MASTER

Developing a spatial decision support tool to explore which vacant inner city retail properties are interesting to transform into housing based on target group's preferences

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DEVELOPING A SPATIAL DECISION SUPPORT TOOL TO EXPLORE WHICH VACANT INNER CITY RETAIL PROPERTIES ARE INTERESTING TO TRANSFORM INTO HOUSING BASED ON TARGET GROUP'S PREFERENCES

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SAMENVATTING

De winkelvastgoedmarkt heeft ongeveer 4 tot 5 procent frictieleegstand nodig om winkeliers voldoende gelegenheid te geven voor mutaties. Binnensteden van de G7-20 (7e tot 20e grootste steden in Nederland) en middelgrote steden hebben een leegstand die ruim boven dit frictieniveau ligt. Middelgrote stadscentra bereiken bijna een gemiddelde leegstand van 12%. Hoge winkelleegstand kan een negatieve invloed hebben op het ondernemings- en investeringsklimaat van een binnenstad en in gebieden met een hoge structurele leegstand is de kans op een negatieve verslechteringsspiraal groter. Omdat winkelleegstand de aantrekkelijkheid van de binnenstad beïnvloedt, moet een gemeente de leegstand zo laag mogelijk houden. Op dit moment is er gemeentelijk beleid om het winkelgebied in de binnenstad aantrekkelijker te maken door het winkelgebied compacter te maken. Door bijvoorbeeld beperkingen in het bestemmingsplan wil de gemeente de leegstaande winkelpanden aan de rand van de binnenstad niet opnieuw vullen met een winkelfunctie. Hierdoor blijft de mogelijkheid bestaan om deze leegstaande winkelpanden in te vullen met andere functies. Het is relevant om deze leegstaande winkelpanden te transformeren naar woningen, niet alleen omdat de woningmarkt in Nederland nog steeds overspannen is, maar ook omdat winkelvastgoedinvesteerders van mening zijn dat de transformatie van leegstaande winkelpanden naar woningen de meest kansrijke functie is in de aanloopgebieden binnen de binnensteden, vergeleken met andere functies. Aangezien de gemeente het winkelgebied in de binnenstad aantrekkelijker wil maken en wil zorgen voor voldoende huisvesting voor haar inwoners, hebben ze de mogelijkheid om beide aan te pakken door leegstaande winkelpanden om te vormen tot woningen.

Op dit moment is het echter onduidelijk in welk type woning en op welke locatie mensen zouden willen wonen in een binnenstad. Tot op heden is er weinig onderzoek gedaan naar de wooninteresses van mensen op een complexe locatie als de binnenstad. Als de relatie tussen de woonkenmerken van de binnenstad en de voorkeuren van de doelgroepen begrepen kan worden, zou het mogelijk zijn om te onderzoeken in welke leegstaande winkelpanden mensen graag zouden willen wonen. Daarnaast is de transformatie van leegstaand winkelvastgoed in de binnenstad complex vanwege de vele belanghebbenden. Investeerders stellen dat de transformatievisie en het transformatiebeleid van de gemeente het belangrijkst zijn om de transformatieopgave tot een goed einde te brengen, maar dat het huidige beleid niet altijd concreet genoeg is. Met onduidelijk transformatiebeleid kan de gemeente de grip op de winkelleegstand verliezen. Zodra leegstand optreedt, kan dit een domino-effect veroorzaken binnen een gebied. Naast de negatieve effecten van leegstand hebben deze gebieden dan ook meer kans om huurders aan te trekken die niet passen in het beoogde straatbeeld. Wat een gebied weer minder aantrekkelijk kan maken. Weten welke leegstaande winkelpanden interessant zijn voor doelgroepen in de binnenstad ondersteunt de gemeente bij het voeren van haar transformatiebeleid en het houden van controle over de invulling van het gebied. Daarom is dit onderzoek gericht op het creëren van een tool dat kan onderzoeken welke leegstaande winkelpanden in de binnenstad interessant zijn om te worden getransformeerd naar woningen op basis van voorkeuren van doelgroepen.

Eerst is er een literatuurstudie uitgevoerd om een beter inzicht te krijgen in alle aspecten die bijdragen aan de ontwikkeling van de tool. Uit de literatuur en rapporten blijkt dat burgers, winkeliers, vastgoedinvesteerders en gemeenten de belangrijkste belanghebbenden zijn bij de transformatie van leegstaande winkelpanden. In het studie wordt de macht en de interesse van elk van deze belanghebbenden onderzocht. Het blijkt dat gemeenten, als belanghebbenden met veel macht en interesse, het meest geschikt zijn om een tool te gebruiken. De tool moet alleen winkelpanden te

identificeren die in aanmerking zouden kunnen komen voor transformatie. Daarom worden de huidige belemmeringen, beleidsmaatregelen en beperkingen onderzocht die de transformatie van leegstaande winkelpanden in binnensteden naar woningen in de weg staan. Het blijkt dat winkelpanden niet in aanmerking komen voor transformatie als ze zich op de begane grond van het kernwinkelgebied bevinden. Daarnaast zijn bouwvoorschriften zoals minimale afmetingen, minimale daglichttoetreding en een aparte ingang op straatniveau ook criteria die winkelpanden kunnen uitsluiten van transformatie. Deze criteria kunnen worden gebruikt als uitsluitingscriteria in de tool. Daarnaast richt de literatuurstudie zich op welke woonkenmerken gebruikt kunnen worden om woonvoorkeuren met betrekking tot binnenstedelijk winkelvastgoed te onderzoeken. Er worden in totaal zes verschillende kenmerken geïdentificeerd die in aanmerking zouden kunnen komen voor de verschillende doelgroepen, zoals studenten, starters en ouderen. Wat betreft locatiekenmerken kan het interessant zijn om te kijken naar de afstand tot openbaar vervoer, de nabijheid van groen, de nabijheid van parkeergelegenheid en de drukte op straat. Wat betreft gebouwkenmerken zou het interessant kunnen zijn om te kijken naar vloeroppervlak en prijs. In aanvulling op de bevindingen in de literatuur zijn er drie extra gebouwkenmerken geïdentificeerd door binnenstedelijke panden te bekijken. Als gevolg hiervan zal in dit onderzoek ook worden gekeken naar de voorkeuren van mensen met betrekking tot de historische uitstraling van de gevel, de breedte van de gevel en de verdieping van de potentiële woning.

De tool zal worden ontwikkeld als een spatial decision support system (SDSS) door een multi criteria decision analysis (MCDA) te integreren in een geographical information system (GIS). Het zal de gemeenten moeten ondersteunen bij het besluitvormingsproces over de transformatie van leegstaande winkelpanden naar woningen door winkelpanden te identificeren die in aanmerking komen voor transformatie en door te analyseren welke leegstaande winkelpanden interessant zijn om in te wonen. MCDA kan helpen analyseren welke winkelpanden interessant kunnen zijn voor transformatie door de evaluatie van meerdere criteria met betrekking tot gebouwen en locaties, waarbij panden worden gerangschikt op basis van het utiliteitsniveau dat is afgeleid van kernmerken die gewogen zijn. De gewichten van de kenmerken worden bepaald met behulp van een discrete choice experiment (DCE), een methode die zich richt op de voorkeuren van mensen.

Alle negen vastgestelde kenmerken zijn opgenomen in de DCE. De DCE werd verspreid via een enquête en is ingevuld door 103 personen. De enquête werd ingevuld door mensen tussen 18 en 60 jaar oud, waarbij bijna de helft van de respondenten aangaf student te zijn. Aangezien er geen significante respondentgroep van starters of ouderen was, betekende dit dat alleen de woonvoorkeuren van studenten verder onderzocht konden worden. De resultaten werden geanalyseerd met behulp van een multinomiaal logit model (MNL). Het MNL-model van de volledige respondentengroep laat zien dat de afstand tot een halte van het openbaar vervoer, een parkeerplaats of een park allemaal een negatieve relatie hebben met de voorkeur van mensen. Bovendien, met betrekking tot de locatie van het pand, genereren straten met een lage en gemiddelde drukte significant hogere utiliteit in vergelijking met straten met een hoge drukte. De historische gevel en de breedte ervan lijken een minimale invloed te hebben op de woonvoorkeuren van mensen. Verder laten de resultaten zien dat mensen een significante voorkeur hebben voor de hogere verdiepingen boven de begane grond. Het totale vloeroppervlak en de maandelijkse huurprijs waren de belangrijkste factoren bij het maken van de keuze, waarbij grotere oppervlakten en lagere huren het utiliteit significant verbeterden. Het MNL-model gebaseerd op de studentengroep laat resultaten zien die vergelijkbaar zijn met het model van de volledige respondentengroep. Studenten blijken wel echter een hogere voorkeur te hebben voor prijs, bereikbaarheid en parken.

Om de tool te ontwikkelen, zijn twee essentiële elementen geïntegreerd in het GIS. De uitsluitingscriteria en de gewichten van de MCDA-criteria. De uitsluitingscriteria, geïdentificeerd in de literatuur, worden gebruikt om winkelpanden te vinden die in aanmerking komen voor transformatie tot woningen. De gewichten van de MCDA-criteria, resulterend van de DCE, worden gebruikt om het utiliteit van een winkelpand te bepalen. Beide elementen worden geïntegreerd in GIS met behulp van twee databronnen: een Locatus-database en een OpenStreetMap-database. Zeven van de negen MCDA-criteria zijn geïmplementeerd in de tool, voornamelijk door gebruik te maken van overeenkomstige variabelen uit een van de twee databases. Alleen de breedte en het historische uiterlijk van de gevel zijn niet geïmplementeerd omdat ze volgens de DCE geen significante invloed hebben op de voorkeuren van mensen. Om de SDSS te creëren, is het MCDA-proces geautomatiseerd in het GIS.

Zodra het instrument is ontwikkeld, wordt het gebruikt in een casus voor evaluatie. De casus richt zich op de binnenstad van de Nederlandse stad Heerlen omdat deze van de grote en middelgrote binnensteden de meeste leegstand had. Eerst wordt gedemonstreerd hoe de tool kan worden gebruikt. Daarna wordt de tool geëvalueerd op effectiviteit en gebruiksvriendelijkheid. De effectiviteit wordt getest door te onderzoeken of de tool kan analyseren welke leegstaande winkelpanden interessant zijn om te transformeren naar woningen in twee potentiële herontwikkelingsgebieden. De gebruiksvriendelijkheid van de tool wordt getest door te observeren hoe een persoon die niet bekend is met de software de tool gebruikt.

Dit onderzoek wordt afgesloten met een algemene conclusie over hoe de tool kan worden gemaakt en hoe deze gemeenten kan ondersteunen bij het nemen van beslissingen over de transformatie van leegstaande winkelpanden naar woningen door panden te identificeren die in aanmerking komen voor transformatie en door te analyseren welke winkelpanden de hoogste woonbestemming hebben. Dit onderzoek geeft Nederlandse gemeenten niet alleen meer inzicht in de mogelijkheden van binnenstedelijke huisvesting. Het draagt ook bij aan onderzoek naar woonvoorkeuren in Nederland door meer inzicht te geven in waar en in welk type binnenstedelijk vastgoed mensen zouden willen wonen. Daarnaast leiden de beperkingen in dit onderzoek tot verschillende aanbevelingen voor toekomstig onderzoek op dit gebied. Het zou waardevol kunnen zijn om gedetailleerde informatie te verkrijgen uit interviews met experts die betrokken zijn bij binnenstedelijke transformaties, om andere criteria op te nemen om nieuwe inzichten te krijgen met betrekking tot woonvoorkeuren, om de enquête alleen te verspreiden onder specifieke doelgroepen zoals ouderen, of om de tool te verbeteren als er gegevens over gebouw- of locatiekenmerken van binnenstedelijke gebouwen beschikbaar komen.

SUMMARY

The retail real estate market needs about 4 to 5 percent friction vacancy to give retailers enough opportunity for mutations. City centers of G7-20 (7^{th} to 20^{th} largest cities in the Netherlands) and medium-sized cities have vacancy levels well above this friction level. Medium-sized city centers almost reach an average vacancy rate of 12%. High retail vacancy rates can negatively impact an inner city's business and investment climate, and a negative spiral of deterioration is more likely to occur in areas where the structural vacancy is high. Since retail vacancy affects the attractiveness of the inner city, a municipality needs to keep the vacancy rates as low as possible. Currently, there are municipal policies to make the inner city retail area more attractive by making the shopping area more compact. Through, for example, restrictions in the zoning plan, the municipality aims to not fill the vacant retail properties at the edge of the inner city again with a retail function. This leaves the opportunity to fill these vacant retail properties with other functions. It makes sense to transform these vacant retail properties into housing, not only because the housing market in the Netherlands is still overstressed, but also because retail investors believe that the transformation of vacant retail properties into housing is the most promising function in the approaching areas within the inner cities, compared to other functions. Since the municipality aims to make the inner city retail area more attractive and to provide adequate housing for their residents, they have the opportunity to address both through the transformation of vacant retail properties into housing.

However, currently, it remains unclear in what type of property, and at which location people would like to live in the inner city. Up to the present, little research has been done on the residential interests of people in a complex location such as the inner city. If the relation between the residential characteristics of the inner city and the preferences of the target groups can be understood, it would be possible to explore in which vacant retail properties people would like to live. Besides this, the transformation of vacant inner city retail properties is complex because of the multiple stakeholders involved. To succeed in the transformation task, investors argue that the municipality's transformation vision and policies are most important, but that current policies are not always concrete enough. With unclear transformation policies, the municipality can lose grip over the retail vacancy situation. Once vacancy occurs, it can create a domino effect within an area. Aside from the negative effects of vacancy, these areas are then also more likely to attract tenants who do not fit into the intended streetscape. Which in turn can make an area less attractive. Knowing which vacant retail properties are of interest to inner city target groups will support the municipality in pursuing its transformation policy and keeping control over the infill of the area. Therefore, this research aims to create a tool that can explore which vacant inner city retail properties are of interest to be transformed into houses based on target group preferences.

First, a literature review is conducted to get a better understanding of all the aspects contributing to the development of the tool. Literature and reports reveals that citizens, retailers, property investors, and municipalities are the main stakeholders involved in the transformation of vacant retail properties. In the review, the power and interest of each of these stakeholders is investigated. It is found that municipalities, as stakeholders with a lot of power and interest, are best suited to use a tool. The tool only must identify retail properties that can be considered for transformation. Therefore, current barriers, policies, and restrictions that hinder the transformation of vacant inner city retail properties into housing are examined. It is found that retail properties cannot be considered for transformation if they are on the ground floor of the core shopping area. In addition, building code requirements such as minimum dimensions, minimum daylighting, and having a separate entrance at street level are also all criteria that can exclude retail properties from being considered for

transformation. These criteria can be used as exclusion criteria in the tool. Besides that, the literature review focuses on what residential characteristics can be used to examine residential preferences related to inner city retail properties. A total of six different characteristics are found that could be considered by the different target groups identified, such as students, starters, and elderly. In terms of location characteristics, it might be interesting to look into the distance to public transportation, proximity to green space, proximity to parking space, and the crowdedness of the street. In terms of building characteristics, it might be interesting to look into floor area and price. In addition to the findings in the literature, three extra building characteristics are identified by viewing inner city properties. As a result, this research will also investigate people's preferences regarding the historical appearance of the facade, the façade's width, and the floor level of the potential house.

The tool is developed as a spatial decision support system (SDSS) by integrating a multi criteria decision analysis (MCDA) in a geographic information system (GIS). It should support the municipalities in the decision-making process regarding the transformation of vacant retail properties into housing by identifying retail properties that can be considered for transformation and by analyzing which vacant retail properties are of interest to live in. MCDA can help analyze which retail properties can be interesting for transformation through the evaluation of multiple criteria related to buildings and locations, where properties are ranked based on the utility level derived from weighted attributes. The weights of the attributes are determined using a discrete choice experiment (DCE), a method that focuses on people's preferences.

All nine characteristics identified are included in the DCE. The DCE was distributed through a survey and is completed by 103 individuals. The survey was taken by people between the ages of 18 and 60, with nearly half of the respondents identifying themselves as students. As there was no significant respondent group of starters or elderly, this meant that only the students' residential preferences could be examined further. The results were analyzed using a multinomial logit model (MNL). The MNL model of the full sample shows that the distance to a public transport stop, a parking space or a park all have a negative relationship with people's preference. Additionally, regarding the location of the property, low and medium-crowded streets generate significantly higher utilities compared to high-crowded streets. The historical façade and its width appear to have minimal influence on people's residential preferences. Furthermore, the results show that people significantly prefer higher floors to the ground floor level. The total floor area and monthly rent price were the most important factors for making the choice, with larger areas and lower rents significantly improving utility. The MNL model of the student sample shows results quite similar to the model of the full sample. However, students seem to find price, accessibility, and parks more important.

To develop the tool, two essential elements are integrated into the GIS. The exclusion criteria and the weights of the MCDA criteria. The exclusion criteria, identified in the literature, are used to find retail properties that can be considered for transformation into housing. The weights of the MCDA criteria, resulting from the DCE, are used to determine the utility of a retail property. Both elements are integrated into GIS using two data sources: a Locatus database and an OpenStreetMap database. Seven of the nine MCDA criteria are implemented in the tool, mostly by using corresponding variables from one of the two databases. Only the width and the historical appearance of the façade are not implemented because they do not have a significant impact on people's preferences according to the DCE. In order to create the SDSS, the MCDA process is automated in the GIS.

Once the tool is developed, it is used in a case study for evaluation. The case study focuses on the inner city of the Dutch city of Heerlen because it had the highest vacancy rate among the big and medium-sized inner cities. First is demonstrated how the tool can be used. After this, the tool is evaluated in terms of effectiveness and user-friendliness. The effectiveness is tested by examining if the tool can analyze which vacant retail properties are of interest to transform into housing in two potential redevelopment areas. The usability of the tool is tested by observing a person using the tool who is unfamiliar with the tool's software.

This research closes with an overall conclusion on how the tool can be created and how it can support municipalities in making decisions regarding the transformation of vacant retail properties into housing by identifying properties that can be considered for transformation and by analyzing which retail properties have the highest residential utility. This research not only gives Dutch municipalities more insight into the possibilities of inner city housing. It also contributes to research on housing preferences in the Netherlands by providing more insight into where and in what type of inner city property people would like to live. Additionally, the limitations in this research lead to several recommendations for future research in this field. It could be valuable to obtain detailed information from interviews with experts involved in inner city transformations, to include other criteria to gain new insights regarding housing preferences, to distribute the survey only to specific target groups such as the elderly, or to improve the tool if data on building or site characteristics of inner city buildings become available.

Abstract

The retail vacancy rates in Dutch city centers pose a significant challenge to municipalities seeking to maintain vibrant and economically viable urban areas. Retail vacancies can trigger a downward spiral of deterioration that affects the business and investment climate. To address this problem, municipalities are pursuing policies to reduce retail vacancy by transforming vacant retail space, especially at the edge of the shopping area, into housing. However, little research has been done on the residential preferences of people in a complex location such as the inner city. Knowing which vacant retail properties are of interest to inner city target groups will support the municipality in pursuing its transformation policy and keeping control over the infill of the area. Therefore, this research aims to create a tool that can explore which vacant inner city retail properties are of interest to be transformed into houses based on target group preferences. The tool is developed as a spatial decision support system (SDSS) by integrating a multi criteria decision analysis (MCDA) in a geographic information system (GIS). The criteria used in the MCDA are based upon the weights retrieved from the discrete choice experiment (DCE). In the DCE, nine different attributes have been included that relate to retail properties in the inner city. The results show that the total floor area and monthly rent price were the most important factors in explaining people's preferences, followed by accessibility related attributes, the crowdedness of the street, and floor level of the potential house. The student target group showed results quite similar, but students seem to have a higher preference for price, accessibility, and parks. All significant DCE attributes are integrated into the tool to estimate the utility of retail properties in Dutch inner cities. In combination with the exclusion criteria identified in this research, this tool that can support municipalities in making decisions regarding the transformation of vacant retail properties into housing by identifying properties that can be considered for transformation and by analyzing which retail properties have the highest residential utility.

Keywords

Inner city, Retail, Housing, Discrete choice experiment, SDSS

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TERMINOLOGY AND ABBREVIATIONS

Core shopping area	The area where only retail functions are allowed in the plinth
DCE	Discrete choice experiment
Inner city	The area assigned by the municipality as inner city neighborhood
MAUT	Multi attribute utility theory
MCDA	Multi criteria decision analysis
MNL	Multinomial logit
OSM	OpenStreetMap
PT	Public transport
SDSS	Spatial decision support system
Shopping area	The area in the inner city where retail functions are located
Utility	A measure of preference that consumers assign to a product

1 INTRODUCTION

In the year 2022, the retail vacancy rate in the Netherlands decreased from 6.7% to 6.0% of all the retail properties (Slob, 2023). In 2023 the vacancy rate rose again to 6.2% (Slob, 2024). The main reason for this vacancy increase seems to be the sharp decline in the number of active retailers. Slob (2024) found that retailers shut down their struggling business before it reaches bankruptcy or retailers reach a retirement age, but do not have a business successor. Since the average age of retailers is relatively high, the latter reason is increasingly reported. Nevertheless, vacancy rates did not rise similarly in the different types of retail locations. According to Van Tellingen (2020), the retail real estate market needs about 4 to 5 percent friction vacancy to give retailers enough opportunity for mutations. However, Figure 1 shows that the city centers of G7-20 (7^{th} to 20^{th} largest cities in the Netherlands) and medium-sized cities still have vacancy levels well above this friction level (Exterkate & Ploem, 2023). Medium-sized city centers almost reach an average vacancy rate of 12%. Exterkate & Lucassen (2023) estimate that above this friction level, there is still over 460,000 square meters of vacant retail space in medium-sized centers. The changes in the population (population decline, aging, rise in the number of households), the fact that most people live in or visit large cities, and the growing convergence of the offline and online worlds, are all reasons for the high vacancy rates in small and medium-sized centers (Van Rooijen et al., 2018). Furthermore, in the last decade, the nature of inner city shopping has changed from functional shopping (shopping and purchasing) towards fun shopping, where experience has become increasingly important (Platform binnenstadmanagement, 2016). The composition of the inner city retail area is changing and the demand for retail square meters is decreasing, especially in medium-sized centers.

A lot of stakeholders seem to be connected to the developments in an inner city (Van Aarle et al., 2014). The inner city is a very important location both socially and economically. It gives a municipality character and it serves as a place for a variety of interactions and activities (Hendriksma, 2023; Van Rooijen et al., 2018). High retail vacancy rates can negatively impact an inner city's business and investment climate, and a negative spiral of deterioration is more likely to occur in areas where the structural vacancy is high (Buitelaar, 2014; Evers et al., 2015; RVO, 2017). Since retail vacancy affects the attractiveness of the inner city, a municipality needs to keep the vacancy rates as low as possible. Currently, there are municipal policies to make the inner city retail area more attractive by making the shopping area more compact. Through, for example, restrictions in the zoning plan, the municipality

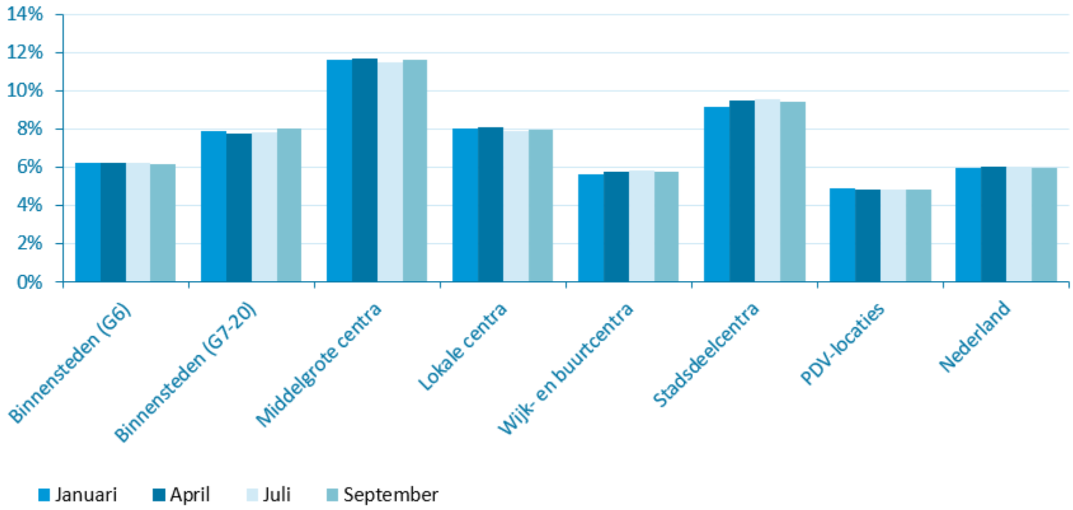

Figure 1: Property vacancy rates in 2023, categorized in retail location types (Exterkate & Ploem, 2023)

aims to not fill the vacant retail properties at the edge of the inner city again with a retail function (Arink, 2023). This leaves the opportunity to fill these vacant retail properties with other functions. It makes sense to transform these vacant retail properties into housing since the housing market in the Netherlands is still overstressed. To illustrate, ABF Research (2023) concluded that there is a direct need for 223,000 housing units to be able to reach a deficit rate of 2% (normal market tension). Through transformation, the supply of housing units can be increased. Aside from that, according to research by Exterkate & Ploem (2021), retail investors think that, in approaching areas within inner cities, the transformation of vacant retail properties into housing is most promising compared to other functions (Figure 2). Since the municipality aims to make the inner city retail area more attractive and to provide adequate housing for their residents, they have the opportunity to address both through the transformation of vacant retail properties into housing.

	Hoofdwinkelstraten binnensteden		Aanloopgebieden binnensteden		Hoofdwinkelstraten middelgrote centra		Aanloopgebieden middelgrote centra	
	Functie	*%*	*Functie*	*%*	*Functie*	*%*	*Functie*	*%*
1	Horeca	89	Wonen	79	Horeca	79	Wonen	83
2	Leisure	56	Horeca	74	Leisure	53	Horeca	67
3	Flexibele kantoorruimte	28	Ambachten	68	Wonen	32	Leisure	56
4	Hotellerie	28	Kunst en cultuur	63	Ambachten	32	Ambachten	50
5	Wonen/kantoorruimte/ ambachten	22	Leisure/flexibele kantoorruimte/hotellerie	53	Flexibele kantoorruimte	32	Zorg/sport	44

Figure 2: Promising functions for vacant retail properties according to investors (Exterkate & Ploem, 2021)

1.1 Problem definition

According to Exterkate & Lucassen (2023), above friction level, more than 460,000 m² of retail floor space is vacant in centers of medium-sized cities. In theory, these square meters offer space for a few thousand houses. However, the transformation of retail properties into housing is not that straightforward. In the inner city, there are different types of retail properties. Retail properties come in different sizes and often major adjustments are made to meet previous demands of retailers. Almost every retail property needs to be adjusted if one intends to use it as a residence since the building then needs to comply with residential requirements of the Environmental building decree (Informatiepunt Leefomgeving, 2024b). Because of these requirements, some properties can already be labeled as not suitable for transformation into housing. Furthermore, some vacant retail properties are located in streets where transformation into housing is not allowed based on land use plans. For example, a municipality can have a policy where no residential use is allowed on the ground level of main shopping streets since contiguous active retail plinths are very important to the attractiveness of their area (e.g. Gemeente Purmerend, 2022). Both the technical requirements and municipal policies already prohibit many inner-city retail locations from being transformed into housing.

Even though a retail property satisfies all technical and legal requirements to be transformed into housing, it may be located at a non-attractive location or possess particular characteristics that are not desired by people who are looking for a new house. However, currently it is hard to explain what is desired by people since it remains unclear in what type of property, and at which location they like to live. Up to the present, only research has been conducted concerning the residential interests of people in the Netherlands, or cities in general (Jansen, 2012; Jong et al., 2012; Luttik, 2000; Molin et al., 1996; Nijënstein et al., 2023; Tan, 2012; Wang & Li, 2004). However, little research has been done on the residential interests of people in a complex location such as the inner city. If the relation between the residential characteristics of the inner city and the preferences of the target groups can be understood, it may be possible to designate in which vacant retail properties people would like to live.

The municipality writes inner city visions and transformation policies (Gemeente Emmen & Seinpost, 2021; Tranformatieteam gemeente Arnhem, 2017) However, to be able to realize their transformation policy, they need the full support from the other stakeholders in the inner city. According to Exterkate & Ploem (2021), investors think that the transformation vision and policy of the municipality are most important to succeed in the transformation task, but they are currently not concrete enough to be able to consider transformation. Baarsen (2022) adds to this that, according to stakeholders, the vision of the municipality can come across as unclear and the communication channels of the municipality are not adequate for everyone. An unclear or abstract transformation policy can be the result of a lack of knowledge by the municipality regarding the transformation of vacant retail properties. Additionally, an abstract policy can result in the fact that the municipality can lose control of the deterioration of retail areas. Once vacancy occurs, it can create a domino effect within an area. Aside from the negative effects of vacancy, these areas are then also more likely to attract tenants who do not fit into the intended streetscape, also called discoloration (in Dutch: 'verkleuring') of the street. Which in turn can make an area less attractive (Meijer, 2023). Therefore, the municipality must keep a grip on the situation. Knowing which vacant retail properties are of interest to inner city target groups will support the municipality in pursuing their transformation policy and keep in control over the infill of the area. For the municipality, it would be useful to have a tool that can use target group preference data to explore which inner-city retail properties are interesting for transformation into housing.

In previous research by Geraedts & Van der Voordt (2007), they developed an evaluation instrument to assess the suitability of office transformations into houses. In their tool, they evaluated the transformation suitability by ticking of building and location characteristics of the respective building to end up with a transformation score. The transformation score says something about how suitable a single property might be to be transformed into a house. If all relevant characteristics are known for the assessment of retail property transformations, a similar approach could be used. However, as this approach does not weigh the characteristics and focuses only on individual properties, it is not possible to prioritize the transformation of different properties in an inner city area. In addition, this approach is particularly time-consuming given that a non-automated method must be employed for each individual property. To support the prioritization of inner city retail transformations into housing, it may be worthwhile to first explore where people want to live in the inner city. Therefore, it can be useful to develop an automated tool that explores which vacant retail properties could be interesting to be transformed into housing based on target group preferences. Research regarding the prioritization of brownfield redevelopments shows that a possible approach to prioritize these vacant retail properties is to make use of a multi-criteria decision analysis method (MCDA) and a geographical information system (GIS) (Hammond et al., 2021). The integration of GIS with a MCDA module provides methods to map, compare, rank, and evaluate the effectiveness of various options for decisions based on a variety of factors, and is often referred to as a spatial decision support system (SDSS) (Arciniegas & Janssen, 2012; Ayeni, 1997). According to Gracia et al. (2018), decision support tools including a MCDA allow for policy makers to create a holistic vision of the project. Besides that, Caprioli & Bottero (2021) observe that a clear and simple visual representation of the data and findings by the SDSS can increase the willingness to participate by various stakeholders. It is therefore interesting to find out if a similar type of tool (SDSS) can be developed that is able to explore which retail properties are interested to be transformed into housing based on target group preferences.

1.2 RESEARCH QUESTIONS

The problems defined in the previous section lead to the following main research question:

> **"How can a tool be created that can explore which vacant inner city retail properties are of interest to be transformed into houses based on target group preferences?"**

To be able to answer the main research question, the following sub-questions are formulated:

- SQ1: Which stakeholders are involved in inner city retail transformations?
- SQ2: What characteristics make a retail property suitable to be transformed into a house?
- SQ3: What inner city building and locational residential characteristics are considered and preferred by the different target groups?
- SQ4: How can the identified exclusion criteria and residential preferences be integrated into a SDSS tool?

1.3 RESEARCH DESIGN

This research focuses on gaining insight into how a tool can be created that is able to evaluate vacant retail properties that are promising to be redeveloped into houses. To reach this goal, the study is divided into several different steps (Figure 3). First, a literature review will be conducted to determine what information is relevant to include in the tool. The review will look into the current situation in the inner city and tries to determine what makes a vacant retail property suitable for transformation into a house. Furthermore, it will be necessary to investigate which building or location characteristics are considered by people if they are interested in living in the inner city. The literature review will result in a preliminary list of criteria that is able to serve as input for step 2. In the second step, the residential preference criteria identified in the literature need to be weighted. To weigh the criteria, relevant data needs to be gathered regarding the specific residential characteristics that are most preferred by people. Since these preferences are not yet revealed on the market, there will be focus on stated preference methods (Boxall et al., 1996). In specific, choice modeling (CM), is a group of methods to capture the rankings and ratings of alternatives derived from people's preferences for a product or service (Shang et al., 2023). To evaluate residential preferences, there are four major forms of CM: contingent ranking, contingent rating, graded paired comparison, and discrete choice experiments (DCE). According to Elrod et al. (2014), choice based approaches provide greater external validity than rating or ranking approaches. Choice tasks better mimic the decisions people have to make on a daily basis. Moreover, choice-based approaches are relatively simple for respondents to complete because they allow them to make decisions independently and eliminate the need to consistently rank or rate scales across various alternatives (Shang et al., 2023). Therefore, this research will use a DCE to capture the weights of the residential preference criteria. Together with the exclusion criteria extracted from the literature, these two elements will be integrated into the tool that will be developed in the third step. This step will elaborate on the development process of the tool. A schematic overview will be given and the use of the different data sources will be explained. Further, it will be shown how the target groups' preference model (MCDA module) will be integrated into the GIS system and how the system is automated. In the final step of this research, the tool created will be applied to a problem area. This step will primarily demonstrate the functionality of the tool, which will then be evaluated. This study will end with a discussion and conclusion on the results achieved.

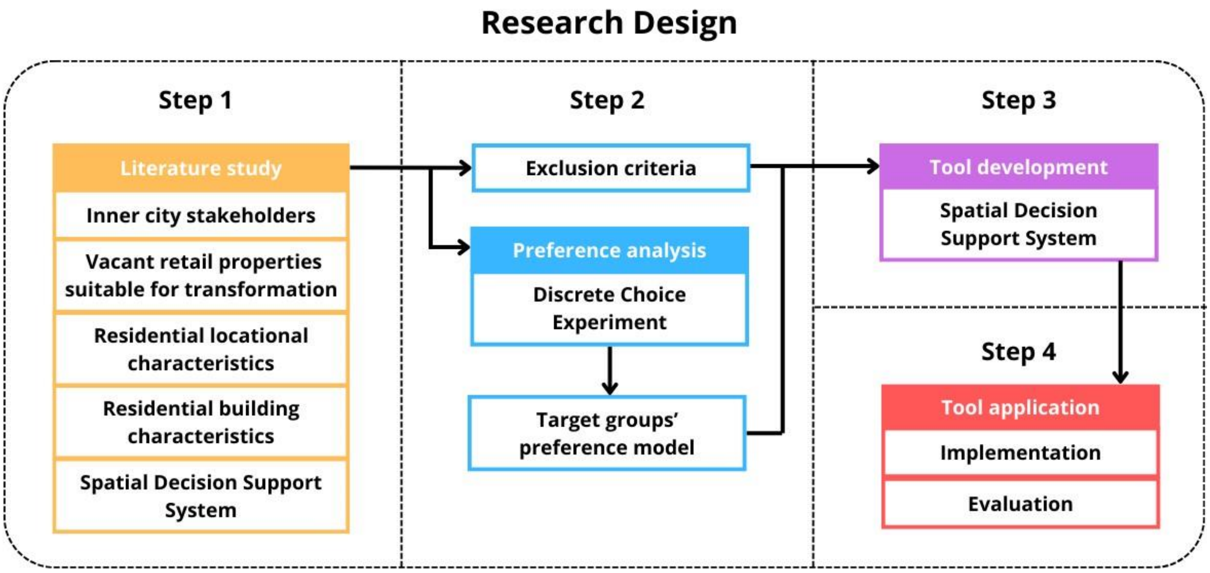

Figure 3: Research design

1.4 RELEVANCE OF THE RESEARCH

This research is relevant in both practical, social, and academic terms. Practically, the tool developed in this research will be able to be used by inner city policymakers. The purpose of the tool is to allow policymakers to have a grip on the attractiveness of the inner city by exploring the residential attractiveness of retail properties in advance. The tool can therefore be used in particular to explore transformation opportunities in the city center, not to calculate the actual feasibility of transforming retail properties into a house. The insights gained from the tool can support policymakers in discussions with inner city stakeholders about specific transformation decisions. Additionally, the tool can support policy-making decisions in the form of, for example, special restrictions for properties at the edge of the inner city that are of interest to inner city target groups.

The tool has societal relevance for a number of reasons. At first, the tool might be able to stimulate the transformation of vacant retail properties into housing. The loss of vacant retail properties from the streetscape is beneficial to the attractiveness of an inner city. The city will look less degraded and will offer a more pleasant experience to visitors. Moreover, new houses will contribute favorably to the housing shortage in the Netherlands. Not only that, the tool also focuses on places where people would really like to live. This is further emphasized by the fact that the tool utilizes utility as measurement, which focuses primarily on people's preferences.

From an academic perspective, this research contributes to two different elements. At first, this research examines people's residential preferences in a specific location such as the inner city. Since the inner city has different characteristics compared to other parts of the country or the city, this research provides new insights into the residential preferences within this typical location. Secondly, this research shows a method of implementing target groups' preference data in a spatial decision support system. New insights can be gained regarding the development, functionality, and challenges of the development of such a tool.

1.5 READING GUIDE

After this introduction, this research is divided into six chapters. Chapter 2 provides a literature review that explores inner city stakeholders, the suitability of inner city retail properties to be transformed into housing, the residential characteristics considered in residential preference research, and the way a spatial decision support system is structured and functions. Chapter 3 describes the methodology by discussing how and what data will be collected and analyzed before developing the tool. Chapter 4 discusses the results of the discrete choice experiment. Chapter 5 shows how the tool is developed. This chapter discusses the implementation of the criteria in the tool. Chapter 6 shows how the tool works via a case study, including an evaluation of the tool. The research concludes in Chapter 7 with a conclusion, a discussion, and further recommendations.

2 LITERATURE REVIEW

This chapter summarizes the literature found to get a better understanding of all the aspects contributing to the development of a tool that is able to explore which retail properties are of interest to be transformed into houses based on target group preferences. The literature review is divided into four paragraphs. The first paragraph will look into which inner city stakeholders are most involved in the transformation of vacant retail properties, and who of them has the most interest and power to exploit the tool. The second paragraph highlights the barriers, rules, and restrictions that prevent retail properties from being redeveloped into houses. These aspects will be used in the tool to find properties that can be considered for transformation. The third paragraph focuses on the residential characteristics that are often taken into account in residential preference research. The characteristics will be used to investigate the residential preferences related to inner city properties in the following chapters. At last, there is elaborated on how a SDSS tools can be applied to this research field.

2.1 STAKEHOLDERS INVOLVED IN INNER CITY VACANT PROPERTY TRANSFORMATIONS

Inner cities are very complex and contain a lot of stakeholders with various interests. Often interests clash, interests are concealed or no effort is made to see each other's interests. However, understanding each other's interests is essential for effective cooperation in inner cities, especially when attempting to reduce vacancy rates. For the inner city to function well, the associated organizations need to be well organized on many different fronts, for different functions, target groups, and at different times (Van Rooijen et al., 2018). Van Aarle et al. (2014) identified multiple stakeholders that are involved in shaping the inner city. The main stakeholders involved in the transformation of vacant retail properties into houses are the citizens, retailers, property investors, and the municipality. This chapter examines the roles played by the various inner-city stakeholders and how vacant retail properties affect them.

2.1.1 Citizens

People living in the inner city have an interest in the transformation of vacant retail properties into housing from different perspectives. The term "citizens" as used by Van Aarle et al. (2014) can be divided into two categories: residents and consumers. Residents have an interest in livability, sufficient employment, and influencing their living environment. Consumers are primarily interested in having the ability to purchase the products they desire at the lowest possible price and in a context that aligns with their preferences. The appearance of multiple vacant retail properties negatively affects both perspectives. Vacant retail properties are a sign of reduced retail availability in the inner city and can also have a negative impact on the livability of the area (Buitelaar, 2014; Evers et al., 2015). From a consumer’s perspective, the transformation of these vacant retail properties into housing does not contribute to retail availability, but it could change the shopping experience, as it reduces the negative externalities of vacant retail properties (Koster et al., 2019). On the other hand, the transformation of vacant retail properties into housing can be beneficial to (future) residents by providing new housing opportunities. Moreover, according to Exterkate et al. (2020), the addition of houses could directly increase support for existing amenities, vibrancy, and livability in inner cities.

2.1.2 Retailers

From the main stakeholders, retailers are most visible in the inner city streetscape. Retailers own (user-owner), but mainly rent (user), a retail property to help them run their business. Retailers want to attract as many visitors as possible to the inner city to increase their opportunity to make a profit (Van Aarle et al., 2014). If the costs of a retail property outweigh the revenue of the business then there is a chance that the retailer will disappear from the inner city and the property becomes vacant.

This is not only unfortunate for the respective retailer, but this can also be disadvantageous for the other retailers in the area. Evers et al. (2015) state that retailers benefit to some extent from the presence of other retailers because of competition, complementation, and visitor flows. If a shop attracts a customer, that customer is also likely to visit other shops on that same shopping street because it saves the customer transport and search effort. These unintended effects can be seen as shopping externalities (Koster et al., 2019). Vacant retail properties generate negative shopping externalities. According to Van Aarle et al. (2014), consumers are not attracted to shopping areas with high vacancy rates. A consumer prefers to shop in an area where there is a continuous supply of stores. Retailers therefore do not prefer to set up a business in an area which is characterized by a lot of vacant properties.

2.1.3 Property investors

Owners of commercial buildings in the inner city can be considered investors. According to Van Aarle et al. (2014) there are three types of investors: private investors, retail funds for private shareholders, and institutional investors. Private investors are individuals who invest their money into retail properties and are often united in associations. Dependent on their borrowed capital, private investors are free in their investment choice. Properties can also be owned by a retail fund for private shareholders. The property is then acquired and operated by a fund manager. Third, there are large institutional investors such as pension funds and insurance companies. The approachability of each type of investor varies. In 2022, 62 percent of Dutch inner city retail properties were owned by individual investors, not companies or institutions. Consequently, most inner cities of the Netherlands face a considerable level of fragmentation. The median number of properties per owner in Dutch inner-city retail zones in 2022 was 1,8 (Team Stadszaken, 2022). This fragmentation can make it quite difficult to get a good idea of how owners view the inner city area.

In general, retail property investors want to have a property at an attractive place, since the value of the property is related to its location and the number of visitors it can attract. In the Netherlands there is a location classification that is relative to the local amount of visitors. In the inner city, the most expensive streets with the largest footfall are referred to as "A locations", whereas approaching streets with a lower footfall are referred to as “B locations” (Van Aarle et al., 2014). In addition to the high value, retailers are also more likely to stay at an attractive place, which creates continuity in the exploitation of the retail property investors. However, if a property is vacant then the investor misses out on a source of income. Investors can use several instruments to attract new tenants. They can use temporary contracts, combine adjacent properties, lower the rents, or change the function within the legal boundaries (Van Aarle et al., 2014). Nevertheless, property owners are cautious with these instruments. They might be stuck with a low rent for a long term in a dynamic market and the value of the property itself can go down. Furthermore, the depreciation of the property due to vacancy is also tax deductible, which does not stimulate the investor to lower the rents to attract tenants either (Jonkers, 2018). All in all, the investor has to determine whether investing in the mentioned instruments will be more profitable than leaving the property vacant for some time. This decision mainly is dependent on the market situation and inner city visions of the local government.

2.1.4 The municipality

The municipality is legally responsible for organizing all space in the Netherlands. As a legislator and facilitator, the municipality should be able to unite the parties in pursuit of a sustainable future, prioritizing the common good over the interests of one individual (Weiss, 2020). For the municipality, the inner city is economically and socially a place of great importance. As a result of its public character and the concentration of different functions, it is a place for various forms of interaction and activity (Van Rooijen et al., 2018). Hendriksma (2023) even describes the inner city as the soul of a city, that gives a municipality character. An attractive city center attracts people from the outside and makes residents proud. However, if buildings are in a poor state and properties are vacant it becomes less attractive for people to go there. Especially when the vacant properties are in strategic locations, such as in the inner city. Vacant properties create an impoverished street and cityscape. This has a negative effect on the city's business and investment climate and a price-dampening effect on property values (RVO, 2017). Areas with a lot of structural vacancies have a high risk of entering a negative spiral of degradation and impoverishment (Buitelaar, 2014; Evers et al., 2015). It then becomes less and less attractive to work or live in the area. In general, vacancy becomes a problem for the municipality when there are negative effects for third parties, due to the appearance of a deteriorated building or greatly altered passerby flows. The size and location of the vacancy then determine the extent of the social problem that interventions require (Evers et al., 2015).

In order to solve these problems or to prevent them from occurring, the municipality compiles an environmental vision (Informatiepunt Leefomgeving, 2024d). An environmental vision includes policy documents in which the municipality outlines the desired spatial development direction for the coming years. In these documents, municipalities show possible spatial interventions to create or remain an attractive inner city and reduce vacancy rates. A frequently mentioned solution is to reduce the size of the shopping area (Hendriksma, 2023). For example, the municipality of Assen aims to create a compact public center by reducing the oversupply of retail properties. The municipality considers retail outside these centers undesirable in principle and tries to reduce these retail square meters (Figure 4). To achieve this goal, the municipality tries to motivate owners to invest in the transformation of their vacant retail premises, by guaranteeing a positive attitude in a necessary planning/legal procedure, for example (Gemeente Assen, 2023). With a planning/legal procedure the municipality can exert considerable influence on the spatial organization of the inner city. Currently, the inner city transformation policy is described through documents such as a retail structure vision (in Dutch: 'detailhandelstructuurvisie') and an inner city vision (both will be implemented in one new environmental vision). Per municipality, it differs how detailed these policy documents are. For example, in the retail structure vision of Emmen, the municipality designates specific inner city transformation areas where the retail function will eventually be eliminated, whereas other municipalities, like Assen, only describe their intentions in an elaboration as visible in Figure 4 (Gemeente Assen, 2023; Gemeente Emmen & Seinpost, 2021).

These vision documents form the policy basis for the legal translation into and substantiation of the zoning plans in the inner city (Van Aarle et al., 2014). Through the environmental plan, and the replacement of the zoning plan, the municipality influences the spatial planning of the inner city. They have the power to make changes to the plan or to accept environmental permit requests for building activities (Informatiepunt Leefomgeving, 2024c). This gives them the power to accept or decline certain function in the inner city. For example, the municipality of Arnhem removed existing, legal retail opportunities in zoning plans outside the desired structure or prohibited new shops from establishing themselves at the edges of the inner city (Arink, 2023). Aside from spatial planning instruments, municipalities can stimulate interventions by granting subsidies to investors. If the plans of the applicant are in line with the government's wishes, a subsidy can be a source to overcome the applicant's financial barrier. If there is no movement at all in the market, the municipality can also take steps by purchasing a property or investing in the quality of the public space (Driessen, 2017; Pots, 2023; Retailland, 2023). For example, municipalities like Amsterdam invest in specific retail properties to improve the balance of functions in the inner city for residents, and to prevent a building from falling into the hands of the undesirable investor (Knoops, 2021). However, the municipality will not quickly deploy financial measures but rather aims at improving the inner city through a vision, legal documents or by consulting the various stakeholders.

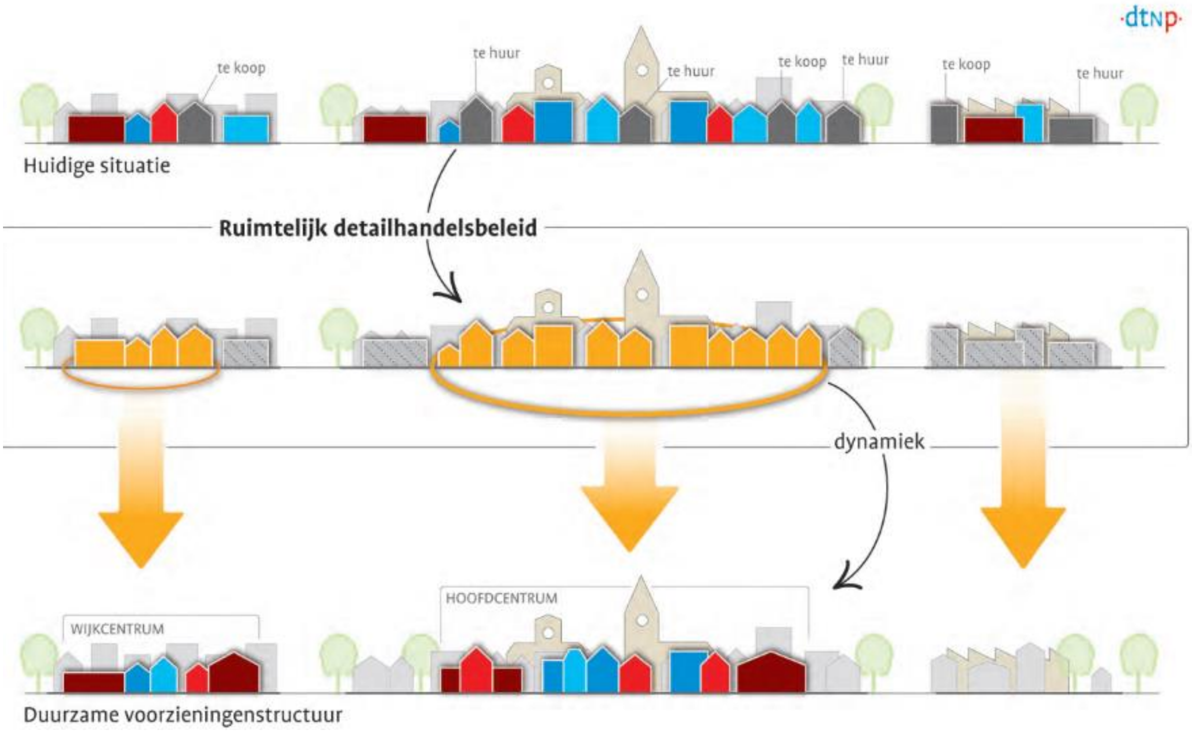

Figure 4, Spatial retail policy: Making the inner city compact (Gemeente Assen, 2023)

2.1.5 Power and interests of the main stakeholders

It is important to identify inner city stakeholder expectations and powers regarding retail vacancy to understand which stakeholder can make the best use of a tool that is able to explore which retail properties are of interest to be transformed into houses. Johnson et al. (2005) constructed a power/interest matrix to map out the involvement of stakeholders. The matrix distinguishes stakeholders based on their level of power and their likelihood of supporting a specific goal. In this case, the interest axis describes the interest in reducing the inner city retail vacancy rates through transformation (Figure 5). The power axis describes how much power a stakeholder has to make things happen. The investor is the owner of the vacant retail property. Investors are only interested in solving the vacancy of the property if it generates sufficient income for the long term. The most powerful instrument of investors is the right of ownership. This right gives them the opportunity to make changes to the property or to sell or rent our the property to whomever they want, within the legal boundaries of the environmental plan. Since investors even have the power to leave the property vacant, they are located in the top right corner with the key stakeholders. If a property is vacant, there is no retailer in the property itself. However, retailers located next to the vacant property can be negatively affected by the negative shopping externalities generated by the vacant retail property. Neighboring retailers wish that the property is again occupied by another retailer who attracts customers. Unfortunately, they do not have the power to take concrete actions. Retailers can only object to new plans in some cases, but then the objection still needs to be reviewed by another party. The citizens have powers similar to the retailers. However, in addition to the retailer's desire for retail space, residents may also have a desire for housing in the neighboring property. The stakeholder with both a lot of power, and interest to reduce retail vacancy, is the municipality. For the municipality, the inner is economically and socially a place of great importance. They aim to create a livable area that has a stimulating effect on the local economy. Retail vacancy has to be reduced since it can decrease the attractiveness of their inner city. Most of the municipal power results from one legal instrument: the environmental plan. All inner city developments have to comply with the environmental plan and the zoning restrictions it includes. With this instrument, they are able to exert significant influence on the composition of functions in the inner city. An environmental plan is most often derived from policy visions. These visions are set up by the municipality but in consultation with other stakeholders. The municipality acts in a directing role to create these visions that will lead to an attractive inner city. The municipality has a lot of power to exercise in the area of the transformation of vacant retail properties, and it also has a lot of interest in dealing with these vacant properties. These aspects, combined with the leading role they take in creating policy visions, make them best suited to use a tool that can provide insight into which inner-city retail properties people would be most interested to live in. The tool would not only be able to help to write a vision but also to substantiate planning decisions.

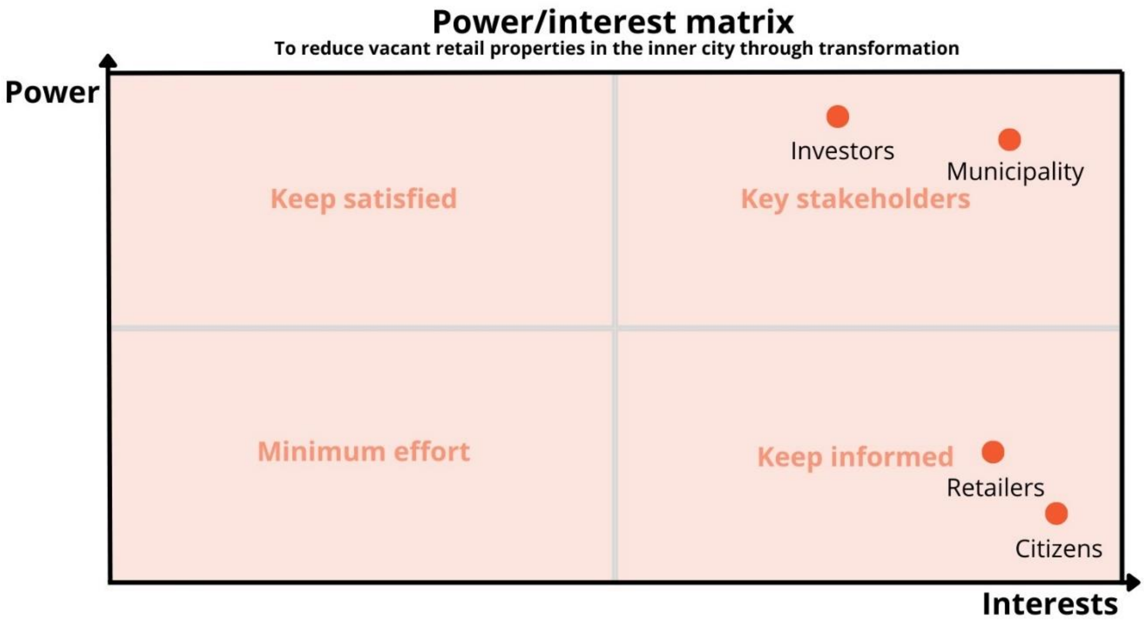

Figure 5 Power/interest matrix: To reduce vacant retail properties in the inner city through transformation

2.2 Suitability of inner city retail property transformations

The transformation of vacant inner city retail properties is not a straightforward process. This chapter discusses the current barriers, policies, and restrictions that hinder the transformation of vacant inner city retail properties into houses. By including policies and restrictions in an assessment format, this section aims to estimate whether a vacant retail property can be considered for transformation or not. At the end of this chapter, there will be discussed which characteristics can function as exclusion criteria for the tool to make a preliminary selection of vacant retail properties.

2.2.1 Institutional barriers to the transformation of inner city retail properties into houses

The previous chapter discussed the main stakeholders engaged in the transformation of vacant retail properties into houses. Although, stakeholders have the intention to make the city more attractive through transformation, there are often so called 'institutional barriers' that discourage stakeholders from taking further action. Institutional barriers are obstacles within an environment that result from deeply rooted norms and structures. They are often built up over a long series of years, reflect past choices and solutions, and can hinder the making of an integrated trade-off between different types of actions (CROW, 2021). Evers et al. (2015) classify the institutional barriers for transformation in the inner city into three categories: financial, user, and public perspectives. The institutions applicable to this research are listed in Table 1, which are only affected by the financial and public sectors.

Table 1, Institutional barriers to function transformation (Evers et al., 2015)

Institution…	**Financial perspective** (Investors)	**Public perspective** (Municipality)
… contributes to the property remaining vacant in its current function	- Large investment portfolios of institutional investors - The depreciation of the building is tax deductible - Rent reduction is tied to financial conditions	- Vacancy ordinance[1] is not popular with municipalities and less suitable in low market pressure, such as declining regions
… increases the cost for transformation to another function	- Book value is too high - Monuments increase transformation costs - Municipal parking standards increase costs - Municipality cannot always provide certainty to investors and have compartmentalized approach	- Risk of planning compensation[2] in case of zoning change - Wide-ranging zoning plan is difficult to reconcile with ladder sustainable urbanization - Wide-ranging zoning plan is unattractive to support for local residents
…hinders the new function	- Monument regulations limit exploitation opportunities - WWS[3] would make operating small homes unprofitable	- Environmental conditions (air, noise) for the new function are stricter than for the old function - Housing development agreements

[1] Leegstandsverordening, [2] Planschade, [3] WWS = Woningwaarderingsstelsel (housing valuation system)

2.2.2 Restrictions through inner city policy

As mentioned in paragraph 2.1.4, the municipality aims to make the inner city more attractive by making the shopping area more compact. In inner city visions, this shopping area is often described as the core shopping area ('kernwinkelgebied'). Within the core shopping area, the municipality often only allows space in the plinth of buildings for active public functions, such as stores, services, or hospitality (Retailland, 2023). A continuous active plinth is very important to the attractiveness of the area according to Gemeente Purmerend (2022). To prevent residential functions on the ground floor of the properties in the core shopping area, municipalities can implement zoning rules in the environmental plan, as observed in documents of the municipality of Goes (Gemeente Goes, 2021). Since these zoning rules are based on the vision of the municipality, the ground floor of the properties in the core shopping area can be considered as not suitable for transformation into houses based on policy and legal documents.

2.2.3 Suitability based on property characteristics.

If there is a change of function, it is also necessary to check whether the environmental plan allows the new use. If this is not the case, a permit for an environmental plan activity is usually required, or an amendment to the environmental plan (Informatiepunt Leefomgeving, 2024a). A permit for an environmental plan activity can only be accepted if the transformation project meets several regulations. The new function (housing) must fit within a balanced allocation of functions to locations and it needs to comply with rules regarding sustainable city development, architectural appearance and cultural heritage. Furthermore, to be able to live on the property, it must comply with the Building Works Environment Decree (building code) for housing (Overheid, 2024). There are retail properties that are built quite similar like a house, because some streets that were previously a residential street became a shopping street. Given that, based on their building structure, these properties are suitable for transformation back to residential use, obtaining a permit for transformation is less difficult than for properties that historically served as retail spaces (SUM architecten, 2022). Vacant retail properties in the inner city can have a different building structure compared to houses and will not directly fulfill the environmental criteria. The change in function in the inner city can be made very difficult because of issues such as fire safety, ventilation, parking, daylight access, usable height, usable floor area, outdoor space, orientation, loading/unloading zones, cultural heritage, and architectural appearance (Jonkers, 2018; NVM Business, 2021; RVO, 2023; SUM architecten, 2022).

An issue that occurs regularly, is that the transformation from retail into housing is not possible because of parking norms (Boer, 2021; Jonkers, 2018; RVO, 2023). Most municipalities have parking norms for an entire area based on current functions. If there is no opportunity to add new parking spaces, it will not be possible to meet the applicable parking norms for a new house. However, it is also visible that municipalities, like Hilversum, take the initiative to change or lower these parking norms to be able to stimulate transformations into housing (Gemeente Hilversum, 2023). Municipalities determine the parking norm based on dwelling type, location, and type of residents, and emphasize that a change of functions should not cause parking problems in surrounding areas. This new municipal perspective of lowering parking norms is advantageous for the transformation of vacant retail properties into housing. Therefore parking norms are not taken into account as a factor excluding retail properties from being transformed into a house.

As mentioned, there are also several difficult-to-adapt structural or architectural aspects which clearly distinguish retail properties from a residential building. Since the building regulations for a retail property are different from those of a residential building, it can occur that a retail property is not able to be transformed into a house based on these building regulations. From 2024 on, buildings have to comply with the new Building Works Environment Decree (Overheid, 2024). When changing the function of a building, the rules of Chapter 3 apply. Chapter 3 describes the rules for the existing building level ('Bestaande bouw'). The fundamentals for the existing building level are the same as for the new building level. However, the specific requirements have been set lower because they have not been set in the past. When transforming a retail property into a residential property, the building thus has to comply with the rules for the existing building level. Below the most relevant rules are discussed.

A frequently mentioned architectural aspect of retail properties that constrains the transformation to housing is the lack of daylight access (Jonkers, 2018; NVM Business, 2021; RVO, 2023; SUM architecten, 2022). The Building Works Environment Decree states that living spaces of a residential property need to have at least a window area of $0.5m^2$ (Overheid, 2024). This means that, excluding the studio housing type, both the living room and the bedroom need daylight access, which can be quite a challenge for retail properties with only a daylight opening in the front façade. Retail properties that have the possibility to also create daylight access at the back façade have much more potential considering the rules of daylight accessibility.

A property can only have a residential function if it meets a minimum of certain dimensions. According to the Building Works Environment Decree houses need to have a non-common living area of at least 10 m^2, at least a residence space with a floor area of at least $7.5m^2$ and a width of at least 2.4m, and a minimum height of 2.1m above floor level (Overheid, 2024). Considering the space needed for furniture and the fact that a bathroom also needs to be included, the minimum floor area for a livable studio could realistically increase to $20m^2$. Although it can still be challenging to arrange a floor plan within $20m^2$, the retail properties below these square meters will certainly be excluded for transformation.

Despite the fact that no outdoor space needs to be included during the transformation, the residential function must be able to be reached with a route to the public road (Overheid, 2024). This means that if a residential function is situated on top of a retail function, the residential function needs to have an entrance with a staircase on the public street. Therefore, the possibility of constructing an entrance at the front facade to the upper floors needs to be considered when transforming vacant retail properties into housing.

2.2.4 Suitability assessment based on exclusion criteria

In the previous paragraphs, multiple criteria have been mentioned that can indicate whether a vacant retail property can be considered for the transformation into housing. Due to the scope of the study, only the building-related matters have been included as possible exclusion criteria. In Figure 6, on the next page, a scheme is presented that determines if a retail property is suitable to be transformed into a house based on the location in the inner city and the Building Works Environment Decree.

Since zoning plans and municipal policy restrict residential functions on the ground floor level of the core shopping area, this criterion can be used to exclude vacant retail properties from the list of potential transformable properties in the inner city. The parking norm has been identified as an issue that can prevent transformations from happening. However, because municipalities are willing to lower parking standards to stimulate transformation, and because parking demand is driven by all functions in a given area, using parking norms as an exclusion criterion does not appear to be relevant in research determining vacant retail properties interesting for transformation. In contrast, regulations of the Building Works Environment Decree must be satisfied to create a legally livable house. Transformations due to a change in functions must comply with the existing building-level regulations. If these regulations cannot be satisfied, then that building will be excluded from a transformation to housing. Several regulations related to the dimensions and accessibility of a property can already be assessed beforehand. The property must meet certain minimum requirements for floor size, width, ceiling height, daylight access, and accessibility via a route to the public street.

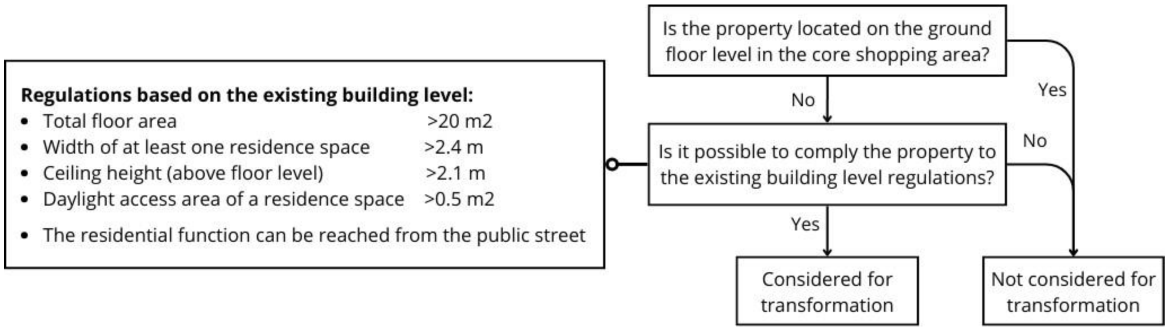

Figure 6, Assessment if inner city retail properties can be considered for the transformation into housing

2.3 RESIDENTIAL CHARACTERISTICS

The value of residential developments depend on the level of utility they can provide to the end user (Otegbulu et al., 2009). The end user has preferences for certain characteristics, whereby the total value of a dwelling with certain characteristics can be determined (Boumeester, 2011). The method of utilizing this information for development purposes is described by Majamaa et al. (2008) as consumer-oriented housing development, which focuses on incorporating user preferences during the development of a project. Since this research focuses on studying residential preferences in the inner city, this literature review will look at what characteristics could be considered by people when choosing a house. The characteristics mentioned in this literature review have been shown to either influence people's preferences or the valuation of a house. While "value" and "preference" are distinct from each other, both indicate that the characteristics might be relevant regarding residential choice. This literature review includes research that addresses value and research that addresses preference in order to provide a comprehensive understanding of the characteristics that could have an influence on residential choice. Where applicable, distinctions between value and preference are presented to illustrate their specific impact on residential choice. First, the locational characteristics (sub section 2.3.1) of a property are investigated, followed by an exploration of relevant building characteristics (sub section 2.3.2). This section ends with a conclusion on what residential characteristics can be applied in this research that focuses on investigating residential preferences related to retail properties in the inner city.

2.3.1 Location characteristics

The location of a house significantly impacts its value, with various factors playing a role (Fernandez-duran et al., 2011; Gelfand et al., 2004). Similar findings are made by Heyman & Sommervoll (2019), who specifically notes the influence of relative location. The relative location can give a planner a better understanding of what makes a location attractive by considering its relative location to for example neighborhood amenities. Exploring other research, the location characteristics of a property are often distinguished into several different categories. Hurtubia et al. (2010) define three categories: Land-use attributes, socio-economic attributes, and accessibility attributes, while others only make the distinction between location and neighborhood characteristics (Kam et al., 2018; Tan, 2012). This review makes a similar distinction by dividing the location characteristics into transportation accessibility-related characteristics, neighborhood amenities, and socio-economic neighborhood characteristics. For this research, it is fundamental to identify which location characteristics are most considered in other research, and how these characteristics had an influence on the residential choice of future residents. An elaboration of the location characteristics is presented below.

2.3.1.1 Transportation accessibility-related characteristics

Accessibility can be defined in several ways, and therefore has a variety of meanings. Accessibility can for example be defined, as the perceived benefit of a group of travel alternatives (Ben-Akiva & Lerman, 1979), as the ease of access to each land use activity from a location using a particular mode of transportation (Dalvi & Martin, 1976), or as the degree to which a location allows an individual to participate in various types of activities in various locations and the connectivity between one location and the rest of the locations in the region (Chen et al., 2008). This section focuses on the transportation accessibility-related characteristics, and thus mainly on the availability, distances, and externalities of different transportation modes.

The accessibility of the location of a property has an effect on the valuation of a property. In general, there seems to be a higher demand for properties that are accessible by a variety of different transport options (Ellison & Sayce, 2007). Research by Yan (2020) examines the relationship between households' location choices by making a distinction between walkability, transit accessibility, and car accessibility. According to the study, all three types of accessibility seem to be important to households, with transit and car accessibility being of the greatest importance. Other research supports the relationship between transit or public transportation systems and residential choice. Meng et al. (2021) found that the distance to the train station is a significant factor in the user's residential choice. Households want to live close to a public transport system, but also not to close according to Heyman & Sommervoll (2019). In their research, they showed that the value of a property rises when moving away from a metro station. Taking into account that people value short commuting times, this is surprising. However, it also needs to be taken into account that some types of transportation systems can produce air or noise pollution which are also factors influencing the residential choice behavior of end users (Danielis et al., 2007). Similar observations appear in research into car accessibility. In research, this type of accessibility is often measured by looking at the distance to the nearest highway ramp (Borgers & Timmermans, 1993; Heyman & Sommervoll, 2019). People prefer to be within a certain range of a highway ramp, but not too close as highways cause air and noise pollution. In research, the level of transportation accessibility is thus often described by the availability and distance of different modes of transportation. Aside from that, research indicates that accessibility has a significant but further modest positive influence on residential choice (Borgers & Timmermans, 1993; Zondag & Pieters, 2010). Other variables about the dwelling itself or the demographics and amenities of the neighborhood seem to be more dominant in explaining the influence on the residential choice.

2.3.1.2 Neighborhood amenities

Being able to reach desired services and facilities within an area, as well as their proximity to one another, is referred to as access to amenities. It can for example be measured in terms of distance to schools, work, shops, and green spaces. This section describes how education, work, shopping facilities, green spaces, water features, parking spaces and the proximity of cultural heritage buildings are considered by the end users.

Education is an essential facility in one's life. The access to education is often described as the distance to the nearest school. Tan (2012) found that the distance to a school is very much considered and related to the residential choice of households. Moreover, research shows that the proximity of a school can increase the value and willingness to pay for the surrounding houses (Jang & Kang, 2015; Tam et al., 2022; Wen et al., 2014). It indicates that households are willing to invest more money to benefit from the facilities of a nearby school. Nevertheless, not all households share this idea, since some of them do not have members that need education. It is therefore important to pay attention to the target groups that are involved, looking at the influence of educational facilities on residential choice.

For a large group of people, work is the place they travel to most often during the week. In general, people do not prefer large commuting distances. Rouwendal & Meijer (2001) further add to this that the acceptance of commute distance can be offset by a preference for some residential characteristics. The distance to work may thus depend on the preferred living situation. Moreover, research in the Netherlands has found that "working" in particular most often precedes "living" (Hoogstra, 2013). In the Netherlands, people more often look for work near where they live rather than live near where they work. There is a relationship between the distance to work and housing choice, but research shows that it is probably not as influential as other housing attributes.

People have a common wish to save time and effort on traveling. This implies that daily trips to a shopping area should not be too long. Research by Jim & Chen (2007) had similar findings. They discovered that the distance to a shopping area is negatively correlated with the valuation of a house.

The closer the distance to a retail area, the higher the value of a house. However, this is not always the case. According to research by Jang & Kang (2015), residential properties near retail stores are being sold at a lower price due to negative externalities. Retail areas can generate high traffic volumes, noise, and crowding, which can have unfavorable effects on residents in the area. Shopping facilities can thus influence the location choice of households positively and negatively.

The availability of green spaces within the neighborhood can be identified as an environmentally friendly amenity that stimulates recreational activities. In research by Ardeshiri et al. (2018) they identified that these public green spaces are the most preferred amenity to have when choosing a neighborhood to live in. Additionally, Mccord et al. (2014) and Zalejska-Jonsson et al. (2023) both found that public green spaces have a significant positive impact on residential property values and the perceived attractiveness of housing developments. This is further supported by articles that observe a positive relationship between public greenery and housing prices (Bridgwater, 2022; Jang & Kang, 2015; Jim & Chen, 2007; Morancho, 2003). The proximity of a public green space can thus be of major influence on people's location choices. Luttik (2000) did not only investigate the availability of greenery but also included the effects of water features in the area. The study's findings indicate that the presence of water features have a positive influence on housing prices in the Netherlands. Jim & Chen (2007) found the same in their research in China and also observed that water features would raise the attractiveness of residential properties. Public greenery and the availability of water bodies are both considered to be valuable assets that can enhance the desirability and value of residential properties.

A parking place can be seen both as a building and a locational characteristic. A private parking place is considered to be a building characteristic whereas the availability of parking places in general can be seen as a locational characteristic (Boumeester, 2011). There is limited research on the influence of parking spaces on residential choice behavior. Research by Borgers et al. (2010) emphasizes that the preferences are very diverse. For security reasons, people prefer to see their cars from inside their houses. Nevertheless, they are also willing to park their cars further away at a secured parking lot in exchange for a traffic-free residential street.

Literature indicates that there is also a relationship between the value of residential buildings and the presence of historic or heritage-listed buildings. Research of Duijn & Rouwendal (2013) looked into whether various Dutch households' location preferences are influenced by their cultural heritage. They quantified the value that households place on cultural heritage and found a positive willingness to pay for residential locations close to protected historical inner cities. Lazrak et al. (2014) had similar findings, but the effects of cultural heritage buildings only has a significant effect on the housing values within a 50 meter radius. It shows that effect of cultural heritage is most significant when it is clustered at one place such as a city center. Franco et al. (2016) adds to this that while having a home close to a historic site adds value to the price of the property, larger concentrations may draw visitors from outside the area, which tend to have a negative effect on the living quality of the end users.

2.3.1.3 Socio-Economic neighborhood characteristics
People choose a residential location based not only on its spatial characteristics but also on the basis of the socioeconomic characteristics of a neighborhood. According to Hurtubia et al. (2010), the choice for a certain neighborhood can depend on the average income, ethnic group, safety, and familiarity of the neighborhood. Several articles show intercorrelation between these attributes. In research on how older people perceive 'aging in place', Wiles et al. (2012) observed that people sought familiar neighborhoods that conferred a sense of security and warmth. It demonstrates how safety is not necessarily determined by numbers, but also by a person's affinity with a certain area. Nevertheless,

in most research safety is measured based on available data such as crime rates. The higher the crime rates, the lower the safety, and the less people prefer to live in such a neighborhood (Yan, 2020). Research by Wang & Li (2004) observed similar findings regarding these socioeconomic characteristics related to location choice. In their study in China, people showed a strong preference towards secure districts with a good reputation. The lowest preferred districts were the ones mostly represented by lower income groups, and known for their negative behavior. The study showed that in their choices people often look at their own social identity and status. People prefer to live in a safe and familiar neighborhood. The income level of a neighborhood is trough gentrification often related to the quality of housing in a neighborhood. A high-income neighborhood is more likely to contain the preferred characteristics than lower-income neighborhoods through the availability of the budget. Therefore, it does not seem to be relevant to incorporate income level of neighborhood in residential preference research.

2.3.2 Building characteristics

Building characteristics is the overarching name for all attributes related to the physical building itself. Research into residential preferences defines five dimensions of housing attributes. These dimensions are house size and exterior finish, floor plan, interior finish, technical systems, and environment (Hofman & Halman, 2014; Soon & Tan, 2020). Those interested will choose the property that best meets their requirements. As a result, understanding how customers rank the importance of various housing attributes is essential. This section describes the characteristics that have been identified in the literature.

2.3.2.1 Housing size

As expected, housing size is positively related to the value of the house (Morancho, 2003; Selim, 2008). In similar locations, houses with a larger living area tend to be more expensive. According to Hurtubia et al. (2010), the amount of space required by end users is typically determined based on the size of the household and its income. People with a higher income can spend more on living space than others. However, this does not imply that households always prefer a bigger dwelling while having a fixed cost limit. It can also be that households prefer a smaller house for practical reasons such as lower maintenance costs. The space needed is thus dependent on the size of a household. The country's demographics can therefore partly explain the demand for a certain amount of space (Welsh et al., 2014).

Not only the square meters, but also the ceiling height of a dwelling can play a role in a house buying decision. Vartanian et al. (2015) investigated the aesthetic preferences by changing the ceiling height and perceived enclosure. They found that dwellings with higher ceilings were more likely to be judged as beautiful than rooms with lower ceiling heights. People also preferred an open room over an enclosed room. It therefore seems that people like to have a spacious environment to live in. Nevertheless, there are also arguments for people to have lower ceiling heights. Handley (2011) rightfully points out that higher ceilings will also come with issues concerning lower energy efficiency, lack of coziness, and sound transmission. Future users therefore have to make trade-off between aesthetic and practical aspects of both the high and low ceilings.

2.3.2.2 Number and size of the different rooms

Closely related to the size of the dwelling is the floor plan. A floor plan describes the number and orientation of the different types of rooms within the dwelling. Research of Tan (2012) investigated people's trade-offs between different housing attributes when buying a house. Floor plan-related attributes that could be considered were the number of bedrooms and bathrooms, the size of the living and kitchen area, and the total size of the built-up area. Of these attributes, only the number of bedrooms was significantly important to the end users. Opoku & Abdul-muhmin (2010) found that not only the size and number of bedrooms but also the number of bathrooms are significantly considered. Nevertheless, the research of Jim & Chen (2007) and Morancho (2003) both rightfully describe the fact that the number of bedrooms and bathrooms is primarily determined by floor area. As a result, the size of the apartment influences the preference for bedrooms and bathrooms.

2.3.2.3 Housing type

There are various types of houses where people can choose from. Most articles make the distinction between single-family and multi-family houses. Single-family houses are, for example, detached, semi-detached, or terraced houses. Whereas multi-family houses are like apartments, which are part of a building containing more than one house. It is hard to define if people have a specific preference for a certain housing type because housing types are often bound to specific locations and specific target group needs. Kauko (2006) explains that for people living in multi-family homes, location is more important than for people living in single-family homes, since in the latter case, people place greater value on particular aspects of the house itself. For equally priced cases, people make for example the trade-off whether they need living space or the amenities of a central location. This trade-off is then very much dependent on the target group preferences, since families with children often need more space than singles.

2.3.2.4 Availability and size of balcony or yard

Exposure to outdoor spaces has been linked to reduced stress, improved cognitive function, and enhanced mental well-being (Pearson & Craig, 2014). People have the opportunity to enjoy the outdoor air in public spaces, but also in private spaces if residents own a balcony or yard. In their research on green spaces, Coolen & Meesters (2012) argue that public and private green spaces cannot just simply be substituted for each other. Public green spaces are important because they enhance both the experience of nature and the livability of the surrounding area. Whereas a residential yard can be seen as an outdoor space that provides opportunities for informal leisure. Privacy and security are therefore important aspects of residential yards (Bell et al., 2020). Bell et al. (2020) further mention that having a private outdoor area eliminates the possibility of conflicts arising from the layout, management, and utilization of shared spaces. People have the opportunity to express their wishes in their own private space. A space that eventually will be beneficial for health and well-being.

2.3.2.5 Building façade

User preferences for the individual elements of the façade have not been very much explored in research. Most research focuses only on the judgements of experts in the field or the impact of participation of non-experts to the design of a façade. Nevertheless, the aesthetics of the façade can make several differences, especially in a frequently visited area such as the city center. Retail properties are characterized by having a large window-to-wall ratio. Taehoon et al. (2019) investigated the satisfaction of participants based on the window size in offices. They found that a higher window-to-wall ratio increases people’s satisfaction regarding visual comfort, spaciousness, and openness. However, this higher ratio leads to a lower sense of privacy. In residential choices, people also have to make the trade-off between spaciousness and privacy. Since households are very much concerned about their privacy, it can be a very important decision (Soon & Tan, 2020). Closely related to both the inner city area as well as privacy is the distance of the façade to the street. It is easier for pedestrians to look into one’s house if the building’s façade starts directly on the street. This means that people create more privacy by having a front yard, increasing the distance of the street to the façade.

2.3.2.6 Energy efficiency

In the last decade, the housing stock's environmental performance has become more of interest to households in the last decade. Through energy efficiency certification people will have more insight in dwelling sustainability (Fuerst et al., 2015). This also allows studies to investigate the relationship between energy efficiency and people's residential choice. Research by Lee et al. (2018) revealed that consumers' choice of residential property is significantly influenced by the energy efficiency of the building. More specifically, it was observed that consumers mainly favor highly energy-efficient buildings. People may favor energy-efficient buildings because of additional comfort as well as the reduced effects of energy use on the environment. However, most often the energy saving costs are the key factor in choosing an energy-efficient dwelling (Bani & Hieminga, 2022). Research by Belaïd & Flambard (2023) rightly mention that the choice for an energy efficient dwelling entails making trade-offs between current expenses and potential gains. This means that the choice for an energy-efficient dwelling can also differ per target group.

2.3.2.7 Price

Źróbek et al. (2015) found that, in comparison to other characteristics, home buyers' most important factor behind the residential choice is the price. According Molina et al. (2021) price can set boundaries for people's residential choices, as people need to make trade-offs between other characteristics if they can not afford to buy a property. In their research Molina et al. (2021) emphasize that aside from size, location, and typology, price is one of the most important housing characteristics in people's search process for a new home. Price can be very determined by how the house-searching process starts and ends. Aside from that, some characteristics can even be deemed less important since they did not lead to the intended price.

2.3.3 Residential characteristics of inner city vacant retail properties

The literature identified many characteristics that could influence the residential choice decisions of people. All the characteristics identified in the literature are shown in Table 2. Nevertheless, this research focuses on a very specific situation: vacant retail properties in the inner city. This means that the location characteristics need to be related to the specific inner city area. Whereas the building characteristics need to be related to the characteristics of a retail property. Additionally, research shows that the inner city is highly likely to attract specific target groups. The main target groups for inner city housing identified in the literature are students, starters, young couples, and senior citizens (Blijie et al., 2009; Boissevain, 2020; Geraedts & Van der Voordt, 2007). These target groups could live in relatively small dwellings and they frequently underline the importance of having access to the amenities that the inner city provides. By looking at the target group's preferences and the specific characteristics of an inner city vacant retail property, this section aims to select the most relevant characteristics that can identify which vacant inner city retail properties are most preferred in the inner city.

Table 2: Residential characteristics identified in literature

Characteristic	Sources	Relevant
Location characteristics		
Distance to public transport	(Danielis et al., 2007; Heyman & Sommervoll, 2019; Hubbard, 2009; Meng et al., 2021; Mulliner et al., 2020; Nijënstein et al., 2023; Yan, 2020)	Yes
Distance to a highway ramp	(Borgers & Timmermans, 1993; Heyman & Sommervoll, 2019)	No
Distance to school	(Jang & Kang, 2015; Strzalka, 2019; Tam et al., 2022; Tan, 2012; Wen et al., 2014)	No

Distance to work	(Hoogstra, 2013; Rouwendal & Meijer, 2001)	No
Distance to a shopping area	(Jang & Kang, 2015; Jim & Chen, 2007)	No
Proximity of a green space	(Bridgwater, 2022; Jang & Kang, 2015; Jim & Chen, 2007; Luttik, 2000; Mccord et al., 2014; Morancho, 2003; Zalejska-Jonsson et al., 2023)	Yes
View on a water feature	(Jim & Chen, 2007; Luttik, 2000)	No
Proximity of a parking place	(Borgers et al., 2010)	Yes
Proximity of cultural heritage	(Duijn & Rouwendal, 2013; Franco et al., 2016; Lazrak et al., 2014)	No
Safety of the neighborhood	(Mulliner et al., 2020; Wang & Li, 2004; Wiles et al., 2012; Yan, 2020)	No
Crowdedness of the street	(Jang & Kang, 2015)	Yes
Building characteristics		
Floor area	(Guo & Bhat, 2007; Hurtubia et al., 2010; Karsten, 2007; Morancho, 2003; Selim, 2008; Welsh et al., 2014)	Yes
Ceiling height	(Handley, 2011; Vartanian et al., 2015)	No
Number of bedrooms	(Opoku & Abdul-muhmin, 2010; Tan, 2012)	No
Number of bathrooms	(Opoku & Abdul-muhmin, 2010; Tan, 2012)	No
Dwelling type	(Jong et al., 2012)	No
Balcony/yard	(Bell et al., 2020; Coolen & Meesters, 2012; Pearson & Craig, 2014)	No
Window-to-wall ratio	(Soon & Tan, 2020; Taehoon et al., 2019)	No
Energy efficiency	(Bani & Hieminga, 2022; Belaïd & Flambard, 2023; Lee et al., 2018)	No
Price	(Molina et al., 2021; Yi & Lee, 2014; Źróbek et al., 2015)	Yes

Most characteristics found in research are related to the location of the house. Since this research focuses very specifically on the neighborhood level, the inner city, the differences in relative location will probably not be that large. It is therefore important to investigate which characteristic is relevant in describing one's residential choice. In research, most mentioned transportation accessibility-related characteristics were public transport and car accessibility, respectively defined by the distance to the nearest public transport stop and nearest highway ramp. The distance to the nearest highway ramp could be a rightful way to describe car accessibility. However, in inner cities, people often do not have a private parking space in front of their houses. This means that the travel time by car is also dependent on the distance to the parking space. Therefore it is more relevant for this research to focus on the proximity of the nearest 'private' parking space to describe car accessibility. Generally speaking, most inner cities in the Netherlands are reachable by public transport. The distance to a public transportation mode is frequently mentioned by students and the elderly as an important characteristic influencing location choice (Hubbard, 2009; Mulliner et al., 2020; Nijënstein et al., 2023). Both target groups desire a short walking distance to a public transportation mode. However, within larger inner cities, differences can occur concerning the walking distance to the nearest public transport mode. Consequently, this research attempts to find out if the distance to the nearest 'private' parking space and the distance to the nearest public transportation mode have a relation with the residential choice of people in the inner city.

A neighborhood amenity that seemed to have a relation with residential choice is the distance to a shopping area. Since the inner city is characterized by the availability of many shops, the distance between a house and a shop becomes almost negligible. It becomes more of a standard for all the houses instead of an influencing factor. The same situation occurs when examining the influence of the presence of cultural heritage buildings on residential choice. It is hard to measure the impact if all vacant retail properties are already in a historical inner city. Nevertheless, the historical inner city and the presence of shops can cause large visitor flows and crowdedness in front of houses. The crowdedness can vary between different parts of the inner city and may cause noise pollution and a feeling of a lack of privacy, which is not preferred by residents. It can therefore be interesting to investigate the effect of crowdedness on people’s location choice.

Research indicated that specific households consider the proximity of a specific type of school in their location choice. For example, families with children like to live next to elementary schools, whereas student like to live close to the university. As mentioned at the beginning of this section, the target groups for inner city housing are students, starters, young couples, and senior citizens. From these target groups, only the students are particularly in need of an education facility and desire to live close to an educational facility such as a university (Strzalka, 2019). Since the distance to a school is only important to one specific target group, it will not be generalizable in the latter stage of the analysis. Therefore it will not be taken into account in the preference analysis. Besides that, the distance to work will also not be included. The distance to work may be offset by a preference for certain housing characteristics, and work locations show much more variation than school locations, making it difficult to include distance to work in housing choice research.

The proximity of green spaces and water features also seem to have a relation with the residential choice. These amenities both exert their influence on people's residential choices through their aesthetic characteristics. The perceived attractiveness of a house can be increased through a view of a water feature or green space. However, green spaces can also be preferred due to the possibility of recreational use instead of just the view. Green spaces, like parks and public gardens, can serve as a low-threshold meeting place for residents, which contributes to the feeling of social cohesion (Struiver et al., 2018). Partially due to this factor, target groups like the elderly also indicate that the availability of greenery is important in their residential location choice (Mulliner et al., 2020). Therefore, this research will only investigate the relationship between green spaces on people’s residential choices in the inner city.

According to several sources, neighborhood safety has a relation with the desire for people to live at a certain location. Besides that, research shows that especially senior citizens desire to have a home in a safe neighborhood (Mulliner et al., 2020). Inner cities in the Netherlands are characterized by a mix of functions. As a result, social security is not always present at certain times of the day. The sense of security can differ per inner city, which can make one inner city more attractive to live than the other. However, it is complex to define differences in levels of safety within a neighborhood like the inner city. Therefore, in the scope of this research, the sense of safety is not included.

Several building characteristics had a relation with the residential preference of people. However, not all characteristics are relevant or within the scope of this research. This research focuses on vacant retail properties. It limits the dwelling type to only that of a retail property and does not yet include a specific number of rooms, such as bedrooms or bathrooms. Furthermore, since the space is very limited in the inner city, vacant retail properties most often do not contain private outdoor space like a yard or a balcony. Additionally, yards are most often preferred by families with children, who are not identified by literature as target groups for inner city housing (Coolen & Meesters, 2012). As a result, this research will not take these characteristics into account.

Housing dimensions can be reflected in the dimensions of inner city vacant retail properties. Research shows that target groups may differ in their preference regarding residential floor areas. It is therefore of interest to see how significant individuals consider residential floor space in the inner city. In addition to floor area, ceiling height is also identified as a feature that could influence people's residential choices. However, it will not be included in the preference analysis, as it is already accounted for as an exclusion criterion. The dimensions, like floor area and ceiling height, do indicate the limits for future adjustments to a property. In contrast, window-to-wall ratios and energy efficiency are characteristics that can more easily be adjusted according to the wishes of future residents. Therefore, in this research, it makes more sense to only incorporate dimensions of the property in the residential preference research instead of specifications like window-to-wall ratios and energy efficiency.

Properties in the inner city can very much differentiate in price. To illustrate, Teulings et al. (2017) observed in their research that, in shopping areas with a single center, rents decline by about fifteen percent relative to this center. In addition, the inner-city target groups vary in affordability (Geraedts & Van der Voordt, 2007). Research shows that the price of a property has a large influence on the residential choice. Therefore the estimated property price needs to be incorporated into the research on people's residential choice in the inner city.

2.4 SPATIAL DECISION SUPPORT SYSTEM

Municipalities have plans to make the shopping area of the inner city more attractive by making the inner city more compact through the transformation of vacant retail properties into houses. However, not only is it currently unclear whether vacant properties are interesting to be transformed into houses, the process of actually transforming the property also involves multiple stakeholders with different goals and priorities, like investors and retailers, making it more difficult to make decisions.

The development of a new multi criteria spatial decision support system (MC-SDSS) can help address the problems mentioned above. It could give insight into which vacant retail properties might be interested in being transformed into housing, and it could be used to support the decision-making process in discussions with other stakeholders. A MC-SDSS consists of two main components: a multi criteria decision analysis (MCDA) and a geographical information system (GIS). When combined, MCDA and GIS can be considered as a set of techniques and instruments for merging geographic data with preferences (value judgments) and modifying it to provide information for decision-making (Malczewski & Rinner, 2015). In this case, MCDA can help identify vacant retail properties are interesting to be transformed into houses based on target group preferences. Whereas, GIS can help with the processing, analysis, and visualization of the MCDA data to create a clear overview of the problem situation, which can be used to support the municipality's policies. According to Voogd (1982) MCDA can also be used to demonstrate to other stakeholders that the decision-makers made proper use of the available information and thoughtfully comprehended the possible effects of the planned proposal. Furthermore, it even has been stated that the integration of GIS with MCDA decreases the possibility of making mistakes in spatial decision-making and planning processes by providing decision-makers with a reproducible and traceable approach (Lipshitz & Massam, 1998). Below both components are further explained.

2.4.1 Multi Criteria Decision Analysis (MCDA)

Multi criteria decision analysis (MCDA) is a commonly employed method used within environmental management decision support systems (Figure 7). According to Taherdoost & Madanchian (2023), MCDA aims to solve decision-making problems by considering more than one criterion in the selection process. The multi criteria problem of this study is related to people's residential preferences. As shown in the study of Jansen et al. (2011), while deciding between alternative dwellings, decision makers (people) must assess numerous criteria of the available alternatives at the same time, such as dwelling size, cost, and number of rooms. When considering multiple criteria, these decisions can become quite complex. Moreover, probably not every criteria is equally important to the decision-maker. It could be that a person thinks the price of a property is way more important than its location. Such a choice situation between different properties can be seen as a MCDA problem that is defined by three basic inputs: a set of alternatives (A), a set of criteria (C) to describe each alternative, and weights (W) to describe the importance of each criterion (Taherdoost & Madanchian, 2023). The evaluation of a property (alternative) based on weighted attributes (criteria) is related to the Multi-Attribute Utility Theory (MAUT). The main assumption underpinning this theory is that a decision-maker chooses the alternative (for example, a specific house) that produces the highest multi-attribute utility out of a set of possible options (Jansen et al., 2011). Each alternative is described by attribute values, which are paired with importance weights to produce a multi-attribute utility. The alternative with the highest multi-attribute utility is then most likely to be preferred.

As shown in Figure 7, MAUT is again divided into several different methods. The main differences between these methods are related to determining the importance of the attributes. The relative importance of housing attributes can be predicted and explained in several different ways (Jansen et

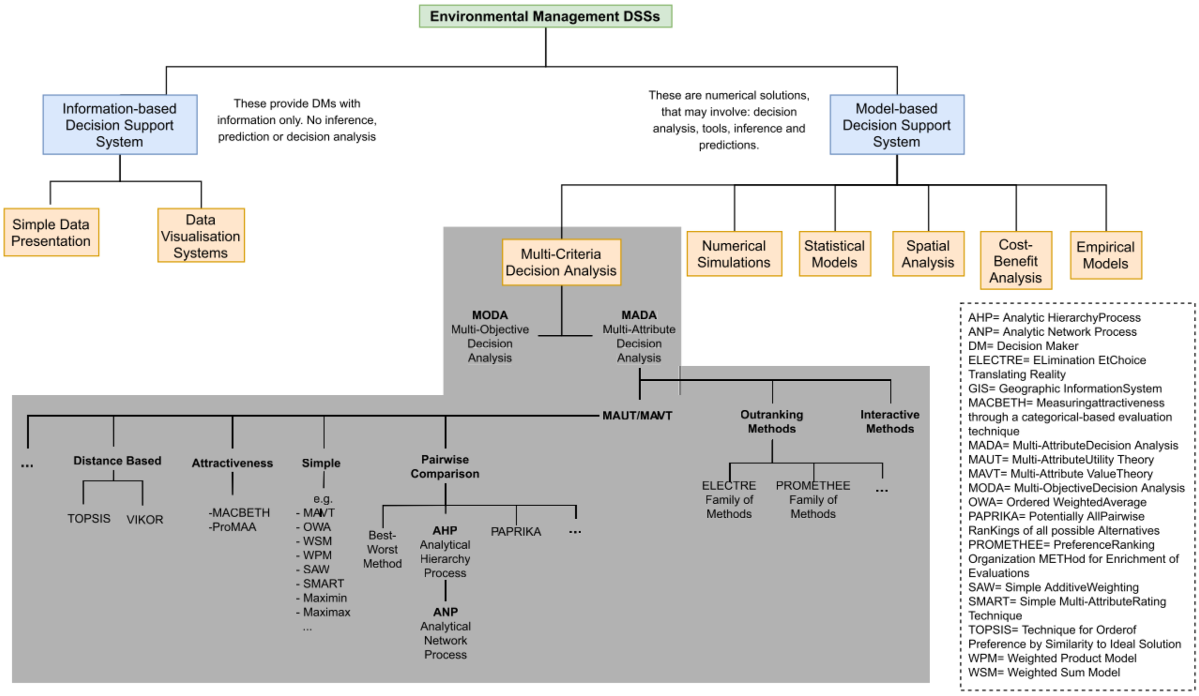

Figure 7, Decision-making methods used within environmental management DSSs (Hammond et al., 2021)

al., 2011). The choice of a method to predict the relative importance of housing attributes depends on the data available, time consumption, and the desired outcome. In this research, new data needs to be gathered, since there has not yet been revealed what people's residential preferences are in a specific area like the inner city. Additionally, this research aims to create a model that can predict if people would like to live in a certain property based on the attributes of a property. A suitable method to create such a model is to make use of a Discrete Choice Experiment (DCE). DCE is not included in the figure and research of Hammond et al. (2021), but the method is closely related to methods under the Pairwise Comparison branch of MAUT. Below is discussed how the DCE has been applied in previous research.

2.4.1.1 Discrete Choice Experiment

Discrete choice experiments can be used to investigate residential preferences (Aliu & Ajala, 2014; Earnhart, 2002; Molin et al., 1996; Orzechowski et al., 2005; Rofè et al., 2017; Romero-espinosa et al., 2021). Studies use DCE for different purposes related to the implementation of user preferences in urban planning decisions. In their research, Molin et al. (1996) indicate that due to government regulations, housing developers feel an increased need to build housing that reflects the needs and preferences of the target market. They show how a DCE can be used to predict consumer response to new housing projects, which is then used to write recommendations on what type of housing should be built in an area. Besides that, research shows how DCE can also be used to investigate whether there is a market for certain sustainable urban development (Rofè et al., 2017). Rofè et al. (2017) indicate that the results of their DCE could be an incentive for planners and developers to start building sustainable neighborhoods. That DCE can be used to make policy is further demonstrated by the research of (Romero-espinosa et al., 2021). In their research, they use the DCE to find out which city amenities are important to people in work-related relocating decisions. The insights from this research allow policymakers to make decisions about which amenities to incorporate or improve first in their city to attract specific types of workers. All in all, the above studies show that the results of the DCE can have multiple applications. To illustrate how a DCE could work, an example from research by Rofè et al. (2017) is elaborated upon below.

DCEs often involve two parts: collecting data with an experiment and developing a model based on the experimental data. According to Shang et al. (2023) the experiment of the DCE is mainly about making a choice between (fictional) alternatives while considering trade-offs among the alternatives. DCE typically comes in the form of a survey, in which respondents are repeatedly given a number of alternatives in a choice set and asked to select one from a choice set. Figure 8 shows an example of such a choice task (Rofè et al., 2017). In the choice task, each housing alternative is described by characteristics that are assumed to influence the residential choice of the respondent. If house A is chosen over house B, it is because house A has more preferable levels of the included characteristics. These preferences indicated by the respondents can then be converted into a model, a discrete choice model (DCM). In a DCM, the preference for each characteristic level is expressed by a weight. These weights allow decision-makers to identify which properties maximize the utility for future users, increasing the development's chances of acceptance (Marmolejo-duarte & Ruiz-lineros, 2013).

		
Neighbourhood form	Neighbourhood form: Curvilinear roads and cul-de-sacs Public space: Open space between buildings	Neighbourhood form: Connected grid Public space: Neighbourhood Park
Distance to shopping center and various services	Need to drive to shopping center and services	Walking distance to neighbourhood shopping center and services
Number of floors in buildings	7–13 floor building	14+ floor building
Number of parking spaces	2 parking spaces per apartment	1 parking space per apartment
Accessibility to public transit	5 min walking distance to bus stop. Bus passes every 10minutes.	15 min walking distance to bus stop. Bus passes every 30 min.
Price of 4 room apartment	ILS 1,200,000 *(~$343,000 US Dollars)*	ILS 1,000.000 *(~$285,700 US Dollars)*
	○	○

Figure 8: Example of a choice task (Rofè et al., 2017)

2.4.2 Geographical Information System (GIS)

A geographical information system (GIS) is a universal management technology that captures, analyzes, models, and displays spatial data (Böhner et al., 2005). GIS is used in a great variety of research areas. One of GIS's main applications is urban planning (Yeh, 2005). Urban planners use GIS as both a spatial database and a tool for analysis and modeling. It can be used for development control, general administration, plan-making, and strategic planning.

GIS software consists of three important components: a database management system (DBMS); tools for creating intelligent digital maps that can be analyzed or queried for more information; and an easy-to-use graphical user interface (GUI) (Singhal & Gupta, 2010). These components allow GIS to perform a spatial analysis, and generate informative maps based on specific data. Figure 9 illustrates how visual layers are linked to databases. These databases and layers can eventually be integrated into one final database containing all of the information needed for the analysis. In GIS, geographic data is shown as different features: points, lines, areas, or continuous surfaces (Reddy, 2018). The location and shape of these features is referred to as ‘map data’. The actual descriptive data associated with these map features is known as 'attribute data' (Reddy, 2018). The interaction between these two data types strengthens GIS, allowing for the analysis of multiple spatial and non-spatial criteria.

GIS can support in decision making by processing, integrating, and visualizing spatial data (Arciniegas & Janssen, 2012). GIS allows for the integration and analysis of various data using spatial analysis tools (Singhal & Gupta, 2010). These spatial analysis tools can assess factors like proximity to public transport, availability of amenities, and other environmental features, necessary for evaluating the suitability of transforming vacant retail properties into housing. By integrating MCDA output into GIS, it becomes possible to create maps that visualize the suitability of locations (Gomes & Lins, 2002). GIS can overlay and analyse multiple criteria layers, generating composite suitability maps that highlight optimal locations for housing based on the results of the MCDA. Additionally, GIS can dynamically update these models as new data becomes available or as criteria weights are adjusted. Furthermore, GIS supports advanced spatial querying, enabling the exploration of scenarios (Gomes & Lins, 2002; Malczewski & Rinner, 2015). This capability allows decision-makers to test different strategies and assess their potential. GIS can further support these decisions through its ability to visualize spatial data (Arciniegas & Janssen, 2012; Batty, 1992). GIS can be used to generate maps and geographic representations of retail properties, the environment, and amenities. This visual context helps to understand the spatial distribution these properties in inner cities and in communicating spatial information to stakeholders in a clear and comprehensible manner.

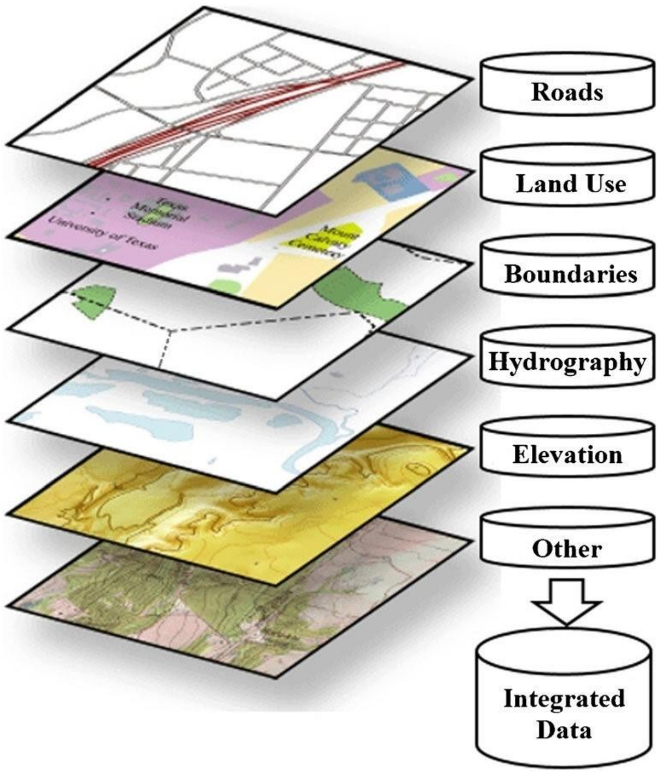

Figure 9, GIS Layer analysis (Çalış Boyacı & Şişman, 2021)

2.5 CONCLUSION

The goal of this literature review was to get a better understanding of all the aspects contributing to the development of a tool that can be used to explore which vacant inner city retail properties are of interest to be redeveloped into housing based on target group preferences. The literature review was divided into several sections and thereby answered 3 different sub-questions.

The first sub-question was: *"Which stakeholders are involved in inner city retail transformations?".* The review indicated that citizens, retailers, property investors, and the municipality are the main stakeholders involved in the transformation of vacant retail properties. The needs, interests and instruments of each stakeholder are evaluated and used to determine which stakeholder is most suitable to exploit the tool. The outcome suggests that the municipality is the stakeholder of choice to use the tool. The tool does not focus on the feasibility of transforming retail properties into housing, making it of less interest to real estate investors. The tool only uses user preferences to explore which retail properties are of interest for residential transformation. Since the municipality has an interest in creating an attractive inner city environment for its residents and visitors, it could use this tool to guide decisions on where to start the transformations of vacant retail properties into housing. These decisions can be enforced by the municipality through the application of zoning restrictions, for example.

The second sub-question was *"SQ2: What characteristics make a retail property suitable to be transformed into a house?"*. To properly answer this question, the literature first looked at the barriers that prevent the transformation of retail properties into inner-city houses. It then examined this in more detail by looking at policies and building regulations. First of all, transformations in the inner city do not yet seem to proceed fluently due to financial or legal issues such as zoning. The latter is also reflected in policies of many municipalities that only want retail in the plinth of the core shopping area to increase attractiveness. Retail properties on the ground floor of this area are therefore considered unsuitable for transformation. In addition, there are also some rules from the building code that exclude certain retail properties for transformation into a house. These rules mainly indicate the minimum dimensions that a property needs, but also daylighting and having its own entrance. These rules will also be taken into account when developing the tool.

The third sub-question was *"What inner city building and locational residential characteristics are considered and preferred by the different target groups?".* To make a holistic selection of these, the research first looked at what housing characteristics are typically considered in residential preference studies. A total of sixteen different characteristics were identified related to the building itself or the location of the building. Not all of the characteristics were relevant to this study because the characteristic must be applicable to an inner city location, it involves the transformation of retail properties, and it needs to be something the target groups would consider. A selection of six characteristics relevant to this research were identified. In terms of location, it might be interesting to look at the distance to public transportation, proximity to green space, proximity to parking space, and the crowdedness of the street. In terms of building, it might be interesting to look at floor area and price in the preference research. The following conceptual model illustrates the relationship between building and locational characteristics and the residential preference for inner city retail properties.

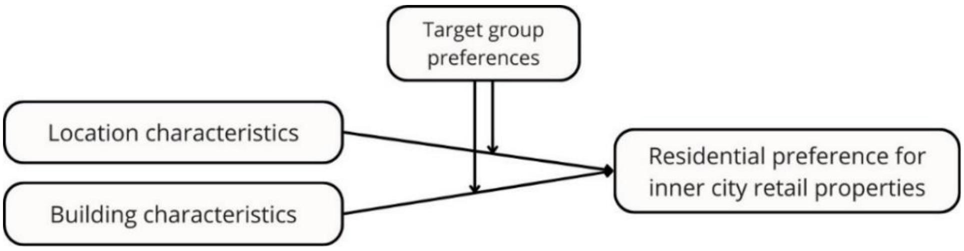

Figure 10, Conceptual model

The final part of the literature review looked at how a SDSS works and why it is well applied in this particular context. A SDSS integrates a multi criteria decision analysis (MCDA) with geographical information systems (GIS). MCDA can help identify retail properties that can be interesting for transformation through the evaluation of multiple criteria related to buildings and locations, by ranking properties based on the highest utility derived from weighted attributes. The weights of the attributes can be derived using a DCE, which can be used to gather data on residential preferences and predict the preference of properties based on their attributes. GIS, on the other hand, enhances the MCDA by processing, analyzing, and visualizing spatial data. It supports urban planning through database management and intelligent maps, allowing for extensive spatial analysis. GIS can integrate MCDA outputs to create maps that illustrate the suitability of different locations for housing. It can dynamically update models with new data, perform advanced spatial queries, and generate visual representations to aid decision-making. The integration of MCDA and GIS in a SDSS can help municipalities make well-informed data-driven decisions while also demonstrating to stakeholders that the decision-making process is thorough and thoughtful.

3 METHODOLOGY

The methodology is the bridge between the findings in the literature review and the discrete choice experiment (DCE) as well as the development of the tool. This chapter will discuss how and what data must be collected and analyzed for the development of the tool. First, the scope of the tool will be defined by showing where the spatial decision support system (SDSS) can assist the municipality in its decision-making process. Next, the exclusion criteria from the literature will be reviewed to see which can be included in the tool to determine which retail properties can be considered for the transformation into housing. Further, the methodology will focus primarily on the collection and analysis of preferences regarding housing characteristics. A number of characteristics that are considered in residential preference research will be included in the literature. However, since no research has yet been done on inner city residential preferences, there will first be an exploration of missing characteristics that could be essential for the analysis of this special location. This will be explored by viewing inner city properties. Once there is a comprehensive list of characteristics, this chapter will describe how these characteristics will be incorporated into as criteria in the DCE. The design of the experiment will be described in detail, from preparation to the final method of analysis and data collection. The final selection of residential characteristics will be used as criteria in the next chapter's DCE (Figure 11). The DCE will result in weights for the MCDA criteria that can be used to assess the residential preference or utility of inner city properties. In the next step, these weighted criteria, as well as the exclusion criteria, are implemented in a geographical information system (GIS) to create a functional tool. To evaluate whether the tool is capable of exploring which vacant retail properties are of interest for transformation into housing, the tool will be applied in a case study in the next step. Finally, the development research is closed with a conclusion.

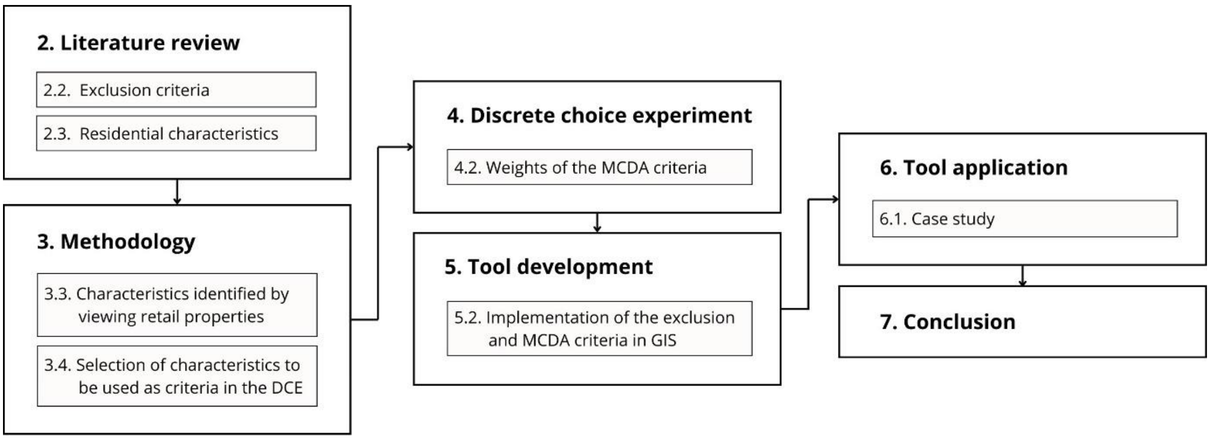

Figure 11, Tool development steps

3.1 THE SUPPORT OF THE SDSS IN THE DECISION-MAKING PROCESS OF THE MUNICIPALITY

As concluded from the previous chapter, the municipality is the stakeholder who can get the most from using the tool. The tool is a spatial decision support system (SDSS) meaning that the tool should be able to assist the municipality in its decision making process. Based on the steps presented in research by Afërd & Shaqiri (2015), the decision-making process of the municipality regarding the transformation of vacant retail properties into housing is illustrated (Figure 12). Figure 12 shows that the SDSS developed in this research will support the municipality with the identification and analysis of the alternatives. In this process, the alternatives are the (vacant) retail properties that can be considered for transformation into housing. The SDSS will support the municipality in identifying these retail properties based on several exclusion criteria. Besides that, the SDSS will help in analyzing which vacant retail properties are of interest to live in. The municipality can use the properties' residential utility as reference to find transformation opportunities in the inner city. Combined with building-specific feasibility studies, retail properties suitable for transformation into housing can be identified and action can be taken.

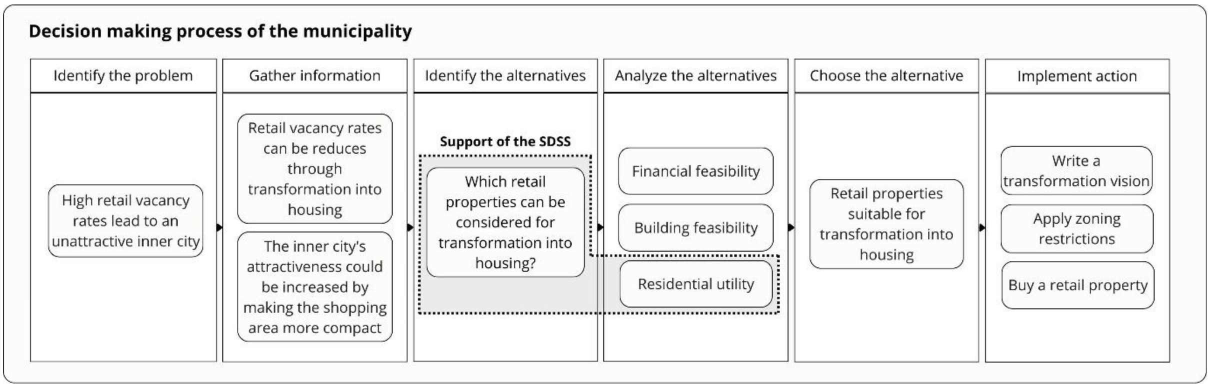

Figure 12, The support of the SDSS in the decision-making process of the municipality

3.2 PROPERTY SUITABILTY

3.2.1 Assessable exclusion criteria

In the literature review, several exclusion criteria have been identified. Based on these criteria, several retail properties can already be filtered out that are not considered for the transformation into residential space. Because these criteria ensure the exclusion of these properties, they are also referred to as exclusion criteria in this research. Table 3 shows all exclusion criteria that are going to be used in the spatial decision support system. The first exclusion criterion is related to restrictions through inner city policy. A retail property is considered unsuitable for transformation if it is on the ground floor within the boundaries of the municipality's core shopping area. This is because an inner city's attractiveness is enhanced by having a continuous retail plinth in this area. Additionally, retail properties with floor areas less than the specified threshold are eliminated, as minimum dimensions are required to transform a property into a livable house. The final criteria taken into account excludes all properties that do not have an entrance at the public street. Other exclusion criteria described in the literature review are not taken into account due to unavailable data

Table 3, Exclusion criteria

Exclusion criteria	Criterion
Restrictions through inner city policy	
Ground floor of the core shopping area	Located within the boundary
Property suitability	
Total floor area	Total floor area < 20 m²
The residential function can be reached from the public street	The property has not its own entrance at the public street

3.2.2 Excluding retail properties

The SDSS tool will be developed using a retail property database. GIS can be used to create queries or layers to include only a selection of retail properties that can be considered for the transformation into houses. Therefore, the first step is to exclude retail properties which are not suitable for transformation into housing. All properties with a total floor area below 20m² should be excluded from the database using a query. On top of that, a query should exclude all properties that do not have their own entrance from the database. Next, the decision maker should draw the boundaries of the core shopping area. These boundaries are represented in the format of a vector layer. All properties inside this vector layer that only have an entrance to the building's ground floor level should be removed from the dataset, leaving a final set of properties to which the MCDA can be applied.

3.3 Observed characteristics of inner city retail properties

In the literature review, many characteristics were identified that are taken into account in people's choice concerning residential dwellings. However, there has not yet been investigated which characteristics are taken into account when choosing to live in an inner city retail property. It might be that specific characteristics of a retail property can have a significant influence on people's choice for a certain property. Retail property characteristics that can influence people's choices are identified by viewing (vacant) retail properties in the inner city.

3.3.1 Observations

Figure 13, Retail property (Eindhoven)

Figure 14, Retail property (Den Bosch)

Figure 15, Retail property (DB)

Figure 16. Retail property (Ehv)

Figure 17, Retail properties (DB)

Figure 18, Retail property (Ehv)

Figure 19, Retail property (Ehv)

Figure 20, Retail property (DB)

Figure 21, Retail properties (DB)

Above several different types of retail properties are shown. The retail properties are shown in Figure 13 and Figure 14 are both vacant. Figure 14 shows that retail properties can contain characteristics very similar to residential property. The building has a uniform appearance, the windows are relatively small and clearly separated from the front entrance. However, in contrast, the property shown in Figure 13 contains large windows in the wide façade on the ground floor that are clearly aesthetically separated from the top part of the property. Moreover, the examples shown in the other figures further emphasize that the dimensions and aesthetics of inner city retail properties can be very diverse. For example, the ground level façade of the right property in Figure 17 is considerably higher than that of the retail property in Figure 14, while the retail property in Figure 16 is considerably wider than both properties. The dimensions of a retail property can be seen as restrictions for the future residential layout and as an indication of the property's spaciousness. Because of the different purposes retail properties serve, the properties' width is often the dimension most in contrast to most residential properties. For example, the properties shown in Figure 14, Figure 15 and Figure 17 are very small in width. It can give people a narrow experience and few layout opportunities.

Something else that stands out from viewing retail properties is the presence of an entrance in the facade to the upper floors. From this selection, the properties in Figure 14 and Figure 20 are the only ones that provide access to the upper floors from the street level. The upper floors of the other retail properties from this selection are either reached from within the retail property itself or from a street-level entrance of a neighboring property. If the upper floors can only be reached from the ground floor it is highly likely that the upper floors are part of the retail property and used as part of the shop or as storage space. This means that if the retail property appears to be vacant on the ground floor, it will also be vacant on the floor(s) above since they all belong to the same property. Therefore, it seems that there is much more space to create housing in the inner city than one might notice firsthand.

The aesthetics of the retail properties' facades differ a lot in inner cities. In Figure 21, it is well visible how the composition of different elements is able to create a variety of appearances. In specific, in the figures above can be noticed that the ground level façade can aesthetically differ or be the same as the rest of the façade. For example, the ground level façades visible in Figure 13, Figure 16, Figure 19, and Figure 21 differ from the top part of the respective building, whereas the facades visible in the other figures are uniform from the bottom to the top of the building. The uniformity of the façade could be influential on people’s residential choice. Moreover, the architectural appearances of the retail properties can differ very much between different inner cities because of their history. A façade can have either a historical or modern architectural appearance. For example, the retail property in Figure 18 looks very modern, whereas the retail property in Figure 20 looks very historical. In Figure 19 is also visible that properties can be a mixture of both, with often a modern ground level façade and a historical characteristics higher in the façade. In general, the architectural appearance of a retail property can be described by the uniformity and architectural style. Since people can prefer different appearances, these characteristics are likely to influence people’s residential choices.

3.3.2 Observed characteristics

By viewing inner city (vacant) retail properties some additional characteristics can be identified that could influence people’s residential choices (Table 4). It was concluded that especially the width of the property’s façade can be an important dimension to take into account in residential preference research because of spaciousness and layout opportunities. Aside from that, it was noticed that there is not only space to live on the ground floor level but also on the floors above it. Research Box (2003), confirms that there are several opportunities to make housing on the upper floors possible. Because of privacy and crowdedness, living on an upper floor in a busy inner city might provide a different experience than living on the first floor. Therefore, it is interesting to find out on what floor level people prefer to live. Lastly, the architectural appearance of retail properties can be very different. Facades can be modern, historical, or a mixture of both. People will most likely have different preferences for certain aesthetics. However, it is interesting to investigate how much the influence of the architectural appearance is on people’s willingness to live in former retail properties in inner city areas.

Table 4, Observed retail property characteristics that could influence residential choice

Building characteristic	**Explanation**
Façade width	The façade width limits residential layout possibilities.
Floor level	Having a house on the 1st floor can generate a different living experience than having a house on the street level in a busy area like the inner city.
Historical appearance	People can have different preferences for certain historical expressions.

3.4 RESIDENTIAL PREFERENCE ANALYSIS

The residential preferences are analyzed using a Discrete Choice Experiment (DCE). This paragraph first explains the theories behind the method. Following that, the final selection of attributes will be discussed, as well as the decision for levels associated with the attributes. Then, there is a description of how these attributes were included in the experiment, and how they will be analyzed. At the end of this paragraph, there will be a brief explanation of how the data were collected.

3.4.1 Discrete choice experiment

3.4.1.1 Random utility theory

DCE is a quantitative research methodology that evaluates a set of attributes that affect people's decision-making and determines their relative importance (Shang et al., 2023). DCE is theoretically based on two different concepts. DCE builds upon the fact that rather than the products themselves, decision-makers prefer to derive the utility in the underlying attributes of products (Lancaster, 1966). Secondly, DCE is based on the random utility theory (McFadden, 1974). This theory demonstrates that decision-makers are rational and aim to maximize utility considering all of the available options. In other words, decision-makers will most often choose the option that suits them the best. The decision-makers in this DCE are the individuals who have to choose which property they prefer based on certain property characteristics. The retail property characteristics are the underlying attributes of a property that together determine how much utility (satisfaction) an individual derives from that property. The individual's utility U for a property is expressed by the following equation:

$$U_{ij} = V_{ij} + \varepsilon_{ij} \quad (1)$$

In this equation, i refers to the individual making the choice and j to the alternatives (properties) that can be chosen. The utility is the sum of an explainable component V_{ij} and a non-explainable component ε_{ij} (Mazzanti, 2003). The ε_{ij} component consists of all unidentified variables that influence individual decisions, such as unobservable characteristics, specification- and measurement errors. V_{ij} is the deterministic element of utility and is expressed in equation 2 below. V_{ij} is determined by the property's attributes and levels (X_{nij}) and the corresponding weight (β_n) per unit X.

$$V_{ij} = \sum\nolimits_{n} \beta_n X_{nij} \quad (2)$$

Taking into account both the explainable component V_{ij} and non-explainable component ε_{ij}, the utility can be explained by the following equation:

$$U_{ij} = \sum\nolimits_{n} \beta_n X_{nij} + \varepsilon_{ij} \quad (3)$$

X_{nij} indicates which attribute levels the property possesses. Attribute levels refer to the values assigned to attributes (Shang et al., 2023). To illustrate, an attribute of a property can be energy efficiency. The corresponding attribute levels can then for example be different energy labels. β_n is a parameter estimate and indicates with what value this attribute level contributes to the total utility of a property. For example, if individuals prefer to have a property on the first floor over a property on the ground floor, then properties on the first floor will generate a higher utility then properties on the ground floor. However, a property consists of multiple attributes, which makes the choice task more difficult. In the DCE, individuals have to make trade-offs between different attributes when choosing between properties. Based on the choices individuals make, an estimation can be done which attributes are considered as most important.

3.4.1.2 Attributes and levels

Through literature and viewing of building and location characteristics of inner city retail properties, a selection of attributes has been made that will be implemented in the DCE (Table 5). By reasoning and reviewing existing residential preference studies, the discovered characteristics are converted into measurable attributes, which are expressed by their corresponding levels. This paragraph will further elaborate on the choice of specific attributes and their corresponding levels.

The attributes are divided into location- and building attributes. The first two location attributes concern the distance to a transportation mode. A distinction is made between public transport (PT) and car. The distance to the nearest station, stop or parking space is expressed in walking distance. To put walking distance in perspective, Oostenbrink & Lankhorst (2021) have investigated acceptable walking distances in the Netherlands. They emphasize that persons with different conditions accept varying walking distances and that those in densely populated areas accept shorter walking distances than other pedestrians. According to their research, people find 200-500 meters an acceptable walking distance to the nearest bus stop and only 100-200 meters an acceptable walking distance to their parked car. These walking distances can be used as indicators for establishing the appropriate walking distance levels. However, the scale will be a bit different in the inner city because inner cities are densely populated areas with an often high density of public transportation modes. Besides that, inner cities, in contrast to the outskirts of the city, can have greater walking distances to the nearest (private) parking space due to high building density and limited space.

Additionally, the literature showed that people prefer to live close to a public park. The attraction of a park is not only dependent on the travel distance but also the park size (Giles-corti et al., 2005). However, according to research by Bertram et al. (2017), the target groups for inner city housing identified in 2.3.3 prefer closer parks while the park size matters less. In this research, the park is described as a green space with a minimum area of 5000m^2. These green spaces can stimulate people to perform recreational activities. The distance to a public green space is again expressed in walking distance and based on existing research (Bertram et al., 2017; Shen et al., 2017).

A characteristic specifically related to the inner city is the crowdedness of the street. The crowdedness of the street can cause noise pollution or a lack of privacy for the residents. The crowdedness can be expressed in terms of passerby flows. The measurement of the number of people passing a retail location on a given day can indicate the level of attractiveness of that location. It can be expressed as the number of passerby or as a percentage relative to the busiest point in the respective inner city. With the latter, a division is made in the following segments: A1 (75-100%), A2 (50- 75%), B1 (25- 50%), B2 (10- 25%) and C (5- 10%) (Bolt, 2003). These segments of Bolt (2003) can give the respondent's perspective on how the street is situated in an inner city. However, respondents might not be able to put these percentages in perspective in terms of the crowdedness of a street. Therefore, the B1, B2, and C segments are respectively defined as streets with a high, medium, or low passerby flow. These crowdedness levels need to be explained by examples to ensure respondents understand what they mean. This research will not include A-locations, because it is most likely that these will be situated in the core shopping area.

By viewing inner city retail properties, it was concluded that there are three building characteristics that could influence residential choice. First, retail properties can have a historical, a modern, or a ‘50% historical façade’. The latter level is implemented since the ground floor façade can differ from the façade of the upper floors. Second, it was seen that the upper floors in the inner city could also be part of the vacant retail properties. These upper floors can also be used as residential space and therefore three different floor levels are distinguished in this research. Third, inner city retail property facades can differ quite a lot in width, which could influence future users’ living experience. This research distinguishes three levels of property width ranging from 5 to 10 meters. Due to the limited space in the inner city, most retail properties’ facades fluctuate between these dimensions.

Literature also showed that people prefer different residential floor areas. It is decided to base the floor areas on different housing types. The housing types most eligible to be placed in an inner city retail property are a studio, a one-bedroom apartment, and a two-bedroom apartment. Considering the average dimensions of these housing types, the average living space of Dutch people (CBS, 2017) and floor areas in rental reports (Van Gils, 2024), the levels of floor area are defined as follows: 40m^2, 60m^2 and 80m^2.

Lastly, in the DCE, the price for the property is expressed in euros rent per month. The price is expressed in rental prices instead of buying prices because it is highly likely that the current owner keeps exploiting the property to ensure constant revenues. As a result, these inner city properties will not fall in the social rental sector. Therefore, the levels for rent price are based upon prices in the middle and free rental sector (Rijksoverheid, 2024).

Table 5, List of attributes and their level for the DCE

Attribute	Attribute levels
Location	
Walking distance to nearest public transport stop	250m 500m 750m
Walking distance to the nearest parking place	100m 300m 500m
Walking distance to nearest park (>5000m2)	300m 800m 1300m
Crowdedness of the street	Low Medium High
Building	
Historical façade (architectural appearance)[1]	0% 50% 100%
Floor level of the new house	Ground First Second
Width of the façade	5.0m 7.5m 10.0m
Total floor area	$40m^2$ $60m^2$ $80m^2$
Rent price per month	€900 €1100 €1300

[1] E.g. 50% historical façade means that the other 50% is a 'modern' façade.

3.4.1.3 Experimental design

Each alternative proposed in a choice task consists of multiple attributes to describe the alternative. However, the number of attributes should not be too large because then respondents may lose overview and the choice task becomes too complicated and less justified. This research aims to include 9 different attributes containing 3 levels each. This results in 19,683 (3^9) possible alternatives. An experimental design in which all possible alternatives are incorporated is called a full factorial design (Hensher et al., 2015). However, it is nearly impossible to investigate all these possible alternatives in an experiment. To reduce the cognitive burden on respondents, a fractional factorial design can be created. In a fractional factorial design only a fraction of the total number of alternatives is used (Hensher et al., 2015).

To create the smallest efficient fractional factorial orthogonal design, one needs to decide how many effects are taken into account. The effects can either be main effects or interaction effects. The main effects can be defined as the direct independent influence an attribute has on the respondent's choice. Whereas an interaction effect is an influence on a respondent's choice that results from the combination of two or more attributes that would not have been detected if the attributes had been estimated independently of one another (Hensher et al., 2015). In this research, it is assumed that the attributes in Table 5 do not have interaction effects with each other. Therefore, this research will proceed with an orthogonal main effects-only design. The smallest orthogonal main effects-only design including 27 alternatives is generated with SPSS software (Table 6). To clarify that all attributes in the design are statistically independent from each other, a correlation matrix is added in Appendix A.

Table 6, Experimental design: fractional factorial design with nine attributes containing three levels

Alternative (property)	A1	A2	A3	A4	A5	A6	A7	A8	A9
1	0	0	2	1	1	0	1	0	2
2	2	1	2	0	0	1	1	0	0
3	1	1	2	1	0	0	2	1	1
4	1	1	1	2	1	0	0	1	0
5	2	0	1	0	2	2	0	1	2
6	1	2	1	0	0	2	2	0	0
7	0	2	1	1	0	1	0	1	1
8	1	0	1	1	2	1	1	2	0
9	2	1	1	1	1	1	2	0	2
10	2	2	2	1	2	0	0	2	0
11	1	0	0	2	0	1	2	2	2
12	0	1	0	1	2	2	2	2	0
13	0	2	0	2	1	1	1	1	0
14	2	2	0	0	1	0	2	2	1
15	0	0	1	2	2	0	2	0	1
16	1	0	2	0	1	1	0	2	1
17	0	1	2	2	0	2	0	2	2
18	0	0	0	0	0	0	0	0	0
19	2	0	0	1	0	2	1	1	1
20	0	2	2	0	2	1	2	1	2
21	2	1	0	2	2	1	0	0	1
22	1	2	0	1	1	2	0	0	2
23	0	1	1	0	1	2	1	2	1
24	2	2	1	2	0	0	1	2	2
25	1	2	2	2	2	2	1	0	1
26	2	0	2	2	1	2	2	1	0
27	1	1	0	0	2	0	1	1	2

The coding above in Table 6 needs to be translated into interpretable alternatives to create a hypothetical choice situation. This code is fixed for the experiment, but the translation of the code can be customized. It can still be determined which attribute levels are assigned to code 0, 1, or 2. When assigning codes, it should be taken into account that alternatives can become dominant or unrealistic. Considering the attribute levels in Table 7, there does not seem to be a combination that could create an unrealistic alternative (property). However, an alternative may be dominant, which indicates that the respondent is very likely to choose the alternative or not based on a particular combination of attribute levels. The dominance is tested by assigning a score to every attribute level. The positive levels score a 2, the middle levels a 1 and the negative levels a 0. For example, €900 rent per month will score a 2 while €1300 will score a 0. The total dominance score ranges from 0 to 18, where 0 is the most negative scoring alternative and 18 is the most positive scoring alternative. Table 7 shows which attribute levels are assigned to the design code in Table 6. The interpretable alternatives including the dominance scores are shown in Appendix B. It has been observed that only 2 of the 27 alternatives may be considered dominant. Switching the code of the attribute levels and the columns of the attributes, has been attempted to mitigate dominant alternatives. However, several attempts showed that new dominant alternatives emerged as soon as columns or codes shifted. Therefore, it is decided to keep the alternative list as presented in Appendix B.

Table 7, Translation of the design code through attribute levels

Column	Attribute	Attribute levels		
	Location	**0**	**1**	**2**
A1	Walking distance to nearest public transport stop	250m	500m	750m
A2	Walking distance to nearest parking place	100m	300m	500m
A3	Walking distance to nearest park (>5000m2)	300m	800m	1300m
A4	Crowdedness of the street	Low	Medium	High
	Building			
A5	Historical façade	0%	50%	100%
A6	Floor level of the new house	Ground	First	Second
A7	Width of the façade	5.0m	7.5m	10m
A8	Total floor area	$40m^2$	$60m^2$	$80m^2$
A9	Rent price per month	€900	€1100	€1300

The alternatives listed in Appendix B will be used in the choice tasks of the discrete choice experiment. This research will present the choice experiment in an online survey. Each choice task consists of 2 randomly selected alternatives and a 'neither' answer option. To prevent order bias, the alternatives are randomly assigned twice, resulting in a total of 54 (2x27) different choice tasks (Appendix C). The choice tasks are divided into six blocks of nine (e.g. choice tasks 1-9, choice tasks 10-18, …). Each respondent must complete at least one block of nine choice tasks, but has also the option to complete an additional block of nine choice tasks. Each respondent is randomly assigned a block, and the mandatory and additional blocks are always different from each other. On top of that, the choice tasks within a block are displayed in a random order to further prevent order bias.

3.4.1.4 Analysis method for DCE data

Multinominal Logit Model

A common method to analyze DCE data is to make use of logit-based regression models. In specific, McFadden's multinomial logit (MNL) model (McFadden, 1986). The MNL model is based upon the random utility theory (see Paragraph 3.4.1.1). When presented with a set, the model estimates the probability P that an individual will choose an alternative j:

$$P_{ij} = \frac{e^{V_{ij}}}{\sum_{i'} e^{V_{i'j}}} \quad (4)$$

In this equation, the $V's$ represent the deterministic utilities that summarize the desirability of the alternatives. The strict utilities are determined through equation 2. In this equation, MNL is able to estimate the weights or parameters β, as the attributes and levels X are already known. These corresponding weights can then be used in the equation to calculate which vacant retail properties generate the highest utility, and are most promising to be transformed into a house based on their attributes.

The performance of the model can be tested using the likelihood ratio index, also known as McFadden's pseudo R^2, often used with discrete choice models (Hauber et al., 2016; Train, 2002). The statistic measures the performance of the model with its estimated parameters ($LL(\beta)$) to that of a model with all parameters equal to 0 ($L(0)$), which is typically the same as having no model at all. The log-likelihood index measures the goodness of fit, and is defined as follows:

$$\rho^2 = 1 - \frac{LL(\beta)}{LL(0)} \quad (5)$$

If the estimated model $LL(\beta)$ is similar to having no model at all ($LL(0)$), then ρ^2 equals 0, which is the lowest value ρ^2 can take. It indicates that the model does not give new insights at all. On the other hand, if the model can predict the choices of the decision-maker perfectly, then ρ^2 equals 1. The composition of equation 5 indicates that the model always improves when adding an additional variable. However, this is not necessarily the case. To eliminate this effect, an adjusted version is also available. The equation of the adjusted ρ^2 is shown below (Long & Freese, 2001). In this equation K is the number of parameters.

$$adjusted\ \rho^2 = 1 - \frac{LL(\beta) - K}{LL(0)} \quad (6)$$

Willingness to pay

Stakeholders in the inner city may be interested in learning about not only the utility but also the financial aspects of a retail property, which is something discrete choice models can also help with. Discrete choice models can be used to develop indicators to estimate how much money people would be willing to invest in order to gain some benefit from a certain object or activity. These measures are referred to as willingness to pay (WTP) (Hensher et al., 2005). WTP indicators are calculated as the ratio of two parameter estimates while keeping everything else constant. If at least one attribute is measured in monetary units, the ratio of the two parameters will yield a financial indication of WTP. In residential preference research of Jiang & Chen (2016), the WTP for individual 'i' and attribute 'n' is calculated using the corresponding attribute coefficient (β_{in}) and the price coefficient (β_p):

$$WTP_{in} = \frac{\beta_{in}}{\beta_p} \quad (7)$$

Additionally, according to Hensher et al. (2005), It is important that both of the attributes considered in the equation are statistically significant in order to generate a meaningful estimate of WTP. As a result, it is essential that the price coefficient turns out to be significant for this calculation to have an added value.

3.4.2 Data collection

The discrete choice experiment is implemented in an online survey to gather the data. The survey is created using LimeSurvey software. An example of the survey is shows in Appendix D. The survey includes introduction questions to get the respondent ready for the choice questions and to get an idea of what the respondent's current living situation is. Following the experiment's instructions, the real choice tasks are displayed as seen in Figure 22. Each respondent has to make one block of nine choice tasks at minimum. However, after filling in personally related information, the respondents have the opportunity to make another block of nine choice tasks voluntarily.


* Welk binnenstedelijk pand heeft uw voorkeur?

		Pand A	Pand B	Geen van beide
Locatie	Openbaar vervoer halte	250m	250m	-
	(Prive) parkeerplek	100m	300m	
	Park (>5000m2)	1300m	1300m	
	Drukte op straat	Gemiddeld	Hoog	
Gebouw	Historische gevel	50%	0%	
	Verdieping	Begane	Tweede	
	Gevelbreedte	7,5m	5,0m	
	Totaal vloeroppervlakte	40m2	80m2	
	Huurprijs per maand	€1300	€1300	

Kies één van de volgende antwoorden

Pand A | Pand B | Geen van beide

Figure 22, Preview of a choice question

It has been decided to not focus on specific target groups when distributing the survey. The only criterion is that the respondent must be able to rent a house, which means that the person should be over 18 years old. The survey is distributed in the period of May to mid-June. First, the survey was sent to my direct network (family, friends, colleagues) and my social network (LinkedIn, Instagram, and Facebook). Aside from that, flyers including QR-code are hung in certain places such as around coffee corners. Finally, survey exchange platforms were used (Appendix E).

3.5 CONCLUSION

This chapter has shown that the tool can be used by the municipality to identify and analyze opportunities to transform retail properties to housing. Identification of properties that can be considered for transformation is done by testing a property for minimum floor area, whether the property has a private entrance, and whether the property is not on the first floor of the core shopping area. These requirements will be included in the tool through queries and area markings in a layer. Once these criteria are checked, the properties can be assessed by a utility calculation. The utility calculation is the MCDA part of the tool. To obtain an appropriate utility formula, this study uses a discrete choice experiment (DCE), which relies on the random utility theory. In the DCE, a total of nine different attributes are evaluated. This evaluation is done by distributing the DCE through an online survey. The results will then be analyzed by means of a Multinomial Logit Model, which will yield various weights that can be used of evaluating residential utility of inner city retail properties.

4 DISCRETE CHOICE EXPERIMENT

This chapter will show and discuss the findings of the discrete choice experiment (DCE). First, an overview of the demographics and current living situations of the experiment's participants is presented. Next, a brief explanation is given of how the choice data from the survey is converted into a format that can be used in multinomial logit (MNL) analysis. At first, the MNL analysis will be done using the data of the full sample. Subsequently, the MNL analysis will also be done for the target group students and reference group employees/employers. These three MNL analyses result in different attribute level weights. The DCE weights of the full sample are used at the end of this chapter to determine the willingness to pay (WTP) for each residential attribute. Additionally, the MNL weights can be used as weights for the MCDA criteria to develop the tool in the next chapter.

4.1 THE SAMPLE

The survey with the discrete choice experiment was online for over a month around May 2024. During this period 146 respondents started the survey, but only 106 respondents made the full survey. Within this group of 106 respondents, three respondents are excluded from the analysis. This group of three included a person below 18 years old and two persons for whom there were clear indications that the survey was not conscientiously filled in. This results in a total of 103 respondents taken into account in the analysis.

4.1.1 Demographics

After the discrete choice experiment, the respondents filled in questions about their personal characteristics. The demographic data resulting from these questions is summarized in Table 8. This table shows the distribution of the gender, age, household composition, household income, and work situation of both the respondents sample and the Dutch population over the age of 18. Demographic statistics of the Dutch population are added to see if the respondent's sample represents the Dutch population.

Table 8 shows that the gender distribution is almost equally divided within the sample. This distribution corresponds almost exactly with the gender distribution of the Dutch population over the age of 18 (CBS, 2024). In contrast, the age distribution between 18 and 60 years old deviates quite a lot from the age distribution in the Netherlands (CBS, 2024). In the sample there is a significant larger number of people between 18 and 30 years old in comparison to the Dutch population. This is further underlined by the fact that 46.6% of respondents are students. This age distribution within the sample is highly likely the result of using a personal network in distributing the survey. Nevertheless, according to Boissevain (2020) the students and starters between the ages of 18 and 30 years are considered target groups of inner city housing, which can be of interest in discussing the results of the experiment.

There are no exact statistics available for Dutch people over the age of 18 living in households. There are some statistics for the total population, but the distribution will differ significantly because most persons under the age of 18 still live with their parents. Nevertheless, in this sample, most respondents live together without child(ren) or as a one-person household. Only one out of ten respondents live with their child(ren), indicating that the average household size in this sample is small. Smaller households require less space (Welsh et al., 2014). The issue of limited space in the inner city should therefore probably not be the primary concern for this sample.

The household income distribution of the sample remarkably quite resembles the household income distribution of the Dutch population (CBS, 2022). Only the first 2 income categories differ from the national distribution while the age categories and student-to-worker ratio do not necessarily represent the distributions in the Dutch society. The rent prices per month stated in the experiments are based on prices in the middle and free rental sector (Rijksoverheid, 2024). Taking into account this income distribution, the price of a property is likely to have an influence on choice.

Table 8, Demographics of the sample

Characteristic	Value	Respondents sample (N=103)	Dutch population (above 18 years old)
Gender	Man	49.5%	49.7%
	Woman	50.5%	50.3%
Age	18-24 years	45.6%	16.1%
	25-30 years	31.1%	14.1%
	31-60 years	23.3%	69.8%
Household composition	One person household	35.0%	-
	Living together without child(ren)	40.8%	-
	Living together with child(ren)	10.7%	-
	Living at my parent(s)	6.8%	-
	Student house	3.9%	-
	Not specified	1.9%	-
Household income	Less than €20,000	27.2%	11.7%
	€20,000 till €40,000	10.7%	36.1%
	€40,000 till €60,000	24.3%	22.5%
	€60,000 till €80,000	13.6%	15.5%
	More than €80,000	14.6%	14.3%
	Not specified	9.7%	-
Work situation	Student	46.6%	-
	Employee/employer	53.4%	-

4.1.2 Current living situation

In his research into residential preferences, Boumeester (2011) addresses that residential preferences only become meaningful when they can be compared to the household's housing situation in terms of dwelling and environment. This research is mainly focused on the current contrast to the inner city environment, as well as the current method of transportation. Table 9 shows the respondents' present living environments and orientation within those environments. According to the statistics, the majority of respondents live in a big city, with one in every five already being familiar with the inner city living environment based on the orientation relative to the city center. It is probable that people who live in or near an inner city perceive crowdedness, space, or walking distance differently from those who do not.

Table 10 reveals which transportation modes people currently possess and which are most often used to work or school and leisure time. Existing transportation patterns can have an influence on the willingness to live in inner cities. People with a car might be more interested in having a parking space nearby, while people who frequently use public transport might be more concerned with the distance to the nearest stops. According to the statistics, the transportation mode most frequently used for work or school is quite equally divided between (E-)bike, public transport, and car. This indicates that it is likely that both the distance to the parking place, as well as the distance to a public transport stop are taken into account in respondents' residential choice.

Table 9, Current living situation of the sample

Characteristic	Value	Respondents sample
Living environment	Big city (>100,000 inhabitants)	61.1%
	Medium-sized city (30.000-100.000 inhabitants)	6.8%
	Small city/village (<30.000 inhabitants)	20.4%
	Area outside of the city/village	9.7%
Orientation relative to the city center	0 or 0.5 km from the city center	20.4%
	1.0 or 2.0 km from the city center	34.0%
	3.0 km or more from the city center	15.5%
	Not applicable	30.1%

Table 10, Current transportation behavior of the sample

Characteristic	Value	Respondents sample
Transportation mode possession[1]	(E-)Bike	89.3%
	Scooter/Moped/Motorcycle	8.7%
	Public transport card	62.1%
	Car	61.2%
Transportation mode use to work/school	Walking	2.9%
	(E-)Bike	35.0%
	Public transport	27.1%
	Car	35.0%
Transportation mode use in leisure time	Walking	9.7%
	(E-)Bike	53.4%
	Public transport	6.8%
	Car	30.1%

[1] Multiple options possible

4.2 DATA ANALYSIS

4.2.1 Data preparation

The data from the discrete choice experiment will be analyzed using a multinomial logit model (MNL). However, the choice data coming from the survey cannot be analyzed directly. The data will be analyzed in R. R requires the data to be in a specific format in order to do the analysis and measure the non-linear effects of the attribute levels. According to Hensher et al. (2015), there are two ways to recode the choice data: effect coding and dummy coding. Research of Hu et al. (2022) states that the choice for either one of the methods is based almost solely on the preferences of the researcher. However, they add to this that dummy coding is more straightforward to interpret and less prone to mistakes compared to effect coding. Therefore, there is chosen in this research to recode the data using dummy coding.

Table 11, Example dummy coding rent price

Rent price per month	Dummy 1	Dummy 2
€900	1	0
€1100	0	1
€1300	0	0

An example of dummy coding is shown in Table 11. The attribute levels of 'rent price per month' are recoded using 1's and 0's. In Equation 2, Dummy 1 is now replacing X_{1ij} and Dummy 2 is now replacing X_{2ij}. For example, if a property is assessed solely on the rent price per month, the utility equation for a rent price per month of €900 can be denoted as:

$$V_{ij} = \beta_{1i} * 1 + \beta_{2i} * 0 = \beta_{1i}$$

In this equation β_{1i} represents the coefficient expressing the relative preference for a rent price of €900 per month compared to the reference level, in this experiment the last level. As visible in Table 11, at the reference level, both dummies are set at 0, resulting in a utility of 0 for the third reference level. When a level's coefficient is negative, it indicates that the level is less preferred than the reference level, whereas a positive coefficient indicates that the level is more preferred than the reference level.

4.2.2 Multinomial logit model

The recoded discrete choice data is analyzed using the multinomial logit model (MNL) in R. The results of the MNL model are shown in Table 12. One relevant output of the MNL model is the Log-likelihood of the full model. The log-likelihood can be used to determine the performance of the model and is used in the calculations below.

$$\rho^2 = 1 - \frac{LL(\beta)}{LL(0)} = 1 - \frac{-1275.2}{-1696.3} \approx 0.248$$

$$adjusted\ \rho^2 = 1 - \frac{LL(\beta)}{LL(0)} = 1 - \frac{-1275.2 - 18}{-1696.3} \approx 0.238$$

The $LL(0)$ is calculated taking into account that there were three answer options and 1530 observations. Both ρ^2 and $adjusted\ \rho^2$ have a value between 0.2 and 0.4, which indicates a good model fit according to McFadden (1977). It indicates that the model is effective in explaining the choice behavior of people in the sample.

Table 12 displays various MNL statistics at each attribute level, including the coefficient, standard error, probability, and significance. The coefficient is the parameter estimate and indicates how much the attribute level is preferred compared to the reference level. The standard error represents the variability of this estimate. Dividing the estimate by the standard error gives the statistical significance of the parameter estimate compared to the reference category. The statistical significance is described through probability (P-value) and significance (α). Assuming a 95% confidence interval, attribute levels with α <0.05 have significant effect on the choice probability of the respondents.

Table 12, MNL model estimation

Attribute	Level	Coefficient	Standard Error	P-value	α[1]
Constant		-1.137	0.195	5.193×10^{-9}	***
Walking distance to public transport stop	250m	0.290	0.109	0.008	**
	500m	0.157	0.120	0.189	
	750m	0	-	-	
Walking distance to parking place	100m	0.368	0.103	3.729×10^{-4}	***
	300m	0.195	0.102	0.057	.
	500m	0	-	-	
Walking distance to nearest park	300m	0.357	0.099	3.316×10^{-4}	***
	800m	0.207	0.109	0.0584	.
	1300m	0	-	-	
Crowdedness of the street	Low	0.463	0.088	1.259×10^{-7}	***
	Medium	0.434	0.100	1.450×10^{-5}	***
	High	0	-		
Historical façade	0%	-0.089	0.112	0.431	
	50%	-0.068	0.101	0.501	
	100%	0	-	-	
Floor level of the new house	Ground	-0.605	0.108	1.849×10^{-8}	***
	First	-0.379	0.108	4.256×10^{-4}	***
	Second	0	-		
Width of the façade	5.0m	-0.199	0.105	0.059	.
	7.5m	0.191	0.113	0.092	.
	10m	0	-	-	
Total floor area	40m²	-1.559	0.120	$<2.2 \times 10^{-16}$	***
	60m²	-0.514	0.117	1.146×10^{-5}	***
	80m²	0	-	-	
Rent price per month	€900	1.263	0.121	$<2.2 \times 10^{-16}$	***
	€1100	0.573	0.107	9.419×10^{-8}	***
	€1300	0	-	-	

[1] Significance codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' '

The first parameter estimate is the constant. The constant is highly significant and has a negative coefficient of -1.137. In the analysis design the constant is representing the effect of the 'neither' choice option. A negative constant thus means that respondents generally choose either one of the presented properties instead of the 'neither option'.

The next two attributes are all related to the accessibility of the property. The coefficients of walking distance to public transport stops and parking places show similar patterns. As expected, a smaller walking distance to these places results in a higher utility (Ellison & Sayce, 2007). However, the effect is only significant for the smallest distances compared to the largest walking distances. The 250m difference between 500m and 750m will not likely be the deciding factor in the respondent's residential choice.

The coefficients of the walking distance to the nearest public park are almost identical compared to the coefficients of walking distance to the nearest parking place. Even though the interval between the levels in walking distance is larger, only the effect of the smallest walking distance of 300m is significant compared to a distance of 1300m.

Respondents show a significant preference for low and medium crowdedness in the street compared to high crowdedness. Moreover, the coefficients of 'low' and 'medium' are very similar, indicating that the utility does not increase much when going from a medium crowdedness street to a low crowdedness street. Respondents appear to be most concerned about living in overcrowded streets, which is consistent with Jang and Kang's (2015) findings.

The historical appearance of the façade as well as the width of the façade both do not have a significant effect on the respondents' choice.

Both coefficients for 'floor level of the new house' are statistically significant. According to data, respondents in the inner city are not inclined to live on the ground floor. According to the MNL model, living on the ground floor generates lower utility than living on the first or second floor. This statistic is consistent with the observations made during the observation phase, in which living on the ground floor in the inner city was associated with adverse aspects such as reduced privacy and the nuisance of congested streets. Furthermore, respondents prefer living on the second floor rather than the first floor.

In this experiment, the attribute with the largest significant effect on residential choice in the inner city is the utility of $40m^2$ compared to $80m^2$. If all other attributes are equal, the property of $40m^2$ generates 1.559 less utility than a property of $80m^2$. Besides that, there is also already a significant difference between $80m^2$ and $60m^2$. The respondents generally really care about the space they will get. Morancho (2003) and Selim (2008) suggested that there is also a correlation between floor area and price. Although it is possible that respondents make decisions purely on the square meter price ratio, this cannot be validated using this approach.

Similar to the findings of Molina et al. (2021) and Źróbek et al. (2015), in the MNL model price has a negative correlation with utility. Both attribute levels are statistically significant, indicating that utility declines as price increases. The results reveal that the a rent price per month of €900 generates a much higher utility than a rent price of €1300 per month.

4.2.3 MNL target group comparison

In the DCE, respondents had the option to indicate if they were either a student or an employer/employer. 48 respondents identified themselves as students, while 55 identified themselves as employees or employers. According to Boissevain (2020) and Geraedts & Van der Voordt (2007), students are one of the target groups for inner city housing. Therefore, the emphasis will be on the results of the students. The results of the employees or employers are also discussed but mainly used as a reference. For both groups, a new multinomial logit model is created. Table 13 shows the coefficients and corresponding significance levels of both models next to the full model.

There are some notable differences between the various groups of respondents. At first, it is notable that the models have different R-squared (ρ^2) values. The R-Squared and R-Squared adjusted values of the student model are both considerably higher than the full model, while the employee/employer model has a lower values. According to these R-Squared values, the student's MNL model best fits the data.

Table 13, MNL Estimates of the full, student, and employee/employer model.

Model		**Full (N=103)**		**Students (N=48)**		**Employee/Employer (N=55)**	
Attribute	*Level*	*Coefficient*	*α*[1]	*Coefficient*	*α*[1]	*Coefficient*	*α*[1]
Constant		-1.137	***	-2.025	***	-0.614	*
Walking distance to public transport stop	250m	0.290	**	0.430	*	0.267	.
	500m	0.157		-0.081		0.327	*
	750m	0		0		0	
Walking distance to parking place	100m	0.368	***	0.452	**	0.364	
	300m	0.195	.	0.298	.	0.180	
	500m	0		0		0	
Walking distance to nearest park	300m	0.357	***	0.750	***	0.112	
	800m	0.207	.	0.402	*	0.093	
	1300m	0		0		0	
Crowdedness of the street	Low	0.463	***	0.452	***	0.567	***
	Medium	0.434	***	0.330	*	0.602	***
	High	0		0		0	
Historical façade	0%	-0.089		-0.071		-0.054	
	50%	-0.068		-0.267	.	0.134	
	100%	0		0		0	
Floor level of the new house	Ground	-0.605	***	-0.706	***	-0.601	***
	First	-0.379	***	-0.407	*	-0.392	***
	Second	0		0		0	
Width of the façade	5.0m	-0.199	.	-0.512	**	-0.006	
	7.5m	0.191	.	-0.012		0.331	*
	10m	0		0		0	
Total floor area	$40m^2$	-1.559	***	-1.407	***	-1.785	***
	$60m^2$	-0.514	***	-0.435	*	-0.616	***
	$80m^2$	0		0		0	
Rent price per month	€900	1.263	***	1.515	***	1.129	***
	€1100	0.573	***	0.750	***	0.453	**
	€1300	0		0		0	
R-Squared (ρ^2)		0.248		0.371		0.213	
R-Squared adjusted		0.238		0.347		0.193	

[1] Significance codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' '

Second, the constant coefficient indicates that students generally have a stronger preference to live in the inner city compared to the full sample. Additionally, the distance to the nearest park significantly influences students' residential choices. This distance is not very much considered by the employees and employers in the sample. Besides that, it seems that students did focus more on accessibility features in their choice in comparison to the other respondents.

The coefficients of crowdedness of the street indicate that employees and employers have a significant lower preference to live in a busy street than students. Employees and employers are thus more likely to avoid more crowded streets than students. Nevertheless, although both groups do not prefer to live on the ground floor, employees and employers seem to be slightly less concerned about living on street level.

Remarkably do the student and employees and employers models contain significant values for the width of the façade. The statistics of the student model show that they especially do not prefer to live in a property with a small width. Whereas the employees/employers do find 7.5m to be the most preferred measure for the width of the façade.

As observed in the full model, the total floor area and the rent price per month are the attributes with the most influence on the residential choice. However, students are more concerned about the price, and employees and employers are more concerned about the total floor area. This seems logical given that employees' and employers' incomes are likely to be larger, as is their requirement for space because they are more likely to live with a family.

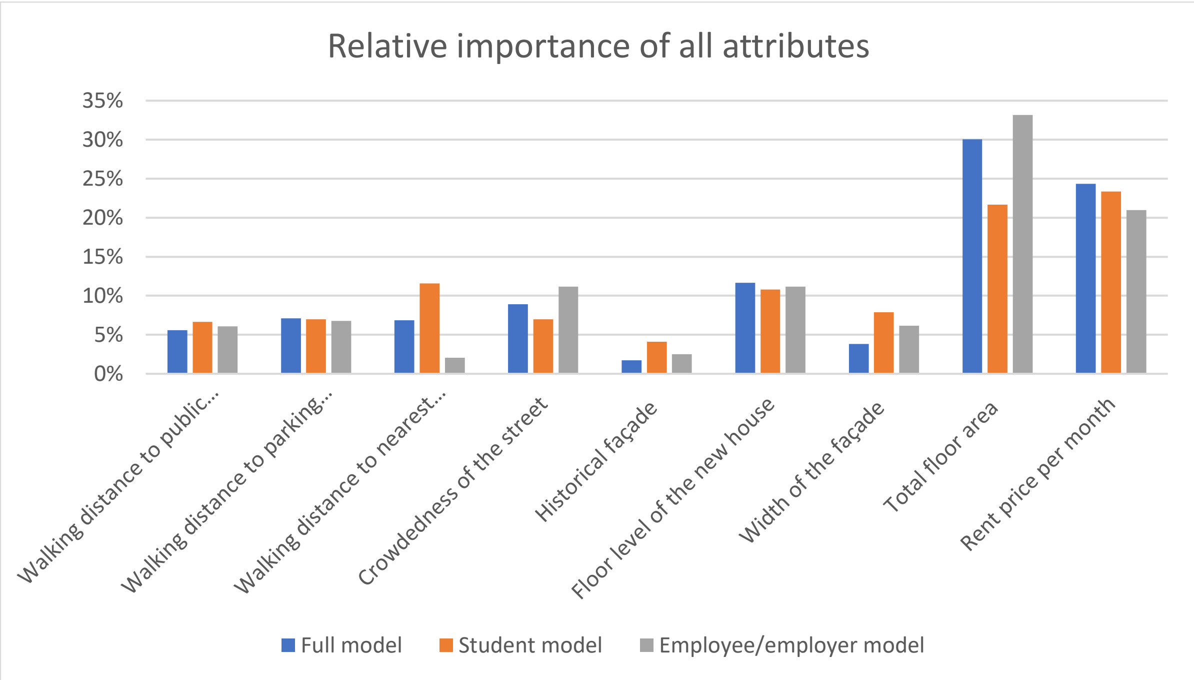

Figure 23, Relative importance of all the attributes

Above in Figure 23, Relative importance of all the attributes, the relative importance of each attribute in each model is shown in percentages. The percentages reveal which attributes correlate the most with the choices made by individuals, and they are computed by dividing an attribute's highest part-worth utility by the sum of all nine highest part-worth utilities (Molin et al., 1996). The relative importance is very much in line with the findings mentioned above. In the full model, the total floor area and the rent price are the most important to the respondents. After these two, the floor level and crowdedness of the streets seem to be the most important factors influencing people's choice for a new home in the inner city. Conversely, the width and the historical appearance of the façade do not seem to be very important according to the full model. The employee/employer model is in most cases quite in line with the full model. Only the walking distance to the nearest park is considered much less important to employees and employers. In contrast, the student model indicates that students do find this much more important in comparison to the full sample. Besides that, students are relatively less concerned with crowded streets and the total floor area.

4.2.4 Willingness to pay

The coefficients of the full MNL model can be used to calculate the willingness to pay (WTP). The WTP of each attribute can be determined by dividing the attribute's coefficient by the coefficient of the 'rent price per month' attribute. A property costing €900 per month results in 1.2630 more utility than the same property costing €400 more per month. Using the latter two numbers, the attributes' WTP can be determined. For example, the WTP for low crowdedness on the streets can be calculated using the calculation below:

$$WTP_{low\ crowdedness} = \frac{\beta_{low\ crowdedness}}{\beta_{rent\ price\ per\ month}} * \text{€}400 = \frac{0.4630}{1.2630} * \text{€}400 = \text{€}146.63/month$$

Table 14, Willingness to pay for the significant attributes.

Attribute	Level	Coefficient	α[1]	WTP (€/month)
	€900	1.2630	***	-
Rent price per month	€1100	0.5729	***	-
	€1300	0		-
Walking distance to public transport stop	250m	0.2899	**	**€91.82**
	500m	0.1570		€49.73
	750m	0		-
Walking distance to parking place	100m	0.3679	***	**€116.51**
	300m	0.1948	.	€61.69
	500m	0		-
Walking distance to nearest park	300m	0.3566	***	**€112.93**
	800m	0.2065	.	€65.41
	1300m	0		-
Crowdedness of the street	Low	0.4630	***	**€146.65**
	Medium	0.4341	***	**€137.49**
	High	0		-
Historical façade	0%	-0.0885		-€28.04
	50%	-0.0681		-€21.58
	100%	0		-
Floor level of the new house	Ground	-0.6045	***	**-€191.45**
	First	-0.3794	***	**-€120.17**
	Second	0		-
Width of the façade	5.0m	-0.1990	.	-€63.03
	7.5m	0.1905	.	€60.35
	10m	0		-
Total floor area	40m^2	-1.5592	***	**-€493.81**
	60m^2	-0.5140	***	**-€162.78**
	80m^2	0		-

[1] Significance codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' '

Table 14, on the previous page, shows the WTP for all attribute levels. Significant WTP values are in bold. The WTP indicates how much one is willing to pay extra or less per month for the attribute level compared to the base level. A positive WTP means that people are willing to pay more for a better attribute. A negative WTP means that people would need compensation to accept an increase in that attribute.

Because the WTP is calculated using the coefficients, the results resonate with the relative importance calculated in the preceding section. However, these WTP values express the value of an attribute in a comprehensible way. According to the model, people are prepared to pay an extra €92 per month to live 500m closer to a public transportation stop, €117 per month to live 400m closer to a parking place, and €113 per month to live 1000m closer to a park. Besides that, people are willing to pay more than €137 extra per month to go from a high crowded street to a medium or low crowded street. The findings also show that people are willing to pay a substantial amount to reside on the second floor. They are willing to pay €120 and €191 per month less to live on the first and ground floors, respectively. People are willing to pay the largest sum of money for square meters in the inner city. The WTP is €494 lower for a 40m^2 house compared to an 80m^2 house. This would mean that the square meter price per month would be €12.35/m^2 extra. However, it can be seen from the ratios between 60m^2 and 80m^2 that the relationship is not linear.

4.3 CONCLUSION

This chapter discussed the results of the discrete choice experiment. The demographics of the sample indicate that the sample is relatively young, with a large proportion of 18-30 year-olds. This is further emphasized by the fact that almost half the sample is a student. Nevertheless, still the preference aspect of the third sub question, "*What inner city building and locational residential characteristics are considered and preferred by the different target groups?*", can be answered by examining the results of the multinomial logit model (MNL). The full sample MNL shows that shorter walking distances to amenities and less crowded streets increase utility. The historical façade and its width appear to have minimal influence on people's residential preferences. Furthermore, respondents prefer higher floors to the ground floor level. The total floor area and monthly rent price were the most important factors for making the choice, with larger areas and lower rents significantly improving utility. The DCE results were analyzed again but for two different groups, the target group students and the employees/employers as a reference. The results were quite similar to the full sample. However, students have a higher preference for price, accessibility and parks, while employees/employers have a higher preference for floor space and less crowded streets.

5 TOOL DEVELOPMENT

This chapter will explain how the spatial decision support system (SDSS) tool is developed. An overview of the development of the tool is shown in Figure 24. The goal is to create a SDSS that can show which retail properties are of interest to be transformed into housing based on target group preferences. To be able to create such a tool, two essential elements identified earlier in this research need to be integrated into the geographical information system (GIS): the exclusion criteria and the weights of the multi criteria decision analysis (MCDA) criteria. The exclusion criteria will be used to find retail properties that can be considered for transformation into housing. The weights of the MCDA criteria, resulting from the discrete choice experiment, will be used to determine the utility of a retail property. These two elements will be integrated into GIS using two data sources: a Locatus database and OpenStreetMap data. To create the SDSS, a MCDA output must be generated within GIS. To enhance the usability of the tool, the MCDA process will be automated in GIS. The result is an interactive map that shows the residential utility of retail properties in the inner city that can be used by policy makers.

This chapter will first explain what data sources will be used to create the tool. Next, it will be elaborated on how the exclusion criteria and the weights from the DCE are integrated into GIS using the data sources. Finally, this chapter will show how the MCDA criteria are automated within GIS to create the SDSS tool.

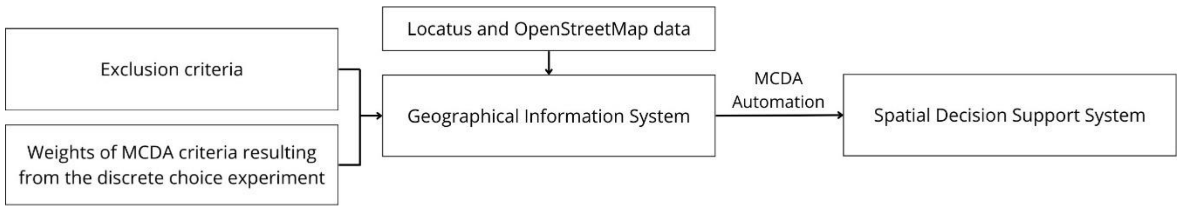

Figure 24, Development of the spatial decision support system

5.1 DATA SOURCES

Data is a critical component of a SDSS. The SDSS tool is created with different data sources. Aside from the data obtained from the discrete choice experiment, data is also gathered from an external company and existing open sources. This data will serve as the foundation for all SDSS-based decisions.

5.1.1 Locatus – Retail Benelux

Locatus is a Dutch data company specialized in location issues regarding retail, housing plans or the office market. To support this study, Locatus has shared its database on retail real estate in the Benelux. This database contains detailed information about almost all retail properties in the Netherlands. The database includes information about the use, function, location, or size of properties, but also passenger flows around the retail locations (Figure 25). Aside from that, the data about a retail property is also linked to x and y coordinates, which is essential if the database is to be implemented in another GIS.

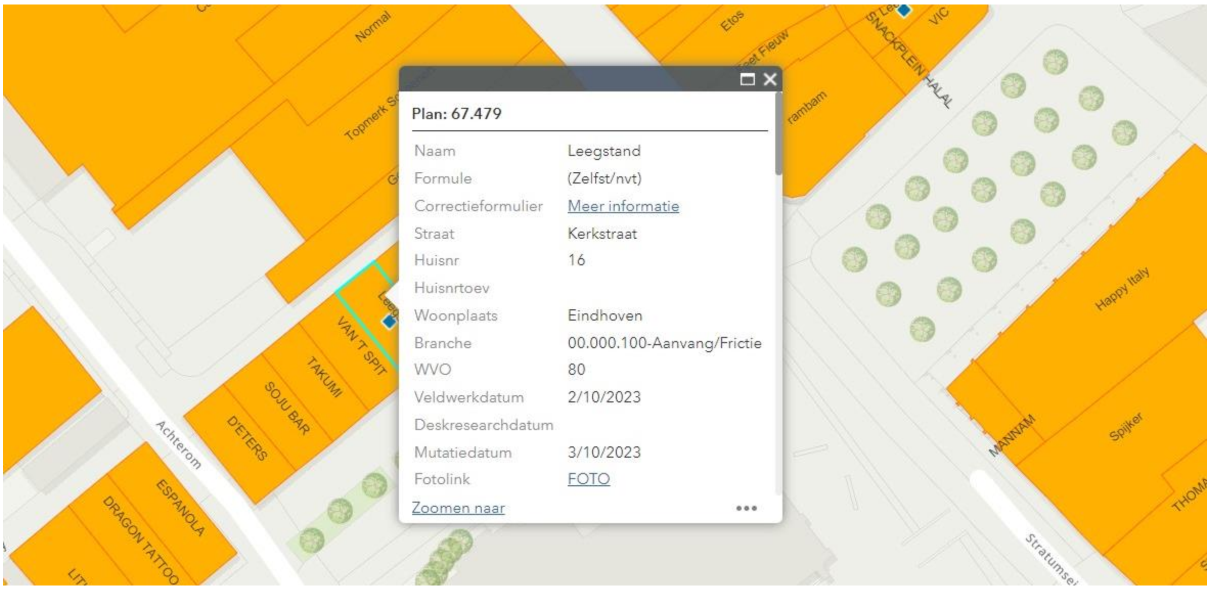

Figure 25, Database retail Benelux (Locatus, 2024)

5.1.2 OpenStreetMap (OSM)

OpenStreetMap (OSM) is a collection of freely available maps created by mappers. Worldwide geographical information about streets, borders, points of interest, and areas is collected and stored in a database (OpenStreetMap, 2024). Figure 26 shows a visualization of OpenStreetMap as the base layer in QGIS. From this base layer, the geographical information can be extracted using plugins such as OSMInfo and QuickOSM. QuickOSM is a plugin that can extract data from the OSM database trough queries. Using these queries, the location of features like parks, parking places or public transport stops can be identified.

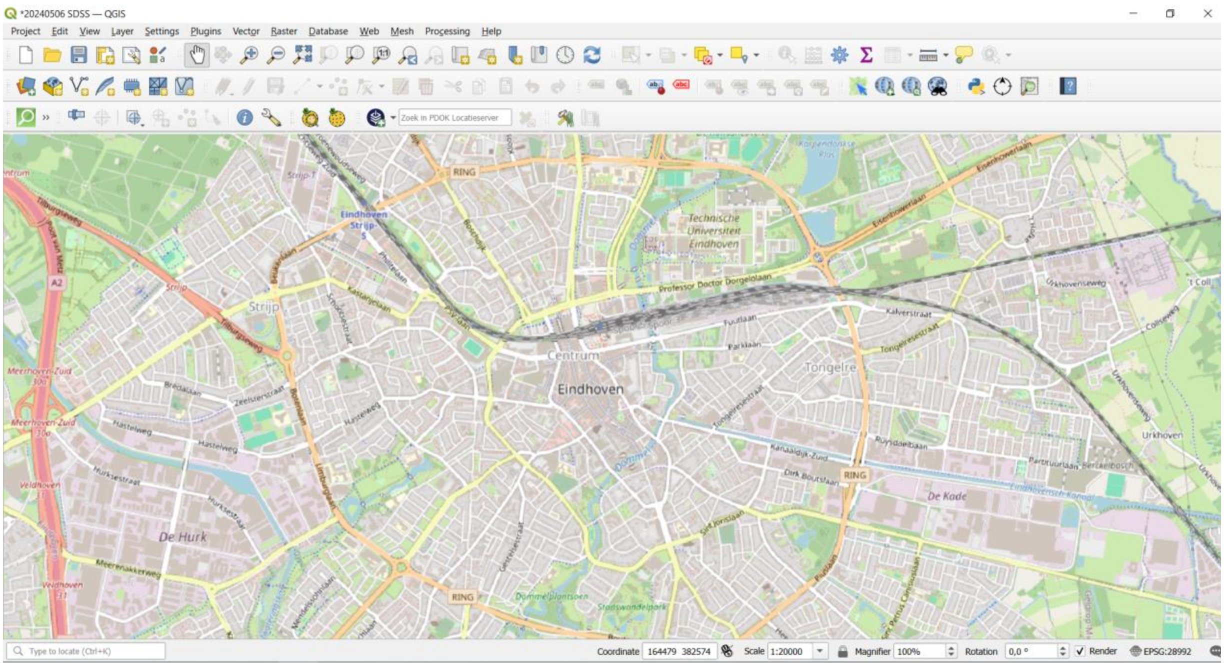

Figure 26, OSM layer in QGIS.

5.2 PROCESSING

This paragraph will describe how the exclusion and MCDA criteria are included in GIS to be able to create the SDSS tool. First, it will be elaborated on how each criterium, including their weight coming from the discrete choice experiment, is integrated into GIS. Second, it will be explained how the process is automated in GIS.

5.2.1 Implementation of criteria in GIS

5.2.1.1 Exclusion criteria

Locatus' database contains information on almost all retail properties in central retail areas. Retail properties outside of the inner city area are already filtered out and thus do not need to be excluded anymore. However, not every retail property in these areas is suitable to be transformed into a house (Paragraph 2.2). First properties with a retail floor area ('WVO') below 20m^2 are excluded from the dataset using a 'select by expression' function in QGIS. Second, the decision maker needs to define the core shopping area in the inner city. All properties in this area with only a ground floor entrance will be removed from the dataset, as no transformations are permitted in the plinth of this zone. In QGIS, the core shopping area can be defined by a yellow-colored polygon feature (Figure 27). This polygon can then be used as vector layer input for the model that extracts all properties suitable for the transformation into houses.

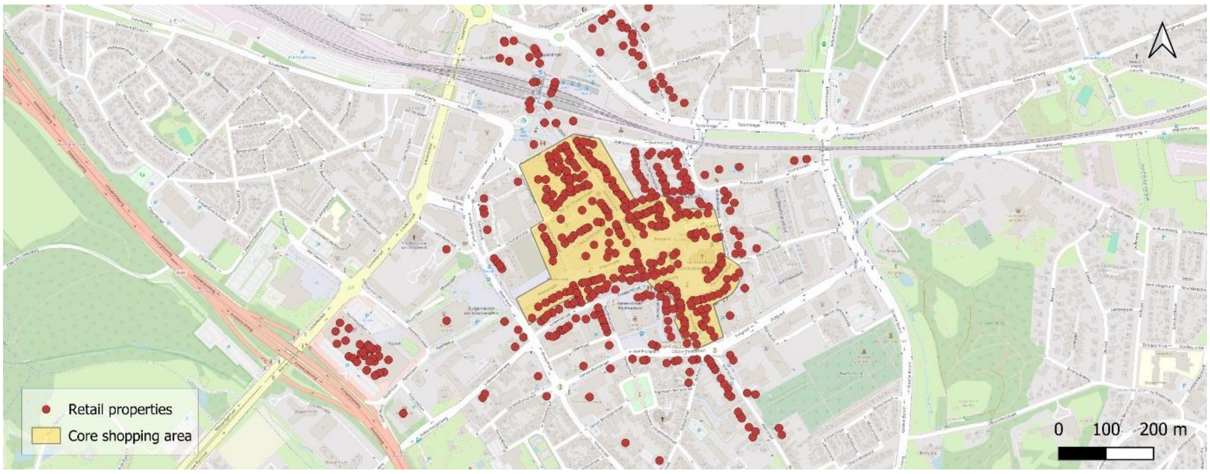

Figure 27, Example of a 'core shopping area' polygon used to exclude retail properties

5.2.1.2 MCDA criteria

The multicriteria analysis is executed in the form of a discrete choice experiment. In the experiment nine different attributes, with each 3 levels, were used to describe an inner city retail property. The goal is to incorporate all of these attributes into the tool so that the model can compute the utility of a property as comprehensively and accurately as possible. In total seven of the nine attributes are implemented into the tool. Only the width and historical appearance of the façade are not considered. Both attributes were not statistically significant in the DCE, and there were no variables available in the Locatus database that could explain the attributes. This subchapter discusses how each of the other seven attributes is implemented in the tool.

Walking distance to nearest public transport stop, parking place and park

The walking distances to the nearest public transport stop, parking place, and park were not defined in the Locatus database. Using the QuickOSM plugin in QGIS, the locations of these places can be identified. QuickOSM uses keys and values to tag things within a specified area. For example, a bus stop is tagged as highway=bus_stop (key=value). If the specified area is "Netherlands", a new layer will be created with all bus stops in the Netherlands.

This research uses public transportation stops as a collective term for all rail stations, metro stations, tram stops, and bus stops. As a result, all of these stops and stations are separately identified and combined into one layer. Next, the distance between retail properties from the Locatus database and the nearest transportation stops is estimated using the 'distance to the nearest hub' tool in QGIS. Unfortunately it was not possible to measure the exact walking distances as specified in the experiment. In QGIS, the distances between the points are computed using Euclidian measurements.

The distance to the nearest parking place and public park are estimated similarly. Because a parking place for a private car can be facilitated in many different ways, all types of parking places are taken into account. This includes ground-floor parking, underground parking, multi-story parking, and also several streetside parking places. Regarding public parks, only those above 5000m2 were included as defined in the discrete choice experiment.

Table 15, Implementation of the distances to transportation hubs and parks.

Attribute	Attribute levels (DCE)	Distance in QGIS	Coefficient
Walking distance to nearest public transport stop	250m	<375m	0.2899
	500m	375-625m	0.1570
	750m	>625m	0
Walking distance to nearest parking place	100m	<200m	0.3679
	300m	200-400m	0.1948
	500m	>400m	0
Walking distance to nearest park (>5000m2)	300m	<550m	0.3566
	800m	550-1050m	0.2065
	1300m	>1050m	0

Crowdedness of the street

The retail property database of Locatus contains two variables expressing the crowdedness of the street. It can be expressed using the number of passersby or using segments. The number of passersby is a measurement of the average number of people that pass the property on a Saturday. Segments are categories made after measuring the ratio between the maximum passerby value in an area and the passerby value of the property itself. Segments demonstrate the quality of a location and are classified into the following categories: A1 (75-100%), A2 (50- 75%), B1 (25- 50%), B2 (10- 25%), C (5-10%) and nvt. Because the ratios are determined relative to the busiest point in the city, an A1 location in a small town does not count as many passersby as an A1 location in a big city.

This research chooses to express the crowdedness of the street in segments because it can be subjective. People who are used to a calm environment may perceive something as crowded faster than people from a busy environment. In Table 16 is shown how the attribute levels of the DCE are defined by the segments. Figure 28 highlights the allocation of the different segments in an inner city. The darkest red is A1 and the lightest red is C. The yellow points are properties of which the segment is not defined ('nvt'). Properties in the A1 till B1 segments are located in the main shopping streets, B2 segment properties in the streets around that, and C segment properties are in streets that are even less crowded. 'Nvt' properties are assigned to the low crowdedness level because in most cities these properties are located further away from the city center than C-segment properties (see Figure 28).

Table 16, Implementation of 'crowdedness of the street'

Attribute	Attribute levels (DCE)	Segment	Coefficient
Crowdedness of the street	Low	'nvt' 'C (5-10%)	0.4630
	Medium	'B2 (10-25%)	0.4341
	High	'B1 (25-50%) A2 (50-75%) 'A1 (75-100%)	0

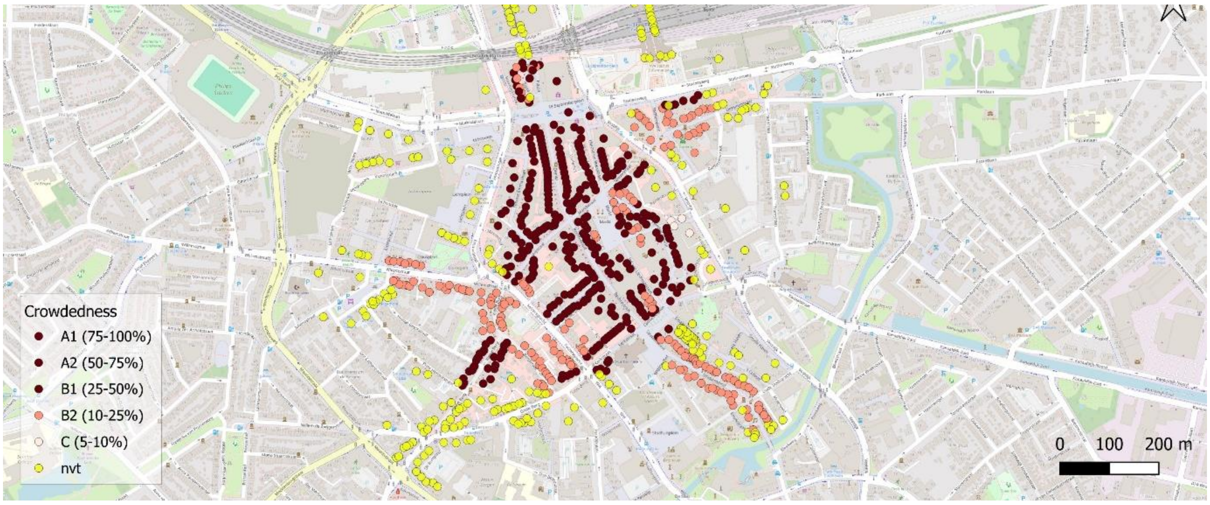

Figure 28, Location of the different segments in Eindhoven

Floor level of the new house

If a retail property has its own entrance on a specific floor level, it will be registered into the Locatus database. However, if the property only has an entrance on the ground floor, nothing will be noted. Therefore, the empty space above a retail property on the plinth only can be assessed if it has its own entrance. Nevertheless, this limitation is in line with residential building restrictions, since a residential function must be able to be reached with a route to the public road (see Paragraph 2.2.4). In the database 'o' means 'only', thus 'o1' is a property with only floor level 1. However, a '1' means that the property has an entrance both on the ground floor level and on the first floor. Because these occurrences are uncommon, this study counts properties with both floor levels as being on the highest floor level. Therefore, properties with a '2' are assigned to the second-floor level.

Table 17, Implementation of 'floor level of the new house'

Attribute	Attribute levels (DCE)	Floor level	Coefficient
Floor level of the new house	Ground	0	-0.6045
	First	1 'o1' 'o12'	-0.3794
	Second	2 3 'o2'	0

Total floor area

In the Locatus database, the floor area of a retail property is defined by the retail floor area: ‘Winkelvloeroppervlakte (WVO)’, and by the usable area of a building object taken from the ‘Basisregistratie Adressen en Gebouwen (BAG)’ Netherlands. However, there is often a large difference between the two values. For example, in the database there is a retail property with a WVO of 95m^2 and a BAG area of 8175m^2. The BAG area includes all square meters registered on the same address, whereas the WVO only refers to the usable space of a retail property. To be able to assess every retail property separately, this research uses WVO as value for the total floor area. How the square meters are divided per attribute level is visible in Table 18.

Table 18, Implementation of ‘total floor area’

Attribute	Attribute levels (DCE)	WVO	Coefficient
Total floor area	40m2	<50m2	-1.5592
	60m2	50-70m2	-0.5140
	80m2	>70m2	0

Rent price per month

The rent price per month has a large influence on people’s residential choices. However, the Locatus dataset does not contain a concrete price attribute. It can be reasoned that segment is related to the price, as this can represent the value of a retail property. Nonetheless, the segment attribute defines the street's crowdedness in the tool. As a result, it was determined to develop a new method of pricing retail properties. The decision-maker should establish the center in the inner city at the most expensive place. With various radiuses, the properties will be assigned to one of three pricing levels. (see Figure 29). The size of the radius is dependent on the size of the inner city and its building spread.

Table 19, Implementation of ‘rent price per month’

Attribute	Attribute levels (DCE)	Radius	Coefficient
Rent price per month	€900	Including retail properties outside of the €1100 circle	1.2630
	€1100	Including retail properties in approaching streets	0.5729
	€1300	Including retail properties most central	0

Figure 29, Rent price circles '€900-€1100-€1300'

5.2.2 Automation of MCDA model in GIS

In the previous chapter is explained how seven of the nine MCDA criteria are defined in the GIS system. If a decision maker needs to compute the utility of each property by hand, then it will be very time-consuming, which is the opposite of what is expected from the tool. Therefore, it has been decided to create a SDSS where the MCDA process is automated in GIS. GIS allows for automation using the Model Designer. In the Model Designer, a chain of actions can be wrapped into a single process, saving time and effort once created. An overview of the model created for the SDSS can be seen in Figure 30. The model is developed using the Dutch language because the Locatus data is in Dutch and the decision maker and user of the tool is highly likely Dutch.

The model contains three types of blocks. The light yellow blocks are the 'input' blocks. These inputs for these blocks must be defined before to running the model, and hence might be chosen differently for different scenarios. The white blocks are the 'algorithm' blocks. These algorithms feature geoprocessing tools as well as database management tools. The dark yellow blocks represent the 'output' blocks, which will al generate an output for the main user interface.

Before running the model, the decision maker needs to: define the core shopping area of the inner city as an exclusion layer; define the price circles appropriate for that city; and create an inner city building layer. These layers and the Locatus dataset will be used as input for the model. The model starts running in the top left. First, the price of each retail property is defined using the price circles drawn by the decision maker. Once the corresponding algorithms ran, all seven criteria become known for each property. Next, all ground floor-level properties within the core shopping area of the inner city are removed from the dataset. The remaining suitable retail properties are evaluated using the part-worth utilities of the criteria, resulting in a total utility for the remaining retail properties. Finally, a map with retail properties is displayed using building polygons and a color scheme, indicating the total utility for the suitable retail properties in the inner city.

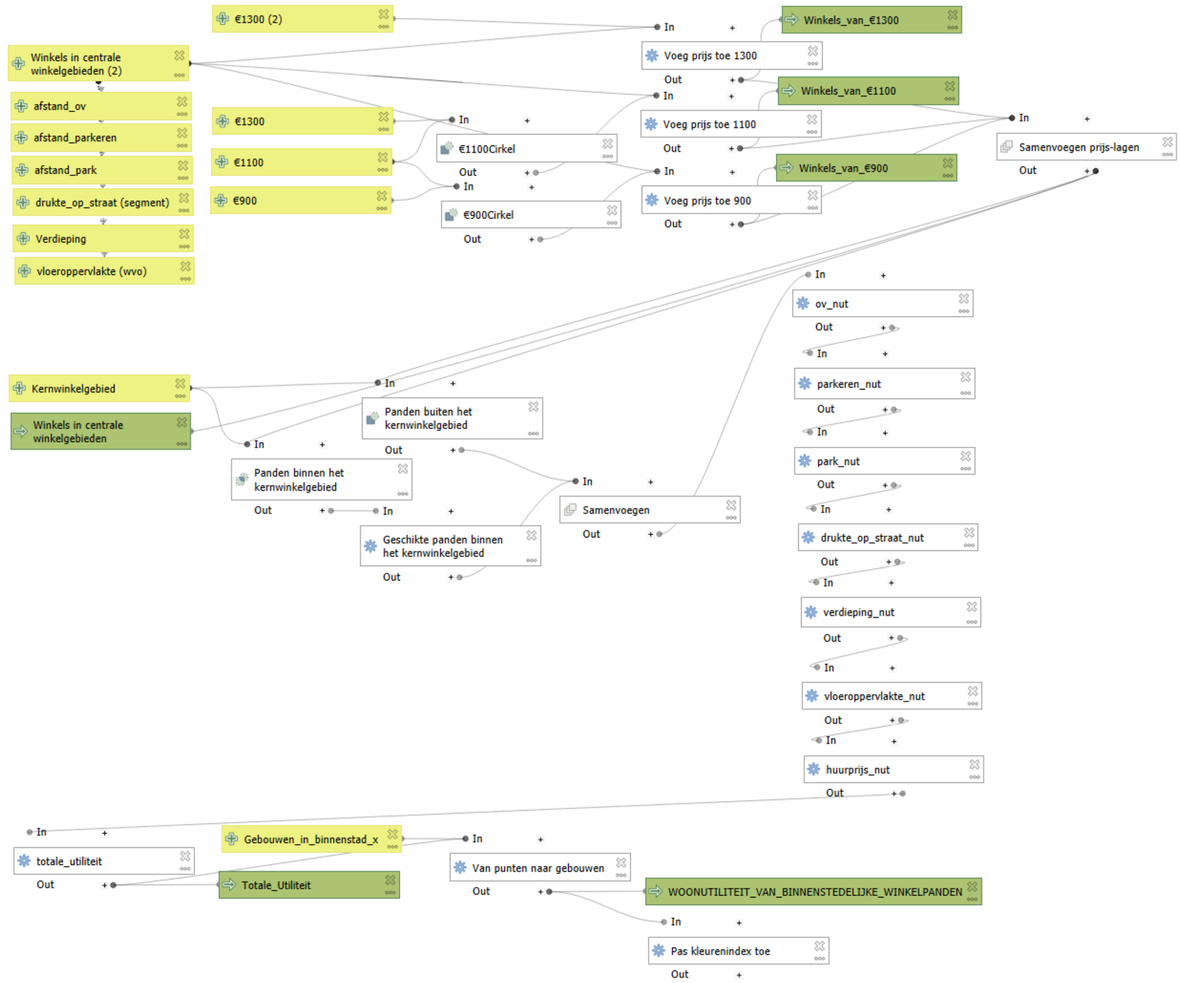

Figure 30, Automation of the SDSS

5.3 Conclusion

Chapter 5 describes how the tool is developed. First, the data sources needed to develop the tool are discussed. The tool used a Locatus database, which provided this research with a large amount of information about retail properties in Dutch inner cities. Additionally, GIS plugins such as OpenStreetMap were used to help define several location characteristics in the tool. Second, there is explains how the exclusion criteria and the MCDA criteria weights, resulting from the DCE, are integrated into GIS. Seven of the nine MCDA criteria are implemented in the tool. Only the width and the historical appearance of the façade are not implemented because they did not have a significant impact on people's preferences according to the DCE. The other seven MCDA criteria could be assigned to a corresponding variable of the Locatus or OpenStreetMap database. However, certain attributes had to be implemented slightly differently. The tool defines walking distance to amenities in terms of Euclidian distance and the monthly rent price is determined by the radius from the city center's busiest point. Finally, the MCDA process is automated in GIS to create the SDSS.

6 TOOL APPLICATION: CASE STUDY

In this chapter, the tool will be applied to a city struggling with many vacant retail properties in the city center and thus at risk of deterioration. It will first demonstrate how the tool can be used. After this, the tool will be evaluated in terms of effectiveness and user-friendliness. The effectiveness will first be tested through a case study.

6.1 PROJECT AREA: HEERLEN

The Locatus dataset contains information to retrieve the number of vacant retail properties in Dutch inner cities. According to the data, Heerlen has the highest vacancy rate among the big and medium-sized inner cities (Appendix H). In 2024, 132 of the 535 retail properties are recorded as vacant, representing a 25% vacancy rate. A high vacancy rate can result in an unattractive city center, which is why the municipality must interfere. Moreover, the interview by RTV Parkstad (2023) with the municipality shows that the municipality is already planning on creating policies to address vacancy, with the transformation of existing properties as an option, including ground-floor housing. Therefore, Heerlen seems to be a suitable area to demonstrate and investigate the usability of the tool.

Figure 31, Location of Heerlen

6.2 TOOL DEMONSTRATION

The tool is designed to support policy decisions regarding the organization of the inner city. In the end, a policymaker should be able to work with this tool. This chapter discusses how the tool works by applying it to the city center of Heerlen.

Before the decision maker can run the MCDA model, three inputs have to be generated or defined (see Paragraph 5.2.2). First, the buildings of the city (center) need to be generated using a simple QuickOSM 'building' query, resulting in an overview of all the buildings in the project area (Figure 32).

Figure 32, Input 1: capturing all the buildings in the city center of Heerlen

The second step is to define the core shopping area of the inner city. The plinth of the core shopping area contributes in creating an attractive inner city. Therefore, most municipalities have restrictions to only allow retail functions on the ground level of the core shopping area. Municipalities with high vacancy rates have plans designed to reduce the size of this area, densifying retail space in the city center and transforming properties on the edge of the city center. In this stage, the municipality can implement these plans into the tool. Figure 33 shows an estimation of the core shopping area of Heerlen.

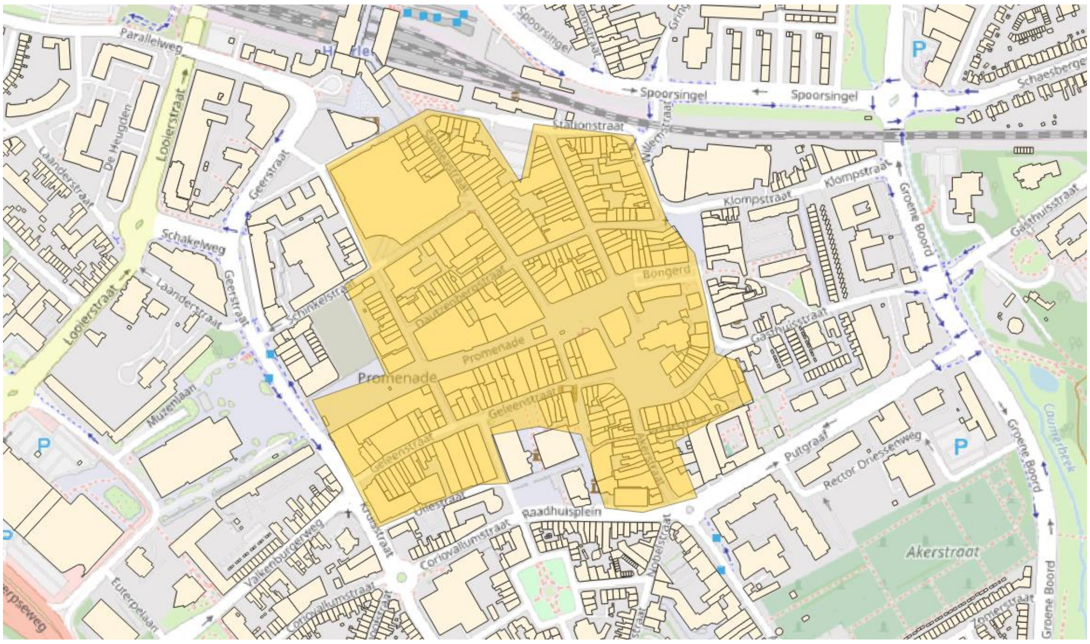

Figure 33, Input 2: drawing the core shopping area

The third input that is expected from the decision maker is an indication of the valuation of the inner city properties. This tool values the properties based on the radius from the busiest point of the city center. The further away from this point, the lower the rent prices. Figure 34 shows an example.

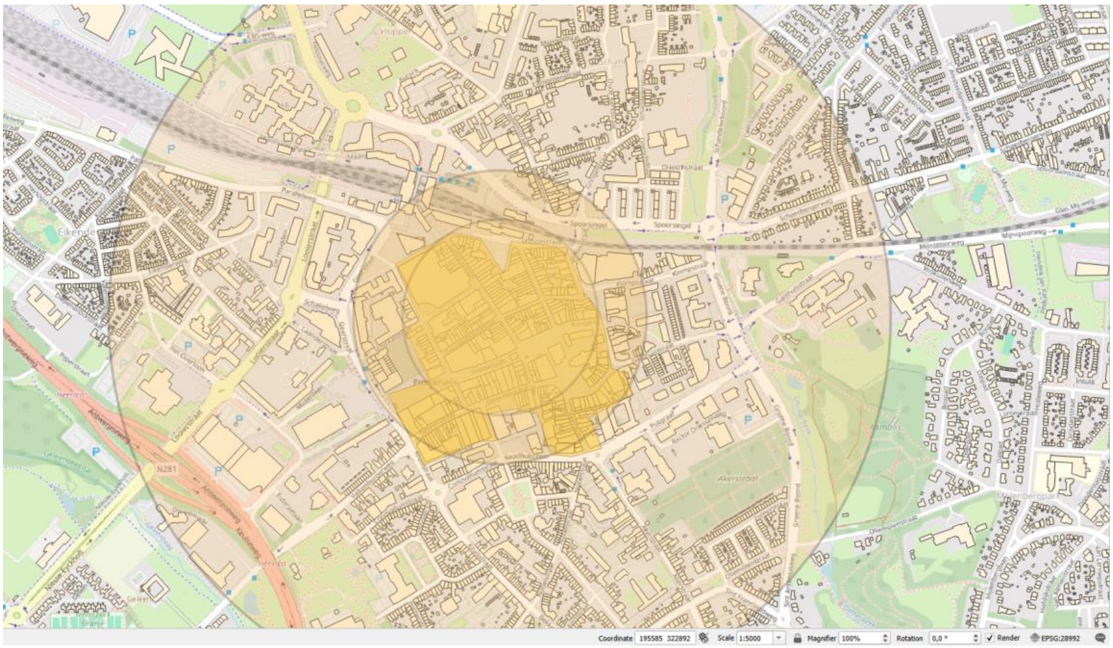

Figure 34, Input 3: creating the price circles

Once the inputs are defined, the MCDA models can be run. The decision maker can choose either to run the full model or a model focused on student preferences, depending on the decision maker's objective. Figure 35 and Figure 36 demonstrate the interface of the SDSS after the two models are applied to the inner city of Heerlen. The SDSS functions as an interactive map that allows the decision-maker to focus on a specific area or click on properties to obtain specific information.

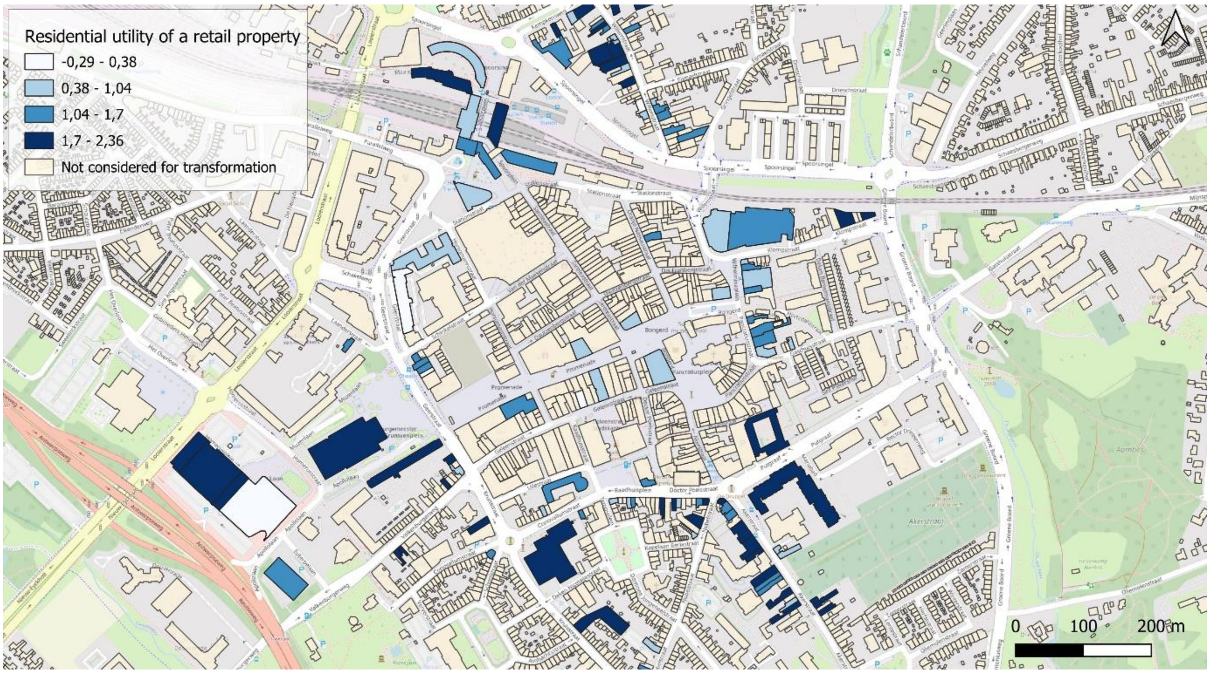

Figure 35, Residential utility map according to the full model

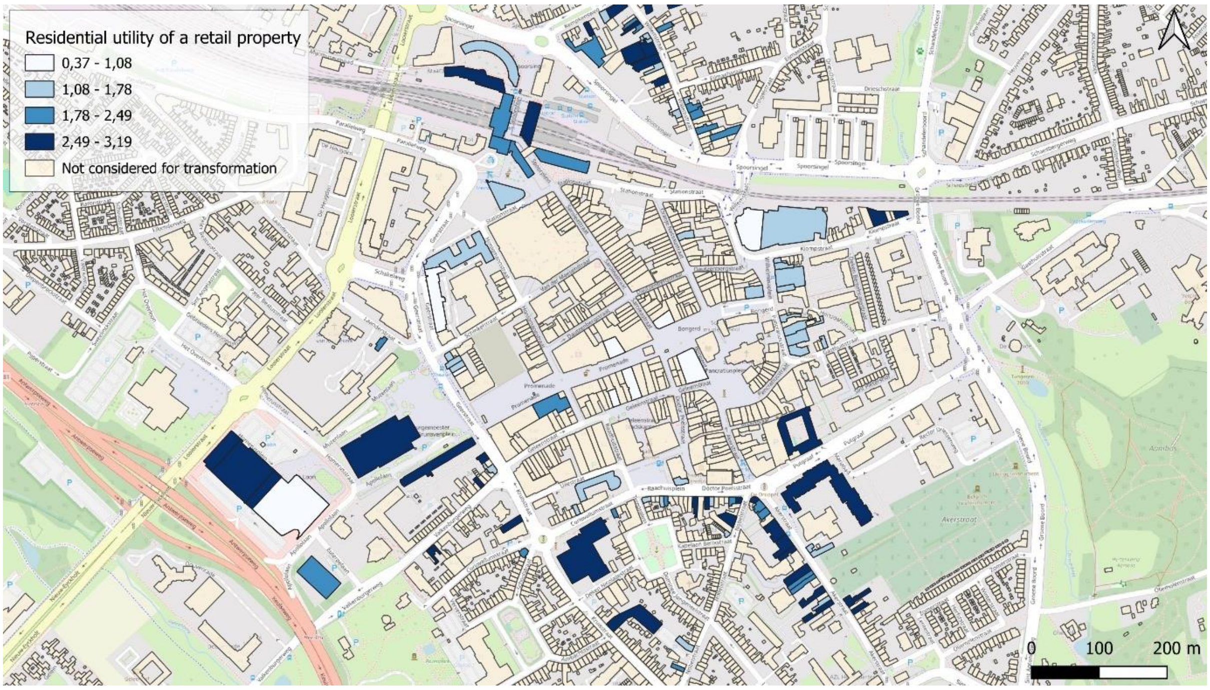

Figure 36, Residential utility map according to the student model

Both utility maps in Figure 35 and Figure 36 show several different things. At first, it is indeed visible that all the properties in the plinth of the core shopping area are excluded from the selection. The tool only displays properties located above ground level in this area. Second, the utility range is different for both models. In Heerlen, the utilities in the full model range from -0.29 to 2.36, and in the student model from 0.37 to 3.19. Furthermore, it appears that properties positioned further away from the city center provide more utility than properties closer. This is most likely due to the fact that these properties are less expensive, located on a less crowded street, and frequently have a total floor area of more than 70m^2.

Figure 37 and Figure 38 show properties at the edge of the city center on a smaller scale. It is visible that utility differences can occur within the same street. Neighboring properties with different utilities often differ only in terms of total floor area, which is an important criterion in people's preferences. Additionally, differences are also observed when looking at the same retail property in both models. The property in the red circle in Figure 37 and Figure 38 is taken as an example. The example shows that both maps cannot be compared. The map that used the full model shows a darker shade of blue compared to the map that used the student model, while the utility of the property is 1.29 in the full model and 1.78 in the student model. The utility difference occurs because students derive greater utility from the property's accessibility and price. It is therefore only useful for a policy maker to compare properties using one of the two models.

Figure 37, Residential utility map on street level scale according to the full model

Figure 38, Residential utility map on street level scale according to the student model

6.3 TOOL EVALUATION

The performance of the tool is evaluated on two different aspects. First, the tool is tested for effectiveness by applying it to the project area Heerlen. Second, the tool's usability is evaluated by having a person unfamiliar with the tool's software use it.

6.3.1 Effectiveness of the tool

The tool's effectiveness in decision making is measured by applying it in a particular scenario. In the interview of RTV Parkstad (2023) is suggested that consideration is being given to transforming retail properties into housing near the Oranje Nassaustraat. In addition, there also seem to be similar plans around the Geleenstraat, where retail properties are being bought by the municipality (Pots, 2023). This evaluation addresses both locations to determine whether the tool can help the municipality decide which area ought to be transformed first. The two locations are indicated by red circles in Figure 39. In addition, the municipality has plans to move the university to the inner city because students bring vibrancy to the city (Zuyd, 2022). In line with this idea, the decision was made to use the student model in this evaluation.

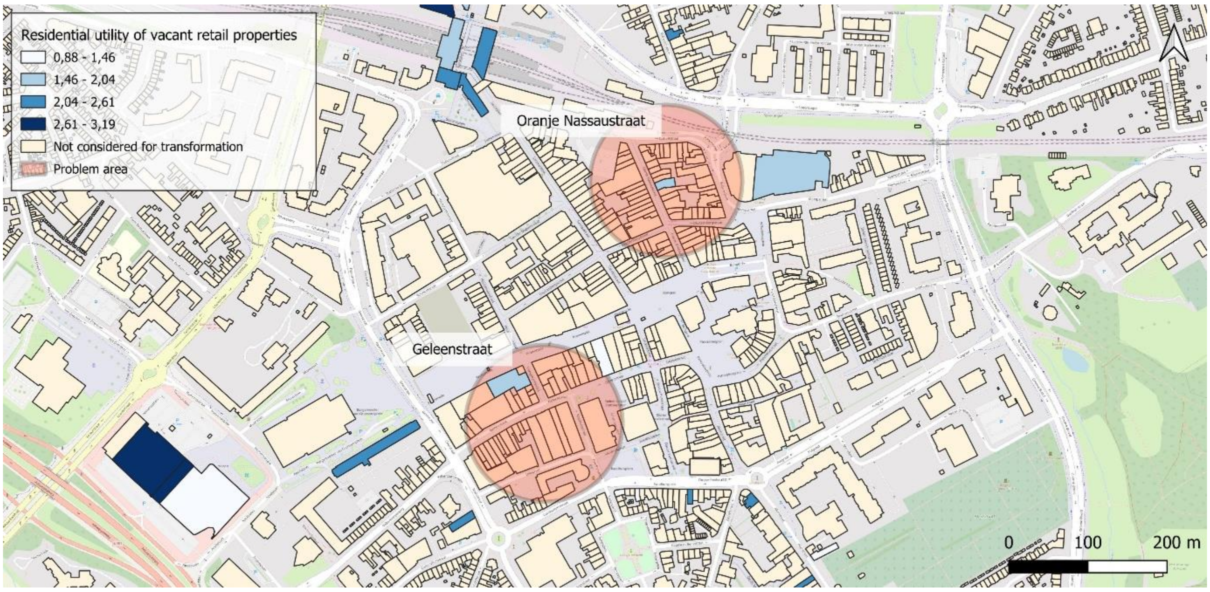

Figure 39, Two potential redevelopment areas in Heerlen: Geleenstraat and Oranje Nassaustraat

Location 1: Oranje Naussaustraat

The Oranje Nassaustraat is a street in the north-eastern part of Heerlen's center that struggles with vacancy. It is close to the station but is not on the direct walking route from the station toward the exact city center. Those vacancies are not directly reflected in Figure 39, which is partly because, on this map, Orange Nassaustraat is still entirely within the core shopping area and no ground-floor housing is supposed to be developed there. Nevertheless, the observations in Appendix I show that people are already living on the ground floor in this street and that the municipality has plans to transform ground floor retail properties here as well (RTV Parkstad, 2023). Therefore, in this scenario, the core shopping area is made more compact, resulting in more retail properties being marked as suitable for transformation. Figure 40 shows which vacant retail properties can be considered for transformation after reducing the size of the core shopping area.

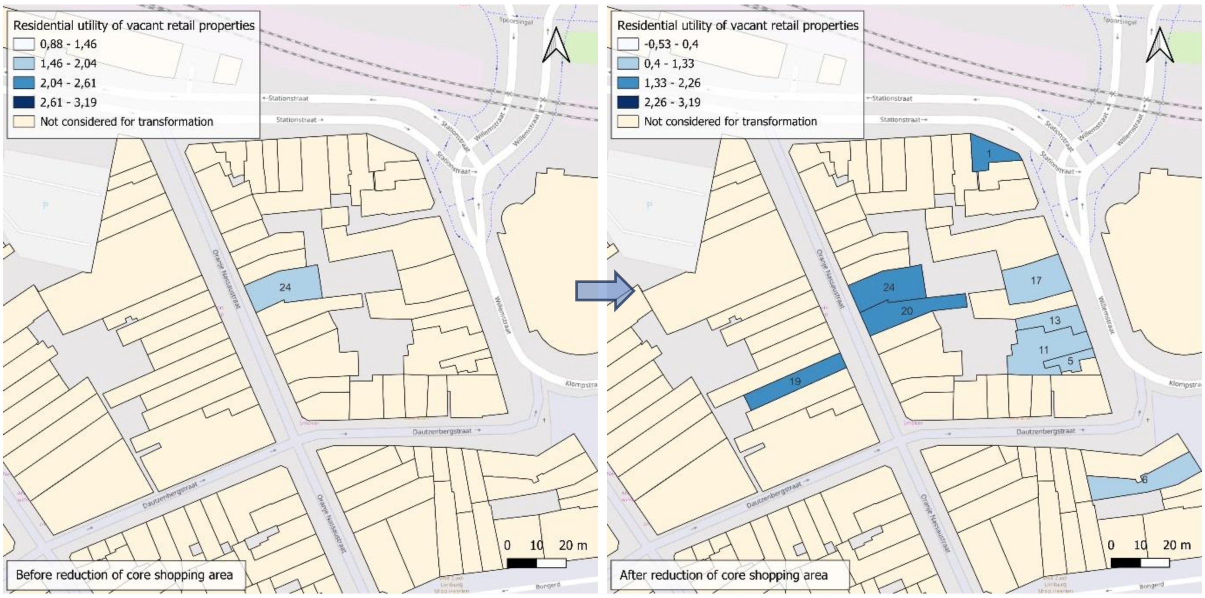

Figure 40, Allowing housing on the ground floor around the Oranje Nassaustraat

In this scenario, transformation is allowed in the northern part of Oranje Nassaustraat. Due to this policy, the tool indicates that three vacant retail properties can be considered for transformation into housing. These are the retail properties numbered 19, 20 and 24. Based on observations, as visible in Appendix I, these properties also appear to be vacant at the time of writing. Table 20 presents the characteristics of the properties with the corresponding total utility score. These properties do not differ much in location, and thus generate the same utility in this regard. The property at Oranje Nassaustraat 24 generates the highest utility score, which is mainly due to the fact that this address has a private front door on street level leading to the first floor.

Table 20, Vacant retail properties in the Oranje Nassaustraat

Oranje Nassaustraat	**Nr 19**	**Nr 20**	**Nr 24**
Distance to public transport	236m	237m	227m
Distance to parking place	78m	95m	87m
Distance to park	531m	532m	523m
Crowdedness of the street	Low	Low	Low
Floor level	0	0	0, 1
Floor area	121m^2	150m^2	473m^2
Price	€1300	€1300	€1300
Total Utility	**1,38**	**1,38**	**1,68**

Location 2: Geleenstraat

The Geleenstraat is located on the southwest side of the city center. In this corner of the city, it is not so much the retail stores that are a pull factor but, for example, nearby museums. By also excluding the Geleenstraat from the core shopping area, the tool shows that there are especially many ground-floor properties vacant on this street. This indication is further confirmed by observations on this street (Appendix I). Furthermore, the observations also note that in the period between March and July 2024, there have been alterations in this area again. For example, the property at Geleenstraat 60 has been filled with a retail function again and the property at number 49 has become vacant again.

Figure 41, Allowing housing on the ground floor around the Geleenstraat

The tool indicates that there are over fifteen vacant properties on the ground floor of the Geleenstraat. For oversight purposes, five vacant retail properties on this street are included in the evaluation. In particular, the focus in this case is on properties that are currently vacant in the western part of the street. These are the properties on Geleenstraat numbers 38, 51, 56, 59, and 72 (Appendix I). Since this street has a longer length than the Oranje Nassaustraat, differences in location characteristics can be seen here. For example, the properties on numbers 51 and 59 have better accessibility to a parking place compared to the other properties. Furthermore, the only difference seen among the properties is in floor area and price. Numbers 38, 56, and 72 have less floor space than the other properties and number 38 falls just within a more expensive rent price category. As a result of these differences, considerable utility differences might exist within a single street. Based on people's residential preferences, the properties at Geleenstraat 51 and 59 appear to be the strongest contenders for transformation into houses.

Table 21, Selection of vacant retail properties in the Geleenstraat

Geleenstraat	**Nr 38**	**Nr 51**	**Nr 56**	**Nr 59**	**Nr 72**
Distance to public transport	243m	187m	186m	179m	139m
Distance to parking place	247m	142m	203m	121m	138m
Distance to park	691m	755m	703m	767m	730m
Crowdedness of the street	Low	Low	Low	Low	Low
Floor level	0	0	0	0	0
Floor area	40m^2	111m^2	70m^2	130m^2	30m^2
Price	€1300	€1100	€1100	€1100	€1100
Total Utility	**-0.53**	**1.78**	**1.19**	**1.78**	**0.37**

Evaluation

The task of the tool is to support a decision maker in deciding on which retail properties to transform into housing based on the level of interest of a target group. First, the tool should be able to indicate where the vacant retail properties are in the city. After making the core shopping area more compact, this was indeed the case, as a large number of retail properties appeared to be vacant in both locations according to the tool. Once all vacant retail properties are identified, the tool should be able to indicate which retail properties generate the highest residential utility for the target group. Based on the utility level, the tool indicated that the retail properties at Geleenstraat 51 and 59 are the most interesting to transform into housing for students (Figure 42). Although not every property in the Geleenstraat has a higher utility score than properties in the Oranje Nassaustraat, the tool can support the municipality's choice to prioritize the Geleenstraat for transformations, as observed comparing Figure 40 and Figure 41.

Figure 42, Vacant retail properties at the Geleenstraat 51 and 59

The tool shows that it can be used to support decisions to a certain extent. However, the evaluation of the tool also revealed some things to consider when applying the tool. Five of the seven characteristics the property is rated on are based on the location of the property. Because of this, the difference within a street is often created by the total floor area and floor level of the property. Although this can certainly be useful, this is something to consider in the assessment. Moreover, properties in a small inner city all tend to have the same score on the accessibility of the property. Last, it was also noted that it is important to keep the data well up to date as changes occur often in the inner city.

6.3.2 Usability of the tool

The usability of the tool is tested by observing a person using the tool who is unfamiliar with the tool's software. This person is asked to run the model and extract information from the tool. Some instructions were given before and during the testing of the tool. If a person wants to run the model, then there are certain inputs that need to be specified first. The inputs in the red boxes in Figure 43 must be filled in manually via a drop-down selection. The evaluation shows that since the names of the inputs are almost identical to the headings, the selection of the correct inputs is done without too much difficulty.

When the tool is run then the interface appears as shown in Figure 44. At this moment, the individual is asked to determine which properties are most preferred among people and how much. Without looking at the legend, the person realized that people had a stronger preference for the dark blue properties over the light blue properties. After receiving instruction on which button to use to extract information from properties, the individual began looking at the properties' details. It is observed that the person cannot immediately find the relevant data. Besides that, the person states that it can be a bit unclear which factors make that a property is preferred.

The evaluation indicates that it is important to have a small instruction document to create a better understanding for the use of the tool. The document should explain how the model is to be run and how the relevant information is to be found. In addition, the use of a color ramp was found to help the person find the properties that would generate the highest level of utility.

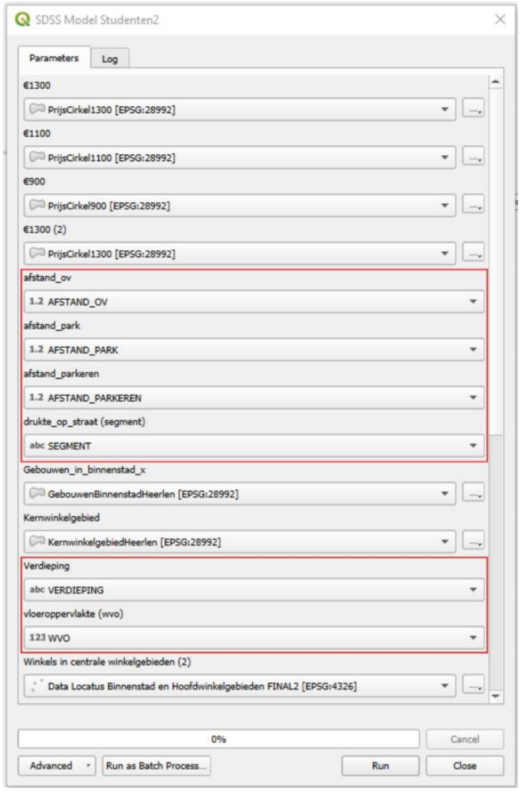

Figure 43, Selecting model inputs

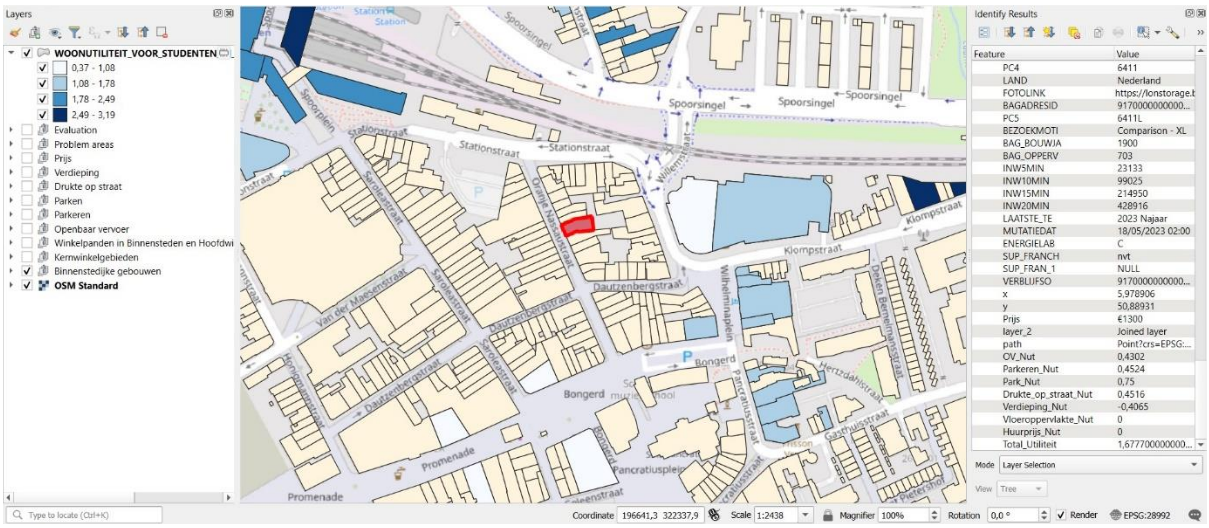

Figure 44, The user interface of the tool

7 CONCLUSION

This chapter will summarize the research in an overall conclusion where the process of answering the research question will be elaborated. In addition, this chapter will consider the relevance and limitations of the research. Finally, recommendations for future research will be made.

Conclusion

The incentive of this research was the observation of a considerable number of vacant retail properties in Dutch city centers. High retail vacancy rates can have a negative impact on the business and investment climate of an inner city, and a negative spiral of deterioration is more likely to occur in areas where the structural vacancy is high. Given that retail vacancy negatively affects the attractiveness of the inner city, it is importance for a municipality to keep the vacancy rates as low as possible. Municipalities show that they want to address vacancy problems by making the shopping area more compact through the stimulation of function change at the edge of the shopping area. In this, investors indicate that function change to residential has the greatest chance of success in these areas, which can be further substantiated by the tight housing market. Knowing which vacant retail properties are of interest to inner city target groups will support the municipality in writing and pursuing their transformation policy and keep control over the infill of the area. For the municipality, it would be useful to have a tool that can use target group preference data to explore which inner-city retail properties are interesting for transformation into housing. To investigate how such a tool can be created, the following main research question is formulated:

"How can a tool be created that can explore which vacant inner city retail properties are of interest to be transformed into houses based on target group preferences?"

To answer this question in a structured way, four sub-questions are formulated. The first sub-question explored "*Which stakeholders are involved in inner city retail transformations?*". Literature and reports revealed that citizens, retailers, property investors, and municipalities are the main stakeholders involved in the transformation of vacant retail properties. The review investigated the power and interest of each of these stakeholders. It was found that municipalities, as stakeholders with both a lot of power and interest, are best suited to use the tool. The tool should support the municipalities in the decision-making process regarding the transformation of vacant retail properties into housing by identifying retail properties that can be considered for transformation and by analyzing which vacant retail properties are of interest to live in. This information can then be used for policy development, implementation of zoning restrictions, and deployment of financial resources.

The second sub-question, " *What characteristics make a retail property suitable to be transformed into a house?*", is raised because inner-city retail properties can be quite different from an average house in terms of building characteristics and the surroundings. Literature reveals that transformations in the inner city do not yet seem to proceed fluently due to financial or legal issues such as zoning. The latter is also reflected in policies of many municipalities that only want retail in the plinth of the core shopping area to increase attractiveness. As a result, retail properties on the ground floor of this area are therefore considered not suitable for transformation. In addition, there are also some rules from the building code that exclude certain retail properties for transformation into a house. These rules mainly indicate the minimum dimensions that a property needs, but also the minimum daylighting and having its own entrance.

The third sub-question is: *"What inner city building and locational residential characteristics are considered and preferred by the different target groups?"*. A total of six different characteristics were extracted from the literature. These characteristics are applicable to the inner-city environment and could be considered by the different target groups identified, such as students, starters, and the elderly. In terms of location characteristics, there should be looked into the distance to public transportation, proximity to green space, proximity to parking space, and crowdedness of the street. In terms of building characteristics, there should be looked into floor area and price. Since no research has yet been done on people's residential preferences regarding inner-city retail properties, three extra building characteristics were identified by viewing inner city properties. This research will therefore also investigate people’s preferences regarding the historical appearance of the facade, the façade’s width, and the floor level of the potential house.

To investigate the inner city residential preferences, all nine characteristics are included in a discrete choice experiment (DCE). The DCE was distributed through a survey and completed by 103 individuals. The demographics of sample are somewhat more skewed than that of the Dutch population in 2022. People between the ages of 18 and 60 made this survey, most of whom are between the ages of 18 and 30. In addition, almost half of the respondents indicated that they are students. As there was no significant respondent group of starters or elderly, this meant that only the students’ residential preferences could be examined further. The results were analyzed using a multinomial logit model (MNL). An MNL is created for the full sample, for the students as the target group, and for employees/employers to use as a reference. The MNL model of the full sample shows that the distance to a public transport stop, a parking space, or a park all have a negative relationship with people's preferences. A large difference in walking distance to these amenities significantly increases utility. Additionally, regarding the location of the property, low and medium-crowded streets generate significantly higher utilities compared to high-crowded streets. The historical façade and its width appear to have minimal influence on people's residential preferences. Furthermore, the results show that people significantly prefer higher floors to the ground floor level. The total floor area and monthly rent price were the most important factors for making the choice, with larger areas and lower rents significantly improving utility. The MNL model of the student sample shows results quite similar to the model of the full sample. However, students seem to find price, accessibility, and parks more important.

The fourth sub-question focuses on the development of the tool by asking “*How can the identified exclusion criteria and residential preferences be integrated into a SDSS tool?”.* The spatial decision support tool is developed through the integration of the multi criteria decision analysis (MCDA) criteria in a geographical information system (GIS). The weights of the MCDA criteria, resulting from the discrete choice experiment, are used to implement people’s residential preferences. To implement the exclusion criteria and weights of the MCDA criteria in GIS, the databases of Locatus and OpenStreetMap are used. The exclusion criteria are only implemented in the tool by means of excluding properties on the ground floor of the core shopping area and the minimum square footage that is required. These criteria can be implemented in the tool in the form of a ‘difference’ polygon and a query respectively. Since the historical appearance and width of the façade did not seem to influence people's preferences according to the DCE, only seven of the nine MCDA criteria are included in the tool. Six of these MCDA criteria can be integrated into GIS by assigning them to corresponding variables in one of the two databases. Only the rent price per month is integrated slightly differently, using polygons to create an area using the radius from the busiest city center point.

To return to the main question. The tool that uses target group preferences to explore which vacant inner city retail properties are of interest to be transformed into houses can be created by integrating different components. The preferences of the target groups with regard to inner city housing must be captured in the form of weights for each criterion, in this case by using a DCE. From then on, these resulting criteria weights will be the MCDA criteria weights. Due to the limited response to the experiment, only the MCDA criteria weights of the student target group could be integrated into the tool. The MCDA criteria weights should only be applied in the tool to retail properties that can be considered for transformation into housing. Therefore, criteria are implemented to exclude retail properties that cannot be considered for transformation into housing based on restrictions and building regulations. Both the MCDA criteria weights and the exclusion criteria are then integrated into a GIS using Locatus and open-source databases. By automating the MCDA, a SDSS tool can be created. This tool can support municipalities make decisions regarding the transformation of vacant retail properties into housing by identifying properties that can be considered for transformation and by analyzing which retail properties have the highest residential utility. The information gained from the tool can be used as an incentive to initiate a transformation feasibility study, to gauge how retail property investors think about transforming of their retail property, or to take action by applying zoning restrictions.

Relevance

In this research, a tool is developed that can give Dutch municipalities more insight into the possibilities for inner city housing. To keep a grip on high retail vacancy rates, these insights can be used to provide decision support for the transformation of vacant retail properties into housing. The tool has the potential to serve as an incentive for municipalities to implement transformation decisions that could result in more appealing city centers and a reduction in pressure on the housing market.

Additionally, this research contributes to several different academic research fields. The first field is the research into residential preferences. Previous research by Troost (2023) is closely related to this subject. This research investigated visitors' preferences for possible functions in an inner city property. His research has shown that the characteristics of vacant retail properties can influence people's preferences for different functions, including the residential function. Different from research by Troost (2023), this research only examines the residential preferences in the inner city by looking at people's preferences from a resident's perspective, rather than a visitor's perspective. In that regard, this research provided more insight into where and in what inner city properties people would like to live.

Secondly, this research contributes to the academic field of the development of spatial decision support systems. It shows a method of implementing target groups' preference data in a geographic information system. The description of the tool's development process could be a source of new insights for scientists in the design of another tool.

Limitations

Several limitations were noted throughout the research. First, the current position of the inner city stakeholders is described using only policy documents and articles that can be found online. Although this can give a view of stakeholder interests in the transformation of vacant retail properties into housing, there can be matters that are only know internally and not published online. Because of this, there could be criteria that were not taken into account when developing the tool.

Second, a total of 103 respondents fully completed the survey. Despite the fact that significant values were produced by the model, it does make it difficult for the research to go into more depth on certain issues such as the preferences of different target groups. In addition, the demographics of the sample do not match that of the Dutch population. Thus, the model for residential preferences is not generalizable across the Dutch population. The sample was overrepresented by people between the ages of 18 and 30, and the category of people over 60 was completely absent. Because of this, this research could only look at the target group of students, and not starters and the elderly as well.

There were also some limitations regarding the assessment of the transformation suitability and the implementation of the MCDA criteria. This study measured a property's transformation suitability only against certain legal requirements. Due to a lack of data, it is not possible to also test matters such as daylighting. In addition, the research also does not consider the actual condition of the building and the costs that would be associated with transforming a property. To be able to apply the label 'suitable for transformation' on properties, a more thorough analysis should be done. Besides that, the MCDA criteria are not included in the tool exactly as described in the experiment. Due to limitations in data, facade width was not included in the tool at all, and price, historic facade, and distance to amenities were implemented a bit differently. Moreover, by choosing categorical variables in the experiment, it was not possible to include variables such as distances, price and square footage as a ratio value in the tool. The tool consequently limits itself to being able to determine less specific the residential utility of inner-city retail properties.

Lastly, the evaluation of the tool is based on assumptions. The effectiveness of the tool is evaluated through a case study based on the statements and purchasing behavior of a municipality, not specific plans. Additionally, the usability of the tool is evaluated separately by a person not involved in the transformation process. A case study proposed by a decision maker from the municipality would enhance the quality of the tool's evaluation.

Recommendations

The above limitations lead to several recommendations for future research in this field. In future research, it could be valuable to obtain detailed information from interviews with experts involved in inner-city transformations. They could not only tighten both the exclusion and evaluation criteria that are being used. They could also more effectively communicate what their points of interests are in the decision making process of the transformations of inner city retail properties.

Future research could use a different approach to obtaining residential preference data. In addition, it is possible to include other criteria in order to gain new insights regarding housing preferences in the inner city. Further, it might also be possible to distribute the survey only to specific target groups, such as the elderly, who were not represented in this research.

Future studies could also seek to improve the tool. If data on building or site characteristics of inner-city buildings become available, these could be incorporated into the tool. In addition, it could be explored whether there is a real-world case in which the tool could be further developed and/or tested in possible collaboration with stakeholders.

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9 APPENDICES

APPENDIX A: ORTHOGONALITY TEST

Correlations

		WD_Nearest_PTs	WD_Nearest_PP	WD_Nearest_Park	Crowdedness	Historical_facade	Floor_level	Width_facade	Floor_area	Rent_price
WD_Nearest_PTs	Pearson Correlation	1	.000	.000	.000	.000	.000	.000	.000	.000
	Sig. (2-tailed)		1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
	N	27	27	27	27	27	27	27	27	27
WD_Nearest_PP	Pearson Correlation	.000	1	.000	.000	.000	.000	.000	.000	.000
	Sig. (2-tailed)	1.000		1.000	1.000	1.000	1.000	1.000	1.000	1.000
	N	27	27	27	27	27	27	27	27	27
WD_Nearest_Park	Pearson Correlation	.000	.000	1	.000	.000	.000	.000	.000	.000
	Sig. (2-tailed)	1.000	1.000		1.000	1.000	1.000	1.000	1.000	1.000
	N	27	27	27	27	27	27	27	27	27
Crowdedness	Pearson Correlation	.000	.000	.000	1	.000	.000	.000	.000	.000
	Sig. (2-tailed)	1.000	1.000	1.000		1.000	1.000	1.000	1.000	1.000
	N	27	27	27	27	27	27	27	27	27
Historical_facade	Pearson Correlation	.000	.000	.000	.000	1	.000	.000	.000	.000
	Sig. (2-tailed)	1.000	1.000	1.000	1.000		1.000	1.000	1.000	1.000
	N	27	27	27	27	27	27	27	27	27
Floor_level	Pearson Correlation	.000	.000	.000	.000	.000	1	.000	.000	.000
	Sig. (2-tailed)	1.000	1.000	1.000	1.000	1.000		1.000	1.000	1.000
	N	27	27	27	27	27	27	27	27	27
Width_facade	Pearson Correlation	.000	.000	.000	.000	.000	.000	1	.000	.000
	Sig. (2-tailed)	1.000	1.000	1.000	1.000	1.000	1.000		1.000	1.000
	N	27	27	27	27	27	27	27	27	27
Floor_area	Pearson Correlation	.000	.000	.000	.000	.000	.000	.000	1	.000
	Sig. (2-tailed)	1.000	1.000	1.000	1.000	1.000	1.000	1.000		1.000
	N	27	27	27	27	27	27	27	27	27
Rent_price	Pearson Correlation	.000	.000	.000	.000	.000	.000	.000	.000	1
	Sig. (2-tailed)	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	
	N	27	27	27	27	27	27	27	27	27

APPENDIX B: ALTERNATIVES

Alternative	WD_PT	WD_PP	WD_Park	Crowdedness	Histocial	Floor_level	Façade_width	Floor_area	Rent_pm	Dominance
1	250m	100m	1300m	Medium	50%	Ground	7.5m	40m2	1300euro	7
2	750m	300m	1300m	Low	0%	First	7.5m	40m2	900euro	7
3	500m	300m	1300m	Medium	0%	Ground	10m	60m2	1100euro	7
4	500m	300m	800m	High	50%	Ground	5m	60m2	900euro	7
5	750m	100m	800m	Low	100%	Second	5m	60m2	1300euro	10
6	500m	500m	800m	Low	0%	Second	10m	40m2	900euro	10
7	250m	500m	800m	Medium	0%	First	5m	60m2	1100euro	7
8	500m	100m	800m	Medium	100%	First	7.5m	80m2	900euro	13
9	750m	300m	800m	Medium	50%	First	10m	40m2	1300euro	7
10	750m	500m	1300m	Medium	100%	Ground	5m	80m2	900euro	7
11	500m	100m	300m	High	0%	First	10m	80m2	1300euro	10
12	250m	300m	300m	Medium	100%	Second	10m	80m2	900euro	**16**
13	250m	500m	300m	High	50%	First	7.5m	60m2	900euro	10
14	750m	500m	300m	Low	50%	Ground	10m	80m2	1100euro	10
15	250m	100m	800m	High	100%	Ground	10m	40m2	1100euro	10
16	500m	100m	1300m	Low	50%	First	5m	80m2	1100euro	10
17	250m	300m	1300m	High	0%	Second	5m	80m2	1300euro	7
18	250m	100m	300m	Low	0%	Ground	5m	40m2	900euro	10
19	750m	100m	300m	Medium	0%	Second	7.5m	60m2	1100euro	10
20	250m	500m	1300m	Low	100%	First	10m	60m2	1300euro	10
21	750m	300m	300m	High	100%	First	5m	40m2	1100euro	7
22	500m	500m	300m	Medium	50%	Second	5m	40m2	1300euro	7
23	250m	300m	800m	Low	50%	Second	7.5m	80m2	1100euro	13
24	750m	500m	800m	High	0%	Ground	7.5m	80m2	1300euro	**4**
25	500m	500m	1300m	High	100%	Second	7.5m	40m2	1100euro	7
26	750m	100m	1300m	High	50%	Second	10m	60m2	900euro	10
27	500m	300m	300m	Low	100%	Ground	7.5m	60m2	1300euro	10

APPENDIX C: CHOICE SETS

Choice tasks	Alt.1	Alt.2	Choice tasks	Alt.1	Alt.2
DC1	1	17	**DC28**	27	17
DC2	2	5	**DC29**	26	5
DC3	3	27	**DC30**	25	27
DC4	4	3	**DC31**	24	3
DC5	5	9	**DC32**	23	9
DC6	6	12	**DC33**	22	12
DC7	7	20	**DC34**	21	20
DC8	8	13	**DC35**	20	13
DC9	9	7	**DC36**	19	7
DC10	10	26	**DC37**	18	26
DC11	11	14	**DC38**	17	14
DC12	12	8	**DC39**	16	8
DC13	13	19	**DC40**	15	19
DC14	14	15	**DC41**	14	15
DC15	15	23	**DC42**	13	23
DC16	16	10	**DC43**	12	10
DC17	17	6	**DC44**	11	6
DC18	18	16	**DC45**	10	16
DC19	19	24	**DC46**	9	24
DC20	20	4	**DC47**	8	4
DC21	21	18	**DC48**	7	18
DC22	22	25	**DC49**	6	25
DC23	23	21	**DC50**	5	21
DC24	24	1	**DC51**	4	1
DC25	25	22	**DC52**	3	22
DC26	26	11	**DC53**	2	11
DC27	27	2	**DC54**	1	2

APPENDIX D: LIMESURVEY (IN DUTCH)

TU/e EINDHOVEN UNIVERSITY OF TECHNOLOGY DEPARTMENT OF THE BUILT ENVIRONMENT

Wonen in de binnenstad

0%

* Waar woont u op dit moment?

Kies één van de volgende antwoorden

- In een grote stad (>100.000 inwoners)
- In een middelgrote stad (30.000-100.000 inwoners)
- In een kleine stad / dorp (<30.000 inwoners)
- Gebied buiten een stad of dorp

* Hoe ligt uw huis georienteerd ten opzichte van het centrum van de stad?

Kies één van de volgende antwoorden

- In het centrum
- 0,5 km van het centrum (±5 min lopen)
- 1 km van het centrum (±10 min lopen)
- 2 km van het centrum (±20 min lopen)
- 3 of meer km van het centrum (>±30 min lopen)

* Heeft u ooit overwogen om in het centrum van een stad te gaan wonen?

Kies één van de volgende antwoorden

- Ja
- Nee

Vul hier uw opmerkingen in:

Indien u ja hebt geantwoord, licht uw antwoord toe.

* Welke van de onderstaande kenmerken van een stadscentrum spreken u aan?

Meerdere antwoorden mogelijk

- Nabijheid van openbaar vervoer
- Aanwezigheid van dagelijkse winkels (bakker, supermarkt, drogist)
- Aanwezigheid van eet-, drink- en ontspan-plekken
- Levendige plekken en bruisende straten
- De charme van de historische architectuur
- Anders:

* Hoe prettig vindt u drukte in de woonomgeving?

Kies één van de volgende antwoorden

Indien u 'Anders:' kiest, licht deze keuze dan toe in het bijbehorende tekstvak.

◯ Ik vind het prettig als het leeft rondom mijn woning

◯ Ik heb geen voorkeur voor veel of weinig drukte

◯ Ik vind het niet prettig, ik ervaar liever rust

◯ Anders: ____________

❓ Een binnenstad kan erg levendig zijn, met veel verkeer, mensen en activiteiten.

---

* Welke vervoersmiddelen heeft u momenteel in bezit?

❶ Meerdere antwoorden mogelijk

☐ Fiets

☐ Elektrische fiets

☐ Scooter

☐ Bromfiets

☐ Auto

☐ OV-abonnement

☐ Anders: ____________

---

* Welke vervoersmiddel gebruikt u momenteel het meest naar uw werk (of school)?

❶ Kies één van de volgende antwoorden
❶ Indien u 'Anders:' kiest, licht deze keuze dan toe in het bijbehorende tekstvak.

◯ Lopen

◯ (Elektrische) Fiets

◯ Scooter/Bromfiets

◯ Openbaar vervoer

◯ Auto

◯ Niet van toepassing

◯ Anders: ____________

---

* Welke vervoersmiddel gebruikt u momenteel het meest in uw vrije tijd?

❶ Kies één van de volgende antwoorden
❶ Indien u 'Anders:' kiest, licht deze keuze dan toe in het bijbehorende tekstvak.

◯ Lopen

◯ (Elektrische) Fiets

◯ Scooter/Bromfiets

◯ Openbaar vervoer

◯ Auto

◯ Niet van toepassing

◯ Anders: ____________

---

* Welke vervoersmiddel gebruikt u momenteel het meest in uw vrije tijd?

❶ Kies één van de volgende antwoorden
❶ Indien u 'Anders:' kiest, licht deze keuze dan toe in het bijbehorende tekstvak.

- Lopen
- (Elektrische) Fiets
- Scooter/Bromfiets
- Openbaar vervoer
- Auto
- Anders: ______

Wonen in de binnenstad

6%

Informatieblad

In de Nederlandse binnensteden bevinden zich leegstaande winkelpanden. Deze leegstand vormt een uitdaging, maar ook een kans voor vernieuwing en herontwikkeling. Leegstaande winkelpanden kunnen herontwikkeld worden naar woningen. Er is alleen nog niet veel bekend over wat mensen vinden om te wonen op een specieke plek als de binnenstad. Dit onderzoek wil hier meer inzicht in krijgen door middel van uw antwoorden in deze vragenlijst.

Uw voorkeur voor een bepaalde woning kan terug worden geleid naar de kenmerken waar deze woning over beschikt. Een woning kan op een gunstige locatie liggen, van een gewenste grootte zijn of een mooi uiterlijk hebben.

In deze vragenlijst zijn winkelpanden in de binnenstad beschreven aan de hand van negen kenmerken. Vier kenmerken zijn gerelateerd aan de **locatie van het pand** en vijf kenmerken zijn gerelateerd aan **het pand zelf.** De onderstaande tabel toont de kenmerken met de bijbehorende mogelijkheden, ook wel waarden genoemd. De minder voor de hand liggende kenmerken worden in onderstaande illustraties gedefinieerd.

	Kenmerken	Waarden
Locatie	Loopafstand naar de dichtstbijzijnde openbaar vervoer halte	250m; 500m; 750m
	Loopafstand naar de dichtstbijzijnde (prive) parkeerplek	100m; 300m; 500m
	Loopafstand naar het dichtstbijzijnde park (>5000m2)	300m; 800m; 1300m
	Drukte op straat (zie hieronder)	Laag; Gemiddeld; Hoog
Gebouw	Historische gevel (zie hieronder)	0%; 50%; 100%
	Verdieping van de nieuwe woning	Begane; Eerste; Tweede
	Gevelbreedte (zie hieronder)	5m; 7,5m; 10m
	Totaal vloeroppervlakte	40m2; 60m2; 80m2
	Huurprijs per maand	€900; €1100; €1300

Definities van niveaus van enkele kenmerken:

Op de volgende pagina wordt u gevraagd een keuze te maken in welk binnenstedelijk (winkel)pand u liever zou willen wonen. U krijgt negen keuzen voorgelegd waarbij u steeds kan kiezen voor 'Pand A', 'Pand B' of 'Geen van beide'. Elk pand is anders en is beschreven aan de hand van de bovenstaande kenmerken. Hieronder volgt een voorbeeldvraag. Neem de mogelijkheden goed door en maak een keuze.

Voorbeeld vraag: *Welk binnenstedelijk pand heeft uw voorkeur?*

		Pand A	Pand B	Geen van beide
Locatie	Openbaar vervoer halte	250m	250m	
	(Prive) parkeerplek	100m	300m	
	Park (>5000m2)	1300m	1300m	
	Drukte op straat	Gemiddeld	Hoog	
Gebouw	Historische gevel	50%	0%	-
	Verdieping	Begane	Tweede	
	Gevelbreedte	7,5m	5,0m	
	Totaal vloeroppervlakte	40m2	80m2	
	Huurprijs per maand	€1300	€1300	

Kies één van de volgende antwoorden

Pand A	Pand B	Geen van beide

Let op, de kenmerken zijn korter beschreven.

Wonen in de binnenstad

12%

Keuzevragen

De keuzevragen beginnen hieronder.
U krijgt negen keuzes voorgelegd waarbij u steeds kan kiezen voor 'Pand A', 'Pand B' of 'Geen van beide'.
Elk pand is uniek en verschilt dus in samenstelling.

Let op, als u niet verder kunt na op Volgende te hebben gedrukt, dan bent u een vraag vergeten te beantwoorden.

* Welk binnenstedelijk pand heeft uw voorkeur?

		Pand A	Pand B	Geen van beide
Locatie	Openbaar vervoer halte	250m	250m	
	(Prive) parkeerplek	100m	300m	
	Park (>5000m2)	1300m	1300m	
	Drukte op straat	Gemiddeld	Hoog	
Gebouw	Historische gevel	50%	0%	-
	Verdieping	Begane	Tweede	
	Gevelbreedte	7,5m	5,0m	
	Totaal vloeroppervlakte	40m2	80m2	
	Huurprijs per maand	€1300	€1300	

Kies één van de volgende antwoorden

Pand A	Pand B	Geen van beide

+ 7 OTHER CHOICE TASKS.

* Welk binnenstedelijk pand heeft uw voorkeur?

		Pand A	Pand B	Geen van beide
Locatie	Openbaar vervoer halte	750m	250m	-
	(Prive) parkeerplek	300m	500m	
	Park (>5000m2)	800m	800m	
	Drukte op straat	Gemiddeld	Gemiddeld	
Gebouw	Historische gevel	50%	0%	
	Verdieping	Eerste	Eerste	
	Gevelbreedte	10m	5,0m	
	Totaal vloeroppervlakte	40m2	60m2	
	Huurprijs per maand	€1300	€1100	

Kies één van de volgende antwoorden

Pand A | Pand B | Geen van beide

Wonen in de binnenstad

50%

Bedankt voor het opgeven van uw voorkeuren! Nu volgt het laatste deel van de enquête. Hieronder worden een aantal vragen gesteld over uzelf. De antwoorden op deze vragen volledig annoniem en worden ze enkel gebruikt voor wetenschappelijk onderzoek.

* In welke leeftijdscategorie valt u?

Kies één van de volgende antwoorden

- ◯ Jonger dan 18 jaar
- ◯ 18-24 jaar
- ◯ 25-30 jaar
- ◯ 31-40 jaar
- ◯ 41-50 jaar
- ◯ 51-60 jaar
- ◯ 61-66 jaar
- ◯ 67 jaar en ouder

* Wat is uw geslacht?

Kies één van de volgende antwoorden

- ◯ Man
- ◯ Vrouw
- ◯ Anders, of zeg ik liever niet

* Welk van de volgende categorieën is voor u het meest van toepassing?

Kies één van de volgende antwoorden

Indien u 'Anders:' kiest, licht deze keuze dan toe in het bijbehorende tekstvak.

- ◯ Student
- ◯ Werknemer/werkgever
- ◯ Met pensioen
- ◯ Anders: ______

* Wat is de samenstelling van uw huishouden?

Kies één van de volgende antwoorden

Indien u 'Anders:' kiest, licht deze keuze dan toe in het bijbehorende tekstvak.

- ◯ Alleenstaand
- ◯ Alleenstaand, met kind(eren)
- ◯ Samenwonend, zonder kinderen
- ◯ Samenwonend, met kind(eren)
- ◯ Zeg ik liever niet
- ◯ Anders: ______

* Wat is het bruto jaarinkomen van uw huishouden?

Kies één van de volgende antwoorden

Indien u 'Anders:' kiest, licht deze keuze dan toe in het bijbehorende tekstvak.

- ○ Minder dan €20.000
- ○ €20.000 tot €40.000
- ○ €40.000 tot €60.000
- ○ €60.000 tot €80.000
- ○ Meer dan €80.000
- ○ Zeg ik liever niet

---

* Wat zijn de vier cijfers van uw postcode?

In dit veld mogen alleen cijfers ingevoerd worden.

Voer enkel de vier cijfers van uw postcode in (zonder de letters)

---

* Bent u bereid negen extra keuzevragen te maken?

Kies één van de volgende antwoorden

- ○ Ja
- ○ Nee

Antwoorden op deze vragen ondersteunen het onderzoek

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IF final question = 'Ja' → + 9 CHOICE TASKS.

IF final question = 'Nee' →

Wonen in de binnenstad

93%

Vragen en opmerkingen

The Survey Code is: GY6R-QH2R-JN35-X8V9, https://www.surveycircle.com/GY6R-QH2R-JN35-X8V9/

Heeft u nog vragen of opmerkingen over deze enquête of het onderzoek?

U kunt hier de vraag stellen of een mail sturen naar d.j.m.krus@student.tue.nl

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APPENDIX E: SURVEY DISTRIBUTION

Dirk Krus • U
Master Student CME & USRE, TU/e | Junior projectmanager, Stevens Van Dijck
3 w •

"De woningnood is zo hoog en ik zie in de binnenstad nog regelmatig winkelpanden die leeg staan, kunnen we daar niet iets mee?"

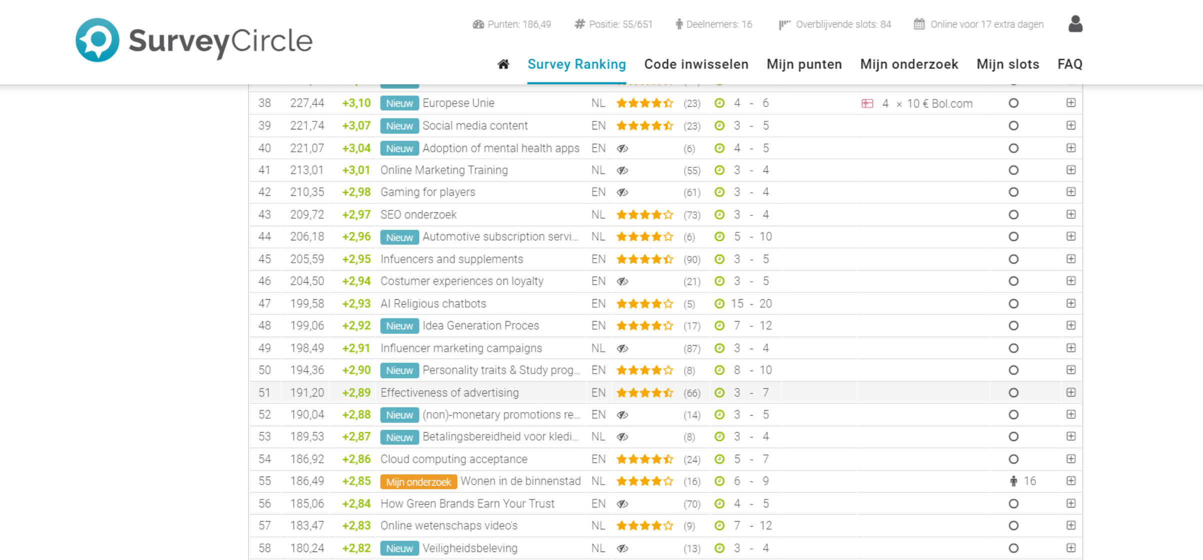
In de Nederlandse binnensteden bevinden zich leegstaande winkelpanden. Deze leegstand vormt een uitdaging, maar ook een kans voor vernieuwing en herontwikkeling. Leegstaande winkelpanden kunnen bijvoorbeeld herontwikkeld worden naar woningen. Er is alleen nog niet veel bekend over wat mensen vinden om te wonen in een winkelpand op een speciale plek als de binnenstad.

In mijn afstudeeronderzoek aan de Technische Universiteit Eindhoven wil ik hier graag meer inzicht in verkrijgen door middel van de onderstaande enquête.

Het invullen van deze enquête zou mij enorm helpen en duurt ±10min.

#vastgoed #retail #wonen #transformatie #onderzoek

Wonen in de binnenstad
tue-be-usre.my-survey.host



SurveyCircle

Punten: 186,49 | Positie: 55/651 | Deelnemers: 16 | Overblijvende slots: 84 | Online voor 17 extra dagen

Survey Ranking | Code inwisselen | Mijn punten | Mijn onderzoek | Mijn slots | FAQ

38	227,44	+3,10	Nieuw	Europese Unie	NL	★★★★½	(23)	4 - 6	4 × 10 € Bol.com	
39	221,74	+3,07	Nieuw	Social media content	EN	★★★★½	(23)	3 - 5		
40	221,07	+3,04	Nieuw	Adoption of mental health apps	EN		(6)	4 - 5		
41	213,01	+3,01		Online Marketing Training	NL		(55)	3 - 4		
42	210,35	+2,98		Gaming for players	EN		(61)	3 - 4		
43	209,72	+2,97		SEO onderzoek	NL	★★★★☆	(73)	3 - 4		
44	206,18	+2,96	Nieuw	Automotive subscription servi...	NL	★★★★☆	(6)	5 - 10		
45	205,59	+2,95		Infuencers and supplements	EN	★★★★½	(90)	3 - 5		
46	204,50	+2,94		Costumer experiences on loyalty	EN		(21)	3 - 5		
47	199,58	+2,93		AI Religious chatbots	EN	★★★★☆	(5)	15 - 20		
48	199,06	+2,92	Nieuw	Idea Generation Proces	EN	★★★★☆	(17)	7 - 12		
49	198,49	+2,91		Influencer marketing campaigns	NL		(87)	3 - 4		
50	194,36	+2,90	Nieuw	Personality traits & Study prog...	EN	★★★★☆	(8)	8 - 10		
51	191,20	+2,89		Effectiveness of advertising	EN	★★★★½	(66)	3 - 7		
52	190,04	+2,88	Nieuw	(non)-monetary promotions re...	EN		(14)	3 - 5		
53	189,53	+2,87	Nieuw	Betalingsbereidheid voor kledi...	NL		(8)	3 - 4		
54	186,92	+2,86		Cloud computing acceptance	EN	★★★★½	(24)	5 - 7		
55	186,49	+2,85	Mijn onderzoek	Wonen in de binnenstad	NL	★★★★☆	(16)	6 - 9		16
56	185,06	+2,84		How Green Brands Earn Your Trust	EN		(70)	4 - 5		
57	183,47	+2,83		Online wetenschaps video's	NL	★★★★☆	(9)	7 - 12		
58	180,24	+2,82	Nieuw	Veiligheidsbeleving	NL		(13)	3 - 4		

APPENDIX F: DESCRIPTIVE STATISTICS

Gender:

Wat is uw geslacht?

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Man	51	49.5	49.5	49.5
	Vrouw	52	50.5	50.5	100.0
	Total	103	100.0	100.0	

Age category:

In welke leeftijdscategorie valt u?

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	18-24 jaar	47	45.6	45.6	45.6
	25-30 jaar	32	31.1	31.1	76.7
	31-40 jaar	6	5.8	5.8	82.5
	41-50 jaar	5	4.9	4.9	87.4
	51-60 jaar	12	11.7	11.7	99.0
	61-66 jaar	1	1.0	1.0	100.0
	Total	103	100.0	100.0	

Household composition:

Wat is de samenstelling van uw huishouden?

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	-oth	14	13.6	13.6	13.6
	Alleenstaand	36	35.0	35.0	48.5
	Samenwonend, zonder kinderen	40	38.8	38.8	87.4
	Samenwonend, met kind (eren)	11	10.7	10.7	98.1
	Zeg ik liever niet	2	1.9	1.9	100.0
	Total	103	100.0	100.0	

[Overige] Wat is de samenstelling van uw huishouden?

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid		89	86.4	86.4	86.4
	Bij ouders	1	1.0	1.0	87.4
	huisgenoot	1	1.0	1.0	88.3
	Huisgenoten	1	1.0	1.0	89.3
	Ik woon nog bij mijn ouders	1	1.0	1.0	90.3
	Inwonend bij vader	1	1.0	1.0	91.3
	Nog thuis wonend	1	1.0	1.0	92.2
	Samenwonend met huisgenoot	1	1.0	1.0	93.2
	Samenwonend, met vader en zusje	1	1.0	1.0	94.2
	Studenten huis	1	1.0	1.0	95.1
	studentenhuis	1	1.0	1.0	96.1
	Studentenhuis	2	1.9	1.9	98.1
	Thuiswonend bij ouders	1	1.0	1.0	99.0
	Thuiswonende	1	1.0	1.0	100.0
	Total	103	100.0	100.0	

Welk van de volgende categorieën is voor u het meest van toepassing? * Wat is de samenstelling van uw huishouden? Crosstabulation

Count

		Wat is de samenstelling van uw huishouden?					
		-oth	Alleenstaand	Samenwonend, zonder kinderen	Samenwonend, met kind (eren)	Zeg ik liever niet	Total
Welk van de volgende categorieën is voor u het meest van toepassing?	-oth	0	0	1	0	0	1
	Student	8	27	10	1	2	48
	Werknemer/werkgever	6	9	29	10	0	54
Total		14	36	40	11	2	103

Household income:

Wat is het bruto jaarinkomen van uw huishouden?

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Minder dan €20.000	28	27.2	27.2	27.2
	€20.000 tot €40.000	11	10.7	10.7	37.9
	€40.000 tot €60.000	25	24.3	24.3	62.1
	€60.000 tot €80.000	14	13.6	13.6	75.7
	Meer dan €80.000	15	14.6	14.6	90.3
	Zeg ik liever niet	10	9.7	9.7	100.0
	Total	103	100.0	100.0	

Which category is most in line with your current situation:

Welk van de volgende categorieën is voor u het meest van toepassing?

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	-oth	1	1.0	1.0	1.0
	Student	48	46.6	46.6	47.6
	Werknemer/werkgever	54	52.4	52.4	100.0
	Total	103	100.0	100.0	

[Overige] Welk van de volgende categorieën is voor u het meest van toepassing?

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid		102	99.0	99.0	99.0
	Zelfstandig raadgevend ingenieur	1	1.0	1.0	100.0
	Total	103	100.0	100.0	

APPENDIX G: MNL IN R

Full model

```
Call:
mlogit(formula = Choice ~ -1 + Con + A1a + A1b + A2a + A2b +
    A3a + A3b + A4a + A4b + A5a + A5b + A6a + A6b + A7a + A7b +
    A8a + A8b + A9a + A9b, data = MNLdata, method = "nr")

Frequencies of alternatives:choice
      1       2       3
0.45098 0.44444 0.10458

nr method
5 iterations, 0h:0m:0s
g'(-H)^-1g = 0.00134
successive function values within tolerance limits

Coefficients :
     Estimate Std. Error  z-value  Pr(>|z|)
Con -1.137003   0.194664  -5.8409 5.193e-09 ***
A1a  0.289920   0.108786   2.6651 0.0076976 **
A1b  0.157026   0.119665   1.3122 0.1894480
A2a  0.367873   0.103377   3.5586 0.0003729 ***
A2b  0.194798   0.102277   1.9046 0.0568289 .
A3a  0.356565   0.099342   3.5893 0.0003316 ***
A3b  0.206536   0.109106   1.8930 0.0583597 .
A4a  0.463033   0.087617   5.2847 1.259e-07 ***
A4b  0.434132   0.100119   4.3361 1.450e-05 ***
A5a -0.088547   0.112385  -0.7879 0.4307595
A5b -0.068133   0.101299  -0.6726 0.5012046
A6a -0.604515   0.107459  -5.6255 1.849e-08 ***
A6b -0.379443   0.107683  -3.5237 0.0004256 ***
A7a -0.199020   0.105433  -1.8876 0.0590740 .
A7b  0.190540   0.112941   1.6871 0.0915890 .
A8a -1.559203   0.119792 -13.0159 < 2.2e-16 ***
A8b -0.513977   0.117143  -4.3876 1.146e-05 ***
A9a  1.263002   0.120734  10.4611 < 2.2e-16 ***
A9b  0.572909   0.107335   5.3376 9.419e-08 ***
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Log-Likelihood: -1257.2
```

Student model

```
Call:
mlogit(formula = Choice ~ -1 + Con + A1a + A1b + A2a + A2b +
    A3a + A3b + A4a + A4b + A5a + A5b + A6a + A6b + A7a + A7b +
    A8a + A8b + A9a + A9b, data = MNLdata_students, method = "nr")

Frequencies of alternatives:choice
       1        2        3
0.487407 0.468148 0.044444

nr method
6 iterations, 0h:0m:0s
g'(-H)^-1g = 8.86E-05
successive function values within tolerance limits

Coefficients :
     Estimate Std. Error z-value  Pr(>|z|)
Con -2.025266   0.329400 -6.1483 7.830e-10 ***
A1a  0.430204   0.174835  2.4606  0.013869 *
A1b -0.081163   0.195670 -0.4148  0.678292
A2a  0.452419   0.165089  2.7405  0.006135 **
A2b  0.297666   0.161074  1.8480  0.064602 .
A3a  0.749962   0.163103  4.5981 4.264e-06 ***
A3b  0.402322   0.175768  2.2889  0.022083 *
A4a  0.451551   0.131375  3.4371  0.000588 ***
A4b  0.329635   0.151477  2.1761  0.029545 *
A5a -0.071011   0.178057 -0.3988  0.690031
A5b -0.267010   0.155192 -1.7205  0.085339 .
A6a -0.706403   0.177831 -3.9723 7.117e-05 ***
A6b -0.406526   0.173815 -2.3388  0.019343 *
A7a -0.512317   0.171388 -2.9892  0.002797 **
A7b -0.012103   0.179671 -0.0674  0.946292
A8a -1.406644   0.191572 -7.3426 2.094e-13 ***
A8b -0.435073   0.188459 -2.3086  0.020967 *
A9a  1.515353   0.201249  7.5297 5.085e-14 ***
A9b  0.749508   0.170825  4.3876 1.146e-05 ***
---
Signif. codes:
0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Log-Likelihood: -470.87
```

Employees/Employers model

```
Call:
mlogit(formula = Choice ~ -1 + Con + A1a + A1b + A2a + A2b +
    A3a + A3b + A4a + A4b + A5a + A5b + A6a + A6b + A7a + A7b +
    A8a + A8b + A9a + A9b, data = MNL_data_employees, method = "nr")

Frequencies of alternatives:choice
      1       2       3
0.41546 0.42754 0.15700

nr method
5 iterations, 0h:0m:0s
g'(-H)^-1g = 4.99E-05
successive function values within tolerance limits

Coefficients :
     Estimate Std. Error  z-value  Pr(>|z|)
Con -0.613693   0.257823  -2.3803  0.017299 *
A1a  0.265746   0.148155   1.7937  0.072861 .
A1b  0.326462   0.159193   2.0507  0.040293 *
A2a  0.363891   0.140310   2.5935  0.009501 **
A2b  0.179560   0.140129   1.2814  0.200059
A3a  0.111554   0.134586   0.8289  0.407180
A3b  0.093250   0.147538   0.6320  0.527360
A4a  0.566648   0.125777   4.5052 6.631e-06 ***
A4b  0.602101   0.140866   4.2743 1.918e-05 ***
A5a -0.053732   0.153773  -0.3494  0.726770
A5b  0.134201   0.141332   0.9495  0.342345
A6a -0.601445   0.143607  -4.1881 2.813e-05 ***
A6b -0.391699   0.145981  -2.6832  0.007292 **
A7a -0.005961   0.140783  -0.0423  0.966226
A7b  0.331045   0.152471   2.1712  0.029916 *
A8a -1.785192   0.165756 -10.7700 < 2.2e-16 ***
A8b -0.615791   0.155739  -3.9540 7.685e-05 ***
A9a  1.128837   0.158822   7.1076 1.181e-12 ***
A9b  0.452709   0.146493   3.0903  0.002000 **
---
Signif. codes:
0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Log-Likelihood: -722.08
```

Appendix H: Selection of the problem area

	Total properties	Vacant properties	Vacancy rate
Inner city			
Alkmaar	779	53	7%
Amsterdam	5045	208	4%
Arnhem	**826**	**90**	**11%**
Breda	949	78	8%
Dordrecht	744	60	8%
Eindhoven	809	46	6%
Groningen	1365	86	6%
Haarlem	1052	64	6%
Leiden	1069	48	4%
Maastricht	**1293**	**110**	**9%**
Nijmegen	900	76	8%
Rotterdam	**1576**	**158**	**10%**
S-Gravenhage	1701	122	7%
'S-Hertogenbosch	874	62	7%
Utrecht	1471	105	7%
Large main shopping area			
Almere	484	36	7%
Amersfoort	592	57	10%
Apeldoorn	**578**	**97**	**17%**
Assen	**427**	**82**	**19%**
Bergen op Zoom	**443**	**86**	**19%**
Delft	686	43	6%
Deventer	599	56	9%
Emmen	435	61	14%
Enschede	610	65	11%
Gouda	535	48	9%
Heerlen	**535**	**132**	**25%**
Hilversum	627	70	11%
Hoorn Nh	510	50	10%
Leeuwarden	645	41	6%
Middelburg	506	34	7%
Roermond	**515**	**91**	**18%**
Schiedam	417	58	14%
Sittard	**429**	**87**	**20%**
Tilburg	626	65	10%
Veenendaal	**427**	**68**	**16%**
Venlo	558	79	14%
Zaandam	463	35	8%
Zeist	429	57	13%
Zutphen	429	33	8%
Zwolle	597	41	7%

Appendix I: Observations in Heerlen's city center

Oranje Nassaustraat number 19, 20 and 24:

Geleenstraat number 38, 51, 56, 59 and 72:

Observations Oranje Nassaustraat:



Observations Geleenstraat: