ERASMUS UNIVERSITY ROTTERDAM

Erasmus School of Economic

Bachelor Thesis Urban, Port, and Transport Economics

What influence does the construction of an 'XXL' distribution centre have on surrounding house prices?

Abstract

The number of XXL distribution centres in the Netherlands has exploded in recent decades. The construction of an XXL distribution centre occupies large pieces of land, which in turn contributes to the scarcity of land in the Netherlands and which is believed to be one of the main contributing reasons for current sky-high house prices. This research analyses the effect of the construction of an XXL distribution centre on the local house price within a radius of 15 km using two hypotheses. The analysis uses the difference-in-difference model in which a treatment effect is estimated through the comparison of changes in a treatment group over time to the changes in a control group over time. The results indicate no significant effect between the construction of an XXL distribution centre and the local house price. Subsequently, the main research question is neither rejected nor accepted.

Name: Sophie Cronk

Student ID number: 510664

Supervisor: F.G. van Oort

Second assessor: J. van Haaren

Date end version: 30-08-2022

Table of Contents

Introduction

Anyone who regularly travels by train between the two largest cities in the Netherlands, Amsterdam, and Rotterdam, frequently sees meters high colossi looming up, as if they suddenly rise from the ground. Gradually the horizon disappears, and one finds oneself surrounded by a tunnel of grey walls in which the only remnants of colourful features are the business logos of big companies such as HelloFresh, Albert Heijn and Rexel, which have established themselves in these gigantic distribution centres.

A distribution centre (DC) is a location where a company has concentrated the logistics of goods. From a distribution centre goods are received, redistributed, and transported to other locations. To accommodate this handling methods for a vast amount of goods and allow efficient usage of land and logistics, DCs tend to be colossal boxes with a minimum of 5.000m^2, 8m height and 2 loading doors which occupy large pieces of land (DGBC, 2022).

The Netherlands, being a busy logistics hub resulting from its close proximities to the sea with an important European port, its strong hinterland connections both by road and by rail, and favourable business climate, has contributed to the eagerness of many national and international businesses to base their distribution centres in the Netherlands (Prick, 2018). Due to the increasing popularity of e-commerce, growing world trade and low interest rates in recent years, the Netherlands has seen an exponential increase in the number of ‘XXL’-distribution centres, centres with more than 40.000m^2, over the past decade (Appendix 1) (Klumpenaar, 2022).

However, according to the NOS (Prick, 2018), the logistics hub of the Netherlands is slowly bursting at the seams due to a shortage of labour and increasing scarcity of land. Furthermore, future predictions on the issuance of permits for the construction of new ‘XXL’ distribution centres argue an expected decrease in the issuance of permits because of current discussions on the development of generic DCs in the Dutch landscape. These ongoing discussions have at present led to a decrease in the number of issued permits for new industrial buildings over the past few years (Appendix 2). Additionally, it is argued that the focus will shift to the construction of smaller DCs on the outskirts of cities, from which goods can more easily and quickly be transported into the city (Buijs, 2021).

The construction of ‘XXL’ distribution centres tends to consume large pieces of land, which in turn contributes to the scarcity of land in the Netherlands and which is believed to be one of the main contributing reasons for current sky-high residential property prices (De Groot et al., 2010). Over the past decade, housing prices in the Netherlands have increased rapidly. Last year a house price increase of 15,2% was recorded which is the highest percentage ever recorded since the start of recording in 1995 (CBS, 2022a).

One of the unanswered questions related to potential negative or positive external effects, is to what extent the increase in housing prices might be related to the increasing number of XXL DCs in the Netherlands. Thus, this research seeks to define the influence of the construction of XXL distribution centres on local house prices in the Netherlands. In addition, the effect of the construction of an XXL DC on house prices within a radius of 15 km is considered. A radius of 15 km has been chosen to include a range of different house prices from various municipalities in both rural and urban locations, in which not only the direct spill over effects such as view obstruction and congestion may be felt but also indirect spill over effect such as employment creation are considered in the analysis. This allows a well-founded conclusion to be drawn. Nevertheless, the limitation of the 15 km radius also ensures that the area, the number of municipalities, which is incorporated in the analysis is not too large. The analysis of changing house prices in a large area is more likely to be susceptible to external factors which may influence the house prices and cause omitted variable bias. By limiting the area to be studied, the risk of omitted variable bias will be limited. Furthermore, the Netherlands is a relatively small country in terms of surface area. By setting a maximum radius around an XXL DC it is also prevented that a municipality surrounding an XXL DC might overlap when choosing XXL DC sites for our analysis, which will in turn otherwise also lead to bias. Subsequently, this leads to the following research question:

What is the influence of the construction of new XXL distribution centres on house prices within a 15 km radius?

An answer to the research question will be provided in the literature review with the help of the following sub questions:

- What are the main characteristics of an XXL DC and how has the development of XXL DCs been characterised the past two decades?
- What market orientation do DCs have and what are the main characteristics of their locations?
- What are advantages and disadvantages attached to arrival of a DC?
- What are the main determinants of residential property value?
- What is the influence of industrial locations on housing prices?

Social and academic relevance

The social relevance of this research lies in establishing and defining what influence the construction of XXL DCs have on the local residential property value. By understanding the potential effect of the construction of XXL distribution centres on local housing prices, local authorities will be able to determine a location's residential and logistical attractiveness. A decrease in the residential property value because of the construction of an XXL DC indicates a lower residential attractiveness, potentially resulting from negative externalities such as traffic congestion and an obstruction of views, tied to the construction of an XXL DC. On the contrary, an increase in the residential property value as a consequence of the construction of an XXL DC indicates a higher residential attractiveness, potentially resulting from positive externalities such as an increase in local employment opportunities, generated through the construction of an XXL DC within certain proximity of the municipality. Subsequently, local, and national authorities will have a better understanding of the impact that the issuance of permits for the construction of distribution centres might have on the local surroundings, such as the creation of local employment opportunities and the improvement of infrastructure availability, which could prevent them from issuing or stimulate the issuance of permits more easily.

In addition to the social relevance, this research contributes to the current academic literature. Previous literature (Kaufman & Cloutier, 2006; De Vor & De Groot, 2011) has examined the influence of general industrial sites on residential property values, yet few conclusions were drawn on the influence of the construction of XXL distribution centres within certain proximity to residential areas and its potential positive effect on local housing prices resulting from probable employment creation and infrastructure improvement. Moreover, previous literature has attempted to identify the relation between the industrial estates and residential property values through a hedonic pricing analysis. This research will apply the difference-in-difference method to identify a possible relation between the construction of XXL distribution centres on local housing prices.

Theoretical framework

Several theories have been devised about the usage of land in (inner-city) areas. The first theories originated in the 19th century and show a clear difference in the complexity and focus of these theories when compared with modern literature. This difference partly explains the emergence of buildings such as DCs.

Classical land use theories

Ideas on the usage of land date back to the early 19th century. In this period Ricardo (in McCann, 2013) devised a theory concerning the usage of land based on two assumptions. The first assumption states that the supply of land is fixed: no additional land can be provided when the demand for land increases. The second assumption regards the demand for land. Ricardo claimed that the demand for lang and the price of land were determined by the products that could be grown on the land. If grain was expensive, the land would be expensive. Additionally, grain would also dominate the usage of land due to the high prices. Ricardo's theory thus assumed an economic approach focused on maximising profit. If grain yielded the most, then land was largely used for the production of grain.

Von Thünen (McCann, 2013) added to this Ricardian theory of land with the regional land use model. Von Thünen assumed the existence of one central location where products where traded and different production types that formed circles around this central place. According to Von Thünen, transport costs played a role in the distribution of production types across the country.

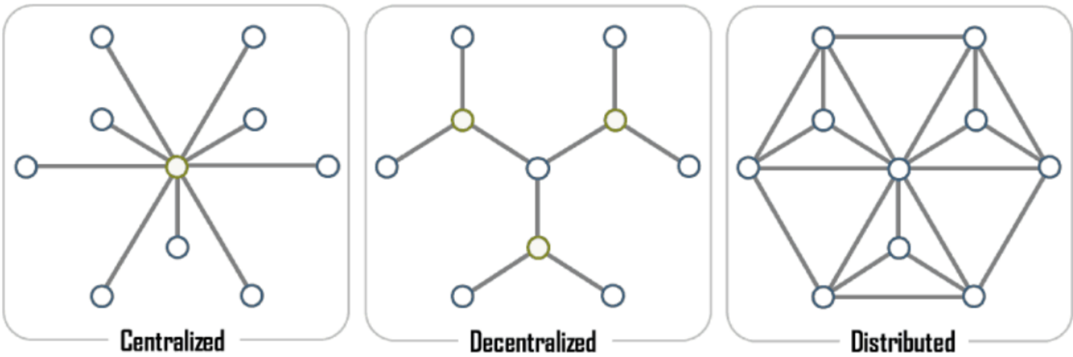
In the early 19th century, a basis was created for theories concerning the layout of land and the usage of land in certain areas around the central market. Subsequently, it became clear that there were (economic) reasons behind the layout of land. Land use theories from this period mainly concern agricultural and residential ("city") land use as society mainly consisted of these. About a century and a half later the theories, with a central location and different types of production, had been expanded to include a CBD (Central Business District) and industrial land use (Alonso, 1960; Hoyt, 1939).

Although both of the above theories have a certain focus on urban and rural planning, they also have a few features in common. They all assume that there is one centre, whether it is a market or CBD. From this central location, the rents of land, transport costs, the transport of people and the growth of a city are considered (Alonso, 1960; Hoyt, 1939; McCann, 2013). In addition, the theories assume that urban/ agricultural facilities are chosen from an economic point of view aimed at maximising profit (McCann, 2013).

Christaller's theory (Openshaw & Veneris, 2003) deviates from the assumption that there is only one central location and has consequently developed a theory based on service levels. Christaller argues that different service levels have different service areas. For example, the service area of a bakery is smaller than that of a city centre. Thus, the service area of one city centre may hold multiple smaller service areas of bakers. This theory assumes that several service areas are located next to each other and therefore no single central market exists. Competition is not taken into account in this theory: it is assumed that the various service areas cannot compete with each other and that buyers of a specific market base their choice on the proximity of the market' service (Openshaw & Veneris, 2003).

The above theories can be subdivided into the following model of Wood and Roberts (2010):

Figure 1: Representation of different interaction models between places



Source: Wood & Roberts, 2010

Each yellow dot in Figure 1 represents a central location, the lines are flows and connect different locations with the central location. The classical theories (Ricardo, Von Thünen, Hoyt & Alonso) with one central location can be grouped into the picture with the title *Centralized*: These theories assume that there is one central location where are lines, such as transport, products, and people, move to. Christaller's theory adds to these theories by assuming that there are several service areas rather than one. Consequently, Christaller's theory is classified under the image *decentralized*.

The far-right image shows a few central locations and many locations that are equal to each other as well as connected to each other. The last image (*distributed*) is central to our current network society where everything and everyone is connected, and cities compete to become one of the central places. The images can be viewed at an urban level, but also at a national and international level (Wood and Roberts, 2010). The *distributed* model in Figure 1 shows that locations are often connected with each other and that the location in the middle has the most connections. This location is the most central and has the largest attraction (most connections). There may also be assumed that locations compete with one another: different lines run from the dots, which means that people can choose which "dot" or city they go to. This creates dynamism in and between cities as cities strive to be the central location and thus strive to be the location that most individuals choose to go to.

Current rural and urban transitions are mainly driven by globalisation. With increasing technological advancements in transport and communication systems, geographical boundaries are disappearing (Gereffi & Korzeniewicz, 1994). This doesn't only imply that cities, countries, and production chains are increasingly interconnected, but also that they are increasingly competing with each other. In recent decades, large (multinational) companies have grown at the expense of small (local) retail companies. This is partly due to economies of scale i.e., large-scale production is more cost-effective than small-scale production (Gereffi & Korzeniewicz, 1994; Stigler, 1958). This increase in scale is also reflected by the number of distribution centres that have been built in the country over the last two decades and the increasing sizes of these distribution centres (Nefs, Zonneveld & Gerretsen, 2022).

Changing land prices due to increased globalisation and competition between locations partially explains the change in house prices. So does the land price contain important information on the characteristics of the residential environment and its value (De Groot et al., 2010). The house price is determined by looking at the environmental characteristics, the land price, as well as the individual characteristics of the house (Visser & Van Dam, 2006). A change in the price of land therefore partly explains the change in the value of a house. The next section will look in more detail at the development of DCs over the past decades.

Development of XXL distribution centres; 2000 – present

DCs similar to those existing today have been around since mid 1900s and mainly served a warehousing purpose in which goods were stored for selling or redistributive intentions in the future. In 1970 a 'standard' DC had a surface area of 10,000 m^2, a height of 5.5 meters and a few gateways purposed for loading up lorries. Much has changed since then as at present the surface area of a 'standard' DC varies between 25,000 – 80,000 m^2, with more and more even exceeding a 100,000 m^2 (CRa, 2019).

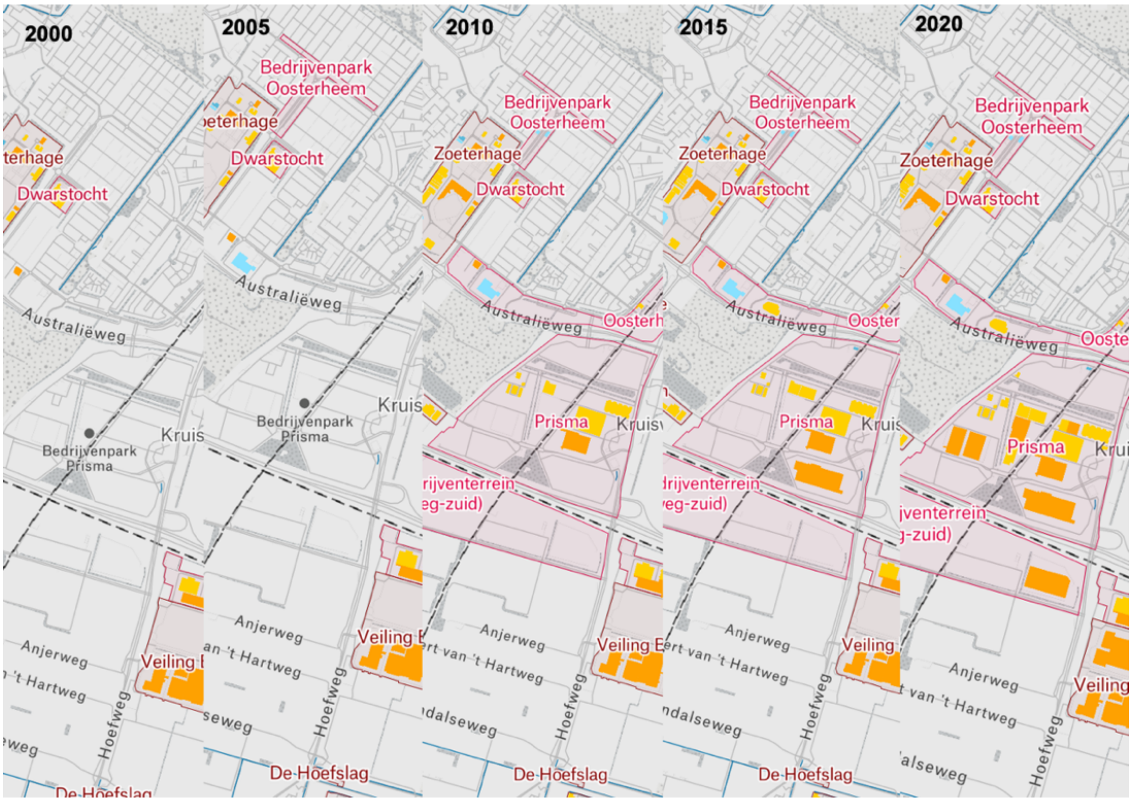
The development of XXL DCs took off in the 2000s, shortly after the dot-com crisis, and was the result of the emergence of e-commerce platforms. In 2014, the end of the global financial crisis and the rise of economies of scale in DCs propelled the surge of 'XXL' DCs (Nefs, Zonneveld & Gerretsen, 2022). Economies of scale in DCs and a strong e-commerce growth have been important trends in the Dutch logistics industry from 2014 until 2020 and contributed to logistics sprawl, a phenomenon in which DCs migrate from urban to rural areas. The consequence of logistics sprawl, referred to as "*verdozing*" or "*boxification*" of the Dutch landscape has been a hot topic on the political agenda since 2008 and has fuelled both political and civil unrest regarding the construction of XXL DCs.

The onset of the COVID-19 pandemic has meant that internet shops have seen their turnover grow explosively. The closure of brick-and-mortar stores has forced more people to turn to online purchases, causing e-commerce platforms to experience unprecedented growth (Schutijser, 2020). Additionally, the modern-day expectation that an online order placed before midnight is delivered the next day demands internet giants to hold large inventories in warehouses. Consequently, the logistics sector in particular has undergone tremendous growth with respect to XXL real estate (Klumpenaar, 2022).

'Micro' ariel figures 2, 3, 4, 5, 6, and 7 show different DC real estate locations in the Netherlands and their development from 2000 up until now. The images illustrate the establishment of new DCs based on their size and functions. These six locations are chosen as an XXL DC was constructed in our analysis time period, between 2010 and 2020. Furthermore, the presence of information on their exact footprint, year of construction and municipality code was required. Lastly, the locations have been selected for a varied spread across the Netherlands to generate a representative sample of the country. In Appendix 4, 5, 6, 7, and 8 the 'macro' development of these locations in ariel imagery can be seen.

Nefs (2022a) has distinguished between four types of DCs based on the company they belong to and the companies' purpose and has assigned each DC in the Netherlands to one of these types. Subsequently, each function has its own colour as a source of identification. The yellow DCs have a trade, import and export purpose. The orange DCs perform transport and logistics services. Furthermore, the light blue DCs are considered to be XXL retail centres. Lastly, the bright blue DCs are identified with logistical secondary functions.

Figure 2: 'Micro' aerial view of the development of Bedrijvenpark Prisma in Bleiswijk, Zuid-Holland

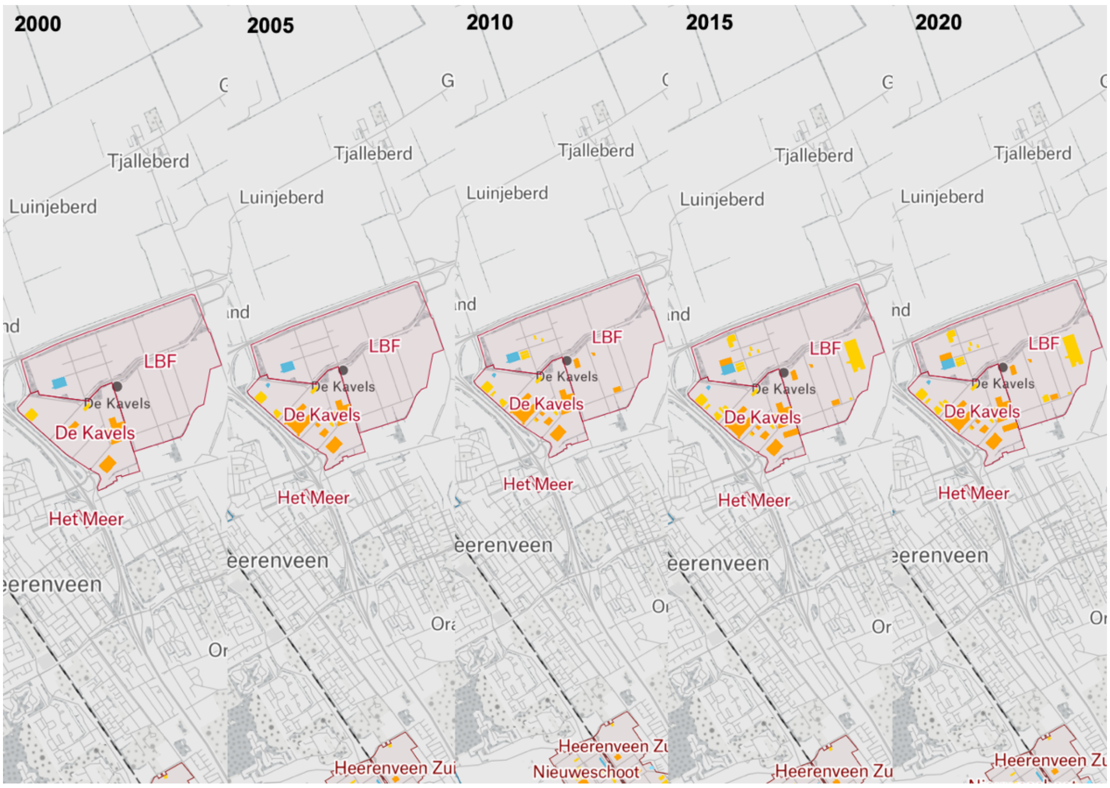


Source: Nefs, 2022a

Figure 3: 'Micro' aerial view of the development of Lelystad Airport in Lelystad, Flevoland

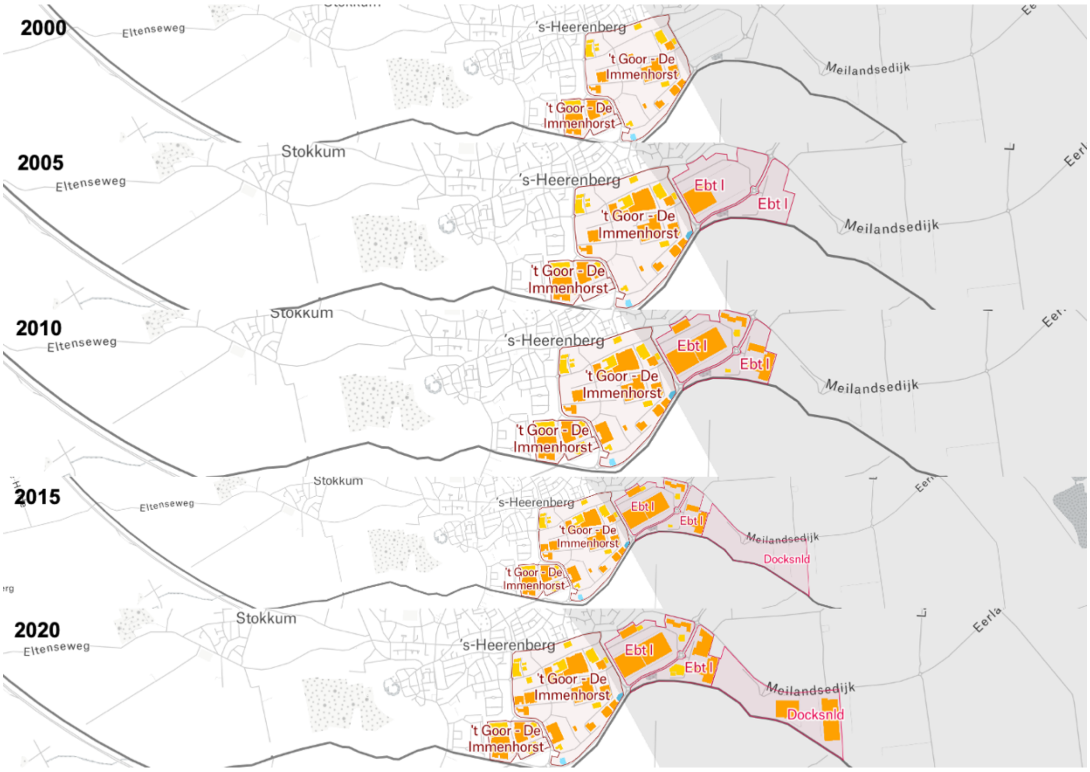
Source: Nefs, 2022a

Figure 4: 'Micro' aerial view of the development of IBF in Heereveen, Friesland



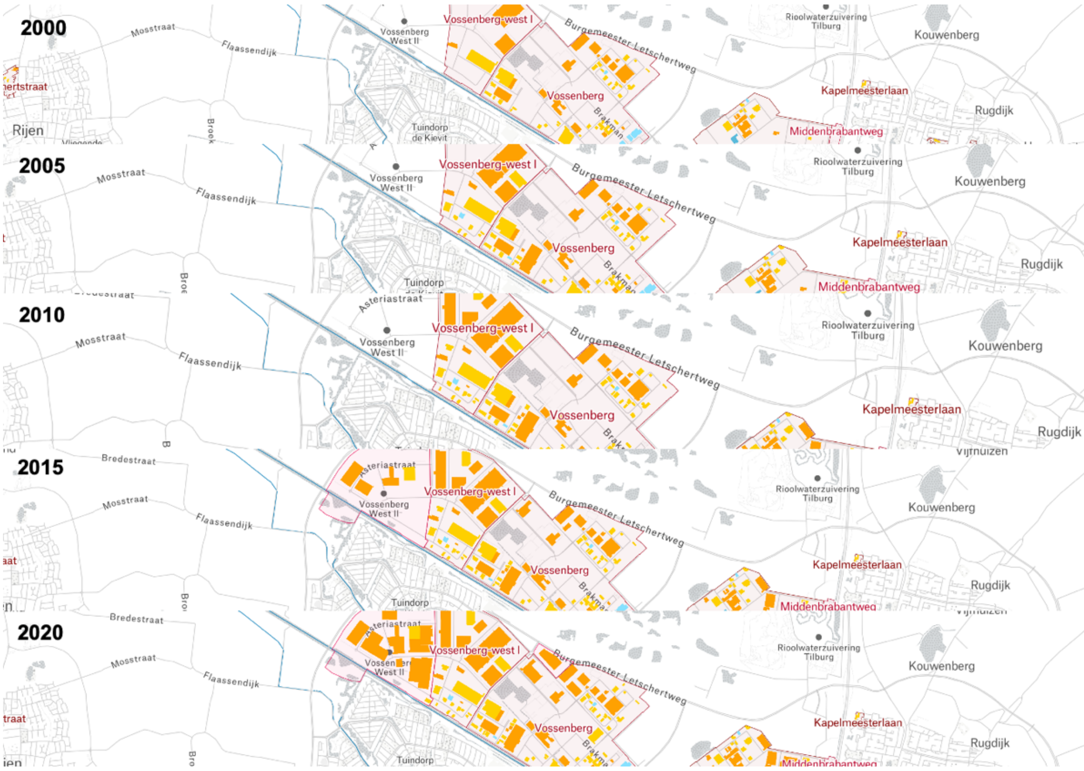
Source: Nefs, 2022a

Figure 5: 'Micro' aerial view of the development of DocksNLD in Montferland, Gelderland



Source: Nefs, 2022a

Figure 6: 'Micro' aerial view of the development of Bedrijventerrein Vossenberg in Tilburg, Noord-Brabant



Source: Nefs, 2022a

Figure 7: ‘Micro’ aerial view of the development of Trade Port Noord in Venlo, Noord-Brabant

Source: Nefs, 2022a

Not only has the actual number of distribution centres in the Netherlands increased, also their average footprint is increasing. More often, logistics companies demand XXL locations above four hectares of surface area (Van Zwet, 2019). The most important driver for the establishment of XXL distribution centres are scale economies. Economies of scale is the economic advantage that is realised by operating on a larger scale. By merging activities in one location, the operators expect to be able to achieve a higher degree of efficiency in, among other things, storage, transport, and the deployment of personnel and robotics. In addition, with the construction of XXL DCs, operators respond to the importance of being able to process larger volumes. Furthermore, XXL DCs might be preferred due to surface scarcity at their current location.

Nevertheless, space is a scarce commodity that you can only ‘give away’ once, landscape is not produced by a continuous assembly line. The explosive growth of XXL distribution centres requires substantial amounts of space and has led to increasing social and political concern.

Market orientation and location choice

When determining the influence of the construction of XXL distribution centres on local house prices it is essential to understand what types of XXL DCs exist and why distribution centres are subsequently constructed in certain locations. Within the Netherlands, a clear picture can be seen in the regional preferences of logistics companies with a certain market orientation. This orientation is linked to the function of a distribution centre: Where do the stored items have to go? Essentially, DCs can have a regional, national (BeNeLux) or (Northwest-) European orientation (CRa, 2019). Depending on the supply chain behind these distribution centres, some locations and regions are considered to be more or less attractive for the companies.

Regionally orientated DCs are known to be logistics companies, shippers (or "*verladers"*) and retail chains that are unable to supply to the whole of the Netherlands from one warehouse and thus have multiple warehouses from which they can supply to multiple regions. These DCs mainly concern supermarkets, wholesalers, and parcel service providers such as Post NL, DHL and DPD.

The majority of logistics companies with a national market orientation are located in the Tilburg and Almere axis (CRa, 2019). This mainly concerns retailers, food suppliers and supermarkets. The borders of the Netherlands (southeast, north) are not suitable for nationally orientated DCs.

Many goods destined for Europe arrive through the Port of Rotterdam. After the abolishment of internal borders, the Netherlands has developed as a strong location for logistics to supply large parts of Europe. Bearing in mind the relatively small Dutch domestic market and its location near the heart of the European purchasing power, the centre of gravity of these European market orientated DCs lie in the South of the Netherlands. The border regions (e.g., West Brabant, Central Brabant, Twente, North Limburg and South Limburg) are thus particularly attractive for such locations.

Despite DCs may having different market orientations and therefore also have different regional preferences, the characteristics of the locations where DCs are built are comparable. Three factors that affect a distribution centre's location decision are: institutional factors, physical location, and availability of labour (Roel, 2022).

Institutional factors are factors that affect the presence and importance of different institutions such as financial institutions, governmental and public-law corporate associations, employers' and employees' associations, and business and industrial service providers, among others. Some municipalities might have a spatial zoning plan which expresses their wish for the establishment of a distribution centre. However, this spatial zoning plan can differ substantially for each municipality despite having an equally large wish for the establishment of a distribution centre which in turn can lead to obstructions during the construction period, think of the time variation in the issuance of building permits between different regions.

The physical location in a DCs location decision consists of three components being the location's proximity, accessibility, and resources. Firstly, a location's proximity indicates the distance from the DC to the outlet, production locations of businesses and suppliers. Secondly, the accessibility of a DC focuses on the availability of infrastructure within proximity. Research shows that businesses prefer to locate near motorways, consequently XXL DCs are often located next to motorways or not far from them (Verhetsel et al., 2015). This is important as lorries are prevented from driving across local, provincial roads which minimizes the delivery time and prevents congestion resulting from the large number of trucks moving. Subsequently, congestion is an important push factor whereupon businesses choose for a location outside of urban areas. Lastly, the available resources of location, being the availability of labour, costs of labour, availability of ground, and the costs of ground play a crucial role in physical location decision (Onstein et al., 2018).

Another important factor in a DCs location decision is the local availability of labour. The Netherlands currently suffers from a labour supply shortage, which means that DCs are faced with a shortage of staff. To avoid shortages and maintain an optimal productivity level, it is crucial for DCs to find the right location that can provide answers to questions such as; are there enough labour forces and undisclosed reserves, in the form of students, re-employing women or frontier workers, to absorb staff fluctuations in the short and long term? Other factors of importance are the regional rate of decline or growth, the degree of competition with other DCs and the construction of new residential areas within close proximity in the future.

The above literature suggests that DCs position themselves in locations where sufficient labour forces and resources are available, the risk of congestion is mitigated, and the institutional factors favour the construction of a DC. These factors are generally found in suburban areas where the proximity to a city can provide the necessary labour force yet the risk of congestion likely to occur in inner-city areas is limited. It is therefore important to draw a radius around the chosen DC locations so that both houses inner-city and rural or suburban areas are included in the analysis.

Distribution centres; pros and cons

With every new distribution centre that is built, economic value creation occurs, such as returns for the investor and additional jobs within the region. Municipalities are often enthusiastic about the arrival or expansion of logistics activities because of the expected positive effects on local employment among other things. Within the inhabitants of the local municipality, however, disadvantages are often associated with the arrival of a distribution centre. These advantages and disadvantages associated with the arrival of a DC will be discussed below.

According to Onstein et al. (2016), the logistics sector accounts for 10% of the total employment in the Netherlands. Majors of municipalities welcoming a new DC often argue that the number of jobs within a DC, especially an XXL DC, is a major contributor to the total employment in the logistics sector and creates employment within all layers of society. However, most of the operational work, 50% of the jobs (CRa, 2019), in a DC is performed by foreign workers that cover long distances during their shifts and work irregular hours. There is little interest in the local labour for a job in a distribution centre. The wages are too low, and the workload intensity is too high (Heijne & Noten, 2020). Additionally, most order pickers do not have the money to arrange decent housing and thus they are housed by their employers in neglected holiday bungalows, often crammed up with several in one bedroom causing distress in the local neighbourhood (Janssen, 2021). Nevertheless, the other 50% of the jobs in a DC, being the tactical and strategic jobs, require workers with a higher level of abstraction and more technical skills. These 'intellectual' jobs are often performed through local labour and thus contribute to the surrounding employment (CRa, 2019).

Besides foreign workers being regarded as a nuisance in the neighbourhood. There are a number of other reasons why the construction of XXL DCs is considered to be a large problem and create much social and political unrest. Firstly, a DCs size, shape, and appearance are considered to be intimidating as everything in its design shows that this typology in no way takes into account the human scale or hitherto known urban or landscape structures. Secondly, DCs are primarily built on land with agricultural purposes. This is due to their large size, which complicates the integration into existing industrial sites. Furthermore, the current demand for DCs is so high and time phased that there is no time to await the restructuring of existing sites. Therefore, DCs are frequently built in empty agricultural landscapes which enforce its negative impact on the Dutch landscape. Lastly, the development of XXL DCs is linked to an enormous increase in traffic movements, causing traffic jams, extra strain on the road network and the emission of large quantities of polluting emissions (CRa, 2019).

However, to keep a DC running, primary logistics activities are frequently linked to various other activities such as caterers or a third-party producer or retailer with a logistics contract. Specifically, this is the case, for example, at an Albert Heijn supermarket (AH) DC, where various carriers who drive for AH find employment at other companies such as Peter Appel, Simon Loos, and Wezenberg Transport (CRa, 2019). Some of these third-party producers or retailers or other 'employment suppliers' might be located in the immediate vicinity of the DC. In addition, various companies affiliated to the DC will benefit from the logistics location. This includes cleaning companies, administration services, or maintenance & repair (e.g., a maintenance facility of a tire or truck manufacturer). Thus, the construction of a DC in close proximity may not bring much direct employment but it does result in a plethora of indirect employment in the region.

In addition, many DCs are undergoing a modernization transition by automating their processes to meet a growing customer demand. Furthermore, this transition improves service and lowers costs (Baker & Halim, 2007). While automation usually means a disruption and displacement of jobs in a DC (Latham & Humberd, 2018), one can also argue that new job opportunities are created, specifically jobs requiring more technical skills. Modernising processes in DCs through automation, IOT, drones, robotics, 3D printing and other thus create new employment opportunities in DCs and contribute to the number of jobs within a municipality.

Despite the negative aspects associated with the arrival of distribution centres, the number of DCs in the Netherlands continues to increase (Klumpenaar, 2022). It can therefore be argued that the benefits attached to the construction of an XXL DC outweigh the perceived 'costs' and that the pro-distribution centre arguments, mainly concerning an increase in regional employment, outweigh the con-distribution centre arguments. Thus, the first hypothesis is:

Hypotheses 1: The construction of an XXL distribution centre has a positive influence on the number of jobs in municipalities within a 15 km radius.

Determinants of housing prices

The housing market is a complex system in which the value of houses is determined by a combination of three sub-markets: the housing market, the financing and investment market, and the construction and land market. In addition, there are interactions between the rental and owner-occupied markets and institutional factors such as building regulations and spatial planning play a role (Van Dam et al., 2013).

The national price of a house is largely determined by the financing options of housing consumers. Not only income, but especially the interest rate plays an important role in this. In addition, the regulations for borrowing money by lenders and the mortgage interest deductions are important. Underlying this is consumer confidence in the housing market.

Nevertheless, the housing market is not a national but rather a regional market (Van Dam et al., 2013). The importance and weight of all factors and actors that may influence housing prices differ per region and can even vary substantially locally. An important factor for the differences in regional housing prices is the tension in the regional housing market; in other words, the relationship between the demand for and the supply of houses within a region (Visser & Van Dam, 2006).

Overall, the price of a house is predominantly, up to 50%, determined by the physical characteristics of a house (Visser & Van Dam, 2006). It is mainly the size of the house, being the surface and content, that plays a decisive role in pricing (Appendix 9). Furthermore, the quality of the living environment plays a crucial role in the valuation of residential property. Hence the immediate vicinity of houses to amenities concerned such as; greenery, open spaces, infrastructure and a neighbourhood's social status positively affect the property's distance to amenities which in turn drives up the price of a house. In contrast, the proximity of a house to an industrial site is argued to have a negative impact on residential property values (Vor, de & Groot, de, 2011). The influence of an industrial site on local housing prices is of importance considering the many similarities that DCs and industrial sites show. These similarities will be explored in the next section.

Influence of industrial locations on housing prices

The fact that the environment influences the house prices has already been concluded from previous research (Kaufman & Norman, 2006). It is now explored to what extent industrial locations have an impact on residential property values within mid-distance.

According to the public, DCs and industrial estates show many similar characteristics. An industrial estate is primarily intended to carry out business activities: effective accessibility by road, paved estates and outdoor storage set the scene. The estates are often closed off by fences and the buildings on the estate mostly have a functional character. For this reason, the sites are characterised by their uniform buildings of a varying scale, simplicity in design and sober finish. Likewise, the exterior of a DC is standard for all sectors and is characterised by a simplified, dull box. In addition, the accessibility and location of the site also plays an important role in DCs location decision, which means that they can often be found next to motorways or other large, paved roads. Furthermore, these areas are often closed with fences. It can therefore be argued that DCs and industrial estates have many visual similarities. Subsequently, it is important to understand the effect of industrial areas on local house prices.

Previous research has emphasized a negative relationship between the proximity of residential areas and industrial estates (De Vor & De Groot, 2011; Visser & Van Dam, 2006; Onstein et al., 2021). De Vor et al. (2011) conclude that industrial sites generate multiple negative externalities such as loud noises, stench, and obstruction of views, which impact their local surroundings, indicating that one's understanding of a neighbourhood's spatial quality is largely affected by the vicinity of an industrial site as well as its size. Additionally, a 'dichotomous' relationship between the distance and residential property values can be established taking the form of a convexly decreasing relation (Appendix 10). This form illustrates that the nearer to an industrial site, the stronger the negative effect of negative externalities is on local house prices. However, beyond a certain distance, the negative effect on residential property values concavely decreases until it vanishes with increasing distance. This research also considers potential differences in the relationship between the dependent and independent variable depending on the proximity to the XXL DC. So does the second hypothesis investigate the effect of the construction of an XXL DC on local house prices within 3 different radii from the new DC.

Visser et al. (2006) share the same conclusion, underlining that industrial sites worsen the local air quality and contribute to noise pollution. Similarly, Onstein et al. (2021) argue that industrial estates entail negative externalities. Environmental externalities such as greenhouse gas emissions, noise nuisance, congestion, pollutants, and fuel consumption make up the bulk of these externalities and contribute to a deteriorating living environment, causing local house prices to fall. Thus, the proximity of residential properties to industrial estates influences the residential property value negatively.

Contrastingly to the research objectives mentioned above, industrial locations also realize positive externalities which might positively affect local housing prices. The construction of an XXL DC might improve local infrastructure (Roel, 2022), an important positive aspect in the valuation of a property, and thus lead to an increased residential property value (Kaufman & Norman, 2006). Furthermore, the construction of an XXL DC brings new technological advancements to a region generating positive technological externalities (KC, 2022). Additionally, the construction of an XXL DC may bring (in)direct regional employment increasing local employment rates and generating positive economical externalities. Lastly, the construction of an XXL DC may generate positive social externalities as the accessibility to products may be improved which in turn might lead to an advancement in the buying access and development of buying trends within surrounding municipalities.

Nevertheless, the negative externalities mainly concern environmental externalities whereas the potential positive externalities created through regional employment growth and infrastructure improvement touch on different aspects in the region such as technological, economical, and social improvements, therefore being of greater importance. Thus, the third hypotheses is the following:

Hypotheses 2: The construction of an XXL distribution centre increases the local residential property value within a range of 15 km.

Data

In order to test the hypotheses and form a model, this research will perform a case study on the influence of the construction of an XXL DC on the local house price. Three datasets were used for this study.

The first dataset to be used contains quantitative data on the average residential property value in the Netherlands per municipality and can be retrieved from the Central Bureau of Statistics (CBS). This dataset provides a detailed overview of all residential and non-residential properties in the Netherlands per municipality and their average "WOZ-waarde", also referred to as WOZ value or residential property value, which indicates the value of a house as per January 1 from the year 1997 until 2020 (CBS, 2022b). The CBS recognizes 355 different municipalities as per January 1, 2020.

The dataset is broken down into the value of residential and non-residential property, and the average residential property value. The numbers are thereafter disaggregated by region, province, COROP area and municipality. After 'tidying up', the remaining panel dataset solely contains municipality codes and their corresponding average residential property values for the years 2010 until 2020.

To answer hypothesis 1, another quantitative dataset from the Central Bureau of Statistics will be used, namely the employment of employees per municipality (CBS, 2021). This dataset contains the total number of jobs minus the jobs in the logistics sector, "*Vervoer en Opslag*", for each individual municipality in the Netherlands for the years 2010 – 2020. By comparing data on the number of jobs in a municipality within a specific year as well as the previous year to data to the construction of DCS within the municipality, it can be determined if the construction of a DC has an impact on local employment opportunities.

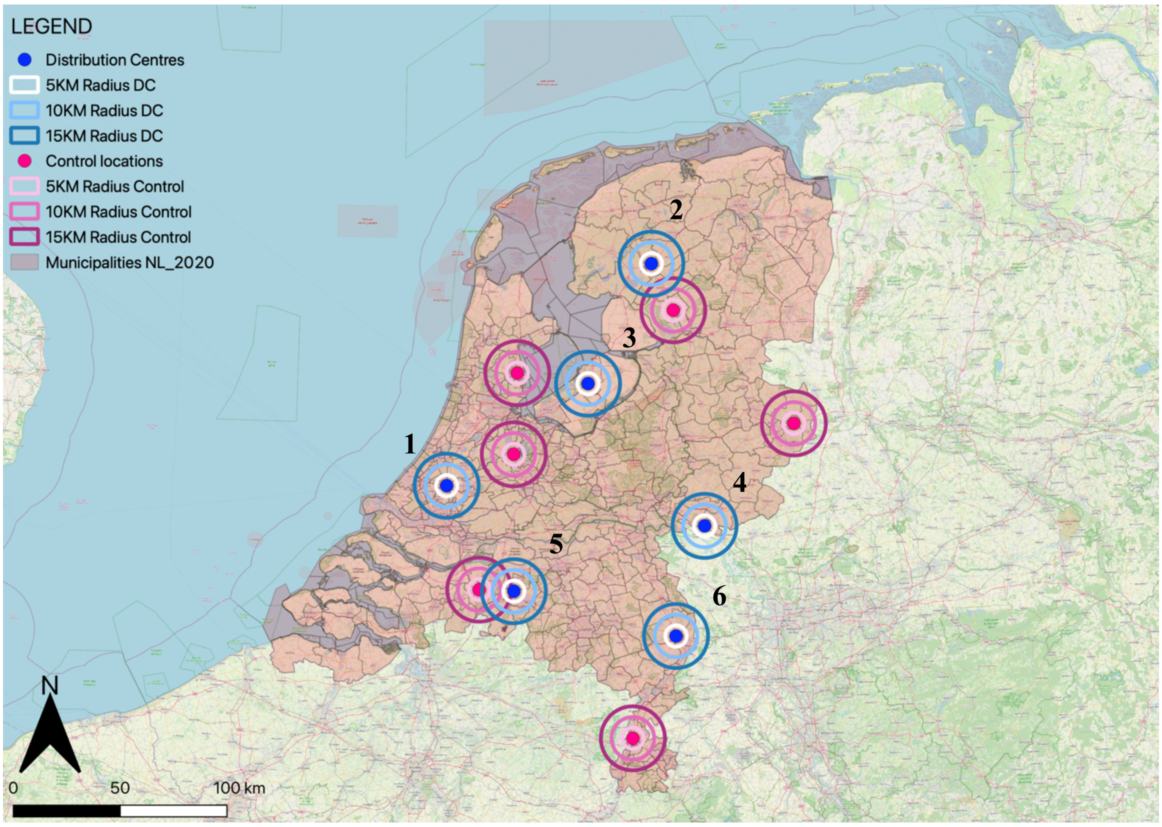
The three datasets retrieved by the CBS will be combined into one large dataset based on corresponding municipality codes within each dataset. Next, twelve distribution centre locations in the Netherlands will be chosen for the analysis of which 6 locations are home to an XXL distribution centre, these are the treatment locations, and 6 locations are not, these are the control locations. The 6 control locations are selected based on matching criteria which is further defined in the methodology. Thereafter the locations are visually marked in QGIS[1].

In order to formulate an answer to hypothesis 2, radii around the determined locations are shown with a perimeter of 5, 10 and 15 km as illustrated in Figure 8. The 15 km radius is divided into three radii of 5 km width in order to be able to analyse the effect of the construction of an XXL DC on the surrounding

[1] QGIS is an open-source geographic information system. With this information system geographical data can be analysed (www.qgis.org).

house prices in more detail. The projection of these radii allows the identification of municipalities within these radii which can subsequently be used for further analysis.

Figure 8: Map of the Netherlands and the locations of 6 chosen XXL distribution centres and 6 control locations without an XXL DC based on matching criteria surrounded by a 5, 10 and 15 km radius.



Source: QGIS

Note: Map of the Netherlands generated through QGIS including the locations of six chosen XXL distribution centres in (1) Bleiswijk, (2) Heereveen, (3) Lelystad, (4) Montferland, (5) Tilburg, and (6) Venlo surrounded by a 5, 10 and 15 km radius. Additionally, the locations of six distribution sites without XXL distribution centre, control locations, are projected including a 5, 10 and 15 km radius.

Quantitative data on distribution centres in the Netherlands is provided by Merten Nefs, a researcher from Delft University (Nefs, 2022b). This dataset provides information for each DC in the Netherlands on, among other variables, the year of construction, footprint, size category, and municipality code. A DC is regarded to be an XXL DC if the footprint is at least 40,000m^2. Thus, the dataset is revised such that solely the data on DC's that occur in one of the six chosen distribution centre's locations with a minimum footprint of 40,000m^2 is maintained. Additionally, the variables year of construction and job density are maintained in the dataset as these variables are control variables within the model.

Several XXL DCs which are incorporated in our research lack information on their total number of jobs as there was no Chambre of Commerce registration in the period 2017-2020. Consequently, the total number of jobs associated with these DCs is assumed to be the average number of jobs for all DCs that are similar in size and have a similar function being trade and logistics. Subsequently, the obtained averages are compared with the existing data for DCs of comparable size and function to determine to reliability of these averages.

Table 1 exhibits the descriptive statistics of the dependent, independent, and control variables used for answering the hypotheses. Hypothesis 1, total jobs and 2, average WOZ, attempt to find a relationship between their dependent variable and independent variable being, the construction of an XXL DC within a 15 km radius. The observations in the table represent the panel data and thus the 11 observations being the yearly observations from 2010 to 2020 for each municipality considered in either one of our hypotheses.

Table 1: Descriptive statistics of the dependent, independent, and control variables from 2010 up to 2020

Variable	Observations	Mean	Std. Dev.	Min.	Max.
Year	1,146	2015.051	3.164931	2010	2020
Average WOZ	1,146	245073.3	59826.65	119000	607,000
Total jobs municipality	1,146	34183.99	73692.05	1800	636800
Construction year DC dummy	1,146	0.0575916	0.2330713	0	1
Surface area	1,146	831.3019	9731.772	0	202482
Total jobs DC density	1,146	1.057592	.6622701	1	12

Note: Descriptive statistics of the dependent, independent and control variables for all municipalities located within a 15KM range from the distribution centre estate.

Methodology

In order to explore the answers to our hypotheses, a difference-in-difference (DiD) model will be used. This DiD model is commonly a linear regression model predicted through ordinary least squares (OLS).

Matching

In the empirical analysis, the municipalities that construct an XXL distribution centre within the area (the treatment group) are compared with municipalities that do not construct an XXL distribution centre (the control group) within their regional borders. The treatment groups are picked based on the construction of an XXL DC between 2013 and 2017. The construction of XXL DCs within these municipalities in earlier or later years than this time period is disregarded as else the time variant effect cannot be obtained.

The control groups are selected based on matching criteria with the treatment group. These criteria include a comparable population count within a municipality with a maximum deviation of 15%. Additionally, similar distances to railways, motorways or other provincial roads are required along with akin proximities to inland waterways and national borders. Subsequently, this leads to the following six pairs of locations: (1) Bleiswijk and Stichtse Vecht, (2) Heereveen and Steenwijkerland, (3) Lelystad and Purmerend, (4) Montferland and Oldenzaal, (5) Tilburg and Breda, and (6) Venlo and Sittard-Geleen.

Difference-in-difference model

The difference-in-difference model is an empirical model in which a treatment effect is estimated through the comparison of changes in a treatment group over time to the changes in a control group over time. In other words, the DiD model allows us to determine what happens to the average residential property value, WOZ value, within a municipality before and after the construction of an XXL distribution centre and thereafter compares the change in the WOZ value to that of a municipality which has not experienced the construction of an XXL DC over the same course of time. Subsequently, the DiD model consists of two stages:

1. Pre – Post stage

In the pre-post stage, the change in WOZ value within a municipality pre the establishment of an XXL distribution centre is analysed compared to the change in the average residential property value within a given municipality post the establishment of an XXL distribution centre.

2. Control – Treatment stage

In the control-treatment stage the changes within the treatment group, the municipality that received an XXL DC, are compared to the outcomes of the control group, a municipality where no XXL DC was constructed. The control municipality must have similar characteristics as the treatment municipality being the number of inhabitants, proximity to motorways and inland waterways as well as the nearness to international borders.

Thus, in our model the treatment group undergoes the treatment, the construction of an XXL DC, in the second time period and not in the first time period. The control group does not undergo any form of treatment in the first or second time period. Thereafter the treatment effect is estimated by deducting the average change in the control group from the average change in the treatment group. In this case, unobserved and fixed biases potentially occurring in the second time period are removed. Based on the above, the following regression model can be constructed:

$$y_{it} = \beta_0 + \beta_1 * T_i + \beta_2 * P_t + \beta_3 * (T_i * P_t) + \varepsilon_{it}$$

In this model, *y* is the dependent variable, the average residential property value, *T* is the dummy variable for the treatment group and *P* represents the dummy variable for the second time period. Additionally, $T*P$ is the coefficient of interest in our analysis and can be described as the interaction term. The interaction term is equivalent to a dummy variable with the value 1 for observations in the second time period in the treatment group. Subscript *i* denotes the treatment or control group and subscript *t* denotes the first or second time period.

The coefficients in the model may be interpreted as follows:

- β_0: The average outcome of the control group prior to the treatment.
- β_1: The average change in *y* between the control and treatment group prior to the treatment.
- β_2: The average change in *y* of the control group in the post-treatment period.
- β_3: The primary parameter of interest in our analysis that captures the treatment effect and shows the average change in *y* of the treatment group in the period after the treatment, compared to what would have happened to the same group had the treatment not occurred.

To answer hypothesis 1, a difference-in-difference model will be used to test whether there is a positive relationship between the construction of an XXL distribution centre within a municipality and the number of jobs within a 15 km radius from the DC. Total number of jobs will serve as the dependent variable and the construction of an XXL DC as an independent variable which will lead to the following DiD model:

$$TotalJobs(y)_{it} = \beta_0 + \beta_1 * Construction\ XXL\ DC(T)_i + \beta_2 * Post\ Construction\ Year(P)_t + \beta_3 * (Construction\ XXL\ DC(T)_i * Post\ Construction\ Year(P_t)) + \varepsilon_{it}$$

For the analysis of the second hypothesis, an identical DiD model will be applied. The dependent variable in this model is the average residential property value for municipalities within a 0-5, 5-10, and 10-15 km radius from the DC. Subsequently, this will lead to the following three multiple regression models:

$$Average\ WOZ_{\ \text{0-5}km}(y)_{it} = \beta_0 + \beta_1 * Construction\ XXL\ DC(T)_i + \beta_2 * Post\ Construction\ Year(P)_t + \beta_3 * (Construction\ XXL\ DC(T)_i * Post\ Construction\ Year(P_t)) + \varepsilon_{it}$$

$$Average\ WOZ_{\ \text{5-10}km}(y)_{it} = \beta_0 + \beta_1 * Construction\ XXL\ DC(T)_i + \beta_2 * Post\ Construction\ Year(P)_t + \beta_3 * (Construction\ XXL\ DC(T)_i * Post\ Construction\ Year(P_t)) + \varepsilon_{it}$$

$$Average\ WOZ_{\ \text{10-15}km}(y)_{it} = \beta_0 + \beta_1 * Construction\ XXL\ DC(T)_i + \beta_2 * Post\ Construction\ Year(P)_t + \beta_3 * (Construction\ XXL\ DC(T)_i * Post\ Construction\ Year(P_t)) + \varepsilon_{it}$$

The models defined above assume a significance level (α) of 5%.

Results

In order to explore the first hypothesis, the relationship between the construction of an XXL distribution centre and the total number of jobs within a 15 km radius of the DC was explored. To investigate this, the time period pre and post the construction of an XXL DC must be regressed using a difference-in-difference model to the total number of jobs for municipalities within a 15 km radius of the DC for the treatment group. For the control group this same pre and post time period is regressed to the total number of jobs for municipalities within a 15 km radius to obtain the general time variated trend. These results can be found in Table 2. The construction of an XXL DC has no significant (5%) effect on the number of jobs within a 15 km radius as the p-value (0.867) is larger than our α (0.05). Thus, we are unable to reject or accept the hypothesis stating that the construction of an XXL distribution centre has a positive influence on local employment opportunities within a 15 km radius.

Table 2: **The complete difference-in-difference regression of the jobs – XXL DC relationship**

	Constant (β_0)	**Treatment dummy (β_1)**	**Time dummy (β_2)**	**Interaction effect (β_3)**	**Observations**	**R^2**	**Adjusted R^2**
Locations with XXL DC	32049.46*** (4318.657)	11183.87 (12774.76)	622.809 (5374.382)	2686.715 (16000.75)	591	0.0049	-0.0002
Locations without XXL DC	32437.38*** (5702.83)		1890.231 (7154.1)		587	0.0001	-0.0016

Note: *p-value < 0.1, **p-value < 0.05 and ***p-value < 0.001. The standard errors are noted between brackets.

Observing a change in the number of jobs in municipalities only, pre and post the treatment, would fail to control for omitted variables such as macroeconomic conditions and the weather of the region. By including municipalities where no XXL DC was constructed as a control variable in a difference-in-differences model, any bias caused by variables common to the locations with and without an XXL DC is implicitly controlled for, even when their variables are unobserved.

The parameters, except for the constant, incorporated in the model show no significant effect on the number of jobs in a municipality within a 15 km range from the XXL DC as can be seen in Table 2. Furthermore, the DiD regression has a very low R-squared of 0.0049. Consequently, the model explains little of the variation and only a very small share of the all the variation in the dependent variable, number of jobs, can be explained by the independent variable, construction of an XXL DC. Nevertheless, the model does suggest a positive relation between the construction of an XXL DC and the number of jobs within a 15 km radius from the DC.

In Appendix 11, the individual DiD regression for each treatment and control group on the jobs – XXL DC relationship are marked. From the results it can be concluded that the estimated parameters in the joint regression of Table 2, all distribution centre locations together, are very similar to the individual regression for each of the locations. For all individual control variables, the constant parameter, time dummy parameter and interaction effect have a positive estimate, except for the interaction effect of Lelystad Airport which is negative. The time variant parameter either holds a positive or negative estimate depending on the location. Surprisingly, the R-squared for the individual locations Venlo (0.8942) and Lelystad Airport (0.9454) are very large which deviates from the R-squared obtained in the collective model (0.0054) in Table 2.

The second hypothesis explores the relationship between the average WOZ value within a specified range from the XXL DC and the construction of an XXL DC through three sub-hypotheses. All three sub-hypotheses adopt the DiD method with parameters identical to those in Table 1. The first sub-hypothesis explores the effect of the construction of an XXL DC on the average WOZ value within a 0-5 km range from the XXL DC as observed in Table 3. Again, the construction of an XXL DC has no significant (5%) effect on the average WOZ value in municipalities within a 5 km radius as the p-value (0.939) is larger than our α (0.05). Thus, the hypothesis arguing that the construction of an XXL DC has a positive influence on the average WOZ value within a 5 km radius cannot be rejected or accepted.

Remarkably, the time dummy parameter in Table 3 indicates that over time, the residential property value for municipalities in the control group decreased. Specifically, the house prices for municipalities in the control group decreased with €15,650.00 in the post time period which sets the WOZ value at €242,850.00 - €15,650.00 = €227,200.00.

Table 3: **The complete difference-in-difference regression of the WOZ value within 5 km – XXL DC relationship**

	Constant (β_0)	**Treatment dummy (β_1)**	**Time dummy (β_2)**	**Interaction effect (β_3)**	**Observations**	**R^2**	**Adjusted R^2**
Locations with XXL DC	242850*** (4886.384)	-21516.67** (7979.432)	-15650** (6125.407)	769.0476 (10002.75)	176	0.1450	0.1301
Locations without XXL DC	470.2549*** (40.63457)		11.12971 (50.75971)		142	0.0003	-0.0068

Note: *p-value < 0.1, **p-value < 0.05 and ***p-value < 0.001. The standard errors are noted between brackets.

The second sub-hypothesis investigates the relationship between the construction of an XXL DC and the average WOZ value within a 5-10 km range from the XXL DC as observed in Table 4. It appears that the construction of an XXL DC has no significant (5%) effect on the average WOZ value in municipalities within a 10 km radius as the p-value (0.946) is much larger than our α (0.05). Hence, the hypothesis indicating that the construction of an XXL DC has a positive influence on the average WOZ value within a 10 km radius cannot be rejected nor accepted.

Table 4: **The complete difference-in-difference regression of the WOZ value within 10 km – XXL DC relationship**

	Constant (β_0)	**Treatment dummy (β_1)**	**Time dummy (β_2)**	**Interaction effect (β_3)**	**Observations**	**R^2**	**Adjusted R^2**
Locations with XXL DC	242897.7*** (3752.161)	-21564.39** (8105.593)	-15306.53** (4676.612)	425.5799 (10148.44)	313	0.0946	0.0859
Locations without XXL DC	470.2549*** (40.63457)		11.12971 (50.75971)		142	0.0003	-0.0068

Note: *p-value < 0.1, **p-value < 0.05 and ***p-value < 0.001. The standard errors are noted between brackets.

Strikingly, both the treatment parameter and time variant parameter are significant when assuming a significance of 5%. The time variant dummy indicates that the average WOZ value for municipalities in the control group once again decreased from pre to post time period. The average residential property value for municipalities in the control group decreased with €15,306.53 in the post time period which sets the WOZ value at €242,897.70 - €15,306.53 = €227,591.17.

The third sub-hypothesis explores the effect of the construction of an XXL DC on the average WOZ value within a 10-15 km range from the XXL DC as observed in Table 5. Again, the construction of an XXL DC has no significant (5%) effect on the average WOZ value in municipalities within a 15 km radius as the p-value (0.825) is much larger than our α (0.05). Consequently, the hypothesis stating that the construction of an XXL DC has a positive influence on the average WOZ value within a 15 km radius is not rejected nor accepted.

Table 5: **The complete difference-in-difference regression of the WOZ value within 15 km – XXL DC relationship**

	Constant (β_0)	**Treatment dummy (β_1)**	**Time dummy (β_2)**	**Interaction effect (β_3)**	**Observations**	**R^2**	**Adjusted R^2**
Locations with XXL DC	258986.4*** (5412.001)	-47923.89** (17273.95)	-14887.13* (6717.079)	-4782.513 (21633.08)	463	0.0607	0.0546
Locations without XXL DC	395.9202*** (23.16797)		8.37586 (29.01066)		519	0.0002	-0.0018

Note: *p-value < 0.1, **p-value < 0.05 and ***p-value < 0.001. The standard errors are noted between brackets.

As in the previous models, the DiD regression for all three sub-hypotheses has a very low R-squared. Hence, the model explains little of the variation and only a very small share of the variation in the dependent variable, average WOZ value, can be explained by the independent variable, construction of an XXL DC. However, all three models mark a negative direct effect of the construction of an XXL DC on the average WOZ value in municipalities within a 5, 10, and 15 km radius from the XXL DC. Particularly, the average WOZ value in the third sub-hypothesis decreases with €4782.513 more than it would have without the construction of an XXL DC. The results of the individual regressions can be found in Appendix 12, 13, and 14.

The extremely low R-squared in all models may be attributed to the fact that the average WOZ value within a municipality is defined by more parameters than only the construction of an XXL DC within certain proximity. To generate a valid outcome, one must consider other determinants of the average residential property value such as architectural variables being the physical characteristics linked to a house as for instance the total number of square footage and the number of bed- and bathrooms. Besides, surrounding variables and local amenities are to be considered such as forests, parks, restaurants, cultural facilities, major roads, and train stations (Kaufman & Norman, 2006).

Discussion

Unfortunately, this study also knows its limitations that may influence the results that have been obtained during the analysis. For example, the internal validity of this research should be further reviewed as the applied models may be subject to endogeneity. With endogeneity there is a correlation between coefficients and the error term. This can be caused by simultaneous and reverse causality. Thus, both the construction of an XXL distribution centre and the average residential property value may mutually affect each other, or the dependent and independent variables may be interchanged. Thus, the housing prices within a municipality may also determine the number of distribution centres in a municipality as distribution centres might prefer to locate themselves in locations where a low cost of living for their employees can be ensured.

Endogeneity may occur through selection bias. Herein the data to be analysed is argued to be not random and representative. The different datasets are collected across various time periods, yet they have overlapping intervals. The three datasets from the Central Bureau of Statistics contain data on the average residential property value per municipality from 1997 to 2020, total length of roads per municipality from 2001 to 2021 and total number of jobs per municipality from 2010 to 2020. The time period in the dataset from Nefs ranges from 1887 to 2020 (Nefs, 2022b). Therefore, these time periods are consistent to a certain extent.

Another aspect that could potentially influence the internal validity of this research is when the omitted variable bias (OVB) is violated. This happens when a number of important variables are missing from the model attaching a too large effect to the independent variable in the model. Future research should incorporate more variables into the model which may potentially affect the average house prices within a municipality such as the number of amenities or the availability of greenery. The explanatory power of the DiD models was on the low side which indicates that more control variables should be added to the model which could subsequently explain a larger extent of the variation in the local house prices.

Lastly, the sample selection bias may also have influenced the obtained results in the analysis. This study consists of a relatively small sample as it looks at the construction of six XXL distribution centres in a mere six locations. However, 165 XXL DCs exist in the Netherland spread across 114 distribution site locations. The reason for choosing 'only' six locations is that the analysis requires a lot of data and time. Consequently, it was decided to test the effect of a small group of DCs so that a first step could be taken towards determining the influence of the construction of XXL DCs on the average house price in the local surrounding.

Additionally, the dataset containing the information on all XXL DCs included many missing values as an abundant amount of distribution centres where not registered with the Dutch Chamber of Commerce between 2017 and. 2020. Therefore, there were a limited amount of XXL DCs that could be used in our analysis and few of them rely on additional assumptions.

With the insights of the limitations of this research, a number of recommendations can be made for further research. First of all, the dataset used could be expanded to gain a wider perspective. This research only considers the date when the construction of the DC was finalized and put into use. However, it is important to take into account the date when the construction of a future DC was announced by the municipality as a period of speculation might follow after the announcement during which investors will suddenly buy purchase or sale surrounding land and residential properties. This might influence the average residential property value for this given period and thus has to be taken into account in future research.

Secondly, the time period of the final integrated dataset ranges from 2010 to 2020 as earlier data on the average residential property value from the CBS was not open to the public. Nevertheless, the development of most XXL distribution centres took off in the early 2000s with some even establishing themselves in the late 1900s. Future research should include data on the average residential property value per municipality, the total road length per municipality and the total number of jobs per municipality from at least 2000 up to 2020.

Furthermore, the inclusion of more control variables such as the number of amenities within a municipality should be included into the model to increase the explanatory power. In addition, data from neighbouring countries such as Germany and Belgium on the variables used in the model should be incorporated into the dataset. The 15 km radius surrounding an XXL distribution centre in Trade Port Noord, Venlo, reaches beyond the Dutch border and into Germany. To optimise the establishment of an effect of the construction of an XXL DC on the average residential property value, also the residential properties in the German region should be considered in the models.

Conclusion

This research was performed to provide an answer to several hypotheses which would ultimately provide an answer to the main research question. Hypothesis 1 stated that there would be a positive relationship between the construction of an XXL distribution centre and the total number of jobs for municipalities within a 15 km radius of the DC. From Table 2, column 5 it appears that the significant effect between the construction of an XXL DC and the total number of jobs for a given municipality within a 15 km radius in all six locations remains inconclusive. Thus, the first hypothesis is neither rejected nor accepted.

Hypothesis 2 argues that the construction of an XXL distribution centre increases the residential property value in municipalities within a range of 5, 10, and 15 km from the DC. In Table 3, column 5 a direct positive yet not significant coefficient is evident between the construction of an XXL DC and residential property values for municipalities within a 5 km range from the DC. Thus, the construction of an XXL DC seems to have an inconclusive effect on local housing prices within a 5 km radius. From Table 4 it appears that the same holds for residential property values within a 10 range. However, in Table 5 we can identify a direct negative yet not significant coefficient indicating that the construction of an XXL DC has once again an inconclusive effect on local housing prices within a 15 km radius. Consequently, the third hypothesis is neither rejected nor accepted.

The main research question in the beginning read as follows: "*What is the influence of the construction of new XXL distribution centres on house prices within a 15 km radius?*". Alas the interaction effects obtained in the two hypotheses are all insignificant and our hypotheses can neither be rejected nor accepted. Thus, the answer to our research question and the results on the effect of the construction of an XXL DC on local house prices within a 15 km radius remains inconclusive.

Literature

ALONSO, W. (1960). *A theory of the urban land market*. Papers and proceedings of the regional science association, 6, 149-157.

Bak, R.L. (2021). *Logistiek vastgoed in cijfers 2021*. Statistiek van de Nederlandse markt voor distributiecentra en opslagruimten. NVM Business. Accessed on April 25, 2022. https://www.nvm.nl/media/qkvlr155/logistiek-vastgoed-in-cijfers-2021.pdf

Baker, P., & Halim, Z. (2007). An exploration of warehouse automation implementations: cost, service and flexibility issues. Supply Chain Management: An International Journal.

Borst, B. van der, Dijk, R. van, Nieuwenhuijzen, J., Ramaer, C. & Saris, K. (2022, April 27). *Gooien met grond*. De Groene Amsterdammer. Accessed on May 18, 2022. https://www.groene.nl/artikel/gooien-met-grond

Buijs, M. (2021, March 9). *Klein heeft de toekomst in het vastgoed*. ABN AMRO. Accessed on April 20, 2022. https://www.abnamro.nl/nl/zakelijk/insights/sectoren-en-trends/real-estate/klein-heeft-de-toekomst-in-het-vastgoed.html

Centraal Bureau voor de Statistiek. (2021, November 5). *Banen van werknemers in december; economische activiteit (SBI2008), regio*. Accessed on May 18, 2022. https://opendata.cbs.nl/statline/portal.html?_la=nl&_catalog=CBS&tableId=83582NED&_theme=244

Centraal Bureau voor de Statistiek. (2022a, Januari 24). *Grootste prijsstijging bestaande koopwoningen in 21 jaar*. Accessed on April 20, 2022. https://www.cbs.nl/nl-nl/nieuws/2022/04/grootste-prijsstijging-bestaande-koopwoningen-in-21-jaar

Centraal Bureau voor de Statistiek. (2022b, March 11). *Waarde onroerende zaken van woningen en niet-woning 1997-2020*. Accessed on May 18, 2022. https://opendata.cbs.nl/#/CBS/nl/dataset/37610/table?ts=1652862386119

CRa, Rademacher & De Vries, and Stec Groep. (X)XL-Verdozing [(X)XL Boxification]. Edited by Board of government advisors. The Hague: CRa, 2019.

Dam, F. van & Eskinasi, M. (2013, April). *Woningprijzen: bepalende factoren en actoren. Een overzicht van bevindingen uit studies van het PBL*. Planbureau voor de Leefomgeving. Den Haag. https://www.tweedekamer.nl/sites/default/files/field_uploads/120912%20PBL%20overzichtspaper_tcm181-232761.pdf

Gereffi, G. & Korzeniewicz, M. (1994). *Commodity Chains and Global Capitalism*. Westport, CT: Praeger.

Groot, H. de, Marlet, G., Teulings, C. & Vermeulen, W. (2010, December). *Stad en land*. Centraal Planbureau. Den Haag.

Heijne, S. & Noten, H. (2020, June). *Fantoomgroei: Waarom we steeds harder werken voor steeds minder* (8th ed.). Atlas Contact.

Hoyt, H. (1939). The structure and growth of residential neighborhoods in American cities. US Government Printing Office.

Janssen, G. (2021, September 19). *Gemeenten worstelen met woningen arbeidsmigranten: 'Raad schiet in kramp'*. NOS. Accessed on May 25, 2022. https://nos.nl/nieuwsuur/artikel/2398445-gemeenten-worstelen-met-woningen-arbeidsmigranten-raad-schiet-in-kramp

Kaufman, D. A., & Cloutier, N. R. (2006). The impact of small brownfields and greenspaces on residential property values. *The Journal of Real Estate Finance and Economics*, *33*(1), 19-30.

KC. (2022). *Distribution Center Growth and Positive Impact*. Kansas City Area Development. Accesed on August 26, 2022. *https://kcsmartport.thinkkc.com/why-kc/trade-corridor-network/distribution-center-positive-impact-on-communities*

Klumpenaar, S. (2022, January 7). *Wie zich ergert aan de 'verdozing' van Nederland, kan het beste bij zichzelf beginnen*. NRC Handelsblad. Accessed on May 18, 2022. https://www.nrc.nl/nieuws/2022/01/07/van-de-doos-een-deugd-maken-kan-dat-nog-a4075997?t=1652871178

Latham, S., & Humberd, B. (2018). Four ways jobs will respond to automation. MIT Sloan Management Review, 60(1), 11-14.

Lennartz, C., Baarsma, B., & Vrieselaar, N. (2019). *Exploding house prices in urban housing markets: Explanations and policy solutions for the Netherlands*. Hot property, 207.

McCann, P. (2013). *Modern Urban and Regional Economics (2nd ed.)*. Oxford University Press.

Nefs, M. (2022a) *Landscapes of trade*. Accessed on June 17, 2022. https://mertennefs.eu/landscapes-of-trade/

Nefs, M. (2022b). *Dutch Distribution Centres 2021 Geodata*. 4TU. ResearchData. Dataset. https://doi.org/10.4121/19361018.v1

Nefs, M. & Daamen, T. (2022). *Behind the Big Box: understanding the planning-development dialectic of large distribution centres in Europe*, European Planning Studies,
DOI: 10.1080/09654313.2022.2057792

Nefs, M., Zonneveld, W. & Gerretsen, P. (2022). *The Dutch 'Gateway to Europe' spatial policy narrative, 1980–2020: a systematic review*, Planning Perspectives,
DOI: 10.1080/02665433.2022.2053879

Onstein, A. T., Bharadwaj, I., Tavasszy, L. A., van Damme, D. A., & el Makhloufi, A. (2021). From XXS to XXL: Towards a typology of distribution centre facilities. *Journal of Transport Geography*, *94*, 103128.

Onstein, S., Ektesaby, M., Rezaei, J., van Damme, D., & Tavasszy, L. (2018). *Welke factoren bepalen de ruimtelijke inrichting van distributienetwerken?* Logitiek+, tijdschrift voor toegepaste logistiek, (6), 72-87.

Onstein, A. T. C., Visser, J. G. S. N., Tavasszy, L., & van Ham, H. (2016). Trends in distribution centres and their locations: sprawl and polarization. In *Vervoerslogistieke Werkdagen 2016* (pp. 355-368). Hogeschool van Arnhem en Nijmegen.

Openshaw, S. & Veneris, Y. (2003). *Numerical experiments with central place theory and spatial interaction modelling*. Environment and Planning. 35(8), 1389-1403.

Prick, A., (2018, March 25). *Nederland, pakhuis van Noordwest-Europa, barst uit zijn voegen*. NOS. https://nos.nl/artikel/2224301-nederland-pakhuis-van-noordwest-europa-barst-uit-zijn-voegen

Roel, (2022). *Mega distributiecentra: welke factoren spelen mee bij het vinden van de perfecte locatie*. Coulant. Accessed on April 20, 2022. https://www.coulant.nl/nieuws/mega-distributiecentra-welke-factoren-spelen-mee-bij-het-vinden-van-de-perfecte-locatie/

Rosen, S. (1974). *Hedonic prices and implicit markets: product differentiation in pure competition*. Journal of political economy, 82(1), 34-55.

Routekaart Logistiek (z.d.). Dutch Green Building Council (DGBC). Accessed on March 27, 2022. https://dgbc.foleon.com/paris-proof/routekaart-logistiek/marktanalyse/

Schutijser, J. (2020, April 28). *Thuiswerken en leven jaagt omzet webshops omhoog*. NOS. https://nos.nl/artikel/2331982-thuis-werken-en-leven-jaagt-omzet-webshops-omhoog

Stigler, G. (1958). *The Economies of Scale*. The Journal of Law & Economics, 1, 54-71.

Verhetsel, A., Kessels, R., Goos, P., Zijlstra, T., Blomme, N. en Cant, J. (2015). *Location of logistics companies: a stated preference study to disentangle the impact of accessibility*. Journal of Transport Geography, 42(2015), 110 – 121.

Visser, P. & Dam, F. van. (2006). *De prijs van de plek; Woonomgeving en woningprijs*. Ruimtelijk Planbureau. Den Haag. Accessed on April 20, 2022. https://www.pbl.nl/sites/default/files/downloads/De_prijs_van_de_plek.pdf

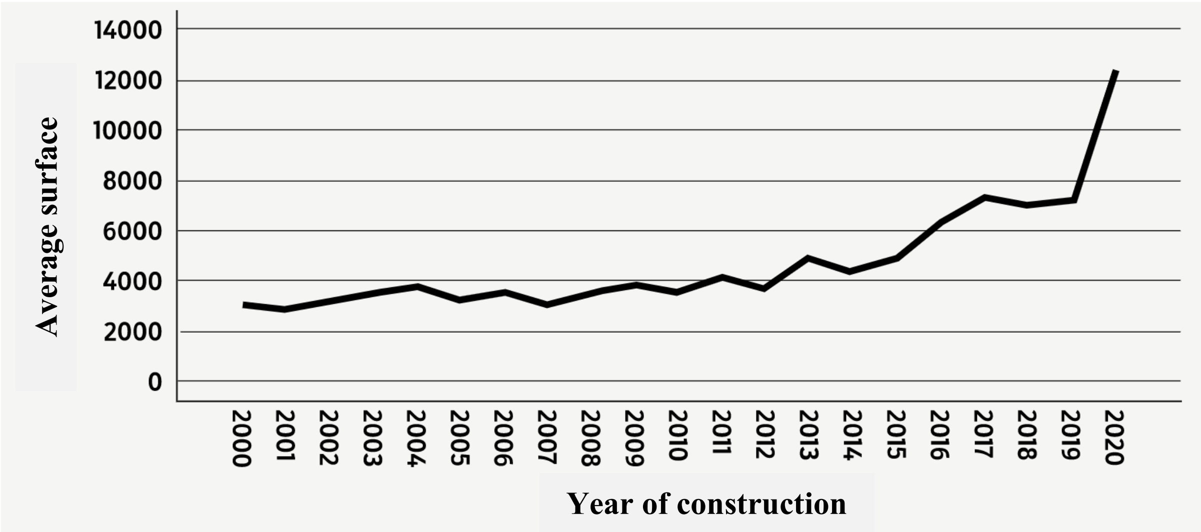
Vor, F. de, & Groot, H. L. de (2011). The impact of industrial sites on residential property values: A hedonic pricing analysis from the Netherlands. *Regional Studies*, *45*(5), 609-623.

Wood, A. & Roberts, S.M. (2010). *Economic Geography: places, networks and flows*. Milton: Francis and Taylor.

Zwet, R. van. (2019). *Sprekende cijfers: Logistiek 2019.* Dynamis. Utrecht. https://dynamis.nl/uploads/media/file/1afbb759-6cb7-4845-a793-bc6699daac9a/sprekende-cijfers-logistiek-2019.pdf

Appendix

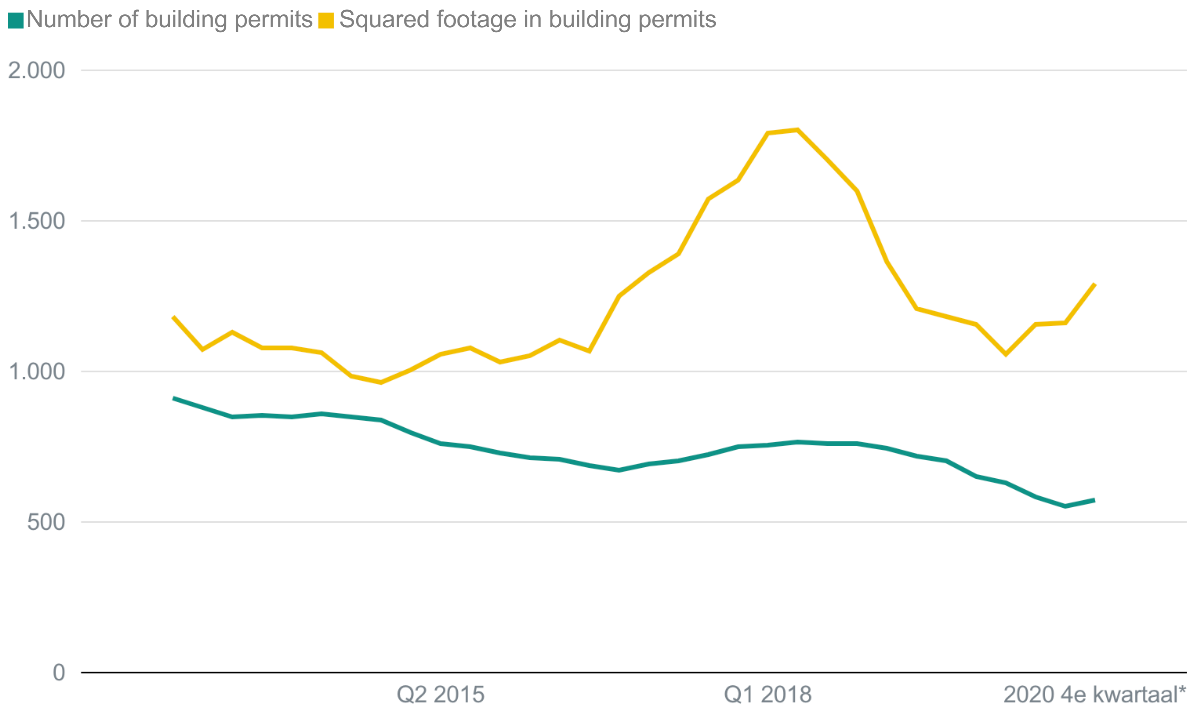
Appendix 1: Average surface per distribution centre



Source: Borst, van der; Dijk, van; Nieuwenhuijzen; Ramaer & Saris, 2022

Note: Graph from De Groene Amsterdammer, an independent weekly newsmagazine, illustrating the average surface area in square footage for a distribution centre per year.

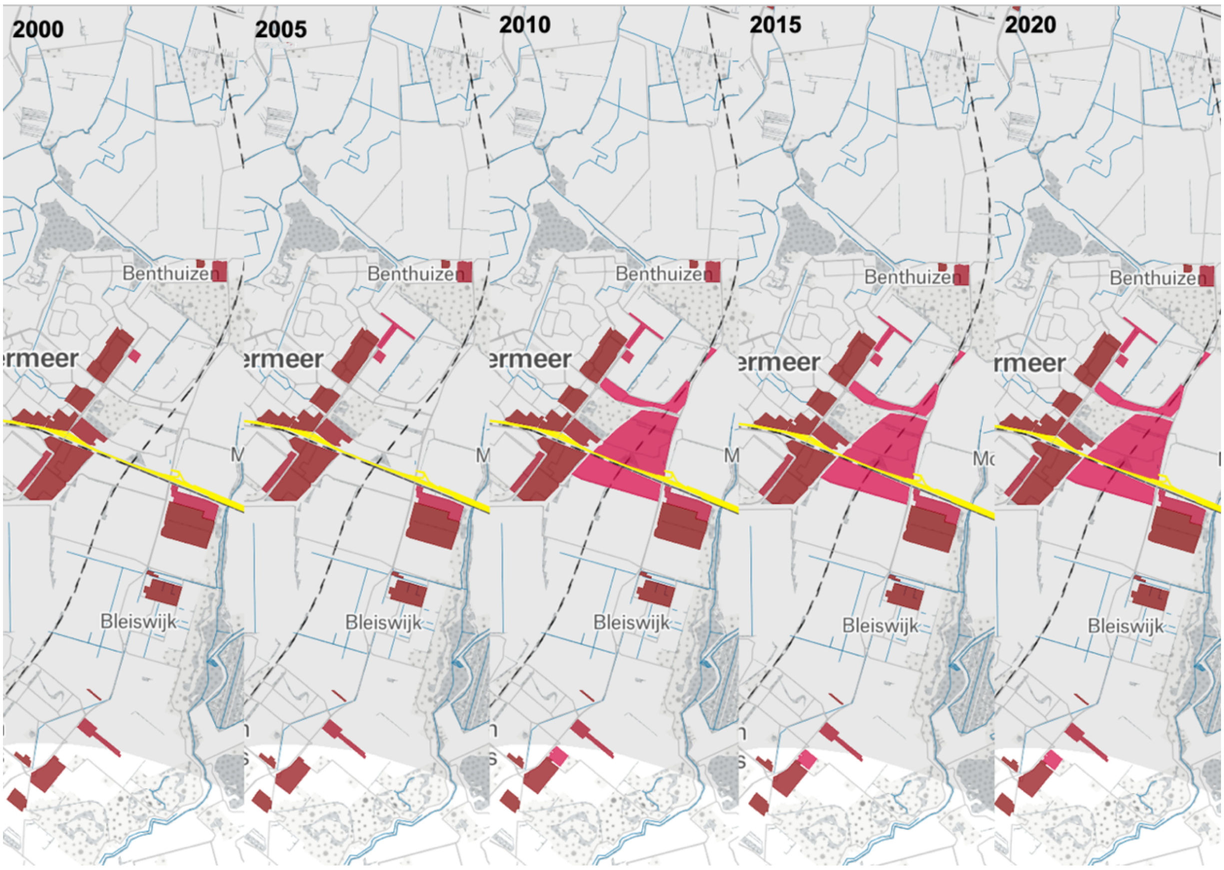
Appendix 2: Decrease in average square footage of new industrial buildings



Source: Buijs, 2021

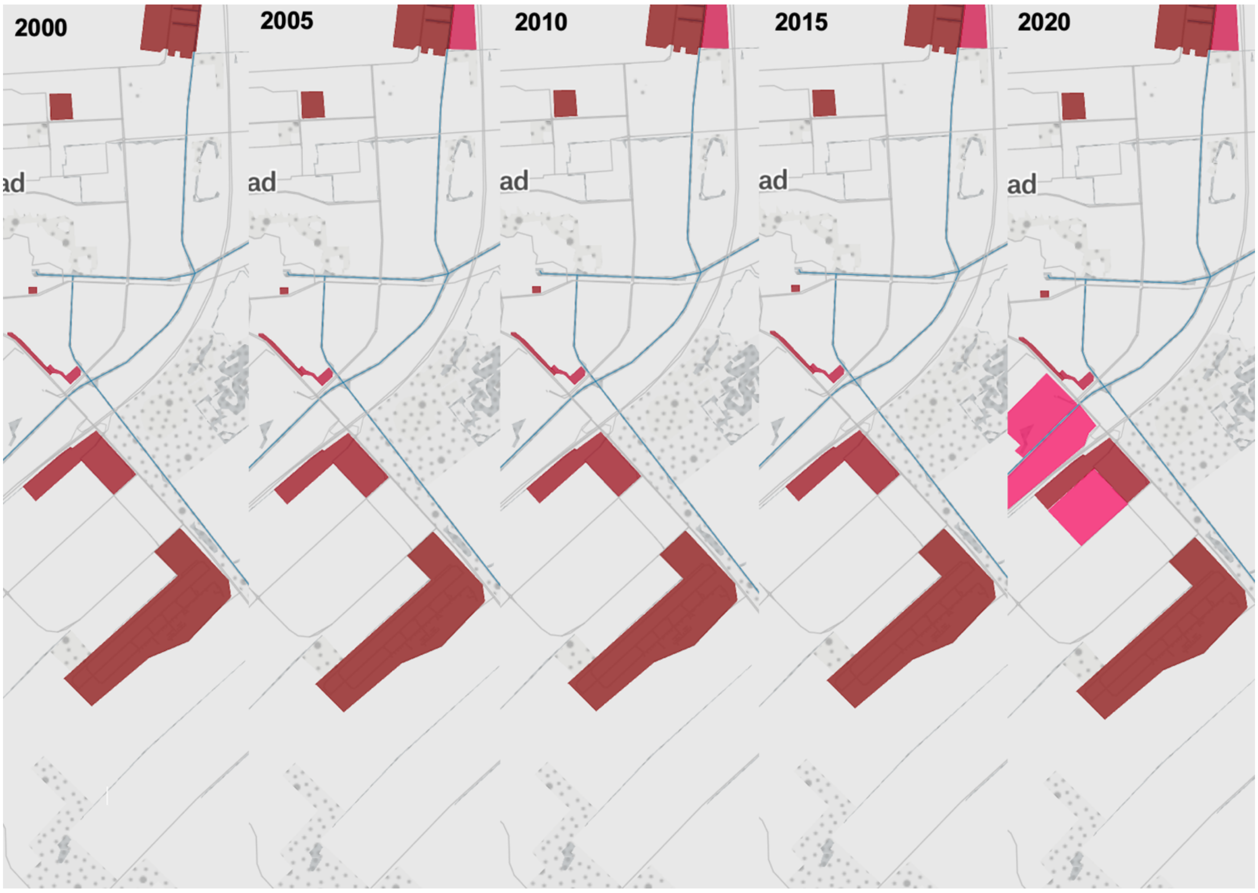
Note: Graph from the Central Bureau of Statistics, retrieved by ABN AMRO Bank. The yellow line indicates the number of building permits for general industrial buildings issued per quarter. The green line indicates the average squared footage allowance for an industrial building as issued in the obtained building permits.

Appendix 3: ‘Macro’ aerial view of the development of Bedrijvenpark Prisma in Bleiswijk, Zuid-Holland



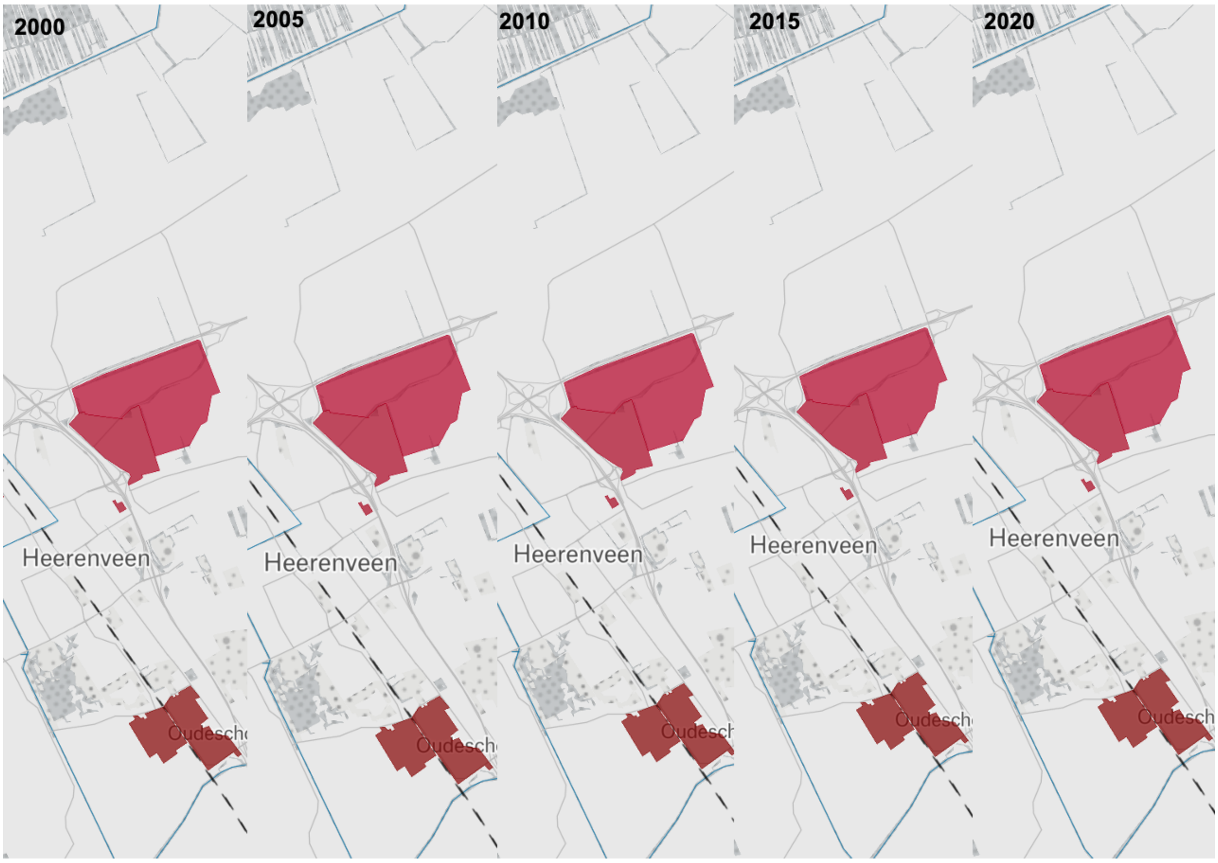
Source: Nefs, 2022a

Appendix 4: 'Macro' aerial view of the development of Lelystad Airport in Lelystad, Flevoland



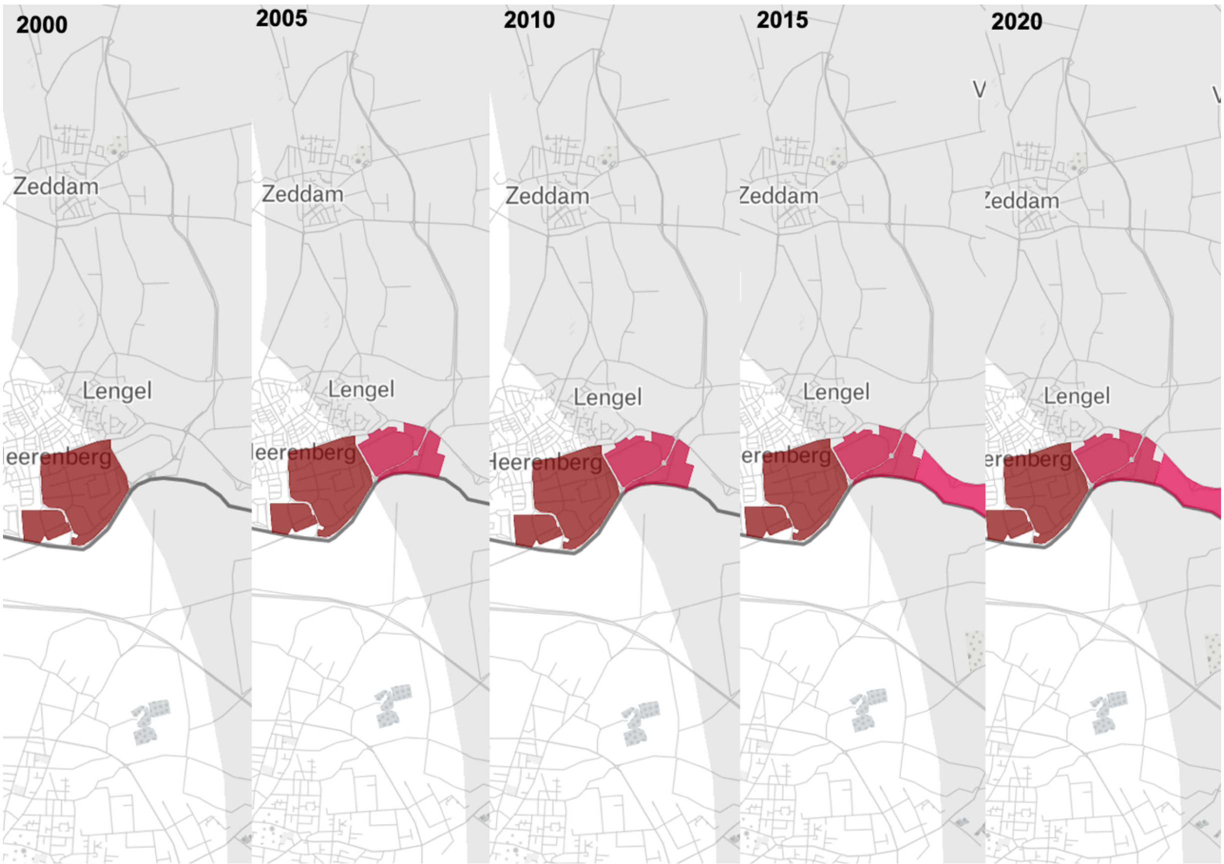
Source: Nefs, 2022a

Appendix 5: ‘Macro’ aerial view of the development of IBF in Heereveen, Friesland



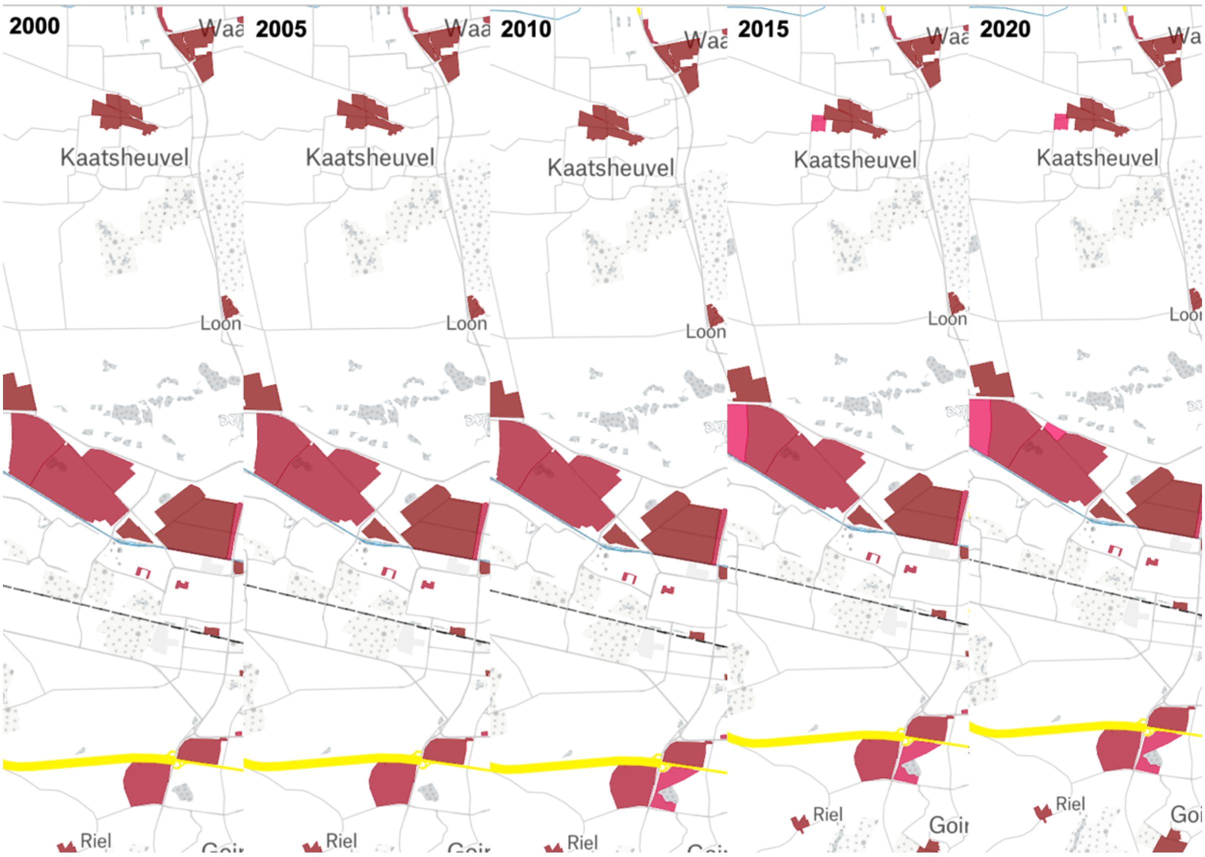
Source: Nefs, 2022a

Appendix 6: 'Macro' aerial view of the development of DocksNLD in Montferland, Gelderland



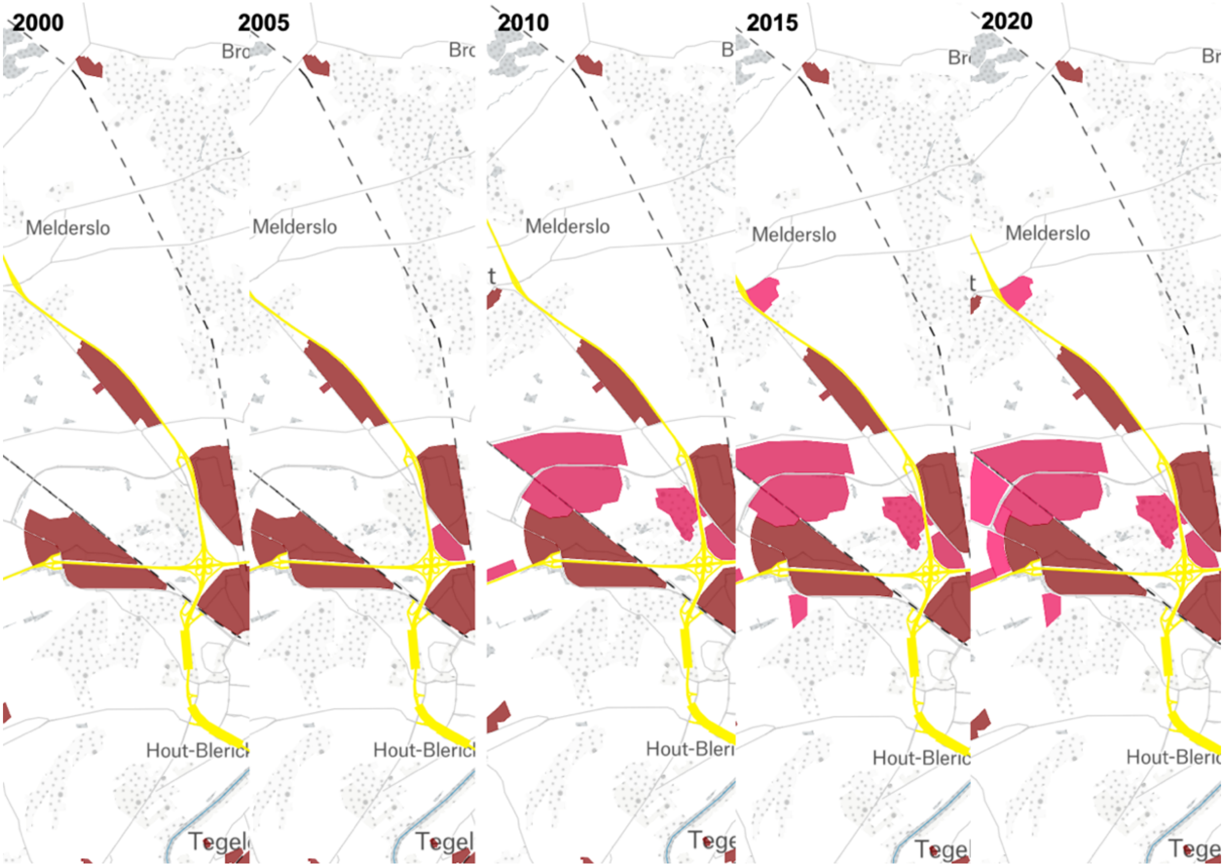
Source: Nefs, 2022a

Appendix 7: 'Maccro' aerial view of the development of Bedrijventerrein Vossenberg in Tilburg, Noord-Brabant



Source: Nefs, 2022a

Appendix 8: 'Macro' aerial view of the development of Trade Port Noord in Venlo, Noord-Brabant



Source: Nefs, 2022a

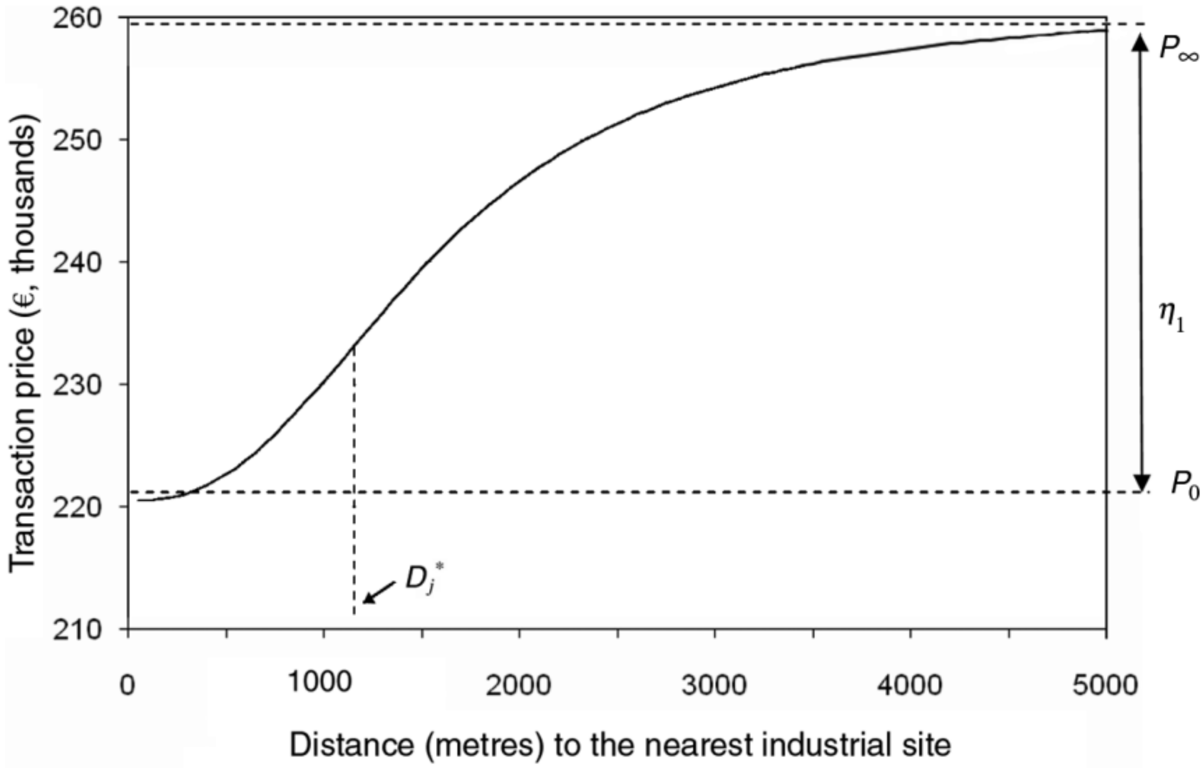
Appendix 9: Variables of property and neighbourhood characteristics affecting the house price

Explanatory variables house prices			
Housing characteristics		Neighbourhood chararcteristics	
Phyisical housing characteristics	Living area	Physical neighbourhood characteristics	Availability forested area within 50 m
	Surface area		Availability parks and public garden within 50 m
	Number of rooms		Availability recreational water within 50 m
	Availability garage		Availability other inland water within 50 m
	Availability garden		Availability recreational greenery within 50 m
Date of construction	-1905		% forested area in the neighbourhood
	1906 - 1944		% recreational water in the neighbourhood
	1945 - 1970		% other inland water in the neighbourhood
	1971 - 1990		% recreational greenery in the neighbourhood
	1991 -		% industrial sites in the neighbourhood
Residential property type	Detached house		Density surrounding addresses neighbourhood
	Semi-detached house		Number of high-rise (higher than 4 floors)
	Corner house		Number of newly built houses (municipality)
	Staggered terraced house	Social neighbourhood characteristics	Share owner-occupied houses
	Terraced house		Share single-family home
Apartment type	Upper house		Population density (inhabitants per km2) neighbourhood
	Ground floor apartment		Share immigrants in the neighbourhood
	Maisonnette		Social status score of the neighbourhood
	Walk-up flat	Functional neighbourhood characteristics	Distance to nearest shops for daily necessities
	Gallery flat		Distance to nearest shops for daily necessities entry and exit motorway
	Downstairs and upstairs apartment		Distance to nearest primary school
Province	Groningen		Distance to city or village centre
	Friesland		Distance to neighbourhood centre
	Drenth		Distance to motorway
	Overijssel		Distance to nearest metro or tram stop
	Gelderland		Distance to nearest bus stop
	Flevoland		Distance to nearest local train trainstation
	Utrecht		Distance to nearest express train trainstation
	Noord-Holland		Number of accessible jobs in 15 min by road
	Zuid-Holland		Number of accessible jobs in 30 min by road
	Noord-Brabant		Number of accessible jobs in 45 min by road
	Limburg		Number of accessible jobs in 15 min by train
	Zeeland		Number of accessible jobs in 30 min by train
			Number of accessible jobs in 45 min by train

Source: Visser & Van Dam, 2006

Note: List of explanatory variables determining the residential property value according to the PBL (Planbureau voor de Leefomgeving), the national institute for strategic policy analysis regarding the environmental, nature and space. The model makes use of dummy variables for the following characteristics: date of construction, residential property type, apartment type and province.

Appendix 10: Transaction price gradient function for a representative property



Source: De Vor & De Groot, 2011

Note: Graph illustrating the relationship between the height of the transaction price, in euros, of a residential property and the distance to the nearest industrial site in metres. The graph indicates a negative effect on the residential property value due to the presence of an industrial site within close proximity; the larger the distance the nearest industrial site, the higher the price of a property.

Appendix 11: **The complete difference-in-difference regression of the jobs – XXL DC relationship for all 12 locations individually**

Location DC	Constant (β_0)	Treatment dummy (β_1)	Time dummy (β_2)	Interaction effect (β_3)	Observations	R^2	Adjusted R^2
Bleiswijk	53108.33*** (8391.872)	-29941.67 (38456.39)	780.2381 (12284.44)	3073.095 (57004.75)	236	0.0044	-0.0085
Stichtse Vecht	40080*** (9046.498)		4667.273 (13362.56)		120	0.0010	-0.0074
Tilburg	18000*** (3623.294)	100250*** (13557.12)	922.5806 (4524.245)	9927.419 (16990.01)	156	0.5288	0.5195
Breda	19537.5*** (4002.661)		713.6905 (5017.601)		132	0.0002	-0.0075
Venlo	18587.5*** (1269.642)	41479.17*** (2839.006)	1407.5 (1883.184)	4205.833 (4210.926)	55	0.8942	0.8880
Sittard-Geleen	22041.67*** (3249.462)		219.8718 (4768.907)		112	0.0000	-0.0091
Montferland	17937.5*** (1420.681)	-5175 (3176.74)	1437.5 (2720.397)	2533.333 (6082.994)	55	0.0651	0.0101
Oldenzaal	22514.06*** (3151.199)		1565.104 (6034.087)		88	0.0008	-0.0108
Heereveen	14308.33*** (2571.169)	13166.67* (5142.338)	1003.205 (3108.392)	3436.081 (6389.665)	49	0.3655	0.3232
Steenwijkerland	9740*** (1180.3)		411.4286 (1479.585)		55	0.0015	-0.0174
Lelystad	10287.5*** (697.1476)	24412.5*** (1207.495)	1879.167 (1334.936)	-5379.167* (2312.177)	33	0.9454	0.9397
Purmerend	66573.86*** (17746.89)		7547.348 (33982.71)		121	0.0004	-0.0080

Note: *p-value < 0.1, **p-value < 0.05 and ***p-value < 0.001. The standard errors are noted between brackets. The model highlights the outcomes of the difference-in-difference model for all 6 treatment and 6 control groups individually.

Appendix 12: **The complete difference-in-difference regression of the average WOZ value – XXL DC relationship for all 12 locations individually within a 0-5 km radius.**

Location DC	Constant (β_0)	Treatment dummy (β_1)	Time dummy (β_2)	Interaction effect (β_3)	Observations	R^2	Adjusted R^2
Bleiswijk	226166.7*** (6294.835)	56500*** (12589.67)	4500 (9336.75)	11033.33 (18673.5)	44	0.5290	0.4937
Stichtse Vecht	302090.9*** (8693.563)		16009.09 (12598.17)		21	0.0783	0.0298
Tilburg	258750*** (4182.888)	-49750*** (8365.776)	-19559.52 ** (5243.528)	4702.381 (10487.06)	44	0.7193	0.6982
Breda	247250*** (11369.56)		-2392.857 (14252.5)		11	0.0031	-0.1076
Venlo	244000*** (3841.097)	-59000*** (6652.974)	-2600 (5697.267)	7600 (9867.956)	33	0.8157	0.7967
Sittard-Geleen	179583.3*** (5254.092)		3016.667 (7793.078)		22	0.0074	-0.0422
Montferland	209125*** (7374.608)	12250 (10429.27)	-2125 (14121.3)	-9916.667 (19970.53)	22	0.0956	-0.0552
Oldenzaal	211750*** (6360.609)		14583.33 (12179.64)		44	0.0330	0.0100
Heereveen	221500*** (7674.685)	-12000 (10853.64)	-16214.29 (9620.727)	1428.571 (13605.76)	22	0.3097	0.1946
Steenwijker land	219250*** (6057.021)		-19250* (7592.877)		11	0.4166	0.3518
Lelystad	171875*** (5122.854)	0.0000 (0.0000)	16791.67 (9809.519)	0.0000 (0.0000)	11	0.2456	0.1618
Purmerend	247875*** (9085.874)		33236.11* (17398.12)		33	0.1053	0.0765

Note: *p-value < 0.1, **p-value < 0.05 and ***p-value < 0.001. The standard errors are noted between brackets. The model highlights the outcomes of the difference-in-difference model for all 6 treatment and 6 control groups individually.

Appendix 13: **The complete difference-in-difference regression of the average WOZ value – XXL DC relationship for all 12 locations individually within a 5-10 km radius.**

Location DC	**Constant (β_0)**	**Treatment dummy (β_1)**	**Time dummy (β_2)**	**Interaction effect (β_3)**	**Observations**	**R^2**	**Adjusted R^2**
Bleiswijk	235229.2*** (6293.888)	47437.5* (18881.66)	6845.833 (9335.344)	8687.5 (28006.03)	99	0.1321	0.1047
Stichtse Vecht	290965.5*** (8906.529)		15754.48 (13089.87)		54	0.0271	0.0084
Tilburg	258666.7*** (3646.441)	-49666.67*** (9647.576)	-20333.33*** (4571.056)	5476.19 (12093.88)	77	0.5367	0.5177
Breda	266357.1*** (6528.933)		-14826.53* (8184.451)		77	0.0419	0.0291
Venlo	244000*** (3841.097)	-59000*** (6652.974)	-2600 (5697.267)	7600 (9867.956)	33	0.8157	0.7967
Sittard-Geleen	201000*** (7667.752)		3352.941 (11002.15)		35	0.0028	-0.0274
Montferland	207562.5*** (4923.403)	13812.5 (8527.584)	-729.1667 (9427.599)	-11312.5 (16329.08)	33	0.0937	-0.0001
Oldenzaal	202625*** (6965.556)		13375 (13338.02)		44	0.0234	0.0001
Heereveen	212625*** (5853.999)	-3125 (10139.42)	-13677.63* (6978.43)	-1108.083 (12506.08)	38	0.1524	0.0776
Steenwijkerland	228812.5*** (8069.24)		-21062.5* (10115.33)		44	0.0936	0.0720
Lelystad	223000*** (5116.82)	-51125*** (8862.591)	13166.67 (9797.964)	3625 (16970.57)	33	0.6198	0.5805
Purmerend	265083.3*** (7209.379)		44916.67** (13804.91)		66	0.1419	0.1285

Note: *p-value < 0.1, **p-value < 0.05 and ***p-value < 0.001. The standard errors are noted between brackets. The model highlights the outcomes of the difference-in-difference model for all 6 treatment and 6 control groups individually.

Appendix 14: **The complete difference-in-difference regression of the average WOZ value – XXL DC relationship for all 12 locations individually within a 10-15 km radius.**

Location DC	Constant (β_0)	Treatment dummy (β_1)	Time dummy (β_2)	Interaction effect (β_3)	Observations	R^2	Adjusted R^2
Bleiswijk	253194.4*** (7745.923)	0.0000 (0.0000)	9542.398 (11322.94)	0.0000 (0.0000)	203	0.0035	-0.0014
Stichtse Vecht	299516.7*** (6214.473)		17183.33* (9217.553)		110	0.0312	0.0222
Tilburg	291550*** (6829.718)	-82550*** (22651.61)	-23869.44** (8518.155)	9012.302 (28382.26)	123	0.2502	0.2313
Breda	260431.8*** (4558.274)		-16626.62** (5714.099)		121	0.0664	0.0586
Venlo	248388.9*** (6533.108)	0.0000 (0.0000)	-5388.889 (9690.165)	0.0000 (0.0000)	33	0.0099	-0.0221
Sittard-Geleen	183250*** (6238.816)		3812.5 (9094.559)		68	0.0027	-0.0125
Montferland	219343.8*** (5601.777)	2031.25 (12525.95)	906.25 (10726.59)	-12947.92 (23985.38)	55	0.0067	-0.0518
Oldenzaal	217958.3*** (5690.244)		13375 (10895.99)		66	0.0230	0.0077
Heereveen	190937.5*** (6664.241)	18562.5 (14901.7)	-9876.894 (8120.668)	-4908.82 (18577.06)	60	0.0883	0.0394
Steenwijkerland	238400*** (7835.182)		-21142.86* (9821.921)		55	0.0804	0.0630
Lelystad	223000*** (5116.82)	-51125*** (8862.591)	13166.67 (9797.964)	3625 (16970.57)	33	0.6198	0.5805
Purmerend	254000*** (6183.902)		52444.44*** (11841.27)		99	0.1682	0.1596

Note: *p-value < 0.1, **p-value < 0.05 and ***p-value < 0.001. The standard errors are noted between brackets. The model highlights the outcomes of the difference-in-difference model for all 6 treatment and 6 control groups individually.