors[5] and is bundled by MSCI/IPD. The minimum rent, which defines the lower limit of commercial rent, is set per year according to ´liberalization-limits´ which were then in force, see appendix II. Since liberalization limits used to be set midyear, end of Q2, the rental limit of 2007 is applicable for dwellings which were rented out in Q1 and Q2 of 2008. This leads towards a minimum rent of €622 in the applied sample[6]. All rent levels above the liberalization limit (€710.68 price level 2015) are free of rent control. The Dutch law sets no upper limits to commercialized rent, as opposed to other definitions[7]. Market evidence of rental dwellings where prices are determined freely, i.e. the whole Dutch residential commercial rental market is of key interest. A portion of rents, however, were excluded due to the fact that they included missing values, could not be classified as commercial rent, could not be spatially geocoded or could be typified as an outlier. The remaining 44,160 rental transaction are based on starting lease rent. Since the data is not specific enough to distinguish repeated rent transactions, due to lack of housing numbers, the data cannot be typified as panel data and could possess repeated observations.

Data of retail locations is provided by Locatus. Locatus is the market leader in the field of independently sourced retail information in the Benelux. Since the Netherlands is the area of interest, all Dutch retail data was initially collected. Locatus conveys extensive samples where retail facilities are spatially specified with X and Y coordinates, which enhances geocoding significantly. The retail data initially counts 250,000 observations and separates 29 different retail categories. However, less than half of these facilities *do not* include net leasable floor space (expressed per m2), thus are excluded from the sample. Thus, the applied set contains roughly 112,000 retail facilities and expands over 16 categories, see appendix III. Applied retail facilities (marked black) and dwellings (marked blue) can be seen in figure 2.

Data of non-retail facilities are provided via the Central Bureau of Statistics (CBS), which delivers geographic information on municipality and neighbourhood level[8]. This information is aggregated in a shapefile where data could be projected, on the fly, over residential geocoded data. This results in closest distances to various facilities based on four digit-postal codes. Examples of these non-retail facilities are hospitals, schools, highway ramps and shopping centers. Note that shopping centers are not the same the retail facilities, since they are expressed as a concentration of retail facilities, but however seems moderately correlated, see appendix X. Locational variables such aggregated income levels, population density and the quantity of surrounding commercialized rental dwellings are expressed on four-digit level and are provided by ABF research[9].

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[5] Altera Vastgoed, Amvest, Bouwinvest, CBRE Global Investors, Delta Lloyd Vastgoed, Eigen Haard, Vesteda and Syntrus Achmea Real Estate & Finance.

[6] Inflation is assumed to be incorporated in the transaction rent, since prices are set quarterly, and is controlled for by implementing yearly indicator variables.

[7] IVBN, Association of Institutional Property Investors in The Netherlands, typifies commercial rent between liberalization limit and €1,200; since rent above this level competes with the owner-occupier market.

[8] Wijk- en Buurtkaart 2013

[9] Vastgoedmonitor database

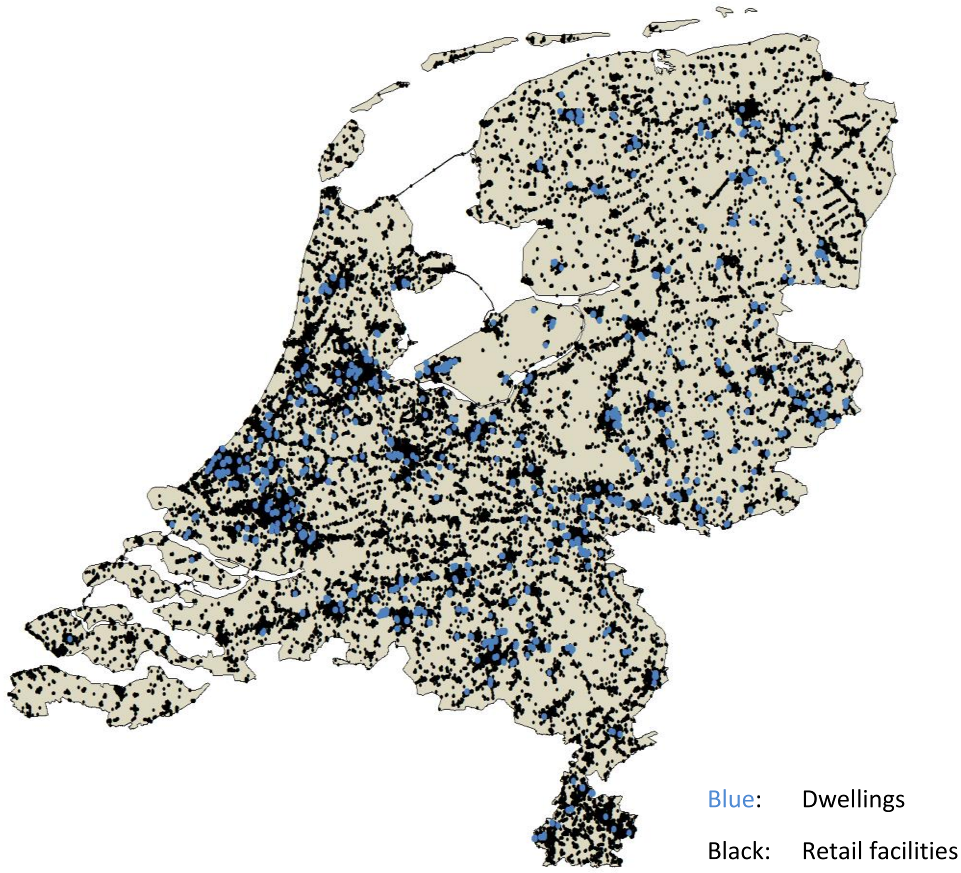

Figure 2. Visualization of data (source: MSCI, Locatus, SARE&F, processed by author)

3.2 Accessibility indices

As mentioned in the introduction of this thesis, accessibility is defined as the "potential of opportunities for interaction a consumer can accomplish by reaching retail facilities". In order to measure this potential, a twostep, gravity model is applied. This model determines an accessibility score per dwelling, based on *supply* and *demand*. This method does not assume an artificial line or circle that defines retail as inaccessible (Wang & Minor, 2002). The key influencing factors within this model are distance, floor space and competition among households.

Supply is a measurement of retail floor space and the distance. This assumes that if a store has a larger capacity for goods and customers, it therefore provides a higher level of accessibility to area residents (Song & Sohn, 2007). Supply is weighted by the distance a consumer has to travel. Distances between two points, such as dwelling A and retail facility B, can be measured in various ways. The first distinction is made between infrastructure distance, and Euclidian distance (straight-line distance). Straight-line distance captures spatial proximity per dwelling. However, this does not accurately measure accessibility between dwellings and retail facilities from the perspective of this study. This study is focused on accessibility *via roads*, where distance will be measured from dwellings, towards retail facilities using infrastructural network distance. In order to measure this distance, an underlying network dataset in a GIS has been established with OpenStreetMaps (OSM)[10]. Roadways of the Netherlands, downloaded via Geofabrik.de (2015)[11], were imported in a GIS by establishing a network dataset. This dataset basically exists of roughly 3 million lines or edges as ArcMap identifies them, and 2 million dots, i.e. junctions. Lines determine length in meters, and dots determine directions. Configuration of the network dataset is set to exclude bike-paths, waterways and pavements, and roadways and highways are of interest for this study. The network dataset determines the shortest route for a car, originating from a dwelling, towards various retail facilities using an Origin-Destination (OD) matrix. The OD matrix originates from a commercial rent dwelling towards the closest five retail facilities per category. Since sixteen categories are distinguished, ninety routes are measured from a single dwelling. In total roughly 4.2 million directions calculated using this method, due to some loose network links. Figure 3 provides a detailed visualization of the network data-set build-up.

Figure 3: Details of network dataset (blue dots represent commercial dwellings in Amsterdam)

Demand is expressed as competing households, since the amount of residents within a dwelling is unknown in available sample. Data concerning competing households are provided by CBS and are as detailed as 100 by 100 meter census blocks. However, a slightly rougher measurement, four digit postal codes, fits the data more accurately. Households in the sample are expressed by commercialized rent transactions, which form a proxy of demand. These 44,160 households, typified

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[10] OSM is open-source nonproprietary data, which is driven by an active voluntary community with more than two million registered users. These users contribute geographical information via their smartphone, GPS-devices, and via automated imports using aerial photography and other inputs

[11] http://download.geofabrik.de/europe/netherlands.html

as dwellings, are geocoded with a GIS using an address locator based on street addresses from BAG[12]. Demand / competition for retail facilities amongst households´ can now be based on actual travel distance, via the OSM network dataset, towards a certain postal code. The amount of households per postal code that are within 15, 30, 45 and 60 minutes of travel time are set, e.g. 677,420 households can reach zip code 1011 within 15 minutes of driving time. Since Dutch travel time surveys towards different retail categories are unknown, and it is quite arbitrary to allocate a maximum travel time to a certain retail, the author has chosen to set the maximum travel time to 15 minutes for all retail categories.

To summarize, accessibility will be measured along supply and demand for each household and results in an accessibility index per dwelling. The implementation can be summarized as follows: The first step, step 1 in figure (4), calculates road network distance from a dwelling towards the five most proximate retail facilities (delimited per category), and is multiplied with gross leasable area (GLA). This measurement determines attractiveness of a retail facility, which is a proxy for demand. This step is expressed in the first part of the numerator in equation (4). The second step in figure (4) represents a measurement from this aforementioned retail facility and determines its accessibility based on competition, i.e. all households within 15 minutes of travel time. Distance is now measured from the retail facility, e.g. one the closes five facilities in previous measurement, towards all competing households within a 15-minute travel time radius[13]. The sum of the distance is multiplied by the sum of all road distance between retail and dwellings within the sample[14]. This forms a proxy for supply, and is expressed in the first part of the denominator in equation (4). Thus the supply-side of households´ accessibility towards retail facilities is an aggregation of its relation towards all accompanying retail within 15-minute travel distance radius.

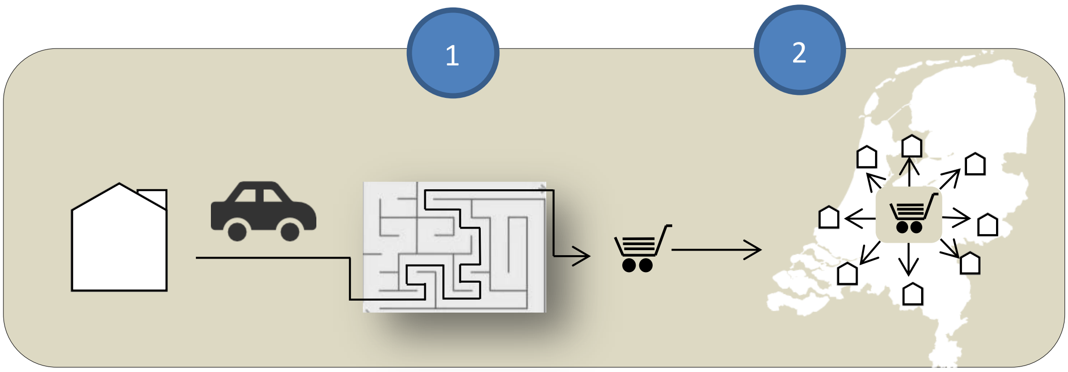

Figure 4. Theoretical example of accessibility measurement

With the inclusion of competition, accessibility *cannot* be interpreted as a simple trade-off between floor space and distance. However, the role of distance, and the rent effect of proximity towards various facilities is not incorporated yet. Some studies interpreted this matter as the ´cost of travel´ (Lacono, Krizek and El-Geneindy, 2008) and stated that the price a household is willing to pay to reach a facility should be expressed as distance decay (Beta or β). Other accessibility studies applied the same line of thought but interpreted Beta as an interaction measure (Nakanishi & Cooper, 1974).

[12] BAG is an abbreviation for (roughly translated from Dutch) Registration Addresses and Buildings.
[13] Underlying data is based on a travel survey performed by CBS from 2012.
[14] This deviation of the original Gravity model was necessary, due to the combination of a large dataset and the absence of advanced computational hardware. Distance should be based on all households and retail facilities within the Netherlands.

When beta is small, impedance is low and accessibility is high and vice versa. Beta can thus be interpreted as the inverse of accessibility, since the higher beta becomes, the higher the unwillingness to travel towards a retail facility (Harris & Rubinfeld, 1978).

Note, that the unwillingness to travel, or the less proximate a household is situated next to a facility, does not imply that rent effect(s) diminish. As a matter of fact, intuitively it could be rationalized that households want to have access to certain facilities, but do not want to position themselves precisely next to it. In order to catch this effect on rents, the accessibility-index should ideally include multiple levels of distance decay. This study applies two forms of distance decay, which will be set to β=1 and β=2, in line with the studies of Jang & Kang (2015) and Song & Sohn (2007). Based on the available data and estimated measurements, the gravity model can now be determined. The method to score each individual dwelling on accessibility can be summarized with the following equation (4).

$$A_i = \sum_{i=1}^{n} \frac{S_j {d_{ij}}^{-\beta}}{\sum_{k=1}^{m} D_K d_{kj^{-\beta}}} \tag{4}$$

A_i is the accessibility index of dwelling *i. n* is the number of retail stores per category (fifteen categories have been distinguished). S_j depicts the gross leasable area of retail store *j*. d_{ij} is the shortest route between dwelling *i* and retail store *j*. d_k describes the number of households within a fifteen minute radius. d_{kj} is the distance between retail and dwellings. β the distance decay parameter. *M* is the number of households and *k* describes the dummy variables (dwelling type, building age, transaction year). This approach states that interaction between locations is positive and distance between them is negative, hence the negative beta. This approach will be executed per dwelling, and since retail categories are distinguished, sixteen different accessibility scores will be calculated per dwelling. The interpretation of the score itself at this point is somewhat fuzzy, since a higher score does not imply better accessibility. The interpretation of this score becomes clear after OLS[15] regression and hopefully explains the variance of rent within the Netherlands.

3.3 Descriptive statistics

Table 3 shows the descriptive statistics of the variables which should be included in the model according to the literature review. Fortunately all variables could be gathered, although some in an aggregated form, and will be applied in the future models. A slight adjustment was performed since the dependent variable, rent per month, looks slightly skewed when plotting a histogram, see appendix IV. The solution was to transform the dependent variable using a natural log. This also applies for floor space, which has similarly been naturally logged. Energy labels have been transformed from continuous variables into three different categories (red, orange and green label). The number of observations (N) in the applied models dropped from the original dataset of 70,000 observations to 44,160 observations. This can be explained since the sample contains a relatively high degree of homogeneous dwellings where distances, from an apartment within a block, towards closest facilities are highly similar of one another[16].

[15] Ordinary least squares

[16] Stata automatically omits variables which contain collinearity from the regression

Table 3 also shows the accessibility variables. Distance to the closest highway ramp, train station and CBD, as well as other non-retail facilities could be found for each observation. On average, dwellings are the allocated farthest from attraction parks, which intuitively makes sense given the number of these parks. Children day-care and out-of-school care are the most proximate on average.

Controlling for submarkets within the Dutch residential sector, dummies will be added per four digit postal code, per year, (relative) location and building age. Relevant variables are conveyed in table.

Table 3: Descriptive statistics

Variable	**Description**	**Obs.**	**Mean**	**Std.Dev.**	**Min**	**Max**
Structural Characteristics						
RENTPM	Rent paid per month (excl. utilities)	44,160	929.519	343.2285	622	3994
lnRENT_PM	Natural log of Rent per month	44,160	6.782645	.2489377	6.432	8.664
FLOORSPACE	Net Leasable Area per dwelling (NEN2580)	44,160	110.2744	23.04564	33.18	281.39
lnFLOORSPACE	Natural log of Leasable Area per dwelling	44,160	4.679018	.2103772	3.501	5.639
PARKING	Amount of parking places	44,160	.3425501	.4757723	0	3
External Characteristics						
QUANT_COM	Amount of commercial dwelling per region	44,160	53910.09	67910.16	700	182800
INCOME	Aggregated income per region	44,160	9386.099	4307.851	210	27200
POP_DENS	Population density per region	44,160	4783.956	2353.257	20	13280
Closest facility[17]						
Pharmacy		44,160	.8975374	.5841532	0	7.4
Hospital		44,160	3.165241	2.267414	0	17.7
Private Clinic		44,160	4.286793	3.404259	0	21.4
CBD		44,160	1.713919	1.112272	0	10.9
Bar		44,160	1.060545	.829631	0	5.1
Cafeteria		44,160	.6484392	.4841502	0	5.4
Restaurant		44,160	.6790596	.5242633	0	3.8
Hotel		44,160	2.020949	1.547517	.1	11.4
Children daycare		44,160	.5910411	.3499898	.1	6.9
Out-of-school care		44,160	.5831344	.3377985	.1	4.5
Primary school		44,160	.6280548	.3318574	.1	4.3
High School		44,160	1.546406	1.070475	.2	12.6
Highway ramp		44,160	1.89375	.9074283	.1	5.5
Train station		44,160	3.148542	3.070054	.2	38.2
Swimming pool		44,160	2.65616	1.63269	.3	17.6
Library		44,160	1.557221	.9893665	.1	6.6
Cinema		44,160	4.498128	3.56932	.2	26.4
Sauna		44,160	5.961203	4.414555	.4	34.4
Amusement park		44,160	5.068265	3.367707	.3	29.9
Theatre		44,160	3.307561	2.87503	.2	24.7
Accessibility Variables						
Retail category	**Examples**	**Obs.**		**Avg. GLA (m2)**	**Avg. Dist. (m)**	
Ai_Supermarket	Alberth Heijn, Jumbo	44,160		100.6	705.2	
Ai_Fashion	H&M, Zara	44,160		64,6	953,4	
Ai_Flora & Fauna	Intratuin	44,160		122,8	994,2	
Ai_Drug stores	Kruidvat, Etos	44,160		55,6	1000,2	
Ai_Car & Bike	Halfords	44,160		67,4	1142,2	
Ai_Electronics	Cell-phone, computer	44,160		67,4	1254,4	
Ai_Juwelry & Opticians	Pearle, Siebel	44,160		26,8	1258,8	
Ai_Household supply	Blokker, Xenos	44,160		100,6	1316,8	
Ai_Sports & Games	Perry Sport	44,160		121,8	1366,8	
Ai_DIY	Gamma, Praxis	44,160		275,8	1394,8	
Ai_Shoes & leather	Van Haaren	44,160		71,4	1453,2	
Ai_Media	Bruna, The Read shop	44,160		50	1644	
Ai_Hobby	Photoshop, partshops	44,160		40,8	1644,8	
Ai_Art & antique	Galeries, antique	44,160		44,4	2414,6	
Ai_Department store	Hema, V&D, Bijenkorf	44,160		691,6	2888,8	
Ai_Lifestyle	Various giftshops, Leen bakker	44,160		1056,8	4715,4	

[17] Closest facility average for all households based on four digit postal code.

Dummies		**Description**		**Perc. %**
BUILT_CAT	1 =	Before 1970		6.89
	2 =	1970-1979		17.93
	3=	1980-1989		25.42
	4=	1990-1999		33.59
	5=	2000-2009		13.53
	6=	After 2009		2.64
DWELLING_T	1 =	Deck-access flat;	Flat with external corridor	14.21
	2=	Apartment block:	Flat with internal corridor	20.78
	3=	Maisonette;	Apartment with two floor levels; internal stairs	2.22
	4=	Other attached buildings	Various attached single-family dwellings[2]	12.81
	5=	Terraced housing	Rows of identical houses which share side walls.	38.91
	6=	Semidetached housing	Pair of houses, which share one wall	5.90
	7=	Miscellaneous	Various dwellings	5.18
LOCATION	1=	Outside of a center		48.51
	2=	Center of village		14.71
	3=	Center of a town (=larger than village)		13.00
	4=	Green area within city (=between rural and urban area)		20.31
	5=	Rurally situated		3.46
FAM	1=	Not a multifamily home		49.59
	2=	Multi family home		50.41
YEAR	1=	2008 (Start of rent contract)		13.75
	2=	2009		11.87
	3=	2010		13.42
	4=	2011		12.92
	5=	2012		12.06
	6=	2013		14.23
	7=	2014		17.64
	8=	2015 (Q1)		4.11
ENERGY	1=	No Label		49.45
	2=	Red Label (F,G)		31.72
	3=	Orange Label (D, E)		8.09
	4=	Green Label (A,B and C)		10.73

3.4 Empirical model

Given the spatial character of this thesis, the relation between housing rent and accessibility will be performed along equation (5).

$$LnR_i = b_o + \sum\nolimits_j \varphi_j S_{i\,j} + \sum\nolimits_k \gamma_k E_{i\,k} + \sum\nolimits_l \theta_l A_{i\,l} + \varepsilon_i \qquad (5)$$

In above-mentioned equation, rent has been naturally transformed. The matrix LnR_i consists of the commercial residential rent of dwelling *i,* also known as the dependent variable. b_0 is the constant, summation *S* denotes structural characteristics of dwelling *i*, summation *E* yields external characteristics of dwelling *i*, and A_{ij} is a summation of accessibility between dwellings *i* and retail facilities *j*. These vectors are identified as independent variables, where epsilon ε_i denotes the error term. Three models will be estimated. Due to the intrinsic character of the housing market and its strong autocorrelation between submarkets, clustered error regression has been performed for all models. The first model, or base-line model, is regressed using control variables, the constant and clustered standard error terms.

The second and third model which will be produced should be the best performing models, where the accessibility variable will be included using two scenarios. All models will control for spatial heterogeneity using four digit postal area dummies with cluster regression. This assumes that each observation within four-digit postal area code are comparable and have local effects. Dummies will be generated per four-digit postal code to include the influence of surrounding property rents. This approach lowers the amount of variation across the sample as whole, and rises the power of explanation within the model. This should result in a parsimonious model, with a relatively high R^2. Using these different models, with slightly different arrangements, should provide evidence for the relationship between housing rents and accessibility more clearly. In addition, it should provide which facility types are (more) influential on housing rents then others.

4. Empirical results analysis

This section provides the results of the OLS regression. The first model which has been estimated is known as the baseline model. It controls for structural characteristics (not shown in table 4, see appendix VII for complete results), neighbourhood variables, energy-labels and distances towards various non retail facilities. The baseline model is extended with the key-interest of this research, i.e. retail accessibility. This has been researched using two scenarios by applying two different distance decay parameters. The results are mostly significant and generally show intuitively plausible outcomes. The final model shows a R^2 of nearly 0.82.

Table 4. Results[18]

lnRENT_PM	Model 1		Model 2		Model 3	
	b	Clustered Std. Err.	b	Clustered Std. Err.	b	Clustered Std. Err.
Constant	3,6426***	0,1554	5,1146***	0,4227	5,0113***	0,3657
lnFloorspace	0,6290***	0,0294	0,6290***	0,0294	0,6290***	0,0294
Red_EnrgyLabel	-0,0386**	0,0188	-0,0386**	0,0188	-0,0386**	0,0188
Orange_EnrgyLabel	-0,0208	0,0197	-0,0209	0,0197	-0,0209	0,0197
Green_EnrgyLabel	0,0500***	0,0174	0,0500***	0,0174	0,0500***	0,0174
Dis_CBD	-0,2456***	0,0353	-0,3740***	0,0606	-0,6117***	0,0984
Dis_Pharmacy	0,1671***	0,0119	-0,7002***	0,2136	-0,6024***	0,1092
Dis_Hospital	0,0136***	0,0031	0,0101	0,0102	-0,0443***	0,0093
Dis_Bar	0,0804***	0,0201	0,2196***	0,0732	0,0956***	0,0190
Dis_Restaurant	0,7123***	0,1114	0,7855***	0,1691	1,3423***	0,2196
Dis_Hotel	0,0058	0,0103	0,0895***	0,0322	0,0234**	0,0119
Dis_Children_daycare	-0,6694***	0,0573	1,1811***	0,4112	0,9810***	0,1870
Dis_Out_of_school_care	0,4371***	0,0488	0,2644***	0,0488	-0,1843*	0,1011
Dis_Primary_school	-1,0611***	0,1404	-1,1257***	0,1921	-1,2608***	0,1686
Dis_High_School	0,0342***	0,0027	-0,1911**	0,0928	-0,0579***	0,0218
Dis_Highway_ramp	-0,0611***	0,0083	0,1741***	0,0466	0,0917***	0,0138
Dis_Train_station	-0,0044	0,0079	-0,0049	0,0096	-0,0266***	0,0030
Dis_Swimming_pool	0,0019	0,0032	-0,1458***	0,0468	-0,1416***	0,0287
Dis_Cinema	-0,0398***	0,0115	-0,1136**	0,0525	-0,3583***	0,0765
Dis_Sauna	0,0475***	0,0068	0,0919***	0,0240	0,1155***	0,0203
Dis_Amusement park	0,0858***	0,0070	0,0092***	0,0026	0,0522***	0,0102
Dis_Theatre	-0,0329***	0,0121	0,1760***	0,0611	0,5069***	0,1032
lnAi_fashion			0,5242***	0,1242	0,1068***	0,0193
lnAi_hobbies			0,1255***	0,4258	0,2980***	0,0754
lnAi_shoes_leather			0,2042**	0,0809	0,1672***	0,0516
lnAi_optics_jewelry			-1,3403***	0,4913	-0,7537***	0,1664
lnAi_media			0,2957***	0,0627	0,7313***	0,1278
lnAi_sport_games			-0,5112***	0,1413	-0,3741***	0,0642
lnAi_art_antique			0,0728**	0,0318	0,0027	0,0082
lnAi_flora_fauna			-0,1146***	0,0429	0,0063	0,0125
lnAi_electronics			0,4297***	0,1239	0,4798***	0,0849
lnAi_car_bike			-0,3582**	0,1490	-0,4911***	0,1176
lnAi_diy			0,2339**	0,0959	-0,2013***	0,0512
lnAi_lifestyle			-0,0482***	0,0173	-0,1132***	0,0249
lnAi_departmentstore			0,2513***	0,0599	0,0754***	0,0124
lnAi_supermarket			0,2545***	0,0976	0,1523***	0,0354
lnAi_drugstores			0,1713***	0,0236	0,0598**	0,0261
N	44,160		44,160		44,160	
R^2	0.7901		0.8161		0.8161	
Structural controls	Yes		Yes		Yes	
Time controls	Yes		Yes		Yes	
Controlled for # of clusters	629		629		629	

*Significant at 10%, **Significant at 5%, ***Significant at 1%

[18] See appendix VIII for full results.

Natural logarithms have been employed on the dependent variable, the accessibility variables and floor space. This implies that the model is log-linear and partly log-log. The interpretation of the coefficients thus should be interpreted as growth-rate and elasticity, respectively. The dummies included in the model describe year of the rent transaction, the type dwelling, in which time period it was built and the location characteristic. The reference category for rent transaction is set to 2015. The reference time period when the dwelling was built is set to 2009 and above. Seven types of dwellings are distinguished, i.e. deck-access flat, apartment block, maisonette, attached-buildings, terraced housing, semidetached and ´miscellaneous dwellings', where the latter is the reference. The results show quite a high power of explanation (R^2 .79), which implies that the variation is explained well in the baseline model already. The models include nearly 44,160 observations with mostly significant results. A_i, in equation (5), is described as a sum of vectors of all accessibility measures where coefficients are regressed per retail category. One accessibility category is omitted[19] due to collinearity. Collinearity also caused some four digit postal codes indicator variables to be omitted in the regression. This can be explained from *the first rule of geography*[20], which causes the error terms of some adjacent postal codes to be correlated with one another. Note that distance to CBD shows some moderate correlation as can be seen in appendix X, but not a strong relationship.

The baseline model delivers results which are intuitively plausible. The more detailed model shows, as can be seen from appendix VIII, continuous upward rent revisions per year. Rents are, however, not deflated thus this seems logical. In general, newer dwellings yield more rent, a slight retro effect can be seen for older dwellings, and attached dwellings are cheaper than semi-detached or detached dwellings. Floor space is expressed as a natural logarithm in the regression and thus should be interpreted as an elasticity effect. This means that the addition of 1% of square meter floor space, results in a rise of rent of approximately 0,69%. This seems intuitively low, however, this coefficient is similar to the coefficients found in other accessibility studies (Ottensmann, 2008; Song & Sohn, 2008). These studies resulted in floor space regression coefficients of .02 and .003, respectively. Locational variables such as neighbourhood average income, population density and the supply of commercial rental dwellings (expressed per four-digit postal code) were initially analysed. However, these variables barely affected rent thus were excluded from the models. The influence of energy labels on rent have also been analysed. Three types of labels were distinguished; red, orange and green. Red and orange energy labels negatively affect rent and a green label yields more rent. The addition of energy labels asserts that if energy label rises from orange to green, i.e. from D to C label, rent rises with approximately 5%[21], ceteris paribus. Energy-efficient dwellings yield more rent since, given that there is no bargaining, less had to be paid for utilities. It can be interpreted that energy-efficiency of a dwelling is capitalized in the rent level already.

The baseline model also accounts for proximity towards non-retail facilities. Proximity effects are measured as kilometres originating from a dwelling towards the closest non-retail facility. The negative relationship between distance and the CBD, i.e. rent becomes higher the more proximate a dwelling is located, is intuitively correct and in line with existing literature (Bramley et al, 2009). Nonetheless, according to the model estimation this implies that if distance between a dwelling and the CBD rises with one kilometre, rent lowers with 24%, ceteris paribus. Although this result is significant in the model it seems intuitively high. Literature shows the influence distance towards the

[19] Retail category ´Household supply´ is omitted due to collinearity

[20] "Everything is related to everything else, but near things are more related than distant things." (Tobler, 1970)

[21] Mathematically correct: +1 m^2 increases the rent per month with ((exp ^{b1} -1) * 100)

CBD of -0,002[22] (Heikkila et al., 1989) and -0.016 (Richardson et al., 1990) as the dwelling gets one mile further away from the CBD on residential value. When distance towards CBD is expressed per kilometre, the housing value on average drops a bit more, i.e. minus 5% per kilometre (Chen, & Hao, 2008). The regression results of primary schools and children day-care facilities which highly influence rent levels are also higher than predicted by literature. The influence of a schools vary across different schools and shows coefficients between -0.0004 and -0.27 (Clark & Herrin, 2000). Other significant outcomes which also result in rent premiums are children day-care facilities, primary schools, cinema´s, theatres, highway ramps and train stations. Aforementioned variables are control variables and determine the baseline model, i.e. Model 1. Since key the focus of this study is on retail accessibility, a separate paragraph has been dedicated to discuss the results.

4.2 Retail accessibility

Models 2 and 3 suggest that accessibility parameters have an effect on rental values. Some accessible facilities influence in a positive manner and some accessible facilities exert negative influence. Both models use the same observations and explain the variation almost equally. Model 2 and 3 extend the baseline model where retail accessibility is calculated using the gravity equation (4) towards retail facilities. For estimating heterogeneous effects of accessibility, different distance decay measures are applied. Model 2 is estimated with weak distance decay, expressed as Beta=1. Model 3 is estimated with strong distance decay, expressed as Beta=2. Recall that the higher the beta, the stronger the effect of distance decay, the higher the unwillingness to travel towards a certain facility. Thus, regression results with a Beta of 2, state that the positive effect of accessibility towards facilities rapidly diminish with distance. When inspecting the results some results appear doubtful, and should be interpreted with caution given the potential of non-BLUE-estimators, see appendix V for full report. In short, the assumption of spatial autocorrelation is violated, which notes that the covariance between different regions is zero. This assumption, however, is less relevant within the real estate literature where houses are proven to exhibit spatial autocorrelation (Basu & Thibodeau, 1998). Thus, spatial autocorrelation is expected. The reason could be in the omission of variables or trends within the data (Brooks & Tsolacos, 2010). The latter seems plausible given the presence of homogeneous dwellings, i.e. similarities for dwellings within apartment blocks, flats and terraced housing neighbourhoods, where rents are often interpolated, similar and/or smoothed. A technique which has been applied to mitigate autocorrelation is to perform regression with clustered error regression on postal codes. Accessibility effects differentiate per retail category (fifteen categories in total) and do not only account for proximity, but also for household competition and attractiveness. The causal relationship between rent and the accessibility index cannot be expressed the same way as with aforementioned variables (non-retail facilities). Competition among households, proximity and distance should be interpreted as substitutes of each another, which all together influence rent. The accessibility variables are naturally transformed, thus they should be interpreted in terms of elasticity. A negative coefficient regarding a parameter implies, in contrast to proximity measures, that accessibility towards a certain retail facility results in a rent discount.

According to model 2 the highest negative influence on residential rent are optics and jewellery facilities. It should be noted that this could be influenced by their accessibility in terms of floor space. As can be seen from the descriptive table (3), optic and jewellery facilities are, on average, quite small. According to the gravity model, this translates in severely low accessibility and another

[22] CBD, however, did not have a statistically significant influence.

aspect that influences this highly negative rent affect is the relatively high average distance and the low willingness to travel in model 2. Other retail facilities which lower rent are accessible sport & game facilities. A common aspect of both of these facilities is that the frequency of visits is relatively low, and do not cover primary needs. This brings us towards the facilities which we frequent the most, i.e. supermarkets. Accessibility towards supermarkets is valued positively. Only the influence of accessible fashion and electronic stores transcends this. If accessibility towards fashion stores rises with 1%, the expectation is that rent to rise by 0,52%.

Model 3, where beta is higher than in the first model, shows a smaller bandwidth between the highest and lowest values. Although model 3 implies that willingness to travel is low and effects rapidly diminish with distance, an increase of 61% of rent per kilometre away from the CBD seems exaggerated. This is however not surprising since the penalty to travel is high in model 3, i.e. Beta=2. Model 3 must be interpreted as a robustness case, which shows sensitivity when the assumption of distance changes. The most positive influence on rent are now media facilities (bookstores) and hobby stores. From further inspection in the data, the cause might be that that these type of facilities consist of a limited amount of generic, nationally known brand, stores and this category mainly consists of privately owned stores. From spatial analysis it could be seen that these type of stores are mainly situated at the edge of the central business district. Possibly resulting in less congestion effects, while benefitting from abundant amenities nearby. Accessible department stores, supermarkets, at & antique, shoes & leather and fashion facilities also yield higher rent.

In order to analyse the Dutch household rent preference, the alteration between the two models is investigated. Proximity effects in model 2 are, in general, endorsed in model 3. When comparing the two models the rent preference of a household becomes more clear. Model 2 shows the need of accessible facilities when willingness to travel is high. Model 3 describes the effects when willingness to travel is low and shows the proximity preference towards different facilities. When willingness to travel becomes lower, due to higher distance decay (Beta), the location of a dwelling becomes more important. Distance in this model has become more important relative to floor space and household competition. As a result, analysis show facilities which experience negative rent effects because they are too proximate to a certain facility. The proximity variable ´distance to restaurants´ already exhibits a negative rent effect in model 2, and this effect becomes stronger in model 3. This effect is also visible for theatres and cinema's. Rent premiums can be found for dwellings which are proximate towards CBD, pharmacy, highway ramps, train stations and cinema´s and especially primary schools. Apparently, Dutch households are willing to pay extra rent for being proximate to these types of facilities. When analysing the alteration between the models for retail accessibility effects, it can be seen that some retail functions result in rent premiums when they are accessible with weaker distance decay, and result in discounts if distance decay becomes stronger. This implies that when consumers are willing to travel less, their perspective on accessible amenities change. Accessible retail facilities which are related towards primary needs, i.e. supermarkets and drugstores positively influence rent, but when willingness to travel is low, they yield less rent. The most remarkable change when willingness to travel becomes more important is the appreciation of accessible hobby and media facilities. DIY stores result in rent premiums when they are accessible but not if they are situated too proximate. Rent decreases the more accessible DIY stores become. The opposite holds for flora & fauna facilities, which exert positive rent influence if they are accessible and proximate (although this variable is not significant in model 3). Overall, it could be stated that accessibility towards retail facilities influence commercial residential rent, as can be seen from both models[23]

5. Conclusion

This study attempted to explain commercial residential rent based on a proximity and accessibility retail amenities. As a result of this study we conclude that accessibility has an influence on housing rent. This is consistent with earlier findings in the literature. In addition, evidence has been found which facilities positively affect rent and which facilities negatively affect rent within the Netherlands. In addition, we used commercial residential rent as the dependent variable. This unique combination is extended with two scenarios which distinguish two types of consumer travel using a gravity model. This information is especially interesting for real estate investors which try to optimally allocate commercial residential rent dwellings based on existing facilities. The most interesting results of this thesis are as follows:

A dwelling yields more rent if it has access to fashion facilities, electronic stores supermarkets, media, department stores. Some facilities can result in rent premiums if they are accessible, but result in discounts if they are situated too proximate. This can be concluded for DIY stores. This type of retail facility negatively influences rent if a dwelling is located proximately. Although outcomes seem clear, the applied approach within this thesis has some drawbacks.

5.1 Discussion

The combination of a large sample and spatial analyses demonstrated powerful effects in the empirical model. Unfortunately, it cannot be stated that the final model is a parsimonious model given the amount of predicting independent variables. However, the power of explanation is desirable. Unfortunately, not all assumptions of the Gaus-Markov theorem could be fulfilled, this implies cautiousness concerning interpretation of results. A way of improving this matter, could be by defining beta empirically. Beta within this study has been derived from literature. The assumption that competition among households is defined by a 15-minute travel time radius was set because of the lack of computational power. This implies that certain facilities do not exert attraction beyond this radius, i.e. no-one travels furthers than 15 minutes for a certain facility, thus no one from Groningen shops in Amsterdam for example. A contribution would be to diminish the maximum travel radius and to empirically estimate beta based on modal split techniques. Another interesting topic for future research is to determine the role of privately owned retail facilities versus national retailers and housing values. The finding of the importance of these type of facilities on residential rent is new, and no results in current literature could be found of this outcome. Another interesting topic would be to determine the relation between privately owned retail facilities and city growth. This has been touched upon in the well cited article "consumer city" by Gleaser, Kolko and Saiz (2001) but outcomes are still unclear and research of this phenomenon could be interesting.

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[23] Since the sample is quite extensive, and data mining issues could be influential, a F-test is performed to check if all proximity and accessibility coefficients together are equal to zero. The outcome is that the null hypothesis, that all coefficients are equal to zero, has been rejected, see appendix IX.

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Appendix

Appendix I. Overview of frequently applied determinants within accessibility studies

Author(s)	Title	Variables				Evaluation
Andersson, D., Shyr, O., & Fu, J., 2010	Does high-speed rail accessibility influence residential property prices?	*Dependent variable* Transaction price (log)	*Structural attributes* Age Floor area in square meters Lot size in square meters Shop/dwelling use dummy Street frontage dummy	*Neighborhood attributes* College educated in district Commercial zone dummy District mean income in NT$ thousand (log Residential zone dummy Road width in meters (log)	*Accessibility attributes* Distance in kilometers to CBD/old railway station (log) Distance in kilometers to HSR station (log) Distance in kilometers to nearest freeway interchange (log) Distance in kilometers to Tainan Science-based Industrial Park (log)	Three estimation techniques were used within the hedonic price regression (OLS): Log-linear, semi-logarithmic and Box-Cox-transformed forms. The best performing model was box-cox transformed with four transformations.
Hewitt, C. M., & Hewitt, 2002	The effect of proximity to urban rail on housing prices in Ottawa	*Dependent variable* Transaction price (log)	*Structural attributes* Age Area of property Number of bathrooms Number of bedrooms Number of fireplaces Number of garages Parking Style of house Type of house Walking distance to train station	*Neighborhood attributes* Change in population Income Public transit users Tax rate	*Accessibility attributes* Distance to nearest water feature Distance to nearest park Distance to point of interest	Several techniques were used, beginning with simple OLS as baseline model, OLS extended with spatial lags and geographically weighted multiple regression (GWMR). The spatial lag model proved optimal for examining effects locally and globally.
Ottensmann, J. R., Payton, S., & Man, J., 2008	Urban location and housing prices within a hedonic model	*Dependent variable* Transaction price (log)	*Structural attributes* Age Air-conditioning Basement dummy Floor space Garage Lot area Number of bathrooms Porch Total number of rooms	*Neighborhood attributes* Income median Percentage black Percentage vacant property School district Tax rate	*Accessibility attributes* Distance to CBD (in meters and time) Distance to employment centers (measured in time including congestion) Mean distance to employment centers (measured in zip codes)	Monocentric baseline model estimated with hedonic pricing technique. Models that expressed accessibility in time performed better than models using distance in meters.

Dorantes, L., Paez, A., & Vassallo, J., 2011	Analysis of house prices to assess economic impacts of new public transport infrastructure: Madrid Metro Line 12	*Dependent variable* Transaction price	*Structural attributes* Air-conditioning Bathrooms in apartment Building floor level Floor space Heating House sale price Lift pool court Parking Rooms in apartment 2 Terrace (square meters)	*Neighborhood attributes* Hospital Income per cap. Per municipality Park Population School Shopping center Street	*Accessibility attributes* Distance to bus stop Distance to CBD Distance to metro station Distance to train station	Box-Cox transformation was not needed for hedonic OLS. The linear OLS was best model and performed better than a spatial lag model.
Debrezion, G., Pels, E. A., & Rietveld, P., 2006	The impact of rail transport on real estate prices: an empirical analysis of the Dutch housing market.	*Dependent variable* Transaction price	*Structural attributes* Age Fireplace Floor space Garage Garden Gas heater Monument Number of bathrooms Number of rooms	*Neighborhood attributes* Population composition Household income	*Accessibility attributes* Distance to nearest railway Distance to most frequently chosen station Distance to highway entry/exit	Hedonic price model with log in P in the Ducth context. Controlled for highway ramps.
Öner, Ö., 2013	Does accessibility to shops explain place attractiveness?	*Dependent variable* Housing price	*Structural attributes* (none)	*Neighborhood attributes* Population density Mean wages Municipal tax Unemployment share	*Accessibility attributes* Retail access Leisure service concentration	Straight line measurements from house to retail
Jang, M., & Kang, C. D., 2015.	Retail accessibility and proximity effects on housing prices in Seoul, Korea	*Dependent variable* Transaction prices (condominium)	*Structural attributes* Floor (level) House size	*Neighborhood attributes* Distance to parks Distance to schools Distance to bus-stops Distance to roads Distance to street	*Accessibility attributes* Retail accessibility towards different types of retail Retail proximity to different types of retail Distance to CBD	Only one type of residential property used (condominium) Accessibility is calculated as supply divided by demand. Supply is determined by floor space and

Adair et al. (2000)	House prices and accessibility: The testing of relationships within the Belfast urban area.	*Dependent variable* Transaction price (log)	*Structural attributes* Bedrooms Central heating Floor space Garage Need of modernization Reception room	*Neighborhood attributes* Catholic household Economically active population Amount of owner occupiers Single person households	*Accessibility attributes* Distance between sectors within the city itself.	Does not account for trips outside of Belfast and accessibility is of little significance
Song, Y., & Sohn, J. (2007)	Valuing spatial accessibility to retailing: A case study of the single family housing market in Hillsboro, Oregon.	*Dependent variable* Sale price (log)	*Structural attributes* Age Floor space Loft size	*Neighborhood attributes* Percentage white inhabitants Midian income Population density	*Accessibility attributes* Distance to CBD Distance to beach Distance to port Distance to park Distance to commercial store	No measurement of size effect of retail store.

Appendix II. Liberalization limits per year

2007 More than € 621,78

2008 More than € 631,73

2009 More than € 647,53

2010 More than € 647,53

2011 More than € 652,52

2012 More than € 664,66

2013 More than € 681,02

2014 More than € 699,48

2015 More than € 710,68

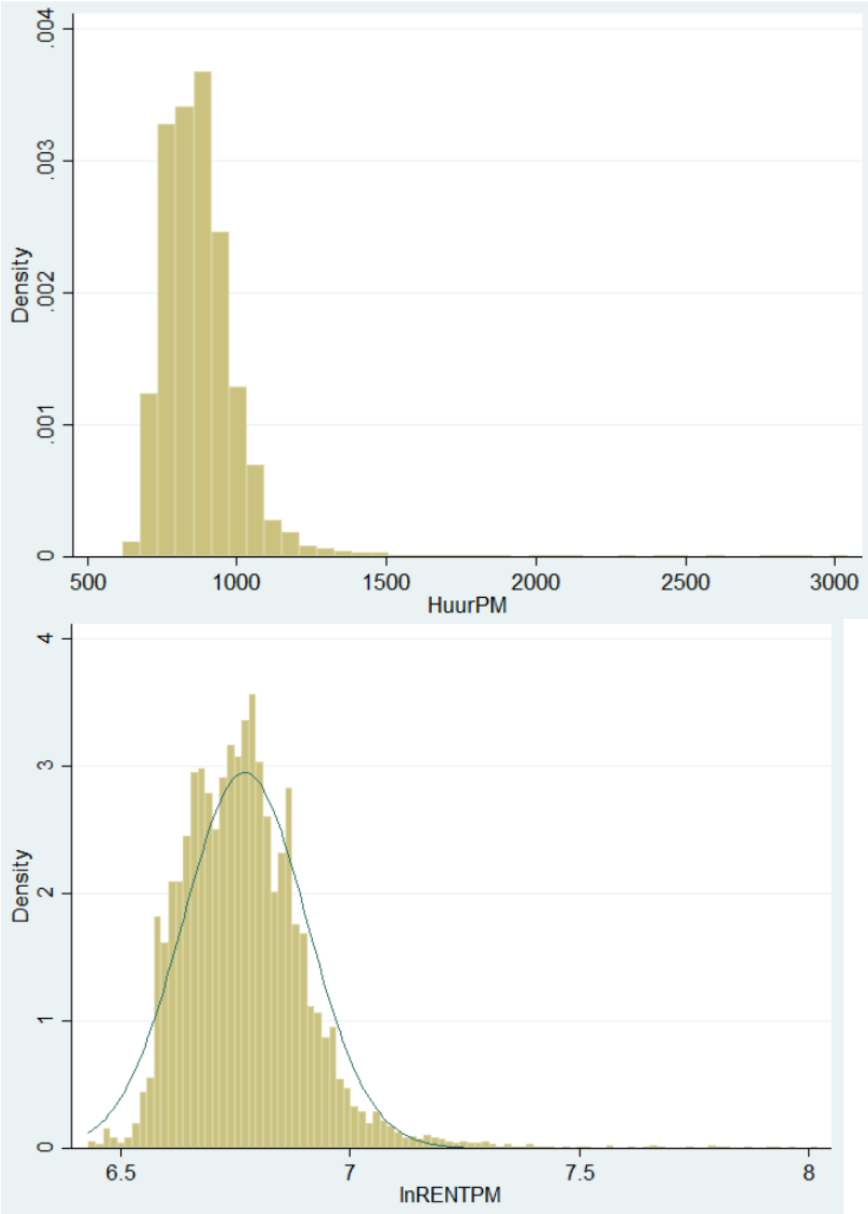
2016 More than € 710,68

Source: www.governance.nl

Appendix III. Overview of retail categories

	Mean	St. dev.	Obs.	Min.	Max.
Supermarket	705.2	100.6	44,160	9.048515	23.8834
Fashion	953,4	64,6	44,160	8.385389	22.84758
Flora & Fauna	994,2	122,8	44,160	8.324543	29.43583
Drug stores	1000,2	55,6	44,160	8.183463	22.50803
Car & Bike	1142,2	67,4	44,160	8.141352	22.26968
Electronics	1254,4	67,4	44,160	7.882374	21.97356
Juwelry & Opticians	1258,8	26,8	44,160	7.306695	21.43226
Domestic_luxury	1316,8	100,6	44,160	8.472715	22.51468
Sports & Games	1366,8	121,8	44,160	8.439865	22.43624
DIY	1394,8	275,8	44,160	9.011209	22.86859
Shoes & leather	1453,2	71,4	44,160	7.995897	21.97995
Media	1644	50	44,160	7.602584	21.46841
Hobby	1644,8	40,8	44,160	7.318881	21.13085
Art & antique	2414,6	44,4	44,160	6.84794	25.33374
Department store	2888,8	691,6	44,160	8.183463	22.55434
Lifestyle	4715,4	1056,8	44,160	9.305589	23.68128

Appendix IV. Natural log of dependent variable (Before and after transformation)



Appendix V. Testing for OLS assumptions:

Five assumption of classical linear regression have been tested to show if the error term, estimated with OLS, has the desirable properties, table 5 (Brooks & Tsolacos, 2010):

Table 5: OLS assumptions

	Scientific annotation	Testing for:	Meaning
(1)	$E(ut) = 0$	*Linearity*	Average value of residuals is zero
(2)	$var(ut) = \sigma 2 < \infty$	*Homoscedasticity*	Variance of residuals is constant
(3)	cov $(ui, uj) = 0$ for i _= j	*Spatial autocorrelation*	Covariance between errors cross-sectionally is zero
(4)	cov $(ut, xt) = 0$	*Independence*	Regressors are not correlated with error term
(5)	$ut \sim N(0, \sigma 2)$	*Normality*	Normal distribution of residuals

The first assumption is not violated since the constant is not suppressed, or is forced through the origin (Brooks & Tsolacos, 2010). The *second* assumption is tested with the Bruesh-Pagan test and Whitest test (appendix VI), these test reject the hypothesis of constant variance of the error term. Given the amount of independent variables, which potentially could be contaminated with mutual influential observations, the solution to this heteroscedasticity is found to perform regression with robust standard errors. The *third* assumption notes that the covariance between different regions is zero. However, this assumption does not according to the literature where houses are proven to exhibit spatial autocorrelation (Basu & Thibodeau, 1998). The reason could be in the omission of variables or trends within the data (Brooks & Tsolacos, 2010). The latter seems plausible given the presence of homogeneous dwellings, i.e. similarities for dwellings within apartment blocks, flats and terraced housing neighbourhoods, where rents are often interpolated, similar and/or smoothed. A way to mitigate autocorrelation is to perform regression wit clustered standard errors. The correlation matrix among independent variables can be found in appendix X. The fourth assumption of i.i.d. [24] is visualized with appendix VII, and looks slightly skewed. The normality assumption, although logarithms have been applied, shows a leptokurtic distribution (see appendix VII). As inference it should be noted that predictors do no fulfil all assumptions the Gaus-Markov theorem, and estimators may not be BLUE[25].

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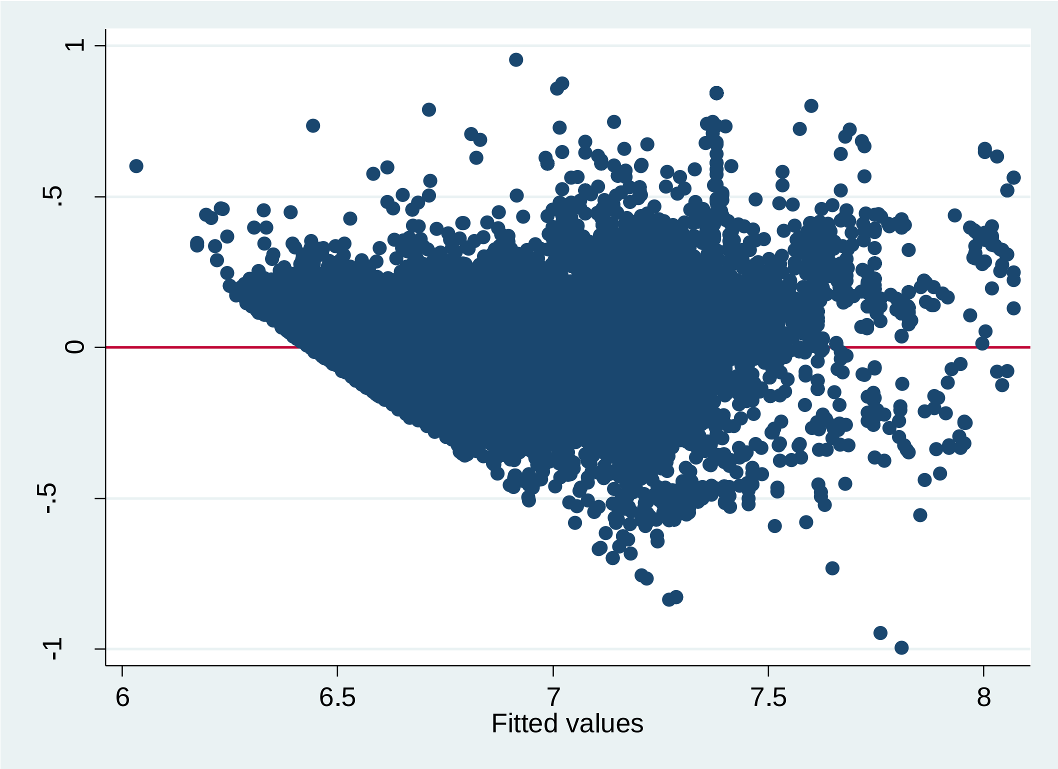
[24] Independent and identically distributed random variables
[25] Best linear unbiased estimator

Appendix VI. Heteroscedasticity of residuals



Breusch-Pagan / Cook-Weisberg test for heteroskedasticity

Ho: Constant variance

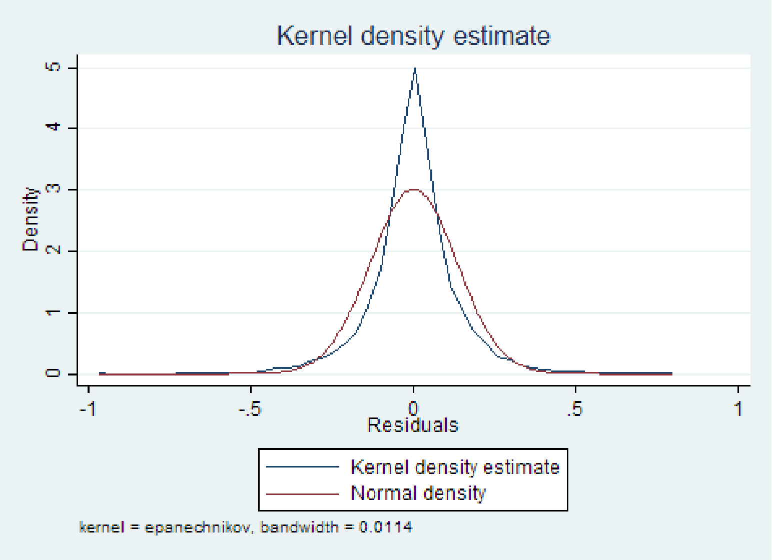
Variables: fitted values of lnRENT_PM

chi2(1) = 6479.38

Prob > chi2 = 0.0001

Autocorrelation

Appendix VII . Normality test (Leptokurtic density plot)



Appendix VIII Results

	Model 1			Model 2			Model 3		
	N		44,160	N		44,160	N		44,160
	R^2		0.7901	R^2		0.8161	R^2		0.8161
lnRENT_PM	Coef.		Std. Err.	Coef.		Std.Err.	Coef.		Std. Err.
Constant	3,6426	***	0,1554	5,1146	***	0,4227	5,0113	***	0,3657
lnfloorspace	0,6290	***	0,0294	0,6290	***	0,0294	0,6290	***	0,0294
parkingplaces	-0,0010		0,0095	-0,0010		0,0095	-0,0010		0,0095
pop_dens	0,0000	***	0,0000	0,0000	***	0,0000	0,0001	***	0,0000
Red_Label	-0,0386	**	0,0188	-0,0386	**	0,0188	-0,0386	**	0,0188
Orange_Label	-0,0208		0,0197	-0,0209		0,0197	-0,0209		0,0197
Green_Label	0,0500	***	0,0174	0,0500	***	0,0174	0,0500	***	0,0174
2008	-0,1039	***	0,0080	-0,1039	***	0,0080	-0,1039	***	0,0080
2009	-0,0914	***	0,0110	-0,0913	***	0,0110	-0,0913	***	0,0110
2010	-0,0749	***	0,0104	-0,0748	***	0,0104	-0,0748	***	0,0104
2011	-0,0693	***	0,0099	-0,0691	***	0,0099	-0,0691	***	0,0099
2012	-0,0489	***	0,0081	-0,0488	***	0,0081	-0,0488	***	0,0081
2013	-0,0352	***	0,0089	-0,0351	***	0,0089	-0,0351	***	0,0089
2014	-0,0219	***	0,0076	-0,0219	***	0,0076	-0,0219	***	0,0076
Before 1970	-0,0359		0,0263	-0,0359		0,0263	-0,0359		0,0263
1970-1979	-0,0604		0,0401	-0,0605		0,0401	-0,0605		0,0401
1980-1989	0,0197		0,0335	0,0197		0,0335	0,0197		0,0335
1990-1999	0,1914	***	0,0504	0,1914	***	0,0504	0,1914	***	0,0504
2000-2009	0,1598	***	0,0353	0,1598	***	0,0353	0,1598	***	0,0353
Deck-access flat;	-0,0314		0,0486	-0,0314		0,0486	-0,0314		0,0486
Apartment block:	-0,0346		0,0474	-0,0346		0,0474	-0,0346		0,0474
Maisonnette;	-0,0614		0,0525	-0,0614		0,0525	-0,0614		0,0525
Attached-buildings	-0,0179		0,0466	-0,0180		0,0466	-0,0180		0,0466
Terraced housing	0,0154		0,0232	0,0154		0,0232	0,0154		0,0232
Semidetached	0,0312		0,0243	0,0312		0,0243	0,0312		0,0243
Not_MultiFamliy home	-0,0925	**	0,0467	-0,0926	**	0,0467	-0,0926	**	0,0467
LOC_Outside of a center	0,3958	***	0,0968	-0,5813	***	0,1555	-0,7795	***	0,1556
LOC_Center_village	0,2884	***	0,0871	0,2589		0,1893	-0,2854	***	0,0815
LOC_Center_town	-1,1657	***	0,1257	-1,0848	***	0,2799	-1,9384	***	0,3772
LOC_GreenArea_city	0,1568	*	0,0844	-0,2808	***	0,0729	-0,5108	***	0,1369
Dis_CBD	-0,2456	***	0,0353	-0,3740	***	0,0606	-0,6117	***	0,0984
Dis_Pharmacy	0,1671	***	0,0119	-0,7002	***	0,2136	-0,6024	***	0,1092
Dis_Hospital	0,0136	***	0,0031	0,0101		0,0102	-0,0443	***	0,0093
Dis_Bar	0,0804	***	0,0201	0,2196	***	0,0732	0,0956	***	0,0190
Dis_Restaurant	0,7123	***	0,1114	0,7855	***	0,1691	1,3423	***	0,2196
Dis_Hotel	0,0058		0,0103	0,0895	***	0,0322	0,0234	**	0,0119
Dis_Children daycare	-0,6694	***	0,0573	1,1811	***	0,4112	0,9810	***	0,1870
Dis_Out-of-school care	0,4371	***	0,0488	0,2644	***	0,0488	-0,1843	*	0,1011
Dis_Primary school	-1,0611	***	0,1404	-1,1257	***	0,1921	-1,2608	***	0,1686
Dis_High School	0,0342	***	0,0027	-0,1911	**	0,0928	-0,0579	***	0,0218
Dis_Highway ramp	-0,0611	***	0,0083	0,1741	***	0,0466	0,0917	***	0,0138

Dis_Train station	-0,0044		0,0079		-0,0049		0,0096		-0,0266	***	0,0030
Dis_Swimming pool	0,0019		0,0032		-0,1458	***	0,0468		-0,1416	***	0,0287
Dis_Cinema	-0,0398	***	0,0115		-0,1136	**	0,0525		-0,3583	***	0,0765
Dis_Sauna	0,0475	***	0,0068		0,0919	***	0,0240		0,1155	***	0,0203
Dis_Amusement park	0,0858	***	0,0070		0,0092	***	0,0026		0,0522	***	0,0102
Dis_Theatre	-0,0329	***	0,0121		0,1760	***	0,0611		0,5069	***	0,1032
lnAi_fashion					0,5242	***	0,1242		0,1068	***	0,0193
lnAi_hobbies					0,1255	***	0,4258		0,2980	***	0,0754
lnAi_shoes_leather					0,2042	**	0,0809		0,1672	***	0,0516
lnAi_optics_jewelry					-1,3403	***	0,4913		-0,7537	***	0,1664
lnAi_media					0,2957	***	0,0627		0,7313	***	0,1278
lnAi_sport_games					-0,5112	***	0,1413		-0,3741	***	0,0642
lnAi_art_antique					0,0728	**	0,0318		0,0027		0,0082
lnAi_flora_fauna					-0,1146	***	0,0429		0,0063		0,0125
lnAi_electronics					0,4297	***	0,1239		0,4798	***	0,0849
lnAi_car_bike					-0,3582	**	0,1490		-0,4911	***	0,1176
lnAi_diy					0,2339	**	0,0959		-0,2013	***	0,0512
lnAi_lifestyle					-0,0482	***	0,0173		-0,1132	***	0,0249
lnAi_departmentstore					0,2513	***	0,0599		0,0754	***	0,0124
lnAi_supermarket					0,2545	***	0,0976		0,1523	***	0,0354
lnAi_drugstores					0,1713	***	0,0236		0,0598	**	0,0261

Appendix IX. F-test

af_apoth = 0; af_ziek_i = 0; af_daglmd = 0; af_cafe = 0:af_cbd = 0;;af_restau = 0;af_hotel = 0;af_kdv = 0;af_bso = 0;af_ondbas = 0;af_ondvrt = 0;af_oprith = 0;af_treinst = 0;af_zwemb = 0;af_bios = 0;af_sauna = 0;af_attrac = 0;af_podium ;lnai_b2_fashion = 0;lnb2_ai_hobbies = 0;lnb2_ai_shoes_leather = 0;lnb2_ai_optics_jewelry = 0;lnb2_ai_media = 0;lnb2_ai_sport_games = 0;lnb2_ai_art_antique = 0;lnb2_ai_flora_fauna = 0;lnb2_ai_electronics = 0;lnb2_ai_car_bike = 0;lnb2_ai_diy = 0;lnb2_ai_lifestyle = 0;lnai_b2_departmentstore = 0;lnai_b2_supermarket = 0;lnai_b2_drugstores = 0

F(33, 17377) = 66.60
Prob > F = 0.0000

Appendix X. Correlation matrix

	lnRENT~M	lnai_b..	lnb2~ies	lnb2_a~r	lnb2~lry	lnb2_~ia	lnb2~mes	lnb2_~ue	lnb2_~na	lnb2_~cs	lnb2_~ke	lnb2_~iy	lnb2_~le	lnai_b..	lnai_b..	lnai_b..
lnRENT_PM	10.000															
lnai_b2_fa~n	-0.0693	10.000														
lnb2_ai_ho~s	-0.0328	0.6737	10.000													
lnb2_ai_sh~r	-0.0722	0.8009	0.7727	10.000												
lnb2_ai_op~y	-0.0453	0.8710	0.7750	0.8500	10.000											
lnb2_ai_me~a	0.0203	0.7313	0.8491	0.7958	0.8298	10.000										
lnb2_ai_sp~s	-0.1460	0.7519	0.7379	0.8262	0.7866	0.7643	10.000									
lnb2_ai_ar~e	0.1513	0.4451	0.6405	0.4394	0.4918	0.6025	0.3965	10.000								
lnb2_ai_fl~a	-0.0408	0.5804	0.6347	0.6718	0.6430	0.6431	0.6348	0.3481	10.000							
lnb2_ai_el~s	-0.0692	0.7538	0.7752	0.8183	0.8200	0.7861	0.7826	0.4677	0.6272	10.000						
lnb2_ai_ca~e	-0.0725	0.7160	0.7491	0.7479	0.7825	0.7519	0.7323	0.4542	0.6538	0.7419	10.000					
lnb2_ai_diy	-0.1876	0.4969	0.5317	0.5354	0.5197	0.5218	0.5912	0.2162	0.5001	0.5497	0.5421	10.000				
lnb2_ai_li~e	-0.0056	0.7105	0.6628	0.7170	0.7457	0.6783	0.7097	0.2264	0.5678	0.7116	0.7382	0.5990	10.000			
lnai_b2_de~e	-0.0881	0.7031	0.5860	0.6675	0.7298	0.6499	0.6932	0.3548	0.5398	0.6717	0.6504	0.4916	0.6404	10.000		
lnai_b2_su~t	-0.0368	0.6635	0.5820	0.5920	0.6473	0.6144	0.6015	0.3869	0.5634	0.6339	0.6631	0.5120	0.5742	0.6118	10.000	
lnai_b2_dr~s	-0.0542	0.8693	0.7610	0.8435	0.8824	0.8027	0.7803	0.4722	0.6393	0.8060	0.7838	0.5793	0.7569	0.6896	0.7159	10.000

	lnRENT~r	lnfloo~e	parkin~s	pop_den	year1	year2	year3	year4	year5	year6	year7	year8	age1	age2	age3	age4	age5	age6	dwel_t1	dwel_t2	dwel_t3	dwel_t4	dwel_t5	dwel_t6	dwel_t7	fam1	environ1	environ2	environ3	environ4	environ5	af_cbd	af_apoth	af_zie~i	af_cafe	af_res~u	af_hotel	af_kdv	af_bso	af_ond~s	af_ond~t	af_opr~h	af_tre~t	af_zweml	af_bios	af_sauna	af_att~c	af_pod~m	
lnRENT_f	10.000																																																
lnfloorspa	0.2474	10.000																																															
parkingpl	-0.2327	0.0113	10.000																																														
pop_den	0.2008	-0.2010	-0.1665	10.000																																													
year1	-0.0792	0.0158	0.0181	0.0004	10.000																																												
year2	-0.0282	0.0236	0.0116	-0.0107	-0.1392	10.000																																											
year3	0.0386	0.0117	-0.0197	0.0011	-0.1539	-0.1428	10.000																																										
year4	-0.0200	0.0327	0.0028	0.0049	-0.1530	-0.1420	-0.1569	10.000																																									
year5	-0.0237	0.0245	0.0316	-0.0249	-0.1433	-0.1330	-0.1470	-0.1461	10.000																																								
year6	0.0212	-0.0121	0.0268	0.0142	-0.1566	-0.1453	-0.1606	-0.1597	-0.1496	10.000																																							
year7	0.0562	-0.0664	0.0262	0.0106	-0.1824	-0.1692	-0.1870	-0.1860	-0.1742	-0.1903	10.000																																						
year8	0.0397	-0.0312	-0.1687	0.0016	-0.0807	-0.0748	-0.0827	-0.0822	-0.0770	-0.0842	-0.0980	10.000																																					
age1	-0.1343	0.0652	-0.0075	-0.0946	-0.0033	0.0053	-0.0020	-0.0049	-0.0089	0.0046	0.0057	0.0044	10.000																																				
age2	-0.2684	0.1207	0.0869	-0.1586	0.0335	0.0243	0.0015	-0.0064	0.0041	-0.0128	-0.0308	-0.0118	-0.1304	10.000																																			
age3	-0.1920	-0.1159	-0.0479	0.1295	0.0126	0.0273	0.0022	0.0023	0.0115	-0.0103	-0.0319	-0.0118	-0.1599	-0.2869	10.000																																		
age4	0.3467	0.0084	-0.0894	0.0986	0.0800	0.0563	0.0426	0.0100	-0.0381	-0.0456	-0.0750	-0.0289	-0.1853	-0.3325	-0.4078	10.000																																	
age5	0.2072	-0.0359	0.0560	-0.0373	-0.1534	-0.1424	-0.0569	0.0064	0.0400	0.0940	0.1500	0.0541	-0.1068	-0.1916	-0.2349	-0.2723	10.000																																
age6	-0.0604	-0.0282	0.0719	-0.0259	-0.0170	-0.0026	-0.0095	-0.0260	-0.0020	-0.0158	0.0524	0.0232	-0.0439	-0.0788	-0.0967	-0.1121	-0.0646	10.000																															
dwel_t1	0.0831	-0.1910	-0.0520	0.1763	-0.0176	-0.0071	-0.0333	-0.0086	-0.0030	0.0016	0.0515	0.0157	-0.0595	-0.1653	-0.0912	0.2066	0.0641	0.0088	10.000																														
dwel_t2	0.0930	-0.2029	-0.1010	0.1257	-0.0550	-0.0131	0.0031	-0.0189	-0.0357	0.0486	0.0413	0.0344	-0.0886	-0.1803	0.1322	0.0867	-0.0227	0.0141	-0.2113	10.000																													
dwel_t3	-0.0211	-0.0555	-0.0219	0.0022	-0.0128	-0.0116	-0.0124	0.0052	0.0004	0.0040	0.0124	0.0210	-0.0355	-0.0260	0.0071	0.0275	0.0039	0.0116	-0.0538	-0.0709	10.000																												
dwel_t4	0.2629	-0.1704	-0.1232	0.1517	0.0232	0.0133	0.0692	0.0414	0.0069	-0.0754	-0.0557	-0.0227	-0.1014	-0.1498	0.0263	0.1191	0.0629	-0.0283	-0.1541	-0.2033	-0.0517	10.000																											
dwel_t5	-0.2914	0.3389	0.0996	-0.2537	0.0318	0.0209	-0.0045	-0.0094	0.0203	-0.0133	-0.0300	-0.0152	0.2560	0.4348	-0.1466	-0.2997	-0.1052	0.0345	-0.3162	-0.4170	-0.1061	-0.3042	10.000																										
dwel_t6	-0.0626	0.2159	0.1296	-0.1450	0.0138	0.0155	0.0032	0.0116	0.0086	-0.0077	-0.0283	-0.0195	-0.0648	-0.0377	0.2179	-0.0734	-0.0699	-0.0400	-0.1039	-0.1371	-0.0349	-0.1000	-0.2051	10.000																									
dwel_t7	0.0207	-0.0148	0.1099	-0.0239	0.0178	-0.0413	-0.0459	-0.0096	0.0066	0.0574	0.0169	-0.0121	-0.0596	-0.0790	-0.0671	0.0596	0.1559	-0.0366	-0.0916	-0.1208	-0.0307	-0.0881	-0.1807	-0.0594	10.000																								
fam1	-0.3060	0.4343	0.2015	-0.3312	0.0483	0.0126	-0.0198	-0.0046	0.0296	0.0113	-0.0516	-0.0280	0.1937	0.3739	-0.0614	-0.2970	-0.0863	-0.0005	-0.3950	-0.5209	-0.1326	-0.3800	0.8005	0.2631	0.1972	10.000																							
fam2	0.3060	-0.4343	-0.2015	0.3312	-0.0483	-0.0126	0.0198	0.0046	-0.0296	-0.0113	0.0516	0.0280	-0.1937	-0.3739	0.0614	0.2970	0.0863	0.0005	0.3950	0.5209	0.1326	0.3800	-0.8005	-0.2631	-0.1972	-10.000	10.000																						
environ1	0.1289	-0.1222	-0.0829	0.2361	-0.0136	0.0039	-0.0009	-0.0027	-0.0236	0.0233	0.0057	0.0098	-0.0484	-0.0271	0.0290	0.0010	0.0215	0.0141	0.0380	0.0263	0.0348	0.1102	-0.0696	-0.1038	-0.0296	-0.1328	0.1328	10.000																					
environ2	-0.1865	0.1781	0.2053	-0.2273	-0.0043	0.0024	-0.0093	0.0101	0.0052	0.0038	0.0019	-0.0166	0.0519	0.2771	-0.0388	-0.2097	-0.0276	0.0172	-0.1331	-0.1503	-0.0275	-0.1318	0.2826	0.1220	-0.0521	0.3137	-0.3137	-0.4023	10.000																				
environ3	0.0754	-0.1169	-0.0512	0.1616	0.0094	-0.0071	0.0092	-0.0202	0.0182	-0.0208	-0.0014	0.0236	-0.0765	-0.0999	0.0049	0.1294	-0.0006	-0.0249	0.1564	0.1215	0.0163	0.0868	-0.2211	-0.0735	-0.0459	-0.2692	0.2692	-0.3569	-0.1639	10.000																			
environ4	-0.0449	0.0671	-0.0870	-0.1389	0.0044	0.0026	-0.0070	0.0118	0.0077	-0.0124	0.0022	-0.0149	0.0908	-0.1089	0.0293	0.0198	-0.0040	-0.0052	-0.0446	0.0159	-0.0222	-0.0751	0.0184	0.0439	0.0793	0.0726	-0.0726	-0.5018	-0.2303	-0.2044	10.000																		
environ5	-0.0188	0.0453	0.1244	-0.1932	0.0210	-0.0098	0.0227	-0.0032	0.0037	-0.0053	-0.0244	-0.0031	-0.0432	-0.0516	-0.0876	0.1496	0.0071	-0.0175	-0.0257	-0.0351	-0.0224	-0.0299	-0.0117	0.0849	0.0982	0.0731	-0.0731	-0.1558	-0.0715	-0.0635	-0.0892	10.000																	
af_cbd	-0.1457	0.1661	0.0555	-0.2974	-0.0057	0.0155	-0.0010	0.0072	0.0199	0.0005	-0.0216	-0.0176	0.0236	0.0421	-0.0031	-0.0371	-0.0238	0.0279	-0.1315	-0.0994	-0.0419	-0.1431	0.2321	0.1037	0.0082	0.2822	-0.2822	-0.1152	0.0976	-0.2843	0.2189	0.1581	10.000																
af_apoth	-0.1035	0.1903	0.0497	-0.2632	0.0083	0.0151	0.0060	-0.0065	0.0283	0.0002	-0.0298	-0.0263	0.0268	0.0225	-0.0271	-0.0223	-0.0073	0.0581	-0.0933	-0.0817	-0.0337	-0.1050	0.1486	0.1359	0.0010	0.2142	-0.2142	-0.1888	0.1624	-0.0777	0.0969	0.1282	0.6001	10.000															
af_ziek_i	-0.2182	0.1688	0.1721	-0.2506	0.0126	0.0200	-0.0091	-0.0016	0.0120	0.0052	-0.0221	-0.0209	0.0727	0.2010	-0.0233	-0.0971	-0.1203	-0.0022	-0.1563	-0.1241	-0.0033	-0.0999	0.2472	0.1315	-0.0604	0.2804	-0.2804	-0.1726	0.4191	-0.1046	-0.1036	0.0744	0.2709	0.2320	10.000														
af_cafe	-0.1206	0.1904	0.0982	-0.3125	-0.0017	0.0193	0.0070	0.0093	0.0113	0.0068	-0.0343	-0.0197	0.0073	0.0123	0.0785	-0.0451	-0.0493	-0.0199	-0.1817	-0.0807	-0.0502	-0.1147	0.1763	0.2012	0.0293	0.2855	-0.2855	-0.0911	0.0343	-0.2729	0.2130	0.2169	0.5567	0.4310	0.2275	10.000													
af_restau	-0.2317	0.2102	0.1115	-0.3216	0.0041	0.0076	-0.0001	0.0100	0.0195	-0.0029	-0.0203	-0.0235	0.0941	0.0545	-0.0247	-0.0437	-0.0338	-0.0137	-0.1579	-0.1638	-0.0554	-0.1752	0.2781	0.2050	0.0140	0.3792	-0.3792	-0.0973	0.0786	-0.2884	0.2229	0.1436	0.6922	0.5305	0.2345	0.5763	10.000												
af_hotel	-0.1453	0.1817	0.0921	-0.2930	-0.0162	-0.0116	-0.0179	0.0123	0.0413	0.0187	-0.0176	-0.0105	-0.0024	0.0511	-0.0665	0.0002	0.0470	-0.0406	-0.1253	-0.0904	-0.0130	-0.1745	0.2067	0.0881	0.0864	0.2841	-0.2841	-0.1775	0.1058	-0.2544	0.2711	0.1357	0.3880	0.2530	0.2171	0.4461	0.4184	10.000											
af_kdv	-0.2168	0.0913	0.1836	-0.2291	-0.0048	0.0179	-0.0134	-0.0030	0.0221	-0.0063	-0.0088	-0.0004	0.0254	0.1573	0.0300	-0.1185	-0.0952	0.0422	-0.0879	-0.0286	0.0020	-0.1444	0.1092	0.1751	-0.0248	0.1848	-0.1848	-0.1454	0.2410	-0.0497	-0.0140	0.0460	0.3747	0.3873	0.2528	0.2035	0.3031	0.1572	10.000										
af_bso	-0.1337	0.0848	0.1293	-0.2246	-0.0132	0.0121	-0.0045	-0.0083	0.0109	0.0106	-0.0053	-0.0011	-0.0151	0.0985	-0.0275	-0.0678	0.0107	0.0328	-0.0701	-0.0538	0.0579	-0.0902	0.0723	0.1468	-0.0085	0.1387	-0.1387	-0.1582	0.2242	0.0206	-0.0415	0.0495	0.3801	0.4666	0.2141	0.2182	0.3153	0.0860	0.6377	10.000									
af_ondba	-0.0317	0.0586	0.0075	-0.1438	-0.0166	0.0053	-0.0031	-0.0075	0.0157	0.0118	-0.0009	-0.0067	0.0367	0.0268	-0.0333	-0.0303	0.0089	0.0378	-0.0404	-0.0060	0.0221	-0.0482	0.0376	0.1000	-0.0594	0.0619	-0.0619	-0.1238	0.1135	0.0422	0.0056	0.0258	0.4722	0.5213	0.2167	0.2791	0.3324	0.1154	0.4959	0.7290	10.000								
af_ondwi	-0.1458	0.1602	0.1192	-0.2224	0.0061	0.0189	-0.0106	-0.0023	0.0087	0.0034	-0.0105	-0.0180	-0.0436	0.1218	0.0805	-0.0957	-0.0730	-0.0152	-0.1132	-0.0662	0.0090	-0.1306	0.1831	0.1001	-0.0203	0.2215	-0.2215	-0.1580	0.2809	-0.1752	0.0204	0.1651	0.3863	0.3613	0.3974	0.4465	0.3087	0.3463	0.2881	0.2293	0.2219	10.000							
af_oprith	0.0428	-0.0604	-0.0775	0.2865	0.0117	-0.0040	-0.0005	-0.0113	0.0042	0.0180	-0.0119	-0.0083	-0.0039	-0.0925	0.0548	0.0425	-0.0031	-0.0351	0.1327	0.0442	-0.0447	-0.0310	-0.1017	0.0029	0.0048	-0.1000	0.1000	0.1206	-0.2278	0.0940	-0.0166	-0.0120	0.0070	0.0425	-0.0922	0.0337	0.0356	-0.0170	-0.0893	-0.0511	-0.0284	0.0162	10.000						
af_treinst	-0.1526	0.0950	0.1373	-0.2332	0.0083	-0.0063	-0.0156	0.0034	-0.0041	-0.0061	0.0234	-0.0107	0.0833	0.1718	-0.0291	-0.1103	-0.0673	-0.0063	-0.0723	-0.0756	-0.0290	-0.1217	0.1641	0.1049	-0.0209	0.2049	-0.2049	-0.1319	0.3202	-0.1570	-0.0029	0.0191	0.1805	0.1890	0.3323	0.1347	0.1741	0.1929	0.2145	0.1448	0.1200	0.2703	-0.0438	10.000					
af_zweml	0.0032	0.1159	0.0888	-0.0914	0.0128	0.0263	0.0147	-0.0113	0.0153	-0.0052	-0.0337	-0.0201	-0.0584	0.0657	-0.0184	0.0519	-0.0569	-0.0487	-0.0943	0.0036	-0.0236	-0.0625	0.0575	0.1098	0.0019	0.1127	-0.1127	-0.1575	0.1775	-0.1219	0.1173	0.0366	0.1728	0.2095	0.2044	0.2646	0.1393	0.1675	0.1679	0.1295	0.1051	0.2627	0.0156	0.2004	10.000				
af_bios	-0.1772	0.1443	0.1439	-0.2538	-0.0158	0.0070	-0.0009	0.0109	0.0084	-0.0014	0.0015	-0.0155	0.0534	0.1568	-0.0029	-0.1293	-0.0393	0.0012	-0.1594	-0.1184	-0.0486	-0.1406	0.2688	0.0935	0.0181	0.3173	-0.3173	-0.2618	0.4747	-0.2573	0.0962	0.0249	0.3484	0.2558	0.3492	0.2775	0.3180	0.3866	0.2234	0.1115	0.1017	0.3050	-0.1648	0.4678	0.2682	10.000			
af_sauna	-0.2057	0.1667	0.1805	-0.2995	0.0038	-0.0067	0.0075	0.0294	0.0230	-0.0002	-0.0371	-0.0246	0.0779	0.1090	-0.1155	0.0009	-0.0244	-0.0232	-0.0838	-0.0950	-0.0678	-0.1655	0.1910	0.1724	-0.0105	0.2693	-0.2693	-0.2240	0.2163	-0.0445	0.0439	0.1843	0.2621	0.2241	0.1985	0.2591	0.3065	0.2247	0.1831	0.1835	0.1388	0.1373	-0.0860	0.2289	0.1272	0.1901	10.000		
af_attrac	-0.1938	0.0861	0.2166	-0.2020	-0.0003	0.0048	-0.0021	0.0061	0.0130	-0.0108	-0.0052	-0.0064	0.0334	0.0907	0.0154	-0.1180	0.0015	0.0245	-0.1068	-0.0694	-0.0127	-0.1309	0.1403	0.1354	0.0456	0.2245	-0.2245	-0.2044	0.3072	-0.1270	0.0570	0.0561	0.1014	0.0891	0.1098	0.1375	0.1628	0.2779	0.1727	0.0918	-0.0558	0.1950	-0.1343	0.2539	0.1869	0.3842	0.2987	10.000	
af_podiur	-0.1849	0.2090	0.1379	-0.2638	-0.0073	0.0060	0.0025	0.0229	0.0171	0.0153	-0.0352	-0.0273	0.1077	0.1936	-0.0811	-0.1212	-0.0211	-0.0225	-0.1748	-0.1414	-0.0403	-0.1800	0.3247	0.0968	0.0131	0.3716	-0.3716	-0.2495	0.5518	-0.3128	0.0586	0.0249	0.4021	0.2857	0.4552	0.2807	0.3767	0.4116	0.2088	0.1511	0.1382	0.3210	-0.1385	0.3239	0.2549	0.6247	0.3228	0.2821	10.000

Appendix XI. Stata Do file

```
use "C:\Users\Leo\Documents\Scriptie\STATA\Scriptie.dta", clear

.Set matsize 99999

destring floorspace, replace force dpcomma

destring rent_score, replace force dpcomma

destring utilities, replace force dpcomma

destring quant_comm, replace force dpcomma

destring d_departmentstore gla_departmentstore ai_b1_departmentstore ai_b2_departmentstore
d_supermarket gla_supermarket ai_b1_supermarket ai_b2_supermarket d_drug_stores
gla_drug_stores ai_b1_drugstores ai_b2_drugstores d_fashion gla_fashion ai_b1_fashion
ai_b2_fashion d_hobbies gla_hobbies ai_b1_hobbies ai_b2_hobbies d_shoes_leather
gla_shoes_leather ai_b1_shoes_leather ai_b2_shoes_leather d_optics_jewelry gla_optics_jewelry
ai_b1_optics_jewelry ai_b2_optics_jewelry d_media gla_media ai_b1_media ai_b2_media
d_domestic_luxury gla_domestic_luxury ai_b1_domestic_luxury ai_b2_domestic_luxury
d_sport_games gla_sport_games ai_b1_sport_games ai_b2_sport_games d_art_antique
gla_art_antique ai_b1_art_antique ai_b2_art_antique d_flora_fauna gla_flora_fauna
ai_b1_flora_fauna ai_b2_flora_fauna d_electronics gla_electronics ai_b1_electronics
ai_b2_electronics d_car_bike gla_car_bike ai_b1_car_bike ai_b2_car_bike d_diy gla_diy ai_b1_diy
ai_b2_diy d_lifestyle gla_lifestyle ai_b1_lifestyle ai_b2_lifestyle, replace force dpcomma

destring ai_beta1 ai_beta2 af_apoth af_ziek_i af_ziek_e af_superm af_daglmd af_warenh af_cafe
af_cbd af_restau af_hotel af_kdv af_bso af_ondbas af_ondvrt af_oprith af_treinst af_zwemb
af_biblio af_bios af_sauna af_attrac af_podium, replace force dpcomma

rename v30 YEAR

drop if missing(lnai_b2_fashion)

drop if missing(lnfloorspace)

drop if missing(lnai_b2_departmentstore)

drop if missing(lnai_b2_supermarket)

*Energy

rename energielabel ENERGY

gen GreLabel = (ENERGY>18)

gen OraLabel = (ENERGY>14 <18)

gen RedLabel = (ENERGY <13)

gen Nolabel = (ENERGY<11)

egen Energycat = cut(ENERGY), at(10,15,18,22)

generate byte Energylabel=13 if ENERGY<=13

generate byte Energylabel=17 if ENERGY<=17
```

```
replace agecat=38 if age>21 & age<=38
replace agecat=64 if age>38 & age<=64
replace agecat=75 if age>64 & age<.
recode ENERGY (#/# = #) (0/10 = 0) (11/14 = 1) (15/18 = 2) (18/21 = 3)
recode ENERGY (11 12 13 14 = 1)
recode ENERGY (15 16 17 = 2)
recode ENERGY (18 19 20 21 = 3)
drop if ENERGY>10
tabulate ENERGY, gen (Energycat)
generate byte Energylabel=1 if ENERGY<=1
*Green label
generate byte GrEnergylabel=1 if ENERGY=>18 & ENERGY<=21
*Orange label
generate O.Energylabel=3 if ENERGY=>14 & ENERGY<=17
*Red label
replace R.Energylabel=4 if ENERGY<=13
*categories
tabulate age_category, gen(age)
tabulate dwelling_type, gen (dwel_t)
tabulate single_multi, gen (fam)
tabulate living_environment, gen (environ)
tabulate YEAR, gen (year)
*logs
gen lnRENT_PM=ln( rent_pm)
gen lnIncome=ln( incomehousehold)
gen lnPop_dens=ln( pop_dens)
gen lnQuant_comm=ln( quant_comm)
gen lnParking=ln( parking)
gen lnfloorspace=ln( floorspace)
gen lnai_b1_fashion=ln( ai_b1_fashion)
gen lnb1_ai_hobbies =ln( ai_b1_hobbies )
gen lnb1_ai_shoes_leather =ln( ai_b1_shoes_leather )
gen lnb1_ai_optics_jewelry =ln( ai_b1_optics_jewelry )
```

```
gen lnb1_ai_media=ln( ai_b1_media )
gen lnb1_ai_domestic_luxury=ln( ai_b1_domestic_luxury )
gen lnb1_ai_sport_games =ln( ai_b1_sport_games )
gen lnb1_ai_art_antique =ln( ai_b1_art_antique )
gen lnb1_ai_flora_fauna =ln( ai_b1_flora_fauna )
gen lnb1_ai_electronics =ln( ai_b1_electronics )
gen lnb1_ai_car_bike =ln( ai_b1_car_bike )
gen lnb1_ai_diy =ln( ai_b1_diy )
gen lnb1_ai_lifestyle =ln( ai_b1_lifestyle )
gen lnai_b1_departmentstore =ln( ai_b1_departmentstore )
gen lnai_b1_supermarket =ln( ai_b1_supermarket )
gen lnai_b1_drugstores =ln( ai_b1_drugstores )
gen lnai_b2_fashion=ln( ai_b2_fashion)
gen lnb2_ai_hobbies =ln( ai_b2_hobbies )
gen lnb2_ai_shoes_leather =ln( ai_b2_shoes_leather )
gen lnb2_ai_optics_jewelry =ln( ai_b2_optics_jewelry )
gen lnb2_ai_media=ln( ai_b2_media )
gen lnb2_ai_domestic_luxury=ln( ai_b2_domestic_luxury )
gen lnb2_ai_sport_games =ln( ai_b2_sport_games )
gen lnb2_ai_art_antique =ln( ai_b2_art_antique )
gen lnb2_ai_flora_fauna =ln( ai_b2_flora_fauna )
gen lnb2_ai_electronics =ln( ai_b2_electronics )
gen lnb2_ai_car_bike =ln( ai_b2_car_bike )
gen lnb2_ai_diy =ln( ai_b2_diy )
gen lnb2_ai_lifestyle =ln( ai_b2_lifestyle )
gen lnai_b2_departmentstore =ln( ai_b2_departmentstore )
gen lnai_b2_supermarket =ln( ai_b2_supermarket )
gen lnai_b2_drugstores =ln( ai_b2_drugstores )
*model I
regress lnRENT_PM lnfloorspace parking pop_dens i.ENERGY year1 year2 year3 year4 year5 year6
year7 year8 age1 age2 age3 age4 age5 age6 dwel_t1 dwel_t2 dwel_t3 dwel_t4 dwel_t5 dwel_t6
dwel_t7 fam1 fam2 environ1 environ2 environ3 environ4 environ5 af_cbd af_apoth af_ziek_i
af_cafe af_restau af_hotel af_kdv af_bso af_ondbas af_ondvrt af_oprith af_treinst af_zwemb
af_bios af_sauna af_attrac af_podium i.postal_code, cluster (postal_code)
```

*model II BETA 1

regress lnRENT_PM lnfloorspace parking pop_dens i.ENERGY year1 year2 year3 year4 year5 year6 year7 year8 age1 age2 age3 age4 age5 age6 dwel_t1 dwel_t2 dwel_t3 dwel_t4 dwel_t5 dwel_t6 dwel_t7 fam1 fam2 environ1 environ2 environ3 environ4 environ5 af_cbd af_apoth af_ziek_i af_cafe af_restau af_hotel af_kdv af_bso af_ondbas af_ondvrt af_oprith af_treinst af_zwemb af_bios af_sauna af_attrac af_podium lnai_b1_fashion lnb1_ai_hobbies lnb1_ai_shoes_leather lnb1_ai_optics_jewelry lnb1_ai_media lnb1_ai_sport_games lnb1_ai_art_antique lnb1_ai_flora_fauna lnb1_ai_electronics lnb1_ai_car_bike lnb1_ai_diy lnb1_ai_lifestyle lnai_b1_departmentstore lnai_b1_supermarket lnai_b1_drugstores i.postal_code, cluster (postal_code)

*model III BETA 2

regress lnRENT_PM lnfloorspace parking pop_dens i.ENERGY year1 year2 year3 year4 year5 year6 year7 year8 age1 age2 age3 age4 age5 age6 dwel_t1 dwel_t2 dwel_t3 dwel_t4 dwel_t5 dwel_t6 dwel_t7 fam1 fam2 environ1 environ2 environ3 environ4 environ5 af_cbd af_apoth af_ziek_i af_cafe af_restau af_hotel af_kdv af_bso af_ondbas af_ondvrt af_oprith af_treinst af_zwemb af_bios af_sauna af_attrac af_podium lnai_b2_fashion lnb2_ai_hobbies lnb2_ai_shoes_leather lnb2_ai_optics_jewelry lnb2_ai_media lnb2_ai_sport_games lnb2_ai_art_antique lnb2_ai_flora_fauna lnb2_ai_electronics lnb2_ai_car_bike lnb2_ai_diy lnb2_ai_lifestyle lnai_b2_departmentstore lnai_b2_supermarket lnai_b2_drugstores i.postal_code, cluster (postal_code)

*Residuals

predict r

*Assumptions

Describe

summarize lnRENT_PM lnfloorspace parking pop_dens i.ENERGY year1 year2 year3 year4 year5 year6 year7 year8 age1 age2 age3 age4 age5 age6 dwel_t1 dwel_t2 dwel_t3 dwel_t4 dwel_t5 dwel_t6 dwel_t7 fam1 fam2 environ1 environ2 environ3 environ4 environ5 af_cbd af_apoth af_ziek_i af_cafe af_restau af_hotel af_kdv af_bso af_ondbas af_ondvrt af_oprith af_treinst af_zwemb af_bios af_sauna af_attrac af_podium lnai_b2_fashion lnb2_ai_hobbies lnb2_ai_shoes_leather lnb2_ai_optics_jewelry lnb2_ai_media lnb2_ai_sport_games lnb2_ai_art_antique lnb2_ai_flora_fauna lnb2_ai_electronics lnb2_ai_car_bike lnb2_ai_diy lnb2_ai_lifestyle lnai_b2_departmentstore lnai_b2_supermarket lnai_b2_drugstores

summarize lnRENT_PM lnfloorspace parking pop_dens i.ENERGY year1 year2 year3 year4 year5 year6 year7 year8 age1 age2 age3 age4 age5 age6 dwel_t1 dwel_t2 dwel_t3 dwel_t4 dwel_t5 dwel_t6 dwel_t7 fam1 fam2 environ1 environ2 environ3 environ4 environ5 af_cbd af_apoth af_ziek_i af_cafe af_restau af_hotel af_kdv af_bso af_ondbas af_ondvrt af_oprith af_treinst af_zwemb af_bios af_sauna af_attrac af_podium lnai_b1_fashion lnb1_ai_hobbies lnb1_ai_shoes_leather lnb1_ai_optics_jewelry lnb1_ai_media lnb1_ai_sport_games lnb1_ai_art_antique lnb1_ai_flora_fauna lnb1_ai_electronics lnb1_ai_car_bike lnb1_ai_diy lnb1_ai_lifestyle lnai_b1_departmentstore lnai_b1_supermarket lnai_b1_drugstores i.postal_code correlate lnRENT_PM lnfloorspace parking pop_dens year1 year2 year3 year4 year5 year6 year7 year8 age1 age2 age3 age4 age5 age6 dwel_t1 dwel_t2 dwel_t3 dwel_t4 dwel_t5 dwel_t6 dwel_t7 fam1 fam2 environ1 environ2 environ3 environ4 environ5 af_cbd af_apoth af_ziek_i af_cafe af_restau af_hotel af_kdv af_bso af_ondbas af_ondvrt af_oprith af_treinst af_zwemb af_bios af_sauna af_attrac af_podium

correlate lnRENT_PM lnai_b2_fashion lnb2_ai_hobbies lnb2_ai_shoes_leather lnb2_ai_optics_jewelry lnb2_ai_media lnb2_ai_sport_games lnb2_ai_art_antique lnb2_ai_flora_fauna lnb2_ai_electronics lnb2_ai_car_bike lnb2_ai_diy lnb2_ai_lifestyle lnai_b2_departmentstore lnai_b2_supermarket lnai_b2_drugstores

summarize rent_pm lnRENT_PM lnfloorspace parking pop_dens i.ENERGY year1 year2 year3 year4 year5 year6 year7 year8 age1 age2 age3 age4 age5 age6 dwel_t1 dwel_t2 dwel_t3 dwel_t4 dwel_t5 dwel_t6 dwel_t7 fam1 fam2 environ1 environ2 environ3 environ4 environ5 af_cbd af_apoth af_ziek_i af_cafe af_restau af_hotel af_kdv af_bso af_ondbas af_ondvrt af_oprith af_treinst af_zwemb af_bios af_sauna af_attrac af_podium lnai_b2_fashion lnb2_ai_hobbies lnb2_ai_shoes_leather lnb2_ai_optics_jewelry lnb2_ai_media lnb2_ai_sport_games lnb2_ai_art_antique lnb2_ai_flora_fauna lnb2_ai_electronics lnb2_ai_car_bike lnb2_ai_diy lnb2_ai_lifestyle lnai_b2_departmentstore lnai_b2_supermarket lnai_b2_drugstores

graph matrix lnRENT_PM lnfloorspace

graph matrix lnRENT_PM lnai_b2_fashion lnb2_ai_hobbies lnb2_ai_shoes_leather lnb2_ai_optics_jewelry lnb2_ai_media lnb2_ai_sport_games lnb2_ai_art_antique lnb2_ai_flora_fauna lnb2_ai_electronics lnb2_ai_car_bike lnb2_ai_diy lnb2_ai_lifestyle lnai_b2_departmentstore lnai_b2_supermarket lnai_b2_drugstores

kdensity r, normal

pnorm r

qnorm r

rvfplot, yline(0)

avplots

swilk r

estat hettest

scatter r RENT_PM