Logistics clustering in space? A study on economies of agglomeration in Noord-Brabant

Robin Navis, January 2020

Abstract: This Master's thesis studies the effect of economies of agglomeration on rents of logistics real estate in Noord-Brabant. Economies of agglomeration may occur when same industry firms co-locate or cluster together in order to benefit from each other. These firms that cluster may experience a positive effect on their productivity due to economies of agglomeration. Three main sources are described which are labour market pooling, input sharing, and knowledge spillovers. In their own way, these sources can all effect logistics firms. For example, lower costs can be achieved when logistics firms combine their transport flows or exchange knowledge. In order to understand the implications of economies of agglomeration in the logistics sector, this paper tries to indicate and measure these economies in the province Noord-Brabant. The Strabo and LISA databases are used in this research. The Strabo database provides data of rental transactions of logistics properties from 1989 to 2017. The LISA database contains employment numbers of multiple commercial properties per year. The effects of economies of agglomeration are indicated and estimated by using multiple hedonic pricing models. Herewith, the effect of property/locational characteristics, infrastructural characteristics, and job concentration indices on the rents per square meter will be clarified. The results of the research indicate that higher rents occur in areas with higher population densities, due to the fact that the proximity of customers will lower transport costs as it also helps to create a local network. In predefined rural areas rents are respectively 14.19% and 17.96% lower than in the denser urban areas. Also, the distance to the highway entrance only impacts rents of smaller (<2,500 m²) firms, with changes of rents per kilometre to -2.51%. Lastly, with the use of the LISA database and the Herfindahl-Hirschman index the concentration indices like the Ellison-Glaeser index and the Location Quotient were constructed. While the Ellison-Glaeser index is somewhat more complex compared to the Location Quotient, both indices are based on standard concentration ratios and can be constructed with readily available data. The Ellison-Glaeser index defines concentration as agglomeration above and beyond what we would observe if establishments/firms simply chose locations randomly. Of these concentrations the Ellison-Glaeser index has a significant effect on the rents of logistics real estate. When the Ellison-Glaeser index rises by ten points the rents per square meter increase by 3.6%, indicating that in regions where localization of firms are beyond that expected by pure randomness, the rents increase. Carefulness is required however. Because the significance is based on a 90% level, the impact can be considered less reliable than to be preferred. Also, the Location-Quotient was not significantly different from zero in any model on all significance levels, indicating no impact of clustered jobs on the property rents.

Keywords: economies of agglomeration, logistics real estate, Noord-Brabant, hedonic modelling, job concentration indices.

Colophon

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1. Introduction

Any paper that tries to deal with the issues of economies of agglomeration faces the same problem: what is exactly meant by economies of agglomeration and how is it measured. The concept of economies of agglomeration implies that a positive effect on the productivity of firms will occur when economic activity is spatially clustered (Mukkala, 2004). The various ways in which economies of agglomeration are defined and measured are discussed in many different studies (Marshall, 1920; Hoover, 1937) and as such are only defined and explained shortly in this paper. Instead, this paper focusses on the identification of economies of agglomeration and especially how these economies benefits logistics firms. The study area is the province of Noord-Brabant. A better understanding of the impact and magnitude of economies of agglomeration can be very helpful for logistics firms, developers and investors. For this reason, the research aim of this study is to get a better understanding of the prevalence of logistics clusters and therefore the impact and magnitude of economies of agglomeration on logistics properties.

Due to a job creation agenda, governments from all around the world are investing in new or existing logistics clusters. These new or existing clusters are central nodes of the global freight transportation network. Some examples of these investments are the Plataforma Logistica – Zaragoza (PLAZA), which is the largest logistics park in Europe, and Panama, which is in the process of developing multiple logistics clusters (Council of the Americas, 2011; Government of Panama, 2010). While new logistics clusters are in development, some other existing clusters are expanding in scale and scope, examples are Singapore, Duisburg, Dubai, Rotterdam, and multiple US locations (Rivera et al., 2014).

Many studies suggest that this clustering of the logistics sector is mainly due to the fact of economies of agglomeration (Rivera et al., 2014). In the economic literature two main sources which improves the productivity of firms are generally identified, namely economies of scale and economies of agglomeration (Courlet, 2008). Economies of scale results from an increase in the volume of production, which therefore highly depends on the firm's internal production functions. On the other hand, economies of agglomeration are an economy of scale which is external to the firm and internal to the region (Catin, 1997). In the analysis of regional development, regional growth and industrial location, economies of agglomeration have played a significant role. As stated, economies of agglomeration can have a positive effect on the productivity of firms when economic activity is spatially clustered. This positive effect will only be present for the firms located in the area in question. Economies of agglomeration are a form of external economies and can therefore not be controlled or created by the firm itself (Mukkala, 2004).

Within this existing literature there is an array of research on economies of agglomeration. Much of the earlier literature examined the relationship between city size and productivity (Sveikauskas, 1975; Moomaw, 1981). Other later empirical papers mainly focused on the identification. Findings by Drennan & Kelly (2009) and Koster et al. (2014) suggests a positive effect of economies of agglomeration of five percent on rents of office space in large central business districts. The underlying explanation is that if firms gain from economies of agglomeration because they are within a dense spatial proximity of same industry firms, then those gains will be reflected in higher rents (Arzaghi & Henderson, 2008).

Other recent studies argued the downside of clustering in space of similar firms. According to Van den Heuvel (2013) and Holmes & Stevens (2002), agglomeration diseconomies can occur when companies cluster, such as high land/lease prices. They stated that therefore relative smaller companies do not benefit from economies of agglomeration. In addition, according to Shaver & Flyer (2000) also larger firms do not have the incentive to cluster because they already possess superior technologies, suppliers, distributors and human capital and therefore do no benefit from other companies in the near vicinity.

Despite many different studies on economies of agglomeration, there is limited insights of these economies in the logistics sector. According to Mukkala (2004) logistics firms can also improve their productivity or lower production costs when benefitting from economies of agglomeration and thereby creating an advantage over their competitors. Most studies that are focused on logistics, support this claim by Mukkala (2014) and argue that logistics clusters, just as other clusters, will benefit from agglomeration economies (Van den Heuvel et al., 2013; Koster et al., 2014; Rivera et al., 2016). Some other authors even say that in regions where these clusters are located higher economic growth and higher rate of innovation will occur than in regions without clusters (Porter, 2000; Delgado et al., 2010). Lastly, big government investments in logistics clusters could suggests that policy makers are indeed acknowledging the positive effects of economies of agglomeration when same industry firms do cluster (Kasarda, 2008; Wu et al., 2006).

There are multiple approaches of measuring economies of agglomeration. The most common way is to directly estimate the production function. In carrying out this estimation, multiple inputs such as numbers of employment, capital, materials and land are necessary (Rosenthal & Strange, 2002). A different approach is with the focus on births of new establishments and their employment. The idea of this approach is that entrepreneurs seek out the most productive regions and therefore chose the locations which will maximize their profit (Carlton, 1983). A third approach is to study differences in wages. With this approach the assumption is made that labour is paid the value of its marginal product in competitive markets. The last approach to measure economies of agglomeration is with the use of property rents (Rosenthal & Strange, 2002). This approach, to use rents, will be used in this thesis, mainly due to the availability of data necessary and available. Very few studies use rents in order to measure the presence of agglomeration economies. Still some have shown that agglomeration economies mainly capitalize in rents (Koster et al., 2014; Arzaghi & Henderson, 2008; Drennan & Kelly, 2009). The approach to use rents stems from the quality-of-life literature and means: "if firms are paying higher rents in a particular location all else equal, then the location must have some compensating productivity differential (Rosenthal & Strange, 2005)." Rents of logistics properties should be higher when co-locating with same industry firms due to different advantages such as an increased productivity, easier access to information, ease of new business formation, new technological and delivery possibilities, and benefits rooted in working together with other institutions such as universities and public organizations (Rivera et al., 2016; Porter, 1998). In addition, this study will focus on the external localization economies of logistic firms. Localization economies is characterized by the geographical concentration of a specific industry, in this case logistics. The external economies of scale depend on the development of the whole industry in the region. In the next chapter, these different sources of economies of agglomeration are further explained.

This paper contributes to the understanding of agglomeration economies when logistics firms are spatially clustered. To link economies of agglomeration to logistics property rents, logistics rental transaction data from 1989-2017 in the province Noord-Brabant are examined (*N*=511). In this paper the following research question will be answered:

"To what extent does spatially clustering of logistics firms create economies of agglomeration in the province of Noord-Brabant?"

To answer this question and test the effects of clustering in space on logistics property rents, this paper uses hedonic pricing models. Hedonic price modelling is a statistical method, which values location-specific amenities by measuring the price differentials (Hoehn et al., 1987). By applying multiple linear regressions, the effects of co-locating can be identified and measured. Also, other attributes comprising property-, locational- and infrastructural characteristics are plotted in the linear regression in order to measure their effects on logistics property rents.

The province of Noord-Brabant in the Netherlands is chosen as study area for three main reasons. Firstly, the province plays a key role in the take up of logistic properties, because of its geographically favourable position. Noord-Brabant and, the other southern province of the Netherlands, Limburg account for half of total transaction volumes in The Netherlands in 2017 (Industrial, 2018). Secondly, the province of Noord-Brabant accounts for five big logistics central hubs in the Netherlands. These central hubs are Eindhoven, Roosendaal, Tilburg, 's-Hertogenbosch, and Breda (Logistiek, 2019). And third, Noord-Brabant is located between Europe's two largest seaports in Rotterdam and Antwerp, and it's also located between two large consumer markets in the likes of Germany and the U.K. (Van den Heuvel et al., 2012). Which therefore contributes as an important link logistics wise.

The remainder of this paper is organized as follows. In chapter 2 the theoretical framework is set out. In this framework the different sources of economies of agglomeration are reported and their benefits/disbenefits will be discussed. Also, a theoretical link will be made between economies of agglomeration and the logistics sector. In chapter 3 the data and methodology are set out. In this chapter the sources of the dataset will be mentioned in addition with the transitions which were made in the data. Also, the methodology is set out with the specification of the hedonic models. The results of the hedonic models are presented with accessory clarification in chapter 4. Lastly, chapter 5 & 6 concludes on the study with a recap of the main conclusions and starts a discussion on how the findings fit in the existing academic literature.

2. Theoretical framework

2.1 Economies of agglomeration

The concept of economies of agglomeration implies that a positive effect on the productivity of firms will occur when economic activity is spatially clustered (Mukkala, 2004). In the economic literature two main sources which improves the productivity of firms are generally identified, namely economies of scale and economies of agglomeration (Courlet, 2008).

Economies of scale results from an increase in the volume of production, which therefore highly depends on the firm's internal production functions. On the other hand, economies of agglomeration are an economy of scale which is external to the firm and internal to the region (Catin, 1997). In the analysis of regional development, regional growth and industrial location, economies of agglomeration have played a significant role. As stated, economies of agglomeration can have a positive effect on the productivity of firms when economic activity is spatially clustered. This positive effect will only be present for the firms located in the area in question. Economies of agglomeration are a form of external economies and can therefore not be controlled or created by the firm itself (Mukkala, 2004).

Economies of agglomeration can be classified in many ways. The usual classification was introduced by Hoover (1937). Hoover (1937) made the distinction between localization and urbanization economies. Localization economies is characterized by the geographical concentration of a specific industry, urbanization economies are characterized by the industrial diversity of the local economic system. This diversity of the local economic system usually emerges in urban densely populated areas. Whereas, localization economies can occur in both urban and non-urban areas (Mukkala, 2004).

Localization economies has been researched far back by Marshall (1920). He made a distinction of localization economies between internal economies of scale and external economies of scale. Whereas, the internal economies of scale depend on the organization and management of the firm's own resources and the external economies of scale depends on the development of the whole industry in the region. Hence, localization economies are internal to the industry but external to the firm.

Marshal (1920) identified three sources of industry specific concentration: pooled labour force, facilities for development of specialized inputs and services, and spatial technology spillovers. The pooled labour force is beneficial to the firm and to the employees. A large local labour market can protect firms and workers from demand-shocks and business uncertainty. In perspective of the firms, recruitment costs will be lower because of this pool of highly skilled workers. Second, the proximity of customers and suppliers helps to create a local network conducive to economic growth and more effective production. High local demand allows producers of intermediate inputs to break-even. This will increase the variety of intermediate goods, which in turn will make the production of the final product more efficient (Mukkala, 2004). Finally, the spatial technology spillovers or knowledge spillovers can also be very beneficial for a firm. Knowledge and ideas about production or new products can be transferred between firms by imitation, inter-firm circulation of employees, business interactions, or by informal exchanges (Saxenian, 1994). The larger the number of workers in a certain industry will create a higher opportunity to exchange knowledge (Henderson, 1986).

In addition to the benefits above from clustering in space, other authors identified disbenefits (Bounie & Blanquart, 2017). Firstly, economies of agglomeration can lead to pressure on the price of land and property, when there is a fixed physical supply (Fujita & Krugman, 2004). Next, due to concentration of economic activity higher sources of pollution will occur (Feitelson & Salomon, 2000). Also, the higher efficiency of supply chains could diminish the advantage of geographical proximity, leading to negative externalities of clusters (Cairncross, 1997; Henderson & Shalizi, 2001). Last, the matching of resources sometimes fails to materialize. For example, specialized workers may be easier to find by firms due to concentration, but this could also lead to tensions regarding the workforce, resulting in increased wages and volatility (Chatterjee, 2003).

As stated above, the different sources of economies of agglomeration can have important implications for a firm's location strategy, as a source of reduced costs. Firms will have an advantage over competitors when benefitting from economies of agglomeration. Whether a firm does benefit from economies of agglomeration depend on different issues. First, the factors of agglomeration have different values to different firms. Second, both firm and agglomeration economy heterogeneity will impact the value of an economy of agglomeration. In the next sector, a linkage is made between economies of agglomeration and the logistics sector.

2.2 Logistics clustering

Logistics real estate is one of the main asset classes of commercial property. A classification of the definition of logistics as 'business' and as 'real estate' is essential for a better understanding of the nature of the logistics market. Logistics as a business can be defined as "the process of planning, implementing, and controlling procedures for the efficient and effective transportation and storage of goods including services, and related information from the point of origin to the point of consumption for the purpose of conforming to customer requirements (Mattarocci & Pekdemir, 2017)." Logistics as in a real estate asset can be seen as the distribution and storage purpose-built buildings used for the process mentioned above.

In the last decade, the European industrial and logistics market has changed vastly. Two major phenomena had a huge impact in changing demand and supply dynamics and therefore shaping the market. These two phenomena are industrial and technological revolutions. The industrial market has undergone a progressive development over the last hundred years and has entered a new phase with changing consumption patterns and global trade (Mattarocci & Pekdemir, 2017). Since late nineteenth century the modern industrial market has been growing. Industrial areas agglomerated around transportation nodes, during the 1920s and 1930s. However, since the 1950s both distribution and manufacturing industries have been decentralized. The improved infrastructure providing accessibility to areas outside of the big cities was one of the many factors contributing to the suburbanization of the industry. Later, technological innovation and globalization impacted the development of the industrial market (Peiser and Schwanke, 1992).

The increasingly clustering of logistics activities has led some researchers to examine economies of agglomeration attributed to these logistics clusters. Marshall (1920) described three main sources of economies of agglomeration, namely labour market pooling, input sharing, and knowledge spillovers. First, labour market pooling can provide firms, which co-locate, a better access to a more flexible labour market, specialized labour, and better training. When addressing logistics firms, these benefits are usually only beneficial when firms operate in different supply chains, since they serve different markets (Van den Heuvel et al., 2012). Second, Marshall (1920) also mentioned input sharing, which relates to the broad local supplier base, that increases flexibility and reduces costs. Input sharing can be beneficial in the logistics sector in different ways. First, lower transport costs can be achieved when logistics firms that co-locate combine their transport flows. According to Jara-Díaz & Basso (2003) cooperation between co-located transport firms can result in lower transport costs due to a denser network, a decrease in empty mileage (Cruijssen et al., 2007a), less repositioning of trucks (Ergun et al., 2007), and a decrease in the distance between customers (Van Donselaar et al., 1999; Wouters et al., 1999), which subsequently also has a positive environmental impact (Van den Heuvel et al., 2012). Also, co-location may lead to supply of storage capacity by third parties, due to (short-term) demand of several firms. Last, multimodal transport could be possible due to an increase of freight volumes. Multimodal transport can't compete with road transport because of insufficient large freight volumes. An increase in freight volumes could enable the development of multimodal transport services, when logistics firms co-locate (Van den Heuvel et al., 2012). Also, Rivera et al., (2014) stated that firms in logistics clusters lease space to each other for short-term surges, share equipment, work together effectively when contracts are being moved from provider.

Third, Marshall (1920) refers to knowledge spillovers, which idea is that geography plays a fundamental role in learning and innovation. Collaboration of different firms are usually the starting point of innovation, and, when the distance increases between firms the cost of exchanging information also increases, all else equal (Malmberg & Maskell, 1997). According to Lasserre (2008), this is mainly because of the need to create trust and understanding between firms, which in turn depends on culture, language and shared values. According to Malmberg & Maskell (2002), the starting point of many spatial agglomerations are the spatial attributes of interactive learning and innovation processes. However, localized knowledge may be less relevant in the logistics sector given the fact that knowledge management hasn't been largely implemented by logistics firms (Neumann & Tomé, 2005). Still, according to Cruijssen et al. (2007b) the difficulty of finding a trusted party is one of the important impediments for horizontal cooperation in logistics. To overcome this impediment, co-location may help. Furthermore, clustered firms have more weight in lobbying for improved infrastructure and regulatory relief with the local government (Rivera et al., 2014).

Other authors highlighted the importance of accessibility and general infrastructure as the main factor for logistics clusters (Bok, 2009). According to Berechman (1994), a better accessibility drives logistics operations to cluster together, as it also reduces costs (Rietveld, 1994). For foreign logistics firms, the transportation accessibility is one of the important determinants considering location (Hong, 2007).

On the other hand, some scholars say the effects of economies of agglomeration when logistics activities are concentrated should not be overstated. According to Carbonara et al. (2002) there is a lack of interfirm relations in industry districts, referring to Dell'Orco et al. (2009) who stated that the companies mostly behave as individual agents in a cluster and that they usually don't know the other firms at near distance. Masson & Petiot (2014) had the same conclusion in their empirical study of the situation in France, which stated that there was an absence of the externalities explained by Marhall (1920) (knowledge spillovers, input sharing, and labour pooling), and on the contrary a presence of diseconomies. They partly explained this due to the high concentration of low-skilled workers, resulted due to logistics activities, which will unlikely lead to knowledge spillovers.

Another recent study argued the downside of clustering in space of similar firms. According to Shaver & Flyer (2000) some firms may have greater benefits than others regarding economies of agglomeration. Firms which already possess superior technologies, suppliers, distributors and human capital do not have the incentive to locate close to other same industry firms. These firms will not only capture the benefits but also contribute to agglomeration economies. Resulting, larger firms (relative to average establishment size in industry) are less likely to agglomerate, their presence would increase local economic activity which then could result in lower costs for neighbouring competitors (Shaver & Flyer, 2000). Also, Alcácer & Chung (2007) argued that whether competitors can absorb economies of agglomeration, especially knowledge spillovers. It is crucial for these knowledge spillovers that they can be absorb by smaller firms. Industry leaders will otherwise freely benefit from agglomeration when competitors can't leverage the knowledge they gather from the larger and more technically advanced firms.

2.3 Hypotheses

Based on the theoretical framework, three hypotheses are formed:

Hypothesis 1: logistics firms pay a significant higher property rent when located near infrastructure nodes. This hypothesis is based on the importance of accessibility and general infrastructure some authors highlight. A better accessibility drives logistics operations to cluster together, this could reduce the costs of transport (Berechman, 1994; Rietveld, 1994).

Hypothesis 2: due to possible economies of agglomeration logistics firms pay a significant higher property rent when clustered. These economies of agglomeration will be based on the density and clustering of logistics employment. The increasingly clustering of logistics activities has led researchers to examine economies of agglomeration attributed to these logistics clusters. Marshall (1920) described three main sources of economies of agglomeration, namely labour market pooling, input sharing, and knowledge spillovers. In their own way, these sources can all effect logistics firms and lower their production costs.

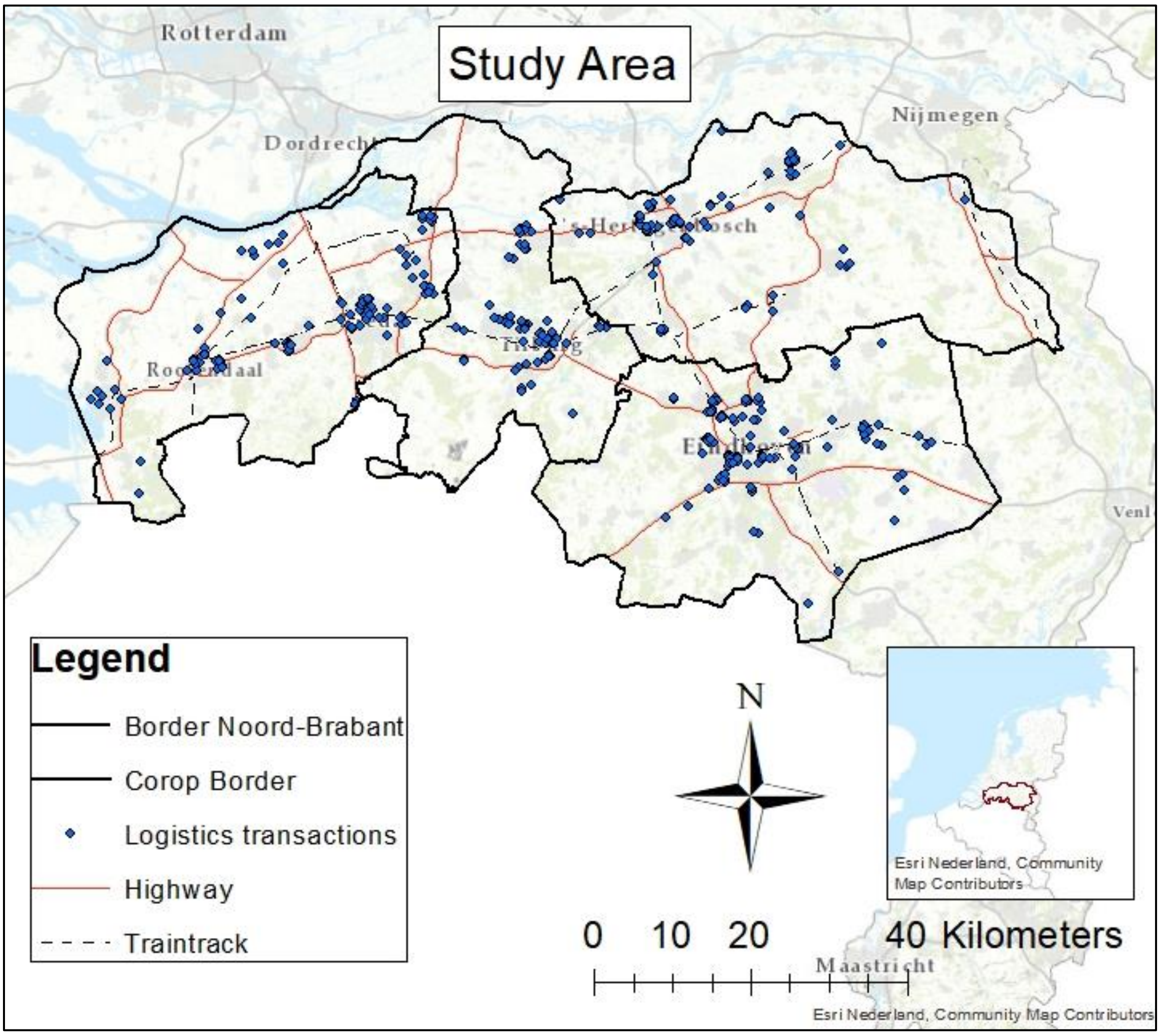
Hypothesis 3: the company size has a significant effect on the benefits of economies of agglomeration implying economies at firm-level. According to Shaver & Flyer (2000) some firms may have greater benefits than others regarding economies of agglomeration. Firms which already possess superior technologies, suppliers, distributors and human capital do not have the incentive to locate close to other same industry firms. Resulting, larger firms are less likely to agglomerate. Also, it is crucial whether firms can absorb economies of agglomeration. Bigger firms will freely benefit when the smaller competitors can't leverage the knowledge gathered from the larger and more technically advanced firms.

3. Data & Methodology

3.1 Study area

In figure 3.1 the study area is shown, the logistics transaction over the years (1989-2017) are linked to the blue dots (*N*=511). Furthermore, the borders are shown of the province and COROP-regions. Lastly, the hard infrastructure such as the highway and train tracks are presented. The study concentrates on Noord-Brabant. Noord-Brabant is a province in the south of The Netherlands and is chosen as study area for multiple reasons:

Figure 3.1: Study area including plotted observations.



Firstly, the province plays a key role in the take up of logistic properties, because of its geographically favourable position. Noord-Brabant and Limburg account for half of total logistics transaction volumes in The Netherlands in 2017 (Industrial, 2018). Secondly, the province of Noord-Brabant accounts for five big logistics central hubs in the likes of Eindhoven, Roosendaal, Tilburg, 's-Hertogenbosch, and Breda. And lastly, Noord-Brabant is located between Europe's two largest seaports in Rotterdam and Antwerp and the U.K.'s and Germany's large consumer markets (Van den Heuvel et al., 2012). These reasons make the province of Noord-Brabant an ideal province for measuring effects of agglomeration economies.

3.2 Dataset

The hypotheses in this study are tested using secondary data from multiple sources. The datasets that were used are the Strabo commercial real estate database and the LISA database employment register. Furthermore, data regarding infrastructure is obtained with the use of ArcGis and a report from the Ministry of Infrastructure and Water Management. The construction year and locational characteristics, such as the surface and growth of the business park, were obtained from the Dutch land registry office.

The Strabo commercial real estate database contains of rental and asset transactions for individual properties at the time of purchase between 1989 and 2017, which includes multiple periods of both boom and bust in the commercial real estate market. The rental transactions of the database were used due to the fact that these could indicate potential economies of agglomeration. In the Strabo database information was given per transaction, this includes rents, surface, transaction date, existing or new build, tenant type, and postal codes with addresses.

The LISA database employment register contains employment numbers of multiple commercial properties between 1995 and 2016. In the LISA database information was given on the total jobs per address for every year. The database was also used in order to calculate the number of jobs in a specific region (municipality and province) per year.

These two datasets were combined in order to match the property characteristics with the job characteristics on property level. Because the LISA database only contained data till 1995, the transaction in the Strabo database from 1989 to 1994[1] were also matched with the job characteristics from 1995. Combining the Strabo database (< 5,500 logistics transactions) and LISA database (< 6,000,000 cases), and further stratification by property type (logistic), study area (Noord-Brabant), property status (rental), surface (< 500m^2), duplicates, outliers, and missing data, reduced the final sample to 511 observations.

Furthermore, data on locational characteristics regarding the business park were obtained from the Dutch land registry office. The Dutch land registry office (CBS) keeps track of different land uses in the Netherlands since the 1940s. In this thesis we use the category business park to construct the surface and growth of the area where the particular transaction took place. With the data from CBS we can map the land uses per year and calculate, with the use of ArcGis, the surface and the growth of the business parks. In this thesis we only got land use data from the years 1996, 2000, 2003, 2010, and 2015. Some years could not be used because of some minor errors in the data

To summarize, the 511 observations are rental transactions of logistic properties in Noord-Brabant in the time period between 1989 and 2017. The transactions contain data with property-, locational-, infrastructure- and job characteristics.

3.3 Empirical Model

To test the effects of economies of agglomeration on logistics rents, multiple hedonic models are set-up. Hedonic price modelling is a statistical method, which values location-specific amenities by measuring the price differentials. The basic concept is as follows: if individuals are to locate in undesirable and desirable locations, lower prices will occur in undesirable locations (Hoehn et al., 1987). The logarithm of the rent per square meter at the time of transaction for a specific property at time *t* is related to a linear function of different characteristics.

The aim of the regression model is to measure the effect of economies of agglomeration on the rents of logistic properties. Some studies have shown that agglomeration economies mainly capitalize in rents. Drennan & Kelly (2009) also used rents to measure economies of agglomeration. In their case they used office rents as the dependent variable and measures of wages, office demand, and vacancy rates as the right-hand variables. In this thesis the dependent variable will also be a measurement of rents with mainly job characteristics as the right-hand side variables to measure economies of agglomeration. These job characteristics are transformed in indices of job concentrations. In short, higher job concentrations in a certain region could indicate higher wages, high demand for space, and low vacancy rates in that specific region. So, the way of measuring economies of agglomeration is alike the study of Drennan & Kelly (2009). In the different variables, including the concentration indices, will be further explained.

[1] Due to the high number of observations that was already removed from the database, the transaction (Strabo dataset) from 1989 to 1994 were matched to the job characteristics of 1995 (LISA dataset) in order to prevent losing more observations.

The natural logarithm of the rent per square meter is the dependent variable for every linear regression model in this study. The independent variables are used to explain their influence on the rents, these are gradually added in the models in order to measure the impact per characteristic. The empirical model will be defined as follows:

$$\text{Ln}\, RentSqm = \beta_0 + \beta_1 PC + \beta_2 LC + \beta_3 IC + \beta_4 JC + \beta_5 N + \beta_6 Y + \varepsilon$$

Where:

Ln RentSqm = The natural logarithm of the rent per square meter
PC = a vector of property characteristics
LC = a vector of locational characteristics
IC = a vector of infrastructural characteristics
JC = a vector of job characteristics
N = fixed effects for COROP labour market region
Y = fixed effects for year of transaction

The Ln RentSqm is the natural logarithm of the rent per square meter for a logistic property during the transaction; β_0 represents a constant; parameters β_1- β_6 are to be estimated. Last, ε is the error term.

3.4 Variables

In the previous paragraph the empirical model was presented. The different characteristics which are added to the models are introduced. Some of these characteristics will help identifying potential economies of agglomeration, others try to explain the rents of logistics properties on other characteristics of the property or location. In this paragraph these characteristics are explained.

3.4.1 Property characteristics

The property characteristics describe the physical structure of the building. These characteristics are obtained from the Strabo database and include attributes like: the surface of logistics space, the surface of the office space, new or existing build, and the function of the property. The surfaces of logistics space and office space were separately added to the models because these surfaces differ in worth per square meter. Also, this will give more insights in the impact of these different spaces on the rents. The function of the logistics building was already divided by the database in manufacturing, warehouse, or distribution centre. This subdivision was also used in the hedonic models. Lastly, the year of construction was obtained from the Dutch land registry office.

3.4.2 Locational characteristics

The locational characteristics describe the characteristics of the location where the transaction took place. The transactions all took place in a predefined business park by CBS. Therefore, the following variables were constructed: the surface of the business park and the growth of the business park in surface. Lastly, the locations are divided in functional urban areas.

Regarding the business park surface and growth, CBS keeps track of the different land uses in the Netherlands since the 1940s. These land uses are classified by nine different main subjects: traffic area, built-up area, semi built-up area, recreational area, agricultural area, forest and open area, inland water, outside waters, and abroad areas (CBS Statline, 2019). These categories are then divided into smaller categories, among which the business park. In this thesis we use the category business park to construct the surface and growth of the area where the particular transaction took place. With the data from CBS we can map the land use business park per year and calculate the surface and the growth of the business parks. In this thesis we only got land use data from the years 1996, 2000, 2003, 2010, and 2015. Some years could not be used because of some minor errors in the data. In appendix I, the business parks were mapped over the years.

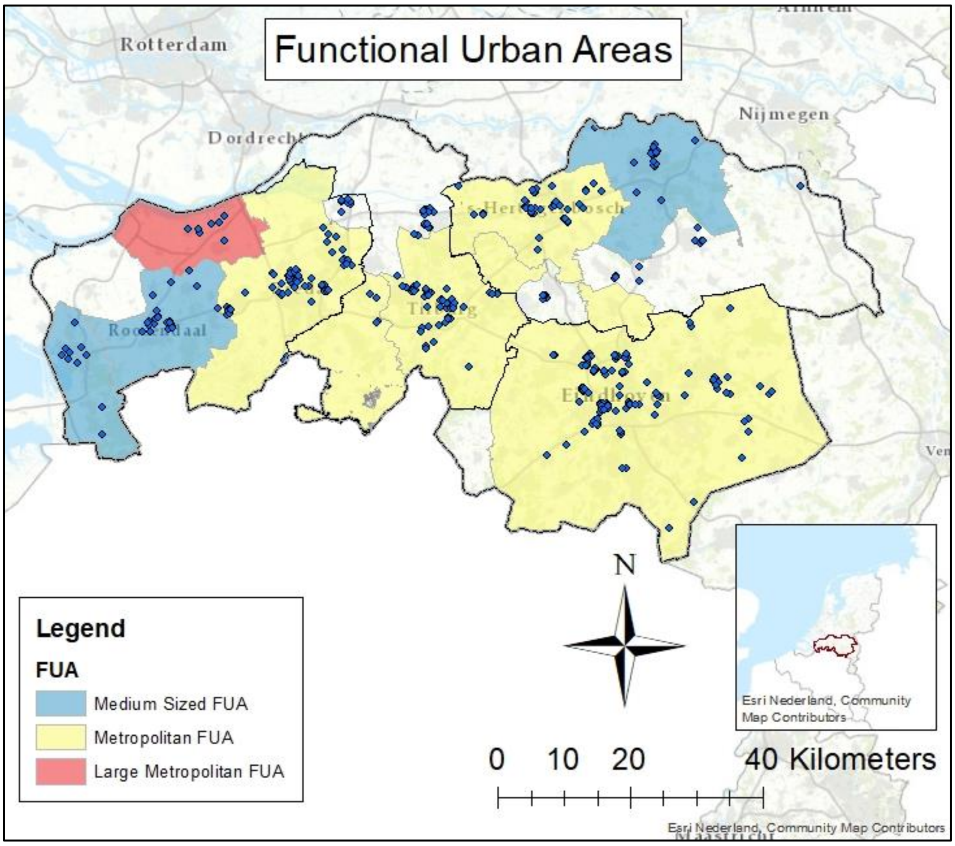
The other variable which is used to define the locational characteristics is the functional urban area. According to the book Redefining 'urban': A new way to measure metropolitan areas (OECD, 2012), an identification is given regarding the functional urban areas. The OECD listed these areas according to four classes:

- Small FUAs, with population between 50,000 and 100,000;
- Medium-sized FUAs, with population between 100,000 and 250,000;
- Metropolitan FUAs, with population between 250,000 and 1.5 million;
- Large metropolitan FUAs, with population above 1.5 million.

These functional urban areas are characterised by a city (or core) and a commuting zone. These commuting zones are thereby functionally interconnected to the city. In the identification of the OECD a city is a local administrative unit, such as a municipality, where at least 50% of its population lives in an urban centre. A centre is defined as an urban centre when it got at least a density of 1,500 inhabitants per km² and a population of 50,000 inhabitants overall.

In this thesis these functional urban areas are used to separate the urban areas from rural areas and what impact these different functional urban areas could have on logistics property rents. In map 3.2, these functional urban areas are shown, which were used in the hedonic models.

Figure 3.2: Functional Urban Areas.



A categorical variable is conducted from a scale 1 to 4 with: 1: Small FUA, 2: Medium-sized FUA, 3: Metropolitan FUA, 4: Large metropolitan FUA. The areas which aren't coloured in the province are the Small FUA's. The western area in Noord-Brabant which was determined as a "Large Metropolitan Area" is mainly rated since these functional urban areas were calculated based on The Netherlands. Therefore, this area benefits from the high population density in the cities of Dordrecht and

Rotterdam. Lastly, to keep in mind, the functional urban areas are based on population data from 2012, earlier data wasn't available.

3.4.3 Infrastructural characteristics

In the theoretical framework some authors highlighted the importance of accessibility and general infrastructure as the main factor for logistics clusters (Bok, 2009). According to Berechman (1994), a better accessibility drives logistics operations to cluster together, as it also reduces costs (Rietveld, 1994). Because of multiple references on accessibility and infrastructure in the literature, variables regarding accessibility were constructed in this thesis.

Accessibility can be measured in several ways. According to Geurs & Van Eck (2003), three basic perspectives are identified on the measurement of accessibility: infrastructure-based, activity-based, and utility-based. The infrastructure-based measurement uses the level of service in transport infrastructure. Typical measurements are the average travelling speed on the road network, levels of congestion, and distances to infrastructural nodes.

In this thesis we use multiple measures of infrastructure-based characteristics on the basic perspectives mentioned above. First, two variables are conducted based on distances to infrastructural nodes. These infrastructural nodes are highway ramps and train stations. With the use of ArcGis the distances to these nodes were calculated and implemented in the models. The disadvantage of this way of measurement is that these infrastructural nodes were based on the infrastructure as it is from 2018. So, it could be possible that when a certain transaction took place these infrastructural nodes weren't constructed at the time.

Second, through a research of the Dutch ministry of infrastructure and water management, data was obtained from the levels of congestion per quarter from 2000 to 2016. A congestion is defined as such when the average speed is dropped to 50 km per hour over 2 kilometres. The levels of congestions are calculated by the average length of a congestion multiplied by the average duration of the traffic congestion (Rijkswaterstaat, 2017). The transactions which took place from 1989 to 1999 were matched to the year 2000.

3.4.4 Jobs concentration characteristics

Economies of agglomeration are characterized by the geographical concentration of a specific industry. A positive effect on the productivity of firms can occur when they are spatially clustered. As a result, because of the increased productivity, easier access to information, ease of new business formation, new technological and delivery possibilities, and benefits rooted in working together, rents of logistics properties should go upwards (Rivera et al., 2016; Porter, 1998). Also, according to Henderson (1986) the larger the number of workers in a certain industry will create a higher opportunity to exchange knowledge.

In order to identify these economies of agglomeration, job related data is used in the hedonic models. The LISA database contains employment data of over 30 years and is therefore used to identify these economies in the logistics sector. The data includes data from macro to micro level, regarding employment numbers from province to property.

With the LISA-database two indices were constructed which both in their own way measures the concentration of (logistics)jobs in a region. Both indices are based on the municipality as a region. Smaller regions such as zipcode 4 areas weren't feasible due to a lack of data. The indices used in this these are the location quotient (LQ) and the Ellison-Glaeser index (EGI). A short explanation is given per index, on the why, when, and how to calculate the certain indices. Furthermore, some limitations per index are described in order to show some shortcomings.

- **Location Quotient**

The location quotient (LQ) has been widely used by researchers in economic geography and regional economics since the 1940s. However, only a handful of development professionals are known to the technique. The technique is, for the most part, even underutilized and largely unappreciated (Isserman, 1977).

For the economic development researcher/professional, the location quotient is one of the most basic analytical tools available. The purpose of the technique is to yield a coefficient, or a simple expression, of how well an industry is represented in a given study region. For example, in the United States, a state can be compared to a larger region such as the whole country. With the location quotient, given the experience of the reference region, we can determine whether the study region has its “fair share” of an industry (Emsi, 2011).

The location quotient is measured on a simple numeric scale, with a quotient of less than one indicating that an industry is “underrepresented” in that study area compared to a reference area. A quotient of one indicates that the region has an identical share to the reference region in that industry. And a quotient of more than one means off course that the region has “more than its share” of an industry compared to the reference region (Emsi, 2011).

In short, the location quotient is the ratio of an industry’s share compared to that of another region. In formula form, let us assume that the area you want to study is a region (r) of a nation (n), and that the employment (E) is the measure of economic activity. In this thesis the share of logistics jobs in a municipality compared to the province. Then the location quotient for industry *i* may be expressed as:

$$LQ_i = \frac{E_{ir}}{E_r} / \frac{E_{in}}{E_n}$$

Where, for example, E_{ir} represents the municipalities employment in industry *i*. E_r representing the total employment in municipality (r), E_{in} the employment in the province in industry *i*. And lastly, E_n is the total employment in the province (Isserman, 1977).

The best attribute of the location quotient is its simplicity. This is just as good news as bad. The good news is the fact that the location quotient can easily be employed. Also, the data necessary for the calculation are easily to come by. The bad news is that the findings with the location quotient cannot always be taken at face value. The location quotient, by itself, says nothing. There can and will be very good reasons why there is an industry under- or over representative in a region. The location quotient will show where the region stands compared to the reference region, but it’s still up to the researcher to evaluate the labour limitations, market access, natural advantages, or other factors that will influence the share of industry employment. Nonetheless, economic developers continue to use the Location Quotient, despite these caveats and cautions. When high resolution data are scare, or more subjective approaches are deemed unsatisfactory, or when the cost for advanced methodologies are too high, the location quotient can be a perfect instrument (Isserman, 1977).

In this thesis the location quotient is measured in a similar way as described above. The share of logistics jobs is compared to the number of total jobs in every municipality per year. Then this share is divided by the share of logistics jobs compared to the total jobs in the whole province.

- **Ellison-Glaeser Index**

The other index used in this thesis is the Ellison and Glaeser’s index (EGI). Ellison and Glaeser (1997) presented an index for agglomeration economies based on a test of comparison between the observed geographic distribution of firms and a random distribution. The randomness of a geographic distribution is in this index defined as the distribution which is expected when there is an absence of economies of agglomeration. Ellison and Glaeser started with a simple location model where they hypothesize that plants gather together either to internalize externalities from other establishments or to benefit from local natural advantages. They first defined an index of raw geographic concentration:

$$G_i = \sum_i (s_{ic} - x_c)^2$$

Where s_{ic} is the share of industry *i*'s employment in area *c* and x_c is the share of aggregate logistics employment in area *c*. Industrial concentration of an industry *i* is measured using the Herfindahl-Hirschman index:

$$H_i = \sum_j z_{ij}^2$$

The Herfindahl-Hirschman index is defined as the sum of squared employment shares by industry *i*, where in this case *j* = 1, 2, …, n, number of firms. The H_i is the function of the number and size distributions of establishments/firms in industry *i*. When a region has a small number of establishments and an uneven size distribution in a certain industry then this index will generally be very high (Ellison & Glaeser, 1997).

The raw geographic concentration G_i of an industry *i* should be proportional to its industrial concentration H_i if there are no agglomeration economies. Ellison and Glaeser show that:

$$E(G_i) = \left(1 - \sum_i x_i^2\right)[H_i + y(1 - H_i)]$$

From which they derived an estimator of excess concentration, called the agglomeration index.

$$\hat{y}_i = \frac{G_i - \left(1 - \sum_i x_i^2\right) H_i}{\left(1 - \sum_i x_i^2\right)(1 - H_i)}$$

While the Ellison and Glaeser index is somewhat more complex compared to the Location Quotient, the index is based on standard concentration ratios and can be constructed with readily available data. The index defines concentration as agglomeration above and beyond what we would observe if establishments/firms simply chose locations randomly (Ellison & Glaeser, 1997).

The index is very useful in showing if and where there is an excess-concentration of an industry but does not tell us what the origin of this excess-concentration is, for example natural advantages or economies of agglomeration. Ellison and Glaeser show that y_i is zero when there are no economies of agglomeration or other natural advantages. Positive values of the index indicating localization of firms beyond that expected by pure randomness. Whereas negative values show or indicating that establishment or firms choose to locate more separate or diffusely than expected by randomness.

3.4.5 Fixed effects

In order to account for changes and correlations within the time period of the transactions in the database (1989-2017), year fixed effects are introduced in the model. Locational fixed effects (COROP region) are added to control for differences in transaction prices between the various COROP-regions where the properties are located. A smaller scale is due to the scale of the study area not feasible, which will also make the results biased.

3.5 Variables description

In table 3.1 detailed information is shown of the employed variables, the variable type (dummy, categorical, or continuous), the transformation that has been undertaken (some irrelevant data entries were dropped, or the natural logarithm was used for a better fit in the model) and the description of the variable.

Table 3.1: Description of the variables.

Variable	Variable type	Transformation	Description
Dependent variable			
Log Rent per square meter	Continuous	Natural logarithm	Rents per square meter < 15,- & > 80,- were dropped
Independent variables			
Property characteristics			
Log Surface Logistics	Continuous	Natural logarithm	Natural logarithm of the property logistics surface;
Log Surface Office	Continuous	Natural logarithm	Natural logarithm of the property office surface
Year Build	Continuous		The year the property was build
New Property	Dummy		Dummy for new/existing build (New = 1)
Function	Categorical		The function of the property; (1) Manufacturing; (2) Warehouse; (3) Distribution Centre
Locational characteristics			
Log Surface business park	Continuous	Natural logarithm	Natural logarithm of the surface of the business park
Growth business park	Continuous		The growth of the surface of the business park compared to the former land use dataset
Functional urban area	Categorical	Small FUA combined with commuting zone, due to low number of observations	Identification of the OECD of urban / rural areas; (1) Small FUA; (2) Medium FUA; (3) Metropolitan FUA; (4) Large Metropolitan FUA
Infrastructural characteristics			
Highway entrance	Continuous		Distance to the nearest highway entrance
Train station	Continuous		Distance to the nearest train station
Traffic Congestion	Continuous		The length of a congestion times the duration per quarter a year
Job characteristics			
Location Quotient	Continuous		Statistical measure of concentration based on job figures/data
Ellison-Glaeser index	Continuous		
COROP fixed effects	Categorical		COROP region
Year fixed effects	Categorical	Year 1986 & 1988 were dropped	Transaction year

In table 3.2 the descriptive statistics of the variables of the full sample are shown. These are the statistics of the variables which are included in the regression analysis. Some of these descriptive statistics are important to point out. First, regarding the dependent variable rents per square meter, the mean rent is circa € 40 per square meter, with surfaces averaged of 1,900 m² for logistics and 100 m² for the office space. The maximum price per square meter is almost € 80 per square meter. This could indicate that this property contains more office space and is basically used as an office. This is also the reason why observations with higher prices per square meter were dropped from the database. Also, the share of new properties in the database is only 2.9%, with construction years running from 1901 to 2014.

Table 3.2: Description statistics of the sample

Variable	Obs.	Mean	Std. Dev.	Min	Max
Dependent variable					
Rent per m²	511	39.98	12.92	15.43	78.41
Independent variables					
Property characteristics					
Logistics Surface (m²)	511	1,900.67	1,988.30	200	12,676
Office Surface (m²)	511	107,58	193.53	0	1,420
New Property	511	0.029	0.17	0	1
Manufacturing	511	0.22	0.42	0	1
Warehouse	511	0.16	0.37	0	1
Distribution Centre	511	0.62	0.49	0	1
Locational characteristics					
Surface business park (ha)	511	329.64	237.39	7.98	856.58
Growth business park (%)	511	20.78	70.98	-89.27	488.61
Commuting Zone/Small FUA	511	0.11	0.31	0	1
Medium FUA	511	0.12	0.32	0	1
Metropolitan FUA	511	0.76	0.43	0	1
Large Metropolitan FUA	511	0.02	0.12	0	1
Infrastructural characteristics					
Highway entrance (m)	511	1,951.00	1,758.16	12.00	14,371.60
Train station (m)	511	4,399.37	3,546.90	66.30	16,478.20
Traffic Congestion	511	11.29	1.97	7.70	15.60
Job characteristics					
Location Quotient	511	1.33	1.82	0.035	30.63
Ellison-Glaeser index	511	0.67	4.86	-18.17	90.13

Next, approximately 11% of the transactions took place in a small FUA, 12% in a medium FUA, 76% in a metropolitan area and only 2% in a large metropolitan area. The low number of transactions in a large metropolitan area can be explained by the fact that only a small area in the province is defined as a large metropolitan area, this due to the fact of higher population density in the cities of Dordrecht and Rotterdam, which both aren’t in the study area Noord-Brabant. Lastly, the economies of agglomeration indices show highly different values indicating municipalities which show high and low concentrations of logistics activity.

4. Results

In this chapter, the results of the hedonic price models are presented which will give an answer to the three hypotheses mentioned in chapter 2. These will help to answer the main research question: *"To what extent does spatially clustering of logistics firms create economies of agglomeration in the province of Noord-Brabant?"* Multiple hedonic models are set up, with in every subsequent model extra variables are added. In this way, the impact per addition of characteristics on the property rents can be measured.

Table 4.1: Baseline specification, models 1, 2 and 3.

Models	(1)	(2)	(3)
Variables	(Log Rents per Sqm)	(Log Rents per Sqm)	(Log Rents per Sqm)
Property characteristics			
Log Surface Logistics	-0.121***	-0.120***	-0.135***
	(0.0174)	(0.0176)	(0.0162)
Log Surface Office	0.0279***	0.0274***	0.0148***
	(0.00575)	(0.00579)	(0.00543)
Year Build	0.00754***	0.00744***	0.00482***
	(0.000782)	(0.000789)	(0.000771)
New Property	0.105	0.101	0.262***
	(0.0734)	(0.0737)	(0.0698)
Function			
Manufacturing	-0.00919	-0.00957	-0.0252
	(0.0306)	(0.0307)	(0.0282)
Warehouse	-0.0195	-0.0232	-0.0104
	(0.0353)	(0.0356)	(0.0327)
Locational characteristics			
Log Surface business park	0.00633	0.00742	0.0116
	(0.0120)	(0.0122)	(0.0114)
Growth business park	-0.000064	-0.0000308	0.000176
	(0.000210)	(0.000189)	(0.000180)
Functional urban area			
Small FUA	-0.128***	-0.122***	-0.153***
	(0.0414)	(0.0443)	(0.0406)
Medium FUA	-0.172***	-0.173***	-0.198***
	(0.0389)	(0.0424)	(0.0396)
Large Metropolitan FUA	0.0348	0.346	-0.00521
	(0.103)	(0.106)	(0.106)
COROP Fixed Effects	No	Yes	Yes
Year Fixed Effects	No	No	Yes
Constant	-10.582***	-10.406***	-5.385***
	(1.557)	(1.570)	(1.522)
Observations	511	511	511
R-Squared	0.3148	0.3163	0.4825

Standard errors in parentheses

***p<0.01 **p<0.05 *p<0.1

Note: the reference group for **New Property** is 'Existing build'; for **Function** it is 'Distribution centre'; for **Functional urban area** it is 'Metropolitan FUA'; the coefficients of the variables **COROP Fixed Effects** and **Year Fixed Effects** can be found in the appendix.

Table 4.1 presents the results of the first hedonic models. In these models the property and locational characteristics are added, with in addition the year- and COROP fixed effects. The models differ whether the fixed effects are added. In these models we can examine the impact of the property characteristics, locational characteristics, and year/COROP fixed effects on the explained variance (R-squared).

Before the hedonic models are set up, several assumptions[2] are checked regarding the regression models. These assumptions must be met in order to get non-biased results. The data from the Strabo- and LISA database are adjusted where necessary.

In model 1 only the control variables for property and location are added. In models 2 and 3, the year- and COROP fixed effects are added. The R-squared for model 1 and 2 are relatively low (respectively 31.48% & 31.63%). When adding the year fixed dummies, the R-squared raises to 0.4825 (model 3). Meaning that the variation of the rents per square meter of logistics properties for approximately 48.25% is explained by the variables in the regression model. Model 3 is used as the base model for the upcoming hedonic models, therefore this model will be discussed in further detail.

First, the property characteristics: 'Surface Logistics', 'Surface Office', 'Year Build' and 'New Property' are all significantly different from zero on a 99% level, indicating that these characteristics all significantly impact the rents per square meter and therefore are important parameters for logistics real estate. Also, the variables 'Small FUA' and 'Medium FUA' are significantly different from zero on a 99% level. Indicating that logistics real estate located in different functional urban areas impacts rents.

Zooming in per variable, we see a coefficient of -0.135 for the variable 'Surface Logistics'. Because the dependent variable and the independent variable 'Surface Logistics' are transformed to a natural logarithm, we can interpret the result as follows: if the property surface increases by ten percent, the rents per square meter decreases by 1.35%. Concluding, properties with larger logistics space show significantly lower property rents per square meter. Due to a usually higher demand for smaller logistics units this result is quite understandable. The coefficient of 'Surface Office' is 0.0148, concluding that an increase of office space by ten percent results in an increase of rents by 0.148%. Regarding new or existing build, new build properties have rents that are approximately 30%[3] higher than existing build properties. Lastly, if the building year increases by one the rents per square meter will increase by 0.48%. Indicating that newer properties show higher rents per square meter.

Regarding the locational characteristics, we see no significant change in the rents per square meter influenced by the surface or growth of the business park. The predefined functional urban areas 'Small FUA' and 'Medium FUA' are significantly different from zero on a 99% level. In this case due to the fact the variable type is categorical the Small, Medium and Large Metropolitan FUA's are compared to the reference group 'Metropolitan FUA. This reference group was chosen due to the large number of transactions which took place in this FUA in the database. First, the variable type 'Large Metropolitan FUA' is not significant significantly different from zero, meaning that the rents per square meter aren't different to the rents per square meter in the 'Metropolitan FUA'. The Small FUA and Medium FUA are significantly different from zero on a 99% level. The rents per square meter of logistics properties are 14.19% lower in the 'Small FUA' and 17.96% lower in the 'Medium FUA' compared to the 'Metropolitan FUA'. The total results of model 3 are presented in appendix III.

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[2] The assumptions indicate that, first there is a linear relationship between the dependent and independent variables collectively, this is checked by plotting multiple scatterplots. Second, the homoscedasticity is checked by plotting the studentized residuals (r), observations are dropped when r > 2.5 and r < -2.5. Third, the multicollinearity of the variables is checked with a correlation matrix and later on with VIF values. The VIF values of the variables are all beneath 2.16 which indicate an absence of multicollinearity between the variables. After that heteroscedasticity was checked with the Breusch-Pagan test, which showed no signs of heteroscedastic residuals. Then, the distribution of the residuals was checked with a PP Plot and QQ Plot, and a Skewness/Kurtosis test. Last, significant outliers were identified and dropped using a boxplot.

[3] (((exp^ 0.262)-1) *100); (the other results are calculated the same way).

Table 4.2 present models 4, 5, 6 and 7, model 3 will serve as the base model. In these models the infrastructural characteristics are added. In model 7 all variables are added. In model 4, 5 and 6 the infrastructural characteristics are separately added, which shows the impact per infrastructural characteristic on the whole model.

Table 4.2: Models 4-7; Base model 3 including infrastructural characteristics.

Models	(4)	(5)	(6)	(7)
Variables	(Log Rents per Sqm)	(Log Rents per Sqm)	(Log Rents per Sqm)	(Log Rents per Sqm)
Property characteristic				
Log Surface Logistics	-0.167***	-0.119***	-0.163*	-0.186*
	(0.0230)	(0.0253)	(0.0872)	(0.0885)
Infrastructural characteristics				
Highway entrance	-0.128**			-0.118*
	(0.0633)			(0.0633)
Highway entr.* Log Surface Logistics	0.0162*			0.0149*
	(0.00867)			(0.00866)
Train Station		0.0246		0.0200
		(0.0328)		(0.0329)
Train Station* Log Surface Logistics		-0.00389		-0.00337
		(0.00454)		(0.00456)
Traffic Congestion			0.0715	0.0650
			(0.0650)	(0.0656)
Traffic Cong.* Log Surface Logistics			0.00239	0.00314
			(0.00735)	(0.00741)
Property characteristics	Yes	Yes	Yes	Yes
Locational characteristics	Yes	Yes	Yes	Yes
COROP Fixed Effects	Yes	Yes	Yes	Yes
Year Fixed Effects	Yes	Yes	Yes	Yes
Constant	-4.711***	-5.613***	-5.922***	-5.462***
	(1.544)	(1.536)	(1.652)	(1.555)
Observations	511	511	511	511
R-Squared	0.4887	0.4839	0.4892	0.4966
Note: Dependent variable is ln (Rents per square meter). Standard errors in parentheses				
***p<0.01 **p<0.05 *p<0.1				

Note: the coefficients of the variables **COROP Fixed Effects** and **Year Fixed Effects** can be found in the appendix.

These infrastructural characteristics were added due to their importance highlighted by different authors. According to Bok (2009) and Berechman (1994), the logistics real estate sector and their operations, are all driven by accessibility and the general infrastructure nearby. For foreign logistics firms, one of the most important determinants, considering location strategy, is the transportation accessibility (Hong, 2007).

In order to measure the accessibility and infrastructural characteristics on logistics firms and their real estate, three variables are added to the models. These are the distance to a highway entrance, the distance to a train station and the traffic congestion. In addition to the basic variables, interaction variables are added. The infrastructural characteristics are interacting with the variable 'log surface logistics'. These interaction variables measure the impact of the infrastructure on the property rents, regarding their logistics surface. Different studies suggest that some firms, based on their size, may have greater benefits than others regarding economies of agglomeration. According to Shaver & Flyer (2000) firms which already possess superior technologies and human capital, in this case the larger firms, do not have the incentive to cluster. On the contrary, Alcácer & Chung (2007) suggest that smaller firms cannot absorb the spillovers of economies of agglomeration due to their lack of technology and (human) capital.

When reviewing models 4-7, the variables 'Highway entrance' and the interaction variable 'Highway entrance * Log Surface Logistics' are the only two variables significantly different from zero. Concluding, the distance to a train station and the level of congestions and their interactions with the logistics surfaces do not impact the rents per square meter of logistics real estate. The variable highway entrance is significant and got a coefficient of -0.118. Meaning that when the distance to the nearest highway entrance increases by one kilometre the rents per square meter will rise by 11.13%.

Interpreting the interaction variable is somewhat more difficult. In order to measure the impact of the distance of the highway entrance regarding the logistics surfaces, the coefficients of the variables in model 7 are put in to the next formula: Coefficient Highway = -0.181 + 0.0149 * Log Surface. Different surfaces of the logistics space will be filled in, in order to conduct the coefficients. These coefficients can later on be interpreted as the percentage change of the rents when the distance to the highway entrance increases by one kilometre. In table 4.3 the logistics surfaces are shown with corresponding coefficient and percentage change of the rent per square meter.

Table 4.3: Interpretation interaction variable 'Highway * Log Surface Logistics'

Surface Logistics (m²)	**500**	**1000**	**1500**	**2000**	**2500**	**5000**	**10000**	**15000**
Coefficient Highway	-0,0254	-0,0151	-0,00903	-0,00475	-0.00142	0,00891	0,0192	0,0253
Δ% Rent/m²	-2,51%	-1,50%	-0,90%	-0,47%	-0.14%	0,89%	1,94%	2,56%

Notable is the difference in percentages regarding the 11.13% calculated above. This can be explained by the significant impact of the logistics surface on the importance of the distance to the highway entrance. According to table 4.3, above 2,500 m² logistics surface the rents increases when the distance to the highway increases. Recalling: "if firms are paying higher rents in a particular location all else equal, then the location must have some compensating productivity differential (Rosenthal & Strange, 2005)." In other words, for the relatively smaller logistics firms the rents are higher closer to the highway entrance, for the larger firms it's the other way around. Concluding that the distance to the highway entrance is a compensating productivity differential for smaller firms, and therefore an important determinant considering location strategy. This isn't the case for larger firms.

Table 4.4 presents models 8-11, model 7 will serve here as the base model. In these models the job concentration variables 'Location Quotient' and 'Ellison-Glaeser index' are added. Just as in the previous models, interaction variables are added in order to account for differences in logistics space. Because of multicollinearity the indices couldn't be added to the same model. The job concentration variables are measured and based on the job figures in their respective year. For example, the year the transaction took place is the same year the job figures are from.

Table 4.4: Models 8-11; Base model 7 including job concentration variables.

Models	(8)	(9)	(10)	(11)
Variables	(Log Rents per Sqm)	(Log Rents per Sqm)	(Log Rents per Sqm)	(Log Rents per Sqm)
Location Quotient	-0.000502	-0.119		
	(0.00676)	(0.148)		
LQ* Log Surface Logistic		-0.0172		
		(0.0214)		
Ellison-Glaeser index			0.00363*	0.0341
			(0.00239)	(0.0361)
EGI* Log Surface Logistic				-0.00461
				(0.00546)
Infrastructural characteristics	Yes	Yes	Yes	Yes
Property characteristics	Yes	Yes	Yes	Yes
Locational characteristics	Yes	Yes	Yes	Yes
COROP Fixed Effects	Yes	Yes	Yes	Yes
Year Fixed Effects	Yes	Yes	Yes	Yes
Constant	-5.452***	-5.202***	-5.512***	-5.567***
	(1.690)	(1.719)	(1.618)	(1.683)
Observations	511	511	511	511
R-Squared	0.4966	0.4925	0.4991	0.4999

Note: Dependent variable is ln (Rents per square meter). Standard errors in parentheses

***p<0.01 **p<0.05 *p<0.1

In the models 8-11 the only variable that's significantly different from zero is the 'Ellison-Glaeser index' in model 10. The variable is significantly different from zero on a 90% level. This significance level indicates lower reliability of the estimates and therefore uncertainty in the results. Nevertheless, the concentration index significantly effects the logistics property rents. The coefficient of the variable is positive at 0.00363. Recalling the interpretation of the Ellison-Glaeser index: 'when the index is zero there are no economies of agglomeration there are no economies of agglomeration or other natural advantages. Positive values of the index indicate localization of firms beyond that expected by pure randomness. Whereas negative values show or indicate that establishments or firms choose to locate more separate or diffusely than expected by randomness.' Concluding this interpretation, the positive value indicates localization of firms beyond that expected by pure randomness. Firms will locate to places where logistics jobs are concentrated. Whereas rents rise with 0.36% when the Ellison-Glaeser index increases by one point. Respectively, when the index raises by ten points, the rents per square meter increases by 3.6%.

Second, the interaction variables are not significant in the models, meaning that we cannot accept hypotheses 3. Company size only effects, based on the previous models, the importance of a nearby highway ramp and has no impact on the benefits of economies of agglomeration. Therefore, we contradict the findings of Shaver & Flyer (2000) and Alcácer & Chung (2007), which all argued that company size does impact the benefits of economies of agglomeration.

5. Discussion

5.1 Company size and economies of agglomeration

Due to the increasingly clustering of logistics activities, many researchers have tried to examine and measure the attribution of economies of agglomeration on this clustering. Marshall (1920) was the first who described three main sources of economies of agglomeration, namely labour market pooling, input sharing, and knowledge spillovers. Same industry firms which were clustered in a specific area or region should all benefit from these main sources of economies of agglomeration. According to Shaver & Flyer (2000) and Alcácer & Chung (2007) this equally benefitting isn't the case. They stated that firms which already possesses superior technologies, suppliers, distributors, and human capital does not have the incentive to cluster with other same industry firms. Also, whether a firm can absorb the economies of agglomeration is crucial when clustered. Some smaller firms can't leverage the economies due to a lack in (human) capital.

In this study, the effects of company size on economies of agglomerations have been plotted in the hedonic models. Starting with interaction models regarding infrastructural characteristics. Many authors highlighted the importance of the general infrastructure and accessibility as the main factor for logistics clusters (Bok, 2009; Berechman, 1994; Hong, 2007). These studies didn't account for differences in company size regarding the importance of infrastructure. According to the hedonic models in this study, smaller logistics firms do have an incentive to locate near a highway entrance. In contrast to the bigger firms, which show higher property rents further away from highway entrances. Concluding, the distance to the highway can be seen as a compensating productivity differential for smaller firms, and therefore an important determinant considering location strategy. A possible explanation for this could be the fact that larger firms more or mostly depend on their human capital and superior technology and knowledge in contrast to their location near infrastructural nodes.

When measuring the effects of company size on the property rents, regarding the concentration of logistics jobs, no significant effects can be found in the hedonic models. Concluding that there is no difference in the importance of the concentration of logistics jobs nearby, regarding the company size.

5.2 Concentration of jobs and economies of agglomeration

All over the world, new logistics clusters are in development or existing clusters are expanding. Many studies suggest this is mainly due to the presence of economies of agglomeration (Rivera et al., 2014). Economies of agglomeration are an economy of scale and can occur when economic activity is spatially clustered (Mukkala, 2004). Regarding the logistics sector, these economies of agglomeration, can provide firms with a more flexible labour market, combining of transport flows, a decrease in distance between customers, and clustered firms can put in more weight in lobbying for improved infrastructure and regulatory relief with the local government (Van Donselaar et al., 1999; Van den Heuvel et al., 2012; Rivera et al., 2014).

Within the existing literature there is an array of research on economies of agglomeration. Many findings suggest that these economies impacts the rents by up to five percent, albeit in the office sector (Drennan & Kelly, 2009; Koster et al., 2014). Other studies argued the downside of clustering of similar firms. Agglomeration diseconomies can occur, such as high land/lease prices or an increase in competition (Van den Heuvel, 2013; Holmes & Stevens, 2002).

In this study job concentration indices were used in order to measure economies of agglomeration in the logistics sector. These indices both measured the concentration of logistics jobs in a specific municipality. Only one of the two indices had a significant impact on the rents of logistics properties. This concentration index is significantly different from zero on a 90% significance level, meaning that the reliability of the results is lower compared to when significant on a 95% or 99% significance level. Concluding that, regarding the logistics sector, there is evidence of economies of agglomeration benefitting firms that cluster, but that these results can be described as less reliable. Also, the Location-Quotient index was not significantly different from zero on all significance levels indicating no impact of clustered jobs on the property rents.

5.3 Data limitations and further research

Just like other studies, this research has its limitations concerning the data. First of all, we used the rents as a measurement for economies of agglomeration. Very few studies use rents in order to measure the presence of agglomeration economies. Still some have shown that agglomeration economies mainly capitalize in rents (Koster et al., 2014; Arzaghi & Henderson, 2008; Drennan & Kelly, 2009). Suggested is to use property yields in order to measure economies of agglomeration. The property yield is calculated by dividing the annual rental income on the costs of buying it. Therefore, the property yields are susceptible to the market conditions, where higher yields reflect higher risks for potential investors. In other words, when the demand for property is high, the cost of buying will increase, which then automatically lowers the yield. Rents do not explicitly reflects demand, because higher rents can easily be the result of other property- or locational characteristics. Second, the database of Strabo contained of thousands of transactions. Unfortunately, due to missing or lacking data, and further stratification the database was largely reduced to only 511 observations. A larger database would result in more accurate findings. Last, the LISA dataset contains data of jobs from 1995 to 2016. Because of the high number of observations that was already removed from the database, the transactions (Strabo dataset) from 1989 to 1994 were matched to the job characteristics of 1995 (LISA dataset) in order to prevent losing more observations.

For further research on economies of agglomeration in the logistics sector it is suggested to research this phenomenon on a smaller regional scale. The database must be sufficient when studying a smaller region. Thereby, a combination of quantitative and qualitative research could and should give a broader perspective on the matter. It is very interesting to know why individual logistics firms chose a specific location to settle. And if this is in a specific cluster, what benefits or disbenefits they experience from it.

6. Conclusion

This paper investigated the effect of economies of agglomeration on the rents of logistics real estate. The approach to use rents stems from the quality-of-life literature and means: “if firms are paying higher rents in a particular location all else equal, then the location must have some compensating productivity differential (Rosenthal & Strange, 2005).“ Rents of logistics properties should be higher when co-locating with same industry firms due to different advantages such as an increased productivity, easier access to information, ease of new business formation, new technological and delivery possibilities, and benefits rooted in working together with other institutions such as universities and public organizations (Rivera et al., 2016; Porter, 1998).

To estimate the effect, multiple hedonic pricing models were conducted. Hence, giving an answer on the main question: *“To what extent does spatially clustering of logistics firms create economies of agglomeration in the province of Noord-Brabant?”*

The findings did not all support the three hypotheses mentioned in chapter 2.2. First, logistics firms only pay significant higher property rents when located near a highway ramp, regarding properties with logistics space less than 2,500 m². This is not the case for firms bigger than 2,500 m². Second, logistics firms pay higher prices in predefined Urban areas. The rents per square meter of logistics properties are 14.19% lower in the ‘Small FUA’ and 17.96% lower in the ‘Medium FUA’ compared to the ‘Metropolitan FUA’. These functional urban areas are based on population numbers, which indicate that near higher sources of population, the rents are significantly higher. Lastly, with the use of the LISA database and the Herfindahl-Hirschman index the concentration indices like the Ellison-

Glaeser index and Location Quotient were constructed. While the Ellison-Glaeser index is somewhat more complex compared to the Location Quotient, both indices are based on standard concentration ratios and can be constructed with readily available data. Of these concentrations indices the Ellison-Glaeser index has a significant effect on the rents of logistics real estate. Recalling the interpretation of the Ellison-Glaeser index: ‘when the index is zero there are no economies of agglomeration or other natural advantages. Positive values of the index indicating localization of firms beyond that expected by pure randomness. Whereas negative values show or indicating that establishment or firms choose to locate more separate or diffusely than expected by randomness.’ When the Ellison-Glaeser index rises by ten points the rents per square meter grow by 3.6%, indicating that in regions where localization of firms are beyond that expected by pure randomness, the rents increase. Carefulness is required however. Because the significance is based on a 90% level, the impact can be considered less reliable than to be preferred. Also, the Location-Quotient was not significantly different from zero on all significance levels indicating no impact of clustered jobs on the property rents.

References

Arzaghi, M. & Henderson, J.V. (2008). Networking off Madison Avenue. *Review of Economic Studies,* 75, 1011-1038.

Berechman, J. (1994). Urban and regional economic impacts of transportation investment: a critical assessment and proposed methodology. Transport. Res. Part A: Policy Pract. 28(4), 351-362.

Bok, M. (2009). Estimation and validation of a microscopic model for spatial economic effects of transport infrastructure. Transport. Res. Part A: Policy Pract. 43, 44-59.

Bounie, N. & Blanquart, C. (2017). Logistics Centers and Agglomeration Economies: Logistics Clusters or Co-located Logistics Activities? The French Case. *World Conference on Transport Research.*

Cairncross, F. (1997). The Death of Distance. Orion Business Books, London.

Carbonara, N., Giannoccaro, I. & Pontrandolfo, P. (2002). Supply chains within industrial districts: A theoretical framework. *International Journal of Production Economics,* Vol. 76, Issue 2, pp. 159-176.

Carlton, D.W. (1983). The Location and Employment Choices of New Firms: An Econometric Model with Discrete and Continuous Endogenous Variables. *Review of Economics and Statistics,* 65: 440-449.

Catin, M. (1997). Disparités spatiales de productivité, accumulation du capital et économies d'agglomération. *Revue économique,* Vol. 48, No. 3, pp. 579-589.

Chatterjee, S. (2003). Agglomeration Economies: The Spark That Ignites a City? *Business Review,* 6(Q4), pp. 6-13.

Council of the Americas, 2011. Join us for Panama: Where the World Meets. Council of the Americas.

Courlet, C. (2008). L'économie territorial, Presses Universitaires de Grenoble, Grenoble.

Cruijssen, F., Cools, M. & Dullaert, W. (2007a). Horizontal cooperation in logistics: opportunities and impediments. Transportation Research Part E 43, 129-142.

Cruijssen, F., Dullaert, W. & Fleuren, H. (2007b). Horizontal cooperation in transport and logistics: a literature overview. Transportation Journal 46, 22-39.

Delgado, M. Porter, M. & Stern, S. (2010). Clusters and entrepreneurship. J. Econ. Geogr. 10, 495-518.

Dell'Orco, M., Sassanelli, D. & Tiso, A. (2009). Optimization of logistics in industrial districts through creation of a community agents. *Chemical Engineering Transactions,* Vol. 18, pp. 321-326.

Drennan, M.P. & Kelly, H.F. (2009). Measuring urban agglomeration economies with office rents. *Journal of Economic Geography*, 11 (2011) pp. 481-507.

Ellison & Glaeser (1997). Geographic concentration in U.S. manufacturing industries: A dartboard approach, NBER working paper no. 4840.

Emsi (2011). *Understanding Location Quotient*. [online] Available at: https://www.economicmodeling.com/2011/10/14/understanding-location-quotient-2/ [Accessed 15-09-2019].

Feitelson, E. & Salomon, I. (2000). The implication of differential network flexibility for spatial structures. *Transport. Res. Part A: Policy Pract.* 34, 459-479.

Fujita, M. & Krugman, P. (2004). The new economic geography: past, present and the future. *Papers in Regional Science,* 83, 139-164.

Holmes. T.J. & Stevens, J.J. (2002). Geographic concentration and establishments scale. *The Review of Economics and Statistics 84*, 682-692.

Government of Panama, 2010. Panama Plan Estrategico de Gobierno 2010-2014. Gaceta Oficial Digital.

Henderson, J.V. (1986). Efficiency of resource usage and city size. *Journal of Urban Economics,* 19, 47-70.

Henderson, J.V. (2003). Marshall's scale economies. *J. Urban Econ.* 53(1), 1-28.

Henderson, J.V. & Shalizi, Z. (2001). Geography and development. J. Urban Econ. 53(1), 1-28.

Hoehn, J.P., Berger, M.C. & Blomquist, G.C. (1987). A hedonic model of interregional wages, rents, and amenity values. *Journal of regional science*, vol. 27, no. 4.

Hong, J. (2007). Transport and the location of foreign logistics firms: the Chinese experience. Transport. Res. Part A: Policy Pract, 41, 597-609.

Hoover, E. (1937). Localization Theory and the Shoe and the Leather Industries. *Harvard University Press,* Cambridge.

Industrial (2018). *Logistics real estate: Dutch Market Report 2018.* [online] Available at: https://www.industrial.nl/wp-content/uploads/2018/02/Report-LOGISTICS-REAL-ESTATE_Dutch-Market-Report-2018-2.pdf [Accessed 12-02-2019].

Isserman, A.M. (1997). The location quotient approach to estimating regional economic impacts. *Journal of the American Institute of Planners.*

Jara-Díaz, S.R. & Basso, L.J. (2003). Transport cost functions, network expansion and economies of scope. Transportation Research Part E 39, 271-288.

Kasarda, J. (2008). The Evolution of Airport Cities and the Aerotropolis. Airport Cities: The Evolution. Insight Media, London.

Koster, H.R.A., Van Ommeren, J. & Rietveld, P. (2014). Agglomeration Economies and Productivity: A Structural Estimation Approach Using Commercial Rents. *Economica,* Vol. 81, no. 321.

Lasserre, F. (2008). Logistics and the Internet: transportation and location issues are crucial in the logistics chain. Journal of Transport Geography 12, 73-84.

Logistiek (2019). *Logistieke hotspots van 2019*. [online] Available at: https://intern.logistiek.nl/poster-logistieke-hotspots-2019?_ga=2.56487022.430825292.1557310091-1217709000.1534862583 [Accessed 12-5-2019].

Malmberg, A. & Maskell, P. (1997). Towards an explanation of regional specialization and industry agglomeration. European Planning Studies 5, 25-41.

Marshall, A. (1920). Principles of Economics (London: MacMillan).

Masson, S. & Petiot, R. (2014). Dynamiques spatiales des activités logistiques d'entreposage et économies d'agglomération: une analyse économétrique. 51st Colloque ASRDLF, Marne-la-Vallée.

Mattarocci, G. & Pekdemir, D. (2017). Logistic Real Estate Investment and REITs in Europe.

Moomaw, R.L. (1981). Productivity and city size: a critique of the evidence. *Quarterly Journal of Economics,* 96, 675-688.

Mukkala, K. (2004). Agglomeration Economies in the Finnish Manufacturing Sector. *Applied Economics*, 36, 2149-2427.

Peiser, R. B. & Schwanke, D. (1992). *Professional Real Estate Development, Urban Land Institute.* Washington: Dearborn Financial Publishing Inc.

Porter, M. (1998). Clusters and the new economics of competitiveness. *Harv. Bus.* Rev. 76, 77-90.

Porter, M. (2000). Location, competition, and economic development: local clusters in a global economy. Econ. Develop. Quart. 12, 15-42.

Rietveld, P. (1994). Spatial economic impacts of transport infrastructure supply. Transport. Res. Part A: Policy Pract. 28(4), 329-341.

Rivera, L. (2014). Logistics Clusters: Prevalence and Impact. *MIT,* pp. 129.

Rivera, L., Sheffi, Y. & Knoppen, D. (2016). Logistics clusters: The impact of further agglomeration, training and firm size on collaboration and value added services. *Int. J. Production Economics,* 179, 285-294.

Rivera, L., Sheffi, Y. & Welsch, R. (2014). Logistics agglomeration in the US. *Transportation Research Part A 59,* 222-238.

Rosenthal, S.S. & Strange, W.C. (2002). Evidence of the Nature and Sources of Agglomeration Economies. *Prepared for the Handbook of Urban And Regional Economies, Volume 4.*

Rosenthal, S.S. & Strange, W.C. (2005). The Geography of Entrepreneurship in the New York Metropolitan Area. *Reserve Bank of New York Economic Policy Review*, 11, 29-53.

Saxenian, (1994). Regional Advantage: Culture and Competition in Silicon Valley and Route 128. *Harvard University Press,* Cambridge, MA.

Shaver, M.J. & Flyer, F. (2000). Agglomeration Economies, Firm Heterogeneity, and Foreign Direct Investment in the United States. *Strategic Management Journal,* Vol. 21, no. 12, pp. 1175-1193.

Sveikauskas, L. (1975). The productivity of cities. *Quarterly Journal of Economics,* 89, 393-413.

Van den Heuvel, F.P., De Langen, P.W., Van Donselaar, K.H. & Fransoo, J.C. (2012). Spatial concentration and location dynamics in logistics: the case of a Dutch province. *Beta Working Paper 386, Research School for Operations Management and Logistics.*

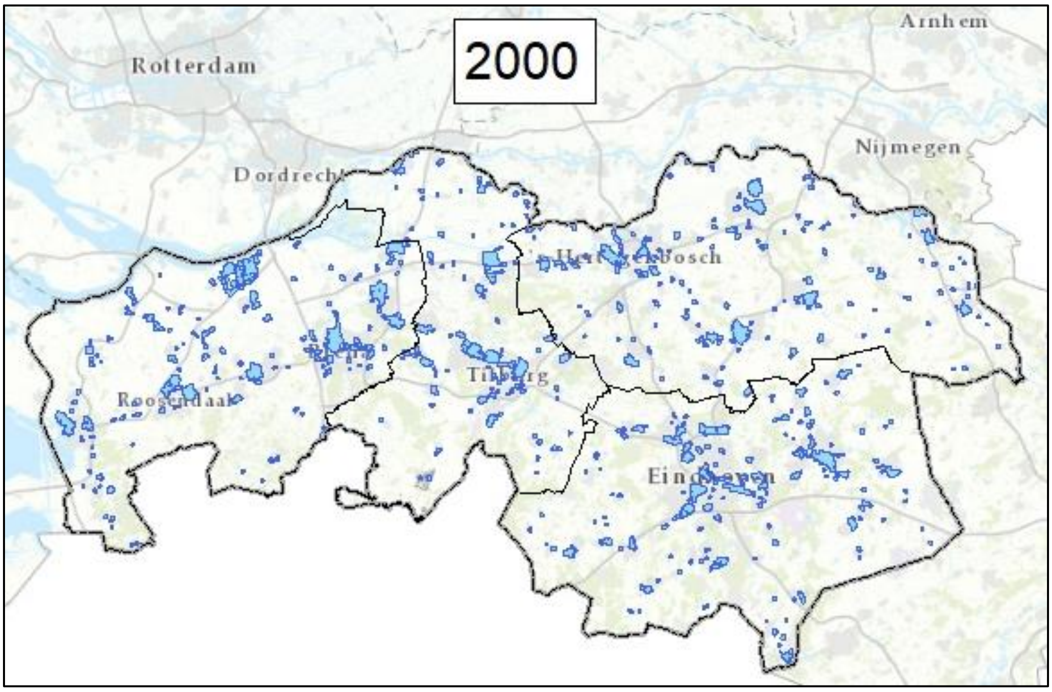
Van den Heuvel, F.P., De Langen, P.W., Van Donselaar, K.H. & Fransoo, J.C. (2013). Proximity matters: Synergies through co-location of logistics establishments. *International Journal of logistics: Research and Applications,* pp. 19.

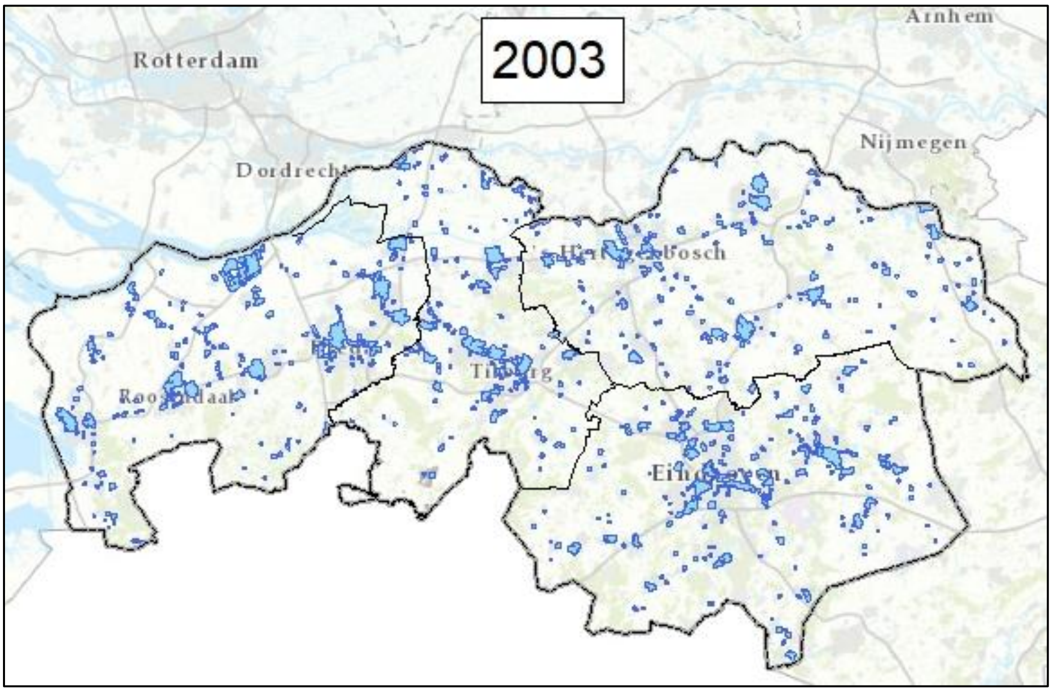
Van Donselaar, K. Kokke, K. & Allessie, M. (1999). Performance measurement in the transportation and distribution sector. International Journal of Physical Distribution & Logistics Management 28, 434-450.

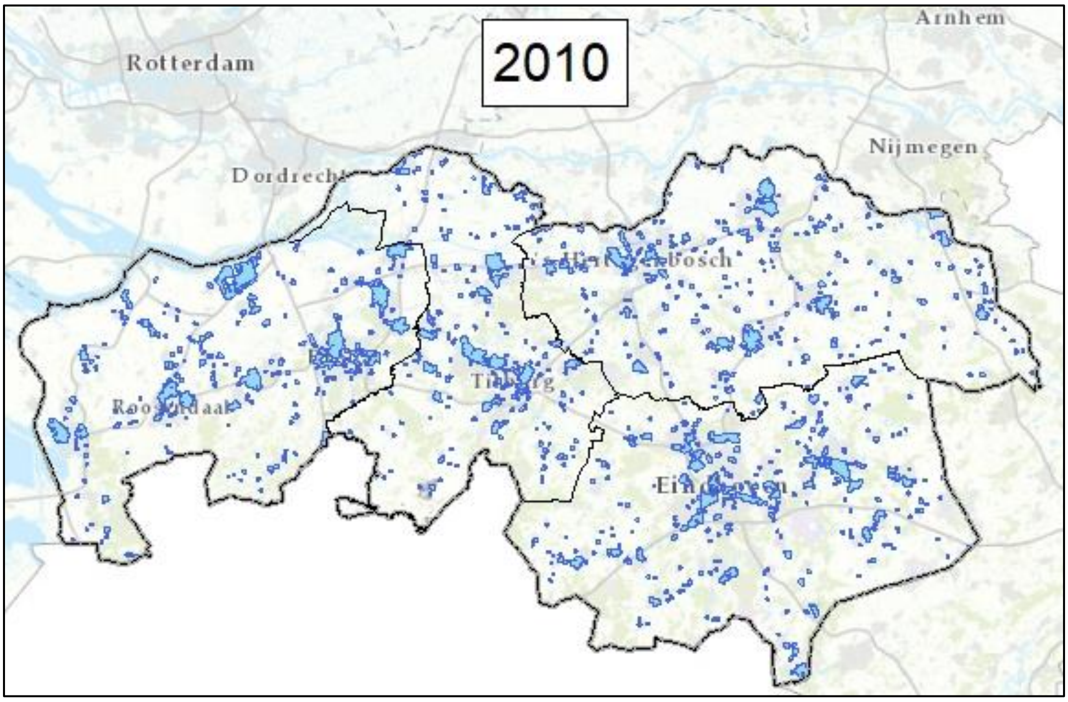
Wouters, M. Kokke, K. Theeuwes, J. & Van Donselaar, K. (1999). Identification of critical operational performance measures – a research note on a benchmarking study in the transportation and distribution sector. Management Accounting Research 10, 439-452.

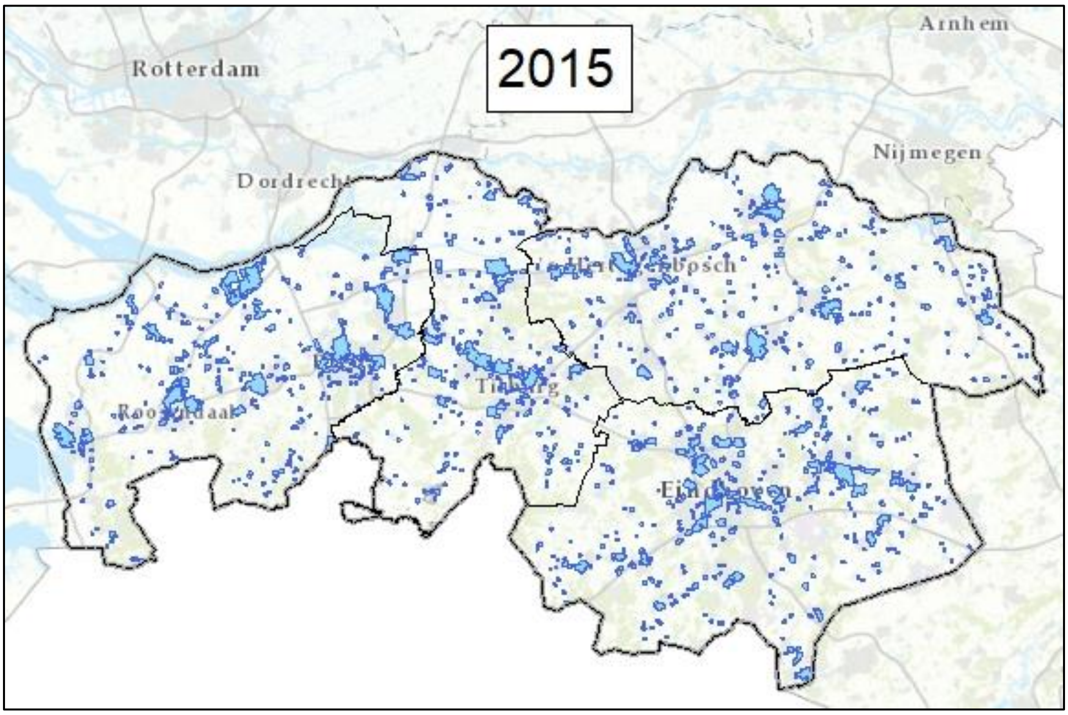
Wu, L. Yue, X. & Sim, T. (2006). Supply clusters: a key to China's cost advantage. Supp. Chain Manage. Rev., 46-51.

Appendix I: Business parks areas in Noord-Brabant, 2000, 2003, 2010 and 2015.






2010
Rotterdam
Arnhem
Nijmegen
Dordrecht


2015
Rotterdam
Arnhem
Nijmegen
Dordrecht

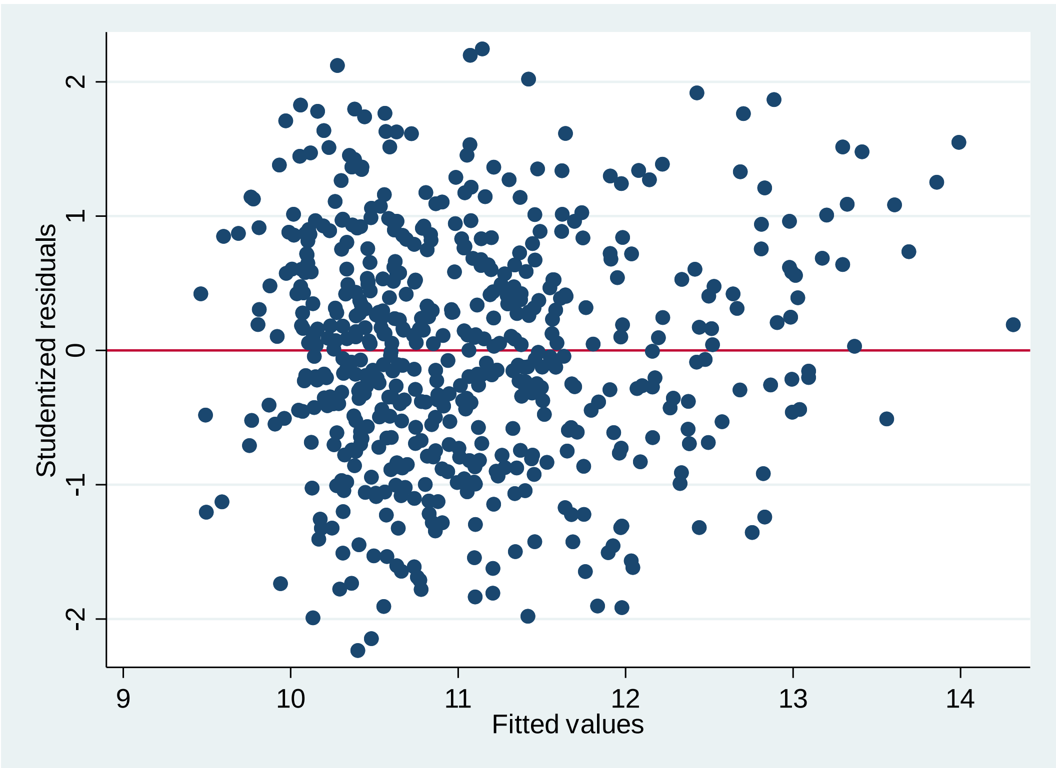
Appendix II: OLS assumptions

Correlation Matrix

Correlation Matrix	Log Rent per Sqm	Log Surface Logistics	Log Surface Office	Year Build	New Property	Manufacturing	Warehouse	Distribution Centre	Log Surface business park	Growth business park	Small FUA
Log Rent per Sqm	1.00										
Log Surface Logistics	-0.2707	1.00									
Log Surface Office	0.2418	0.0409	1.00								
Year Build	0.4009	0.0103	0.1626	1.00							
New Property	0.0992	0.0036	0.0245	0.0823	1.00						
Manufacturing	0.0331	-0.0727	0.0081	0.0281	0.0191	1.00					
Warehouse	-0.0769	0.2303	-0.0056	0.0161	-0.0451	-0.2346	1.00				
Distribution Centre	0.0301	-0.1126	-0.0027	-0.0362	0.0180	-0.6755	-0.5583	1.00			
Log Surface business park	0.0173	0.0903	0.0612	0.0554	-0.0219	0.0126	0.0282	-0.0322	1.00		
Growth business park	0.0132	-0.0618	0.0347	0.0402	-0.0263	-0.0087	-0.0475	0.0435	0.1662	1.00	
Small FUA	-0.0913	-0.0127	-0.0012	0.0267	-0.0604	0.0280	0.0354	-0.0507	0.0997	0.2292	1.00
MediumFUA	-0.1948	0.0726	-0.0388	-0.0431	-0.0274	-0.0625	-0.0288	0.0752	-0.0357	-0.0659	-0.1267
Metropolitan FUA	0.2027	-0.0804	-0.0012	-0.0071	0.0708	0.0353	-0.0127	-0.0205	-0.0586	-0.1710	-0.6168
Large Metropolitan FUA	0.0352	0.1206	0.1077	0.0696	-0.0219	-0.0292	0.0299	0.0022	0.0455	0.1874	-0.0438
Highway entrance	-0.0649	-0.0262	-0.0067	-0.0750	-0.0645	0.0094	0.0263	-0.0280	0.0620	-0.0110	0.0406
Train Station	0.0042	0.0048	0.0023	0.1421	-0.0727	0.0553	0.0231	-0.0648	-0.0068	0.1897	0.6049
Traffic Congestion	0.2666	0.0984	0.0866	0.1976	-0.0423	0.0255	0.0338	-0.0474	0.0559	0.0031	-0.0359
Midden Noord-Brabant	-0.0802	-0.0223	-0.0687	-0.1054	-0.0788	0.0221	-0.0865	0.0468	0.1112	0.2336	0.2123
Noordoost Noord-Brabant	0.0060	-0.0754	0.0059	0.0441	0.0254	-0.0516	0.0233	0.0264	-0.1197	-0.0555	0.2117
West Noord-Brabant	-0.0988	0.1808	-0.0243	-0.0171	0.0183	-0.0343	0.0268	0.0089	0.0243	-0.0669	-0.1078
Zuidoost Noord-Brabant	0.1531	-0.0905	0.0729	0.0624	0.0233	0.0595	0.0232	-0.0684	-0.0091	-0.0741	-0.2474
Location Quotient	-0.0273	-0.0171	-0.0315	-0.0967	-0.0068	0.0436	-0.0336	-0.0117	-0.0573	-0.0208	-0.1474
Ellison-Glaeser index	0.0175	0.0352	0.0802	-0.0225	-0.0494	0.0154	0.0064	-0.0180	0.0515	0.0147	-0.0142

	Medium FUA	Metropolitan FUA	Large Metropolitan	Highway entrance	Train Station	Traffic Congestion	Midden Noord-Brabant	Noordoost Noord-Brabant	West Noord-Brabant	Zuidoost Noord-Brabant	Location Quotient	Ellison-Glaeser index
Medium FUA	1.00											
Metropolitan FUA	-0.6478	1.00										
Large Metropolitan FUA	-0.0460	-0.2240	1.00									
Highway entrance	0.0112	-0.0343	-0.0123	1.00								
Train Station	-0.1701	-0.3159	0.0187	-0.0525	1.00							
Traffic Congestion	0.0068	-0.0266	0.1635	0.0102	0.0517	1.00						
Midden Noord-Brabant	-0.1652	-0.0129	-0.0571	0.2110	0.1069	-0.0599	1.00					
Noordoost Noord-Brabant	0.1133	-0.2200	-0.0645	0.0132	-0.0039	-0.0601	-0.2317	1.00				
West Noord-Brabant	0.3076	-0.2113	0.1994	-0.1458	0.0180	0.0912	0.2865	-0.3236	1.00			
Zuidoost Noord-Brabant	-0.2598	0.4011	-0.0898	-0.0399	-0.0989	0.0121	0.3227	-0.3644	-0.4505	1.00		
Location Quotient	-0.0319	0.1192	0.0404	-0.0051	-0.0365	-0.0479	0.2195	0.0267	0.0330	-0.2291	1.00	
Ellison-Glaeser index	0.0754	-0.0552	0.0300	-0.0400	0.0050	-0.0314	0.0407	0.0103	0.0650	-0.0385	0.0079	1.00

Homoscedasticity



VIF

Variable	VIF	1/VIF
LogSurface~c	1.20	0.835377
LogSurface~e	1.16	0.859294
Bouwjaar	1.29	0.777714
New	1.15	0.868538
Manufactur	1.14	0.878868
Warehouse	1.20	0.834598
LogAreaBBG	1.20	0.831880
GrowthBBGA~a	1.36	0.734799
CommutingZ~e	2.16	0.463510
MediumFUA	1.38	0.725374
LargeMetrFUA	1.26	0.796207
MiddenNoor	1.75	0.570542
NoordoostN	1.77	0.563768
WestNoordB	1.88	0.530883
Highway	1.14	0.877192
Trainstati	1.90	0.527102
LQ	1.25	0.800878
EGI	1.12	0.889058

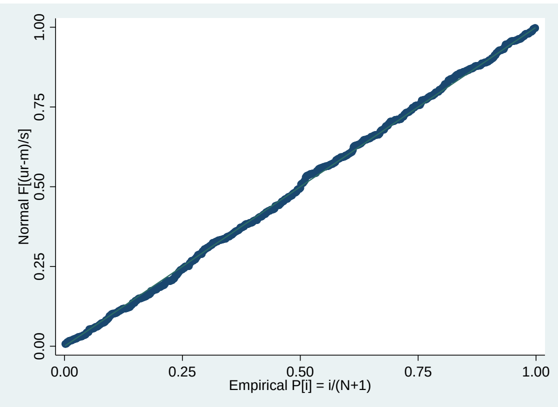
Testing normality assumption with residuals

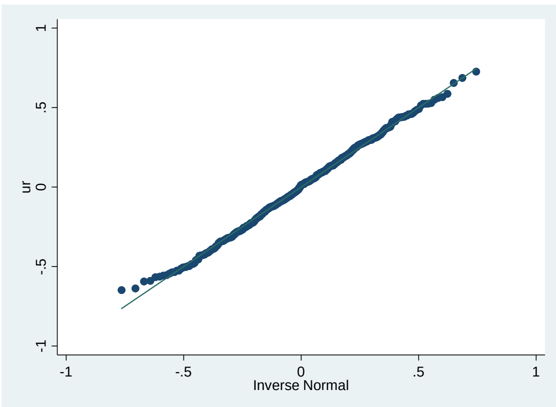
Skewness/Kurtosis tests for Normality

				joint	
Variable	Obs	Pr(Skewness)	Pr(Kurtosis)	adj chi2(2)	Prob>chi2
ur	511	0.8407	0.0300	4.75	0.0931

Shapiro-Wilk W test for normal data

Variable	Obs	W	V	z	Prob>z
ur	511	0.99620	1.303	0.637	0.26215



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Breusch-Pagan / Cook-Weisberg test for heteroskedasticity
         Ho: Constant variance
         Variables: fitted values of LogRentSqm

         chi2(1)      =     0.06
         Prob > chi2  =   0.8094
```

Appendix III: Regression result of the base model.

Source	SS	df	MS
Model	27.1072198	42	.645409994
Residual	29.0792568	468	.062135164
Total	56.1864766	510	.110169562

Number of obs	=	511
F(42, 468)	=	10.39
Prob > F	=	0.0000
R-squared	=	0.4825
Adj R-squared	=	0.4360
Root MSE	=	.24927

LogRentSqm	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
LogSurfaceLogistic	-.1353879	.016264	-8.32	0.000	-.1673473	-.1034285
LogSurfaceOffice	.0148284	.0054339	2.73	0.007	.0041505	.0255064
Bouwjaar	.0048263	.0007709	6.26	0.000	.0033114	.0063412
New	.2618086	.0698372	3.75	0.000	.1245753	.399042
Manufactur	-.0251862	.0282475	-0.89	0.373	-.0806939	.0303215
Warehouse	-.0104195	.0326729	-0.32	0.750	-.0746232	.0537842
LogAreaBBG	.0115549	.0114054	1.01	0.312	-.0108573	.033967
GrowthBBGArea	.0001763	.0001802	0.98	0.328	-.0001778	.0005305
CommutingZone	-.1533571	.0406205	-3.78	0.000	-.2331782	-.0735359
MediumFUA	-.1980962	.039562	-5.01	0.000	-.2758374	-.120355
LargeMetrFUA	-.0052079	.0993071	-0.05	0.958	-.2003509	.1899351
MiddenNoor	-.0208016	.035918	-0.58	0.563	-.091382	.0497788
NoordoostN	.0425205	.0352017	1.21	0.228	-.0266524	.1116933
WestNoordB	-.0220776	.0328068	-0.67	0.501	-.0865445	.0423893
Jaar						
1990	-.1104912	.0964824	-1.15	0.253	-.3000836	.0791012
1991	-.0385608	.0957328	-0.40	0.687	-.2266802	.1495586
1992	.2022552	.0927192	2.18	0.030	.0200577	.3844526
1993	-.0567376	.0891018	-0.64	0.525	-.2318268	.1183516
1994	.167627	.0950056	1.76	0.078	-.0190634	.3543174
1995	.0616598	.0827646	0.75	0.457	-.1009763	.224296
1996	.1426462	.0855807	1.67	0.096	-.0255237	.3108162
1997	.0816853	.0818898	1.00	0.319	-.0792319	.2426025
1998	.1869479	.0830426	2.25	0.025	.0237654	.3501304
1999	.2736787	.0882691	3.10	0.002	.1002259	.4471315
2000	.3271426	.0799966	4.09	0.000	.1699456	.4843396
2001	.3934781	.0854756	4.60	0.000	.2255147	.5614416
2002	.4158121	.0836821	4.97	0.000	.251373	.5802513
2003	.175531	.0905462	1.94	0.053	-.0023964	.3534584
2004	.2596913	.0830764	3.13	0.002	.0964425	.4229402
2005	.3344196	.0835567	4.00	0.000	.1702269	.4986124
2006	.3791466	.0879159	4.31	0.000	.2063879	.5519053
2007	.3771729	.0864301	4.36	0.000	.2073338	.5470119
2008	.3803448	.0837169	4.54	0.000	.2158373	.5448523
2009	.3739299	.0868363	4.31	0.000	.2032925	.5445673
2010	.4479415	.1220132	3.67	0.000	.2081801	.687703
2011	.4493997	.0948097	4.74	0.000	.2630944	.6357051
2012	.3029378	.1033778	2.93	0.004	.0997957	.5060799
2013	.3153554	.1034557	3.05	0.002	.1120602	.5186505
2014	.1764327	.0902749	1.95	0.051	-.0009616	.353827
2015	.3617198	.087728	4.12	0.000	.1893302	.5341094
2016	.3706183	.1036307	3.58	0.000	.1669793	.5742572
2017	.267964	.1901345	1.41	0.159	-.105659	.641587
_cons	-5.38511	1.522089	-3.54	0.000	-8.376083	-2.394136