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A Study in Spatial and Transportation Mismatch in Rotterdam

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Summary

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Spatial mismatch is a hypothesis developed by the late J.F. Kain in 1968 to describe the housing situation in many Midwestern cities in the United States. Over the years the hypothesis has transformed into theories relating to sociology and some recently relating to transportation. In some circles it is believed that transportation mismatch exists more in cities due to citizens lacking access to their transportation infrastructure. But this infrastructure is severely limited by its modes which are narrowed down to basically just roads. So would transportation mismatch exist if a multimodal network of transportation options existed? That is the main question this study is attempting to discover.

The city of Rotterdam, Netherlands has been chosen for its diverse transportation infrastructure, unique spatial structure compared to other Dutch cities and large amount of job seekers. In this study the impact of public transportation access and its role in preventing spatial mismatch especially in areas of lower socioeconomic status will be measured. To accomplish this task, qualitative interviews will take place with researchers and riders of Rotterdam's Metro system. There will also be a quantitative study done using the gravity model which will provide the scores necessary to judge the accessibility of both public and private transportation in various postcodes in Rotterdam and surrounding municipalities.

Through this study it was found that areas of highest accessibility fell within the City Center, yet many districts close to the inner city were left with poor accessibility despite their very good location. These neighbourhoods were also found to be in already deprived areas of the city. The communities seemed to be experiencing the symptoms of spatial mismatch but there did not seem to be a solution put into place to prevent the problem. Other distant and more affluent neighbourhoods with high car ownership had no problem with spatial mismatch. Granting car ownership to more of the residents would seem like a good idea but the income of the neighbourhoods made it difficult for that to become a reality. Providing better access to the Metro line would also be an alternative, yet some of these communities were spatially divided from the Metro line by roads, canals or simply distance. There must be a solution to the problem though.

What was found through the research is that in some troubled districts with low car ownership, low income and spatially divided from the Metro line a housing strategy was able to clean up the neighbourhood. This strategy built middle class homes in deprived neighbourhoods in the location furthest from public transport access. This modernisation of the neighbourhood prevents lower income groups from expanding further from their public transport options and provides the roads with residents who will access them. Accessibility to public transport can have a positive effect on lower income communities but that access is severely limited if the neighbourhood's spatial structure is built more for private transport than public.

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Foreword

The ideas for this thesis all began after a record breaking heat wave in Austin, TX. During that blistering summer, I became so frustrated with the city's design that I figured I could do a better job. With that I sought out an urban planning degree from the nation of urban planners, the Netherlands. Upon moving here I experienced life without a car for the first time since I began driving at the age of 16. I was not trapped by my lack of car ownership, in fact I felt more free than ever. I did recall that there were many communities in the United States that were trapped by their lack of car ownership and these neighbourhoods were the infamous ghettos of American society. Perhaps if these ghettos had the same transport options that I as a poor university student had then maybe the community would not be so deprived anymore. With that I began my research into spatial mismatch theory and my study of Rotterdam to see if maybe accessible public transportation was the solution to blighted urban communities.

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Chapter One: Introduction

An analysis on the effect accessibility to a transportation network with multimodal forms has had on two different neighborhoods according to the ideals of spatial mismatch theory.

Transportation has been important to survival since humans first walked the Earth. The modes of transportation have evolved from simply crawling as a baby to the complicated process of the steam engine and even to the highly scientific point of rocket power. During this evolution, societies have developed their cities around their transportation, but what happens to societies when they can no longer connect with the transportation technology they have before them. This research will be used to demonstrate just how important an access to multimodal transport is for the socio-economic development of two communities in Rotterdam. The research will compare one neighborhood that was in decline but is now becoming stronger and another neighborhood that is showing signs of decline; both of these lie along the Rotterdam metro line network. The paper will focus on three aspects: socioeconomic position, accessibility to public transport and spatial mismatch. Out of these aspects two hypotheses will be tested. One of the hypotheses to be tested is that access to public transport is a factor that can benefit the socioeconomic status of a lower income neighborhood. The other hypothesis is that an availability of public transport can prevent a spatial mismatch in a city if properly provided. The research to test these ideas will be conducted in the neighborhoods of Hoogvliet and Capelle a/d IJssel. These areas have been chosen because they are of similar distance from the center of Rotterdam, similar in geographical size, similar in access to public transport and each is progressing towards opposite ends of the socioeconomic spectrum. These two neighborhoods are both far enough away from the core location of low-skilled jobs that automobile transportation would be a necessity to access the job network if public transport was not provided. Rotterdam also creates the added benefit towards the research of having a large collection of low-skill jobs due to the port. The port is, however, not as well accessed by public transport as that of the inner city. While the research will be conducted here in the Netherlands, there will be a small comparative to the literature used, which is typically from the United States and to cities in the United States as they begin to push towards a more multimodal transportation infrastructure. The reason for the use of United States literature in the research is that the concept of spatial mismatch was contrived in America and it will offer a nice comparative to the European urban plan. Hopefully the information provided by this research will determine whether a successfully implemented multimodal transportation network can prevent the occurrence of spatial mismatch in communities. If these hypotheses are proved correct, the knowledge can be used to save money by directing construction of multimodal transport networks to neighborhoods whose limited accessibility has created a spatial mismatch in relation to their transportation needs. It will also help to guide development policy in the direction of public transit which should help make cities much more sustainable in the

long run. Finally, finding ways to create accessible transport options for disadvantaged neighborhoods will only improve the overall status of the city.

Research Questions

This thesis will be constructed around three research questions. The first research question is:

- What is the effect of accessibility to public transport towards the socioeconomic position of people?

It is important to know whether public transit can help disadvantaged neighborhoods or if there is any effect at all. The next question to be answered is:

- Does the accessibility of public transport and socioeconomic status affect spatial structure?

A lack of accessibility and a lowering of the socioeconomic status of a neighborhood could create riffs between the community and those nearby. Finally the last research question is:

- Can this process be recognized in the neighborhoods of Capelle a/d IJssel and/or Hoogvliet?

This will be the final piece to the puzzle on whether an effective transportation network is showing any outcome towards preventing the dire consequences of a spatially mismatched community. To test the transportation networks effectiveness research will be done over a 4 month time period. In the beginning it will compromise of organizing meetings with researchers and conducting interviews with Metro riders to find out how accessible the Metro is for them and to find out where their job takes them in the city. Capelle a/d IJssel and Hoogvliet will be the two comparative cases for this study but to isolate them alone would not prove how effective transportation is to accessibility. To solve this issue, the entire city of Rotterdam will be used along with both towns located at opposite ends of the C line: Capelle a/d IJssel and Spijkenisse. Spijkenisse also has the added advantage of being the terminus for one end of the D line with the other end being located within Rotterdam's city limits. With the data gathered through the research, the accessibility of neighborhoods to the Metro will be placed in contrast to their accessibility while using a car. The comparison of these two modes is chosen because they provide speed while also giving a larger assortment of locations than other faster modes of transport, such as trains. The towns themselves will also provide an idea of what suburbs would look like with fewer cars.

Reasons for Research

As with any scholastic study, there should be a justifiable reason why spatial mismatch and transportation are so significant for future urban policy. This research is important because the construction of transportation infrastructure is a very costly procedure. If transportation infrastructure is built without taking into account the future impacts it will have among the community then millions, and sometimes billions, of dollars can be wasted. While hopefully no transportation infrastructure is built without a plan, sometimes the experience and knowledge of building the infrastructure does not exist in the area. For many cities in the United States, experience with building road infrastructure, freight rail infrastructure and airport infrastructure has dominated the transportation ideals for so long that other forms such as trams, passenger rail and metros have almost died off. As the United States pushes to a more multimodal transportation system, research needs to be done on how countries with much more experience in multimodal transit handle their transportation infrastructure. By relating the spatial mismatch hypothesis to accessibility of multimodal transportation, results of the research will be able to determine what effects a light rail public transport has among a community and whether or not the metro line is being properly utilized for its intended function. This will help to determine whether certain stations are accessible but take in fewer riders or whether ridership is high because access to other forms of transportation is limited. These results will help to determine whether the citizens of the neighborhoods are better off with the metro line or are not affected by it. It is important to focus on the metro line because it offers similar benefits to trains except is able to serve many more sections of the city at a lower price than a train due to its smaller scale. After this research, a gap will also be plugged in the theories of spatial mismatch by determining how effective transportation is at solving the issue. The research questions are unique because they will be relating a European result and applying the knowledge gained from the experience to American literature based on spatial mismatch theory and accessibility to better assist American city planners. The research will fit in with work already being done to determine how to effectively reach the urban poor and bring them out of the deprived societies they seem to be stuck within. However, much of the research done on spatial mismatch and accessibility to public transport can only be done in theory because the infrastructure has not been created or is poorly constructed. By determining how multimodal transport has served communities in the Netherlands, Dutch experience can be used to effectively assist the implementation of multimodal infrastructure as it begins to be built throughout the United States. This will effectively save America ample tax dollars, which are not easily given up in the States, and hopefully give urban ghettos the ability to bring themselves out from their difficult surroundings by providing passageways to give life back to the communities.

Introduction to Rotterdam

The city with which this research is focused on offers a different approach to urban planning than can be seen in the United States. Rotterdam is a Dutch city but it

is not a typical Dutch city. The heavy toll that the city took during the Second World War caused a completely new urban plan than what had previously been in place. The firebombing of the Germans destroyed much of the original port and most of the inner city. In a way, it became a real-life SimCity game with a near blank canvas to work with. This hole in the City Center would be replaced over time with wider streets, bigger buildings, modern architecture and open space. This is almost a complete contrast to the medieval architecture consisting of narrow streets and old brick buildings found throughout the rest of the Netherlands. Despite the firebombing, Rotterdam still remained an important city so all the new buildings being constructed quickly became used by its citizen. The once barren heart of the city was being transformed into a mechanical heart run on commerce and industry powered by humanity. This beating heart could not survive without arteries to bring the people into the city. Unfortunately after the bombing there were few if any housing options left in the City Center. This meant that residents who were displaced by the bombings had to seek shelter further out of the city, thus expanding the population outwards. To pump in the city dwellers, transportation networks were reconnected to the center of the city including: roads, bike paths, sidewalks, trams, trains, and eventually the light rail of the Metro. Rotterdam has created a robust infrastructure network that allows commuters a variety of options to reach the City Center, yet it still feels like something is missing. That something is the life that a mechanical heart cannot give. Without people living in the City Center, the heart of Rotterdam becomes a ghost town after people have gone home from work. This type of problem has become prevalent in the United States. The creation of a vast road network after the passing of the Federal Aid Highway Act in 1956 practically sealed the demise of the inner city by a rapid growth in suburbanization. After the "white flight" of the 50s and 60s, inner cities lost what it was that gave them their strength and admiration, people. Surrounding the inner city was no longer a necessity since highways had made travel by car to the city center much quicker. The once prosperous neighborhoods surrounding the inner city became empty and property values dropped causing an increase in lower socioeconomic residents. This same type of issue was forced upon Rotterdam with the firebombing. The forcing of citizens to the outer limits of the city acted in a way like "white flight". Yet Rotterdam does not have the severe ghettos that the United States has with their crime, drugs, prostitution and thorough list of social problems. Much of this can be attributed to the policies of the Netherlands such as: no gun laws, providing clean needles for drug users and in Rotterdam a decommissioning of the red light district. There is still the thought in the Netherlands that Rotterdam is a dangerous city. Much of this can be attributed to its reliance on the port (not a clean industry) and the large number of immigrants in the city. However, many of these immigrants have assimilated into Dutch culture and no longer pose a threat to the lives of others. The port itself has even become less of a problem as it moves further westward and technological advances allow the industry to keep itself clean. Perhaps maybe it is not something as obvious as being an immigrant filled port city. Maybe the structure of the city is what leads to all its troubles. Perhaps the disconnection of the old ports and the moving of port jobs west have led to its socioeconomic

problems. Maybe it is the spatial structure of Rotterdam that can be put to blame for livelihood issues.

Importance of Spatial Structure

Spatial structure plays a key part in determining access. For this study it is also important to look at the spatial structure of neighborhoods to determine whether physical barriers prevent residents from gaining access to public transport. These barriers are typically nothing like fences or walls but fall into the more "unseen" category. These include physical impediments such as: roads, rivers, canals and forests. There are also the physical barriers where the lack of infrastructure for different modes of travel becomes the barrier in itself. The most common form of lacking infrastructure is that of sidewalks which would provide a walking path separated from that of road traffic, rain soaked ground and bike paths. The same could also be said for areas that lack roads or bike paths. The infrastructure becomes a form of weaving throughout the city. There are often threads that take you from one end of the weave to the other but sometimes there are holes in the weave. When these holes appear, another thread must be found to cross or go around. Sometimes, certain threads become so large that they form a barrier towards smaller threads crossing it. This is the point where areas become spatially mismatched from their surroundings and can develop into severely at-risk neighborhoods. While physical objects like highways and rivers are the quintessential form of barrier infrastructure, these structures are not built as barriers but they can transform into them with a lack of evading methods. The invention of bridges and tunnels were meant for the exact reason of circumventing barriers, yet still we find neighborhoods divided because a "bridge" has not been created to cross. In this day and age a bridge no longer has to mean something as big as the Erasmusbrug. Instead, it could be something as simple as bike paths and traffic lights crossing a busy street or water taxis providing services to cross a river. These smaller scale infrastructures are extremely important because they provide options. Without options, one section of the city could get cut off from society. Once cut off, they will try and find a way to develop a new society around what they have. It is this new society, who is in juxtaposition of the main one, which turns into the blighted urban region simply because they have lost touch with the rest of society. This type of transformation can even be seen in the animal kingdom in the form of evolution. A continent such as Australia is full of species that lost touch with the rest of the animal kingdom long ago and have since altered themselves to their environment. Isolation only stands to make cultures different and once they are different they no longer see the world in the same way. Some of the most isolated places in Rotterdam occur in old harbors. These locations once had a direct use by docking with ships but now they are dangling pieces of land sticking more into the river than into the city. If these old harbors don't provide the infrastructure that their residents need than they run the risk of becoming spatially mismatched from the rest of Rotterdam. Therefore spatial mismatch is a threat to the entire urban fabric not just the communities where the mismatch exists.

Chapter Two: Literature Review

The main concept surrounding the thesis is that of economist J. F. Kain's Spatial Mismatch Hypothesis in his book *Housing Segregation, Negro employment and metropolitan decentralization* (Kain 1968). Kain's idea centers around three basic principles: the core of unskilled labor has moved towards the suburbs, unskilled workers remain located near the city center, and the distance between these two becomes a barrier that the unskilled workers cannot pass. While Kain never used the words "Spatial Mismatch Hypothesis" in his research has led to much debate and investigation within the academic community. One field of study in which Kain's hypothesis showed a very strong correlation was that of sociology. Sociologist William Julius Wilson was able to use spatial mismatch in creating his own theory on the subject in his book *The Truly Disadvantaged: The Inner City, The Underclass and Public Policy* (Wilson 1987). Wilson was able to spark a revival in spatial mismatch theory in which many other scholars would critically analyze Kain's original 1968 book. Kain had not been idle the whole time and responded to his critics in 1992 with his paper titled *Spatial Mismatch: Three Decades Later* (Kain 1992). In this paper he carefully reviews the methodology and references of his detractors then provides the proper analysis they should have been implementing. This analysis led to a paper by Laurent Gobillon, Harris Selod, and Yves Zenou who would delve further into theory with *Spatial Mismatch: From the Hypothesis to the Theories* (Gobillon, Selod & Zenou 2003) which sums up the hypothesis and presents the theories that have come forth through the years. Gobillon, Selod, and Zenou would again collaborate on the paper titled *The Mechanisms of Spatial Mismatch* (Gobillon, Selod & Zenou 2007), in which they delve into more detail on the fundamental elements towards spatial mismatch. There are four factors that are highlighted in this paper: the first is that the cost of commuting is a discouraging factor for inner city workers to arrive at interviews and subsequently jobs on time, second the access to employment information decreases with physical distance from employment centers, thirdly weighing short term losses higher than long term benefits, and finally a high search cost for inner city workers to find employment in the suburbs. These theories and the initial work by Kain forms the fundamental backbone of what is trying to be accomplished; however, they are not the main source of this thesis. Those honors go to work done by Grengs, *Job Accessibility and the Modal Mismatch in Detroit* (Grengs 2010) and Paul Ong and Douglas Miller's work *Spatial and Transportation Mismatch in Los Angeles* (Ong & Miller 2005), each give clear relations between accessibility and proof of the spatial mismatch theory's relation to transport.

Spatial Mismatch Hypothesis

Spatial Mismatch was first proposed after World War II as the mass exodus of white citizens from the inner city to suburbs in the 1950s and 1960s famously known as "white flight". This migration created a large host of opportunities for businesses to

move out of the inner city to these suburbs to service these rising populations. Not only was there a growing number of clientele in these outskirt neighborhoods but there was also considerably lower business taxes to be paid and property costs were low. Thus suburbs became the focal point for the development of American society in the second half of the 20th century. This was not the case throughout all cultures in the nation. While white societies were thriving in the suburbs, minority cultures were suffering tremendously in a decaying inner city that was slowly rotting away at its core. As the areas surrounding the central business districts of cities became increasingly depraved, the inner city became looked upon as a blight of the town and a dangerous area, especially after dark. This only perpetuated stereotypes of minorities as troublemakers making getting out of the inner city even harder for them. The white citizens who had originally fled to the suburbs in the 50s saw no reason to go back to the inner city with all its violent crime, drug deals, and poverty stricken populous. The minorities who were once admirable hardworking yet unskilled laborers in factories and shops were trapped by their geography and inability to afford to escape the inner city by reaching unskilled jobs in the ever distant suburbs. Kain's (1968) paper specifically focuses on the effects of housing market segregation towards discrimination of black residents in Detroit and Chicago faced relating to employment and their earnings. Kain studied the housing market in Chicago and Detroit to determine if the choice of housing made by unskilled black workers had a detrimental effect on their advancement in society. Kain was able to determine at least three specific functions that would lead to a spatial mismatch: a lack of educational opportunities, discrimination of sectors of society using housing prices and a lack of home-ownership by blacks in Chicago and Detroit. One of the cities to take up Kain's work and apply it to city policy was that of Los Angeles in which they tried to implement better public transportation to one of their more populated minority regions during the 1960s. While Kain's research was fresh and new in 1968, it did not mean that his results were the easiest to conclude. He also sourced his data from studies done from the 1950s and a little into the 1960s which meant that they were at the very beginning of the movement from the inner city to the suburbs and effects of this change were not as evident or able to be properly planned against.

Spatial Mismatch and Sociology

Kain's ideas would continue to be mulled over by researchers and policy makers for the next nineteen years with little accomplished in the way of serviceable application of them. The idea of spatial mismatch was easy to comprehend and much empirical research was done on the hypothesis, however little or no theories could be developed. It was not until William Julius Wilson's work *The Truly Disadvantaged: The Inner City, the Underclass, and Public Policy* (1987) related the concept of spatial mismatch to sociology when we start to see theories begin to form like seedlings sprouting in the soil. In Wilson's work, he provides the basic theory behind spatial mismatch which is as industrial jobs vanish from cities the urban unemployment will increase but the urban disadvantaged will not be able to leave due to a mismatch in space. There is much more to this principle than a simple one

sentence structure, as Wilson relates the cycle to jobs, marriage, children, housing, and culture. It all begins when manufacturing and industrial jobs left the inner city and moved towards the suburbs, of which the workforce was often unskilled minority workers. At the same time as these plants were changing location many of the educated people in Midwestern and Northeastern American cities were also making the trip from the inner city to the outer ring of suburbs. So now the picture begins to form with jobs and brains located outside the city limits. Those who were unskilled or uneducated still located in the city had little opportunities to find employment where they lived. They also had little assistance from people in their community of a higher status in society because all the brilliant leaders had left for a white picket fence and a yard. This led to inner city workers, whose forefathers were once noble hard workers driving the industrial revolution, to take up service industry jobs such as janitors and busboys. Of course these janitorial and restaurant occupations were quickly snatched up by anyone willing to put down their pride and desperate for money. For those less than fortunate men who missed out on the job market were left unemployed and forced to struggle through life (home, marriage, children, social life, etc.) without a job. Women would then have to settle for a man without a job simply because all the men with jobs were often quickly taken up. This didn't necessarily mean that the two would enter into marriage simply because the process of marriage is too expensive for them to pay especially with a lack of breadwinners in the relationship. As is often the case for couples who have little to do and a lot of time, children were brought into this world of unemployment and poverty. Children naturally also cost a lot of money. While their initial capital cost is relatively low compared to marriage, the maintenance cost of raising a child quickly adds up over the years depleting the funds available. These children then grow older and eventually reach an age where they themselves can have children, which is often much younger than they are prepared for thus continuing this poverty entrapped cycle.

When Wilson wrote his work in 1987 a little over one generation had began their lives in the ghettos of American society. At this stage in time, the population of these ghettos was still quite poor and growing increasingly desperate for employment. This desperation often turned to illicit means to acquire the much sought after cash. In their deprived state many minorities saw no decent way to earn a living and if they could survive it was through the unstable world of temporary and part-time employment. To fight this volatility, many minorities went into "self employment" through drug trafficking, prostitution, theft or other illegal activities. Wilson does not delve into great detail about the effect these dishonest trades had within the urban environment but it is worth giving reference to the situation that inner city residents had to deal with on a day to day basis. From the 1950s to about the 1960s, illegal entrepreneurs were able to lay the foundation for their business and set up a clientele base. The drug traffickers were by far the most profitable and left one of the most heinous blights on the ghetto society. Through the 1960s to 1970s a variety of sectors of society were experimenting with mind altering substances and this only increased the clientele and the profits of the dealers. After Richard Nixon declared a "War on Drugs" in 1971,

illegal narcotics businesses grew even more aggressive to stay in the market and more willing to take out competition by any means necessary. By 1987, many of the citizens of the ghetto Wilson wrote about knew someone who had done drugs or had dealt them. In fact, many other social issues; such as having a child out of wedlock, poor schooling system and teen pregnancy, were highly concentrated in ghetto neighborhoods. This meant any person brought into this environment became nurtured by it and came to know the ghetto as their way of life.

With this knowledge comes a stigma associated with anyone that appears they could come from a ghetto area, which in turn creates an image in employers' minds of a worker that will be unreliable or trouble to the company. The profiling of interviewees is not a subject that is easy to talk about but is quite prevalent in hiring practices for companies who are looking to protect their assets and increase profits. This stigma was also demonstrated by citizens of mixed use neighborhoods during the 1970s. Here many residents of middle class or lower middle class would choose to leave the neighborhood to provide a safer and better place to live or raise their families. This left once lively and diverse neighborhoods segregated and disproportionately populated with the poor residents who remained. In this case, the typical people sought for information regarding possible job opportunities, friends and family, were mainly unemployed or illegally employed thus severely hampering the social networks in ghetto environments. These damaged social networks continue to distance themselves from the means with which they could alleviate some of the issues. This detachment only reinforces the physical distance that is present between the inner city residents and the suburban residents. The lower class in ghetto neighborhoods became so accustomed to their depraved environment that they find a sense of pride in surviving it, if they do. Even if they try to escape they are often dragged back in by family or friends who they have become attached to and whom themselves have anchored their lives to the ghetto. Wilson even notes patterns of detachment from broken social networks present in the Netherlands despite the Netherlands having much better social welfare than the United States. This shows how Wilson's idea that a social network is a leading factor in determining the strength of a society is an international principle that has its roots in every culture around the world.

Recent Developments in Spatial Mismatch

Wilson's evidence of spatial mismatch theory towards sociology along with economist David Ellwood, who offered stark criticism to the spatial mismatch hypothesis, helped provide a revival of the spatial mismatch hypothesis in the late 1980s. Even though Kain wrote his paper in 1968, over forty years ago, he remained very active in applying his research towards policy decisions in cities throughout the United States for the next thirty years. Kain would write a review of his work in 1992 titled, *The Spatial Mismatch Hypothesis: Three decades later*. In the paper, Kain reflects back on how spatial mismatch has been applied by various policy makers, criticisms that have come up from it, and how the idea of spatial mismatch has evolved through the years. During the 1960s, ghetto areas throughout the United

States began to grow increasingly troubled leading to the creation of various commissions set up by the federal government in order to study the problem and find cures for the mounting ailments of the urban poor. According to the Kerner Commission, which was part of the National Advisory Commission on Civil Disorders created by President Lyndon Johnson, there were three factors that a city could do. These factors included: allowing suburban residential areas to bring black citizens into their community and encourage them to live closer to the centers of industry, creating incentives for industries to create locations near black residential areas and finally creating a better transport link between new job locations and ghetto neighborhoods (Kain 1992). These principles of the Kerner Commission, on which Kain spent time consulting, developed into the basic structures behind the spatial mismatch hypothesis and it is these beliefs that were criticized by a study done by Christopher Jencks and Susan Mayer. For their study Jencks and Mayer reviewed much of the material over spatial mismatch that had been developed since its inception 22 years prior. While Jencks and Mayer were extremely careful and effective in their work to analyze spatial mismatch they were not exactly positive about the idea. In their findings they found most of the work and findings to be very mixed. They could not find any conclusive correlation between segregated residences and a demand for black workers. They did find some evidence that the location of employment does increase the supply of black workers; however, they could only find scattered results and no clear cut pattern. The final piece of the Kerner Commission that they found inconclusive was that to move blacks to the suburbs or to provide transportation for them showed just as many results of a positive effect as there were for a negative effect, leading to yet another area of confusion.

Since Kain wrote this report in 1992 and Jencks and Mayer's report was in 1990, Kain had the luxury of critically analyzing Jencks and Mayer's findings as well as all of the critics to his work over the three decades since the initial publishing of *Housing Segregation* (1968). In relation to Jencks and Mayer's study in which they were unable to find a clear example of the spatial mismatch hypothesis, Kain notes that their research was mainly taken from two of Kain's earliest critics. It is within these early critiques done by Stanley Masters in 1974 and Bennett Harrison in 1972 that Kain is able to analyze their outcomes and find flaws within their calculations. In relation to Masters' work, Kain noticed a fatal error that completely skewered the data in the factor in his analysis known as the Taeuber segregation index. The flaw with the Taeuber segregation index is that the figure is related to central cities and takes into account intensity of segregation at the block level which in relation to the 1960s central city was rather homogeneously acute. The focus on the central city would then show no obvious relation to a mismatch in space because there would be no variation in spaces used. Masters' proves that the spatial mismatch hypothesis does not work in relation to whether black households are segregated or not. Kain (1992) argues that this was not the intent of his research; instead he meant to determine whether the housing market itself confined blacks to a certain location in the metropolitan area. Kain's most unrelenting critic was that of Bennett Harrison. In Harrison's study he

found that minority workers in suburbs earned just as little and had just as much difficulty in finding employment as their inner city peers, which to him completely disproved the spatial mismatch hypothesis. Kain was not interested in earnings and unemployment levels when developing the idea of spatial mismatch because by doing this he would have assumed that minority workers are able to find a home anywhere they choose, suburbs or otherwise.

Instead Kain and his colleagues have found that even though in the 1980s and 1990s they witnessed a great migration of minorities towards the suburbs they still remained spatially centralized and thus witnessed no benefits from moving away from the inner city. The suburban minorities still had limited job growth, limited public service packages and a poor education system with which they lived in. These problems were made more obvious by data researched by Schneider and Phelan in 1990, through which they concluded that while the population of black suburbs grew the amount of jobs near them developed at a much slower rate creating more demand with less supply. Kain also did research on these black suburbs in Cleveland and Chicago. One of the most striking outcomes he came across was that these new black suburbs were more spatially mismatched than their inner city relatives. Chicago was especially divided because many of the black suburbs were locating further south and southwest of the central business district, whereas the jobs they could attain were being located further north and northwest of the central business district. This begs the question as to why they would move to the suburbs but it is for exactly the same reason as whites did in the 50s and 60s: cheap houses, more room, good education and good neighborhoods. While blacks may enjoy the cheap housing with more space to live, their educational opportunities are typically not very good and the promoted good neighborhoods can often deteriorate quickly with uneducated, unemployed and desperate residents. It is rather evident from reading *The Spatial Mismatch: Three Decades Later* that Kain did not simply rest on his laurels and bask in the luxury of his teaching career at Harvard upon completing his 1968 book. On the contrary, Kain seems to have a fervent rebuttal for each of his detractors and is quick to explain where it was that they misinterpreted the meaning of what the spatial mismatch hypothesis truly is about.

Unfortunately, Kain would not be able to witness much of the renewed interest in his hypothesis throughout the 2000s because he passed away in 2003 and subsequently many works relating to spatial mismatch followed. One of the papers that helped form a current basis for much of the more recent research is that of Gobillon, Selod and Zenou's work *Spatial Mismatch: From the Hypothesis to the Theories* (2003). This paper gives researchers new to spatial mismatch a kind of refresher course to put them up to date with where spatial mismatch has been and where it is today. Gobillon, Selod and Zenou's work begins by reviewing census figures from around the United States from 1980 to 1990 and providing figures with relation to employment centers in the center of the city and in the suburbs. According to their findings, there was indeed a decrease in the amount of jobs in the central city and an increase in the amount of jobs available within the suburbs. One of the hardest

sectors affected by this trend was that of manual labor such as machine operators and material handlers. This data was not prevalent throughout all the cities in the United States though. Cities such as New York did not experience as great a shift but this is most likely due to New York not having any room to expand, thus constricting the amount of jobs that could move outwards. Many of the cities that have been important in the American economy for many years such as Boston, Detroit, and Philadelphia had little growth in either the suburban or central city manual labor departments. In contrast, cities that are rapidly growing today such as Dallas, Houston and Atlanta showed a significant amount of manual position openings in their suburbs and less openings in their inner city. This is a significantly disturbing trend because these three cities also are significantly affected by urban sprawl which itself is putting mounting pressure on the city's infrastructure and ability to remain sustainable. Their data also demonstrates a shift from manual labor towards service industries throughout cities in the United States. So while a city center may be growing rapidly with employment opportunities, many of these new positions are executive, managerial or financial. These more service oriented positions also often pay more when they are located within the city center whereas the situation is reversed for low-skilled workers where they will earn higher wages in the suburbs where their employer will not have to pay as much property tax or for leasing the building.

The ability to earn a higher wage has been a reason for the migration of many blacks towards the suburbs but as evident from Gobillion, Selod and Zenou's data there is still a high percentage of blacks that live in the inner city. This evidence most likely can be attributed directly to Kain's principle that housing markets in the suburbs prevent blacks from finding housing close to low-skilled employment centers thus making moving out of the inner city much more challenging. Another significant challenge faced by blacks is their inaccessibility to transportation to find employment or to their employer. While data shows that commuting distance is typically higher for white workers as opposed to black workers, this data is almost irrelevant because it is not how far the job is but how you get there. Almost the complete majority of white workers have their own car and therefore their own transportation, this means that they can have the most flexibility of mobility to reach their destination. The percentage of blacks who own a car is around one-third less meaning that many rely on public transportation or carpools to reach their employer. Since public transportation is on a fixed path, black riders must follow a set pattern to reach their job and are at the mercy of the mode on how fast they arrive. This can have a detrimental effect for employees who's boss values "time as money" thus causing an employee who is late because of an unreliable public transit system to lose his/her position. A position that requires little skill also makes an employee very expendable because production will not be severely hampered by their replacement.

After gathering data and reviewing trends in the field, Gobillon, Selod and Zenou began to formalize theories that had been floating around the idea of the spatial mismatch hypothesis for decades. Together they devised seven theories of spatial mismatch, while they do not all create a perfect image of what spatial mismatch is

they do indeed provide guidance for future spatial mismatch research. The theories are as such: the efficiency of job search may decrease with distance to jobs, incentives may be too low for workers residing far away from jobs to search intensively, workers may refuse jobs that require too long a commute, an inadequate transportation mode, employers may discriminate against residentially segregated workers, employers may refuse to hire or pay less to distant workers because commuting long distances makes them less productive, and employers may think their white local customers are unwilling to have contacts with minority workers. The first theory has to do with information relating to employment. The further one is from information about jobs the less knowledge about opportunities they will have. This statement is deeply rooted in Kain's original idea although the method through which Gobillon, Selod and Zenou go to apply it is a little misguided from Kain's original purpose. Gobillon, et al. describes a spatial mismatch of information between the inner city and the suburbs. There is indeed a difference in the information provided in these two areas of the city based on geographical location but there are also certain areas of the suburbs where a concentration of blacks reside who have similar struggles in acquiring information like their inner city counterparts. Just being in the suburbs does not improve blacks ability in acquiring information about employment; they must also be located in a suburb with employment opportunities. The next theory is that incentives for workers to search for a job are lowered because of distance. Gobillon, et al. came up with two functions to express this idea, one was based on location and a choice between long-term and short-term gains while the other was based on the high cost in searching far away. In the first function, they find that inner city workers will sacrifice the long-term benefit of a job in the suburbs for the short-term gain of a job in the inner city. This is due to the geographic openness of the suburbs which makes it more costly and time consuming to go from potential employer to potential employer than travelling around the inner city. This function implies that there is an equal amount of appropriate jobs available within the suburbs and the inner city. The second function finds that the cost to travel from employer to employer is much more expensive in the suburbs because of the distance needed to reach them. This in turn relates to the third theory which is that the cost to commute from suburban employment to inner city residence is too high. Using research done by Brueckner and Zenou, a linear city model was developed with a central business district (CBD) at one end and a suburban business district (SBD) at the other. According to this model, when housing segregation is taken into account blacks reside in the CBD because they are forced to and thus have a much longer and costlier commute to reach employment in the SBD since there is too much demand and not enough supply in the CBD. This cost is exacerbated because with a high unemployment, businesses can afford to pay workers less, which in turn makes travelling costs a much higher percentage of a worker's expenses. The fourth theory will be covered later in this paragraph. Skipping on to the fifth theory, that incorporates the practice of the labor market and housing market of "redlining" in which stigmatized neighborhoods are marked as "problem" areas and thus discriminated against. This practice only increases unemployment when the residents of "problem" areas must also pay a high cost to transport themselves to their

jobs. The sixth theory extensively covered by Gobillon, et al. comes from an employer's point of view that workers who have to travel further distances are more tired and less productive due to their commute. This also entails that the worker's hours are less flexible. At the time of their research, Gobillon, et al. did not have enough theoretical research to cover the fourth theory on adequate transportation or the seventh theory on customer contact with minority workers. For this thesis, it is the fourth theory that proper transportation infrastructure can alleviate the problems created by spatial mismatch that will be most important to this paper.

Gobillon, Selod and Zenou would again collaborate on a work titled *The Mechanisms of Spatial Mismatch* (2007). In this paper they expand on the theories presented in their 2003 work and delve much more into how the separation of inner city workers and outer city jobs is created. The first section they address is the workers themselves, which for the majority of the spatial mismatch literature are blacks. They begin by describing the segregating restrictions that are placed on black residents. These include: discrimination based on race, discrimination by customers, incomplete statistics which create a poor image of blacks, the infamous "redlining" of problem sections of a city and certain city restrictions such as zoning and plot size that vary between white ideals and black ideals. Another factor is the choices they prefer. Whether it is living next to people who are similar, the design of homes or how public goods are acquired all plays a part in shaping neighborhoods. These choices are then played out in the next step of the separation of inner city workers and outer city jobs, which is getting to work. In this instance, black workers have three options: travel a far distance to reach the suburbs with the most opportunities for employment, travel a smaller distance by remaining in the inner city and reach an inadequate job, or simply become unemployed. Gobillon, et al. then take the theories they formalized in 2003, categorize them into worker and business sections and expand upon each theory. In relation to their theory on commuting costs, they found from other studies that a "transportation mismatch" goes a long way towards creating the effects seen by spatial mismatch. It seems that access to a private automobile is extremely important in allowing blacks proper access to the labor market. This solution is very helpful but with it brings a huge array of traffic, environmental and infrastructure problems which make car ownership for all an incredibly disastrous idea. In relation to how businesses create spatial mismatch Gobilllon, et al. expand on their theories by describing how a company will choose to move to the suburbs to reduce neighboring competition or because the company requires more space, such as a factory, and the price of land is cheap. The paper closes with a look at policies to alleviate spatial mismatch. Gobillon, et al. find three types of policies that can affect spatial mismatch: bringing people to jobs, bringing jobs to people and connecting jobs and people. The first two policies are meant to attack the issue of spatial mismatch whereas the third, based on transportation, has little empirical evidence relating the two.

Transportation Mismatch

A paper in 2005 by Paul Ong and Douglas Miller looks to shed light on this murky level of knowledge about transportation's effect in the spatial mismatch

hypothesis. The paper titled *Spatial and Transportation Mismatch in Los Angeles* seeks to compare forces of spatial mismatch and location with those of transportation mismatch and access to a private automobile within Los Angeles. Ong and Miller begin by explaining that although much of the literature focuses on minorities, the separation of inner city populations and suburban ones has continued throughout the late 20th century in all racial neighborhoods yet still distant neighborhoods find employment. They then describe how transportation mismatch is the lack of transportation options in underprivileged neighborhoods, since so much of urban development in the United States is driven, both literally and figuratively, by automobile ownership. This relates similarly to the question of the chicken or the egg. Does owning a car prevent unemployment or does a poor labor market prevent owning a car? This problem is addressed by answering the questions at the same time. Ong and Miller start off by explaining to the reader the situation in Los Angeles (LA) before delving into the empirical data. An important fact about LA is the extent to which road infrastructure has perpetuated the city, demonstrated by the 570 miles of highways in the Los Angeles County. LA demonstrates many regions characterized by spatial mismatch such as the high amount of residents below the poverty line in the CBD and in nearby South Central LA. There are regions outside of the inner city such as Long Beach, which is much further to the south, and San Gabriel Valley, to the east, which are poverty stricken. While some of these areas are historically black, it is worth noting that currently they are populated by other minorities as well such as Hispanics and Southeast Asians. Ong and Miller provide data that shows a high degree of citizens lack car ownership near the CBD but many poor suburbs have a higher rate of car ownership. The choice to use other modes of transport besides the automobile is also much higher in poor neighborhoods, or those within the city center, than prosperous ones. Through Ong and Miller's research they were able to find that not owning a car increased the unemployment rate. They also found that unlike factors such as age, lifecycle and race, not owning a car showed a significant decrease in employment levels. Ong and Miller suggest easing the access to automobile ownership as a method for easing the poor's transportation mismatch. While car ownership cannot be universal, that the extension of expensive public transit systems should not be the complete solution. Instead, an improvement of transit services to negate the advantages of car ownership will provide the necessary reduction in the transportation mismatch associated with spatially mismatched neighborhoods.

Ong and Miller called for further research on transport accessibility to be done in other cities throughout the United States and five years later Joe Grengs completed his study on Detroit. In Grengs' work *Job Accessibility and the Modal Mismatch in Detroit* (2010) he begins by demonstrating a growing trend among transportation scholars in finding that it is not so much spatial mismatch as a transportation mismatch that constricts the urban poor. Grengs chooses Detroit because it is one of the founding cities of the spatial mismatch theory and it is one of the most extreme examples of the theory found in the United States, providing a contrast to cities covered such as Boston, New York and San Francisco. Detroit is an extremely auto

oriented city and ranks far lower than its peers in an adequate public transit system. Detroit's offerings for public transportation is mainly two bus lines, one serving the central city and one serving the suburbs with no connecting of the departments. Detroit also finances its public transit by city taxes which are dwindling with Detroit's population. Grengs first reminds us exactly how much the concept of spatial mismatch has changed with this renewed emphasis on accessibility to proper transport. These new outlooks provide a contrast to the information given to policy makers for decades on how to best reinvigorate the poor in cities. In reviewing the literature, he finds four areas where policy making and scholastic work ran into trouble: the vagueness associated with the ideas of spatial mismatch from the very beginning, a lack of clear separation between cars and transit, the narrow focus of studies on black men, and finally the narrow focus of literature on simple crudely defined areas such as the central city and suburbs.

Grengs poses three questions to be answered by his research: are inner city residents disadvantaged from accessing metropolitan jobs, how much difference does a car make, and how do disadvantaged populations experience accessibility to jobs? In response to the first question, Grengs found that even though the areas of highest accessibility were outside of the inner city, it remained a relatively inaccessible region. While the inner city region itself typically has a high accessibility this differs from neighborhood to neighborhood as one zone can offer high accessibility while another can offer little to none. In response to how much difference a car can make, Grengs found that Detroit is severely hampered by its public transportation system, or lack thereof. Through the findings it can be seen that 70% of Detroit's population lives in an area where having an automobile creates high accessibility whereas everyone in Detroit has a low accessibility by public transit. For the final question on how disadvantaged people experience accessibility to jobs, Grengs found that a large percentage of the black, poor and unemployed population actually lived in areas where accessibility was high, granted they owned a car. He then delves deeper than many researchers of spatial mismatch by performing the same equations with the often statistically hidden populations of welfare recipients and poor single mothers. With this data unearthed, he finds that these groups are even more spread out through the metropolitan area but would still have better accessibility if they possessed a private form of transportation. Grengs concludes by stating that while Detroit fits all the traditional criteria for a spatially mismatched city, the new ideas of transport accessibility find it to be a quite accessible city, provided a person has a car. It is this need for a car that plagues most of the newer cities in the United States and the suburbs of older cities. With little planning done in the way for providing public transit infrastructure, these areas present extreme challenges to planners in finding a way to shift the focus of transportation from private to public forms. Grengs points out that for these large sprawling cities it is more effective to try and find ways to provide private transportation for their poorer residents in the short run; as opposed to creating extensive public transportation networks that will take much longer to be effective, while the issues plaguing the urban disadvantaged only increase.

Ong and Miller, and Grengs both give cases that show how a lack of accessibility to public transport has had a detrimental effect on minority neighborhoods in cities throughout the country. In this thesis, Rotterdam and two of its smaller suburbs will be tested on whether they adhere to the structure of spatial mismatch and if the problem of spatial mismatch has been solved by efficient public transit. The effects of accessibility to proper public transportation has had on the specific neighborhoods of Hoogvliet and Capelle a/d IJssel will be judged on how well they coincide with the literature. As can be determined from reading the literature, there is still a lack of data on whether situations created by spatial mismatch could be alleviated with a proper transportation network in place. This is precisely where this paper becomes important because the transit network in Rotterdam is robust and the amount of low-skilled positions is quite large with the location of the port nearby. With this research, conclusions will be able to be made on whether accessibility to public transportation, specifically the metro line, has actually shown a reduction of spatial mismatch in the communities.

Chapter Three: Research Design and Methodology

Research Setup

The literature on spatial mismatch theory and accessibility is much more extensive than the few sources provided but these few form the compass to give direction to the research. The next step, the fieldwork, is using a variety of participatory and non-participatory methods. For the non-participatory approach, a gravity model uses data gathered from the municipality to give statistical representations of locations of jobs and workers. The gravity model is a formula which combines the number of employment opportunities in an area with a function that relates to the increasing barrier of cost based on distance. The gravity model is used extensively by scholars in relation to spatial mismatch and transportation mismatch. The data for the model will generally be census data collected by the municipality on employment status, level of income, job availability and accessibility. The gravity model that is used for this research is an updated form by Qing Shen to account for a difference in accessibility based on space. His equation is as follows:

$$A_i^G = \alpha_i A_i^{auto} + (1 - \alpha_i) A_i^{tran}$$

"where:
A_i^G is the general accessibility score for people living in a residential zone *i*
α_i is the proportion of workers in zone *i* living in a household with at least one automobile
A_i^{auto} and A_i^{tran} are defined below.

$$A_i^{auto} = \sum_j \frac{E_j f(c_{ij}^{auto})}{\sum_k \left[\alpha_k P_k f(c_{kj}^{auto}) + (1 - \alpha_k) P_k f(c_{kj}^{tran})\right]}$$

$$A_i^{tran} = \sum_j \frac{E_j f(c_{ij}^{tran})}{\sum_k [\alpha_k P_k f(c_{kj}^{auto}) + (1 - \alpha_k) P_k f(c_{kj}^{tran})]}$$

where:
A_i^{auto} and A_i^{tran} are accessibility scores for people living in residential zone *i* and travelling by automobile and transit, respectively;
E_j is the number of employment opportunities in zone *j*;
P_k is the number of job seekers living in zone *k*;
$f(c_{ij}^{auto})$ and $f(c_{ij}^{tran})$ are the impedance functions associated with the cost of travel *c* for travel by automobile or transit between zones *i* and *j*; equal to $\exp(-\beta T_{ij})$, where *exp* is the natural logarithmic value of *e*, β is a parameter empirically derived separately for each travel mode to maximize the fit between predictions of the gravity model and the observed distributions of travel times (for the Netherlands this is known as "Value of Time"), T_{ij} is the travel time (minutes) between zones *i* and *j*. For a metropolitan region with *N* zones, *i*, *j*, *k* = 1, 2, …, N (Shen 1998)."

The results of the gravity model are then placed into GIS software to give a visual representation of the situation in Rotterdam, Hoogvliet and Capelle a/d IJssel.

For the participatory approaches, it begins with interviews of Erasmus researchers familiar with the situations in the neighborhoods. The general strategy for all the interviews is to start off with broad questions and follow up on the interviewee's responses, to capture her or his meanings and to avoid imposing the researcher's views on the interviewee. For some of the other participatory research random interviews with residents in the neighborhoods are conducted as they are leaving the stations on their way to work. It is almost certain that interactions with some people who are not residents can be made and therefore may alter the results. However, analysis of the information these non-residential interviewees provide may be able to help contribute towards the work. For the neighborhood residents that are interviewed, simple questions are asked so that information gathering is not too intrusive. These questions include: "How do you reach the Metro?", "Do you own a car?", "What stop will you be getting off at?", "How long does it take you to reach your work?" and "Are you taking the Metro to work?" To help further the results these simple questions are translated into Dutch and the appropriate way to pronounce them is learned from my supervisor or one of the many Dutch employees of IHS. It is anticipated that the questions will be answered in Dutch if asked in Dutch and for that key words should be learned in preparation to the responses that are being sought, such as: "fiets", "auto", "twee kilometer", and many other variations of such. A Dutch assistant can be used to help in communication. Calculations are done on the time and distance from the stations to the center of Rotterdam, which typically has the most jobs. One of the key focuses of this research is a comparison study between the two neighborhoods of Capelle a/d IJssel and Hoogvliet. These two locations have been chosen because they are of similar size and have similar access to the metro line. Where these two neighborhoods differ is that Hoogvliet experienced a dramatic decrease in job availability and proximity upon the Rotterdam harbor expanding, whereas Capelle a/d IJssel's environment has remained relatively stable for most of its existence. These two neighborhoods are compared on how accessible their public transport is, specifically the metro line, and whether employment has been easier to reach because of the increased accessibility. Following this research a situational analysis will be taken of the field notes and interview notes, guided by the theories, which consists of mainly sources from the United States. Again, the main theory behind the research is that a robust and extensive transportation network can reduce the decaying of neighborhoods that become geographically isolated from the jobs the citizens are qualified for. Finally, a research report will be written that combines the researcher's understanding of the relevant theory and previous research with the empirical research results.

Research Sites

The two sites where data is collected have approximate levels of distance, but varying levels of income, and location. Capelle a/d IJssel is located to the east of Rotterdam and near the Prinsenland district. It is typically a suburban neighborhood with larger homes and much more space. The location of the neighborhood is around 10 km from the center of the city and is bordered by the Schollebos to the north, the IJssel River to the south, the eastern edge of Rotterdam to the west and nothing but farmland to the east. Capelle a/d IJssel is much closer to low skill jobs in the city center, but much further from low skill jobs in the Rotterdam Port than Hoogvliet. The Hoogvliet area is further from the center and much more isolated in its location. Hoogvliet is located around 20 km from the center of the city and is surrounded by the A15 highway to the north, the Oude-Maas river to the south and west, and then by farmland and Poortugaal to the east. Both of these neighborhoods have similar access to the metro line, however Hoogvliet's location makes it better at accessing jobs at the Europort but access is limited to road only. The money that is spent on the research will be in relation to the locations.

Limitations

Limitations the researcher may run into include: time constraints of the program, not speaking Dutch and the inequality of the neighborhoods. The time constraints of the program require less time than may be ideal for the study. By not meeting with as many people as possible gathered responses may be limited for the research and things may be missed that would not be revealed otherwise. The choice has been made not to reach all municipal workers and people in the neighborhoods, even though such comparisons might be valuable, in order to allow more depth of understanding regarding the focus group. Additionally, limiting the use of structured interviews will be done in order to minimize obtrusiveness of the interviewer and influence on the interviewees. Being an outsider may also limit what is revealed to the researcher. The community members may be guarded in their conversations during interviews. One of the largest limitations is applying the gravity model properly; however, expert opinions will be sought to make sure the model is performing correctly. It will be imperative that the proper data is gathered for the gravity model. There is the disadvantage of the research being done during the summer due to the citizens of the Netherlands often leaving for holidays then, meaning contacts may be temporarily absent from work. It is understood that the neighborhoods chosen are not complete equals in terms of a variety of factors that would typically be used to classify their changes; such as geography, size, and distance. While the topic areas are generally similar, this is not a lab experiment and any two neighborhoods chosen would have a variety of reasons why they are not the same no matter how many other variables they have in common. The certainties of the results that will be determined from this experiment are unknown but this is not to be viewed as a bad circumstance.

Analysis Structure

To analyze the results a variety of information on costs, employment and distance is used. This data includes all of the variables from the gravity model and statistics based on income groups. 2008 data on employment opportunities, job seekers and 2004 income level of households was gathered from the Centrum voor Onderzoek en Statistiek in Rotterdam (COS Rotterdam 2004 and 2008). 2009 data on car ownership and population was gathered from the Centraal Bureau voor de Statistiek in Den Haag (CBS 2009a & 2009b). 2009 data on job seekers in Spijkenisse was taken from the Gemeente Spijkenisse (Gemeente Spijkenisse 2009). 2010 data on time between zones and value of time was gathered from DS+V and Rotterdamse Elektrische Tram (RET) in Rotterdam (DS+V 2010 & RET, 2010). All the prices and other quantitative data learned from the municipality and passengers are cataloged into an excel spreadsheet which runs the gravity model and then that information is mapped out to show variations using GIS software. The GIS maps will provide a much clearer image of the situations in Hoogvliet and Capelle a/d IJssel. Qualitative data collected through the interviews with researchers and riders is compared to each other to determine trends or conflicting reports. There is a possibility that some of this data may already be available through the municipality but data gathered through research will be used first and then will be compared to municipality research to check for inaccuracies. Once the outcomes received from the research results are finished, conclusions will be made on whether the metro line has caused any problems for the neighborhoods or actually benefitted the neighborhood. The level of accessibility for the residents will be concluded based upon the gravity model's calculations and the interviews with constituents. There will be conclusions made on whether the spatial structure of the neighborhood has been altered based on the metro line's location within the neighborhood.

Expected Conclusions

It is expected the most immediate conclusion gained from the research will be to determine the effect a metro line has on a neighborhood. Whatever result is concluded at the end of the research will be a new result to the researcher. With that said, it is expected that without providing an extensive multimodal transport network, the backbone of which is the metro line, Hoogvliet residents without cars would not have the ability to access jobs located within the inner city once the port expanded. The assumption is based on the location of Hoogvliet and research done by Ong, Miller and Grengs to which shows poorly designed public transport and a lack of private transportation leads to limited mobility in a community (Ong & Miller 2005, Grengs 2010). This lack of mobility can cause a drastic depreciation of a community and create an almost stagnant environment where nothing progresses. Just like with water, a stagnant community can run into many problems due to the restlessness, hopelessness and desperation of the community. It is expected that taking the metro line will allow the residents in Hoogvliet to be able to go much further for less money

than other forms of public transportation. This will prevent them from becoming trapped in their environment and allow them to invest their money in things that will better themselves or their community. The houses near the metro line in Hoogvliet should not be worth as much as some of their distant neighbors, thus providing access for lower socioeconomic statuses to public transport. It is expected that Capelle a/d IJssel will have similar results to that of Hoogvliet; however the historical context of the two could not be more different. Since Hoogvliet used to be a port labor city and the Port of Rotterdam has expanded throughout the years, the job market in Hoogvliet moved further away thus leaving many citizens out of work and causing their socioeconomic status to drop. In contrast Capelle a/d Ijssel has been a suburban city for its existence which in turn means it has always been quite separated from its citizen's job market. In the manner in which Capelle a/d IJssel's results will differ from that of Hoogvliet is in how much the accessibility to public transport is needed by residents of Capelle a/d IJssel. It is assumed that the metro line is accessible by residents but not effectively utilized by them. However, the metro cannot be removed because it would pose large consequences for the city and effectively spatially segregate the community from Rotterdam. It is expected that at least one of the communities will show a correlation between the research questions and the situation present within that community. It is not expected that both communities display evidence toward spatial mismatch in relation to accessibility.

Chapter Four: Research Findings

The research findings will come after a review of the initial research questions.

- Research question 1: What is the effect of public transport towards the socioeconomic position of people?
- Research question 2: Does the accessibility of public transport and socioeconomic position affect spatial structure?
- Research question 3: Can this process be recognized in the neighborhoods of Capelle a/d IJssel and Hoogvliet?

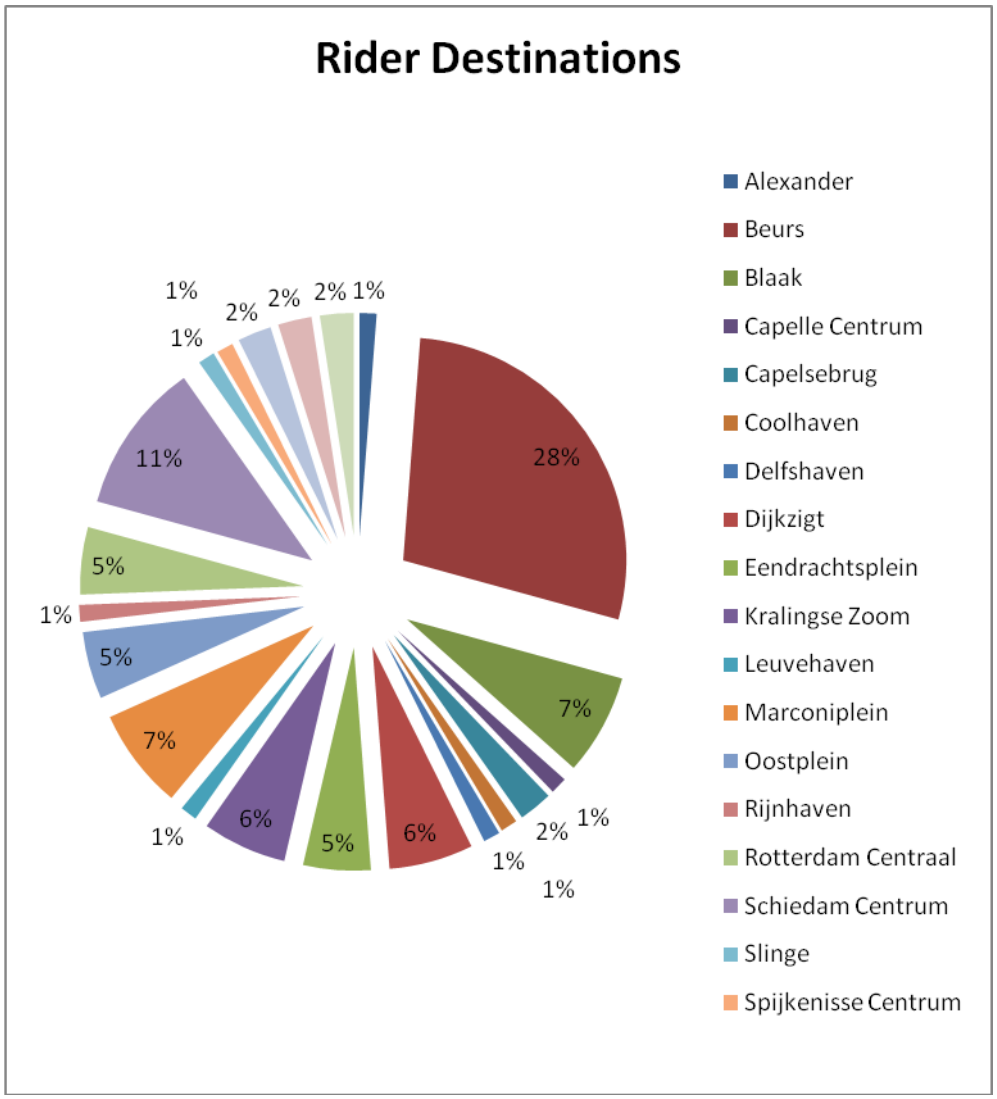
In answering these questions it was necessary to start from research question 3 and work backwards, so as to develop a proper scope of the study. Initially it was believed that focusing on these two neighborhoods alone would provide enough data to determine the accessibility. It was quickly determined that information from these two neighborhoods alone would not be enough to develop a proper image of the effects of spatial mismatch and would provide an incomplete picture of the effect of the Metro line. The scope for the research was therefore expanded to encompass the municipality of Rotterdam and the two cities at the end of the C line of Capelle a/d IJssel and Spijkenisse. To begin the research, statistical data was gathered on all the necessary variables for the gravity model to be used in determining the accessibility of the cities. Some of these variables took longer than others due to the Dutch holiday season coinciding with the time period for gathering data. All variables were eventually acquired in the long run but the pace was much slower than anticipated. As the data was slowly being received the qualitative research was performed. Interviews with researchers led to conclusions that the city of Rotterdam did not experience spatial mismatch due to a variety of factors such as: good public transport, denser communities, Dutch unemployment assistance and many more. This reaffirmed some of the initial hypotheses presented earlier but more research needed to be done.

Questionnaire Results

Interviews with Metro riders at Capelle Centrum, De Terp and Hoogvliet Metro stations on their way to work were performed during the data waiting period. The interviews were done in the morning as people were making their way to work. This allowed enough time to ask questions, as they had to wait for the metro to arrive, and by restricting interviews to weekdays made certain that the appropriate people were being questioned. Information gathered from the riders showed that the center of the city was in fact the main location for many people on their way to work, as Figure 1 demonstrates. From this data it was easy to determine where the main employment opportunities existed along the C line. The most central location in the city, Beurs, and the intersection of the A, B, C, and D line was indeed the location for the largest amount of riders heading to work. Also of note is that the two stops located just one

stop away from Beurs on the C line, Eendrachtsplein and Blaak, constitute 12% of the pie chart. After Beurs, the next largest portion was Schiedam Centrum. This location was actually quite distinct because most of the responses for Schiedam Centrum came from Hoogvliet. For these riders the distance and time it takes to reach Schiedam Centrum is almost exactly equivalent to the time and distance it takes for riders in Capelle a/d IJssel to reach Beurs. Overall the employment centers for riders travelling into Rotterdam are: the city center (Beurs, Eendrachtsplein, Blaak), Erasmus Medical Center (Dijkzigt), Europoint (Marconiplein), the Brainpark (Kralingse Zoom) and Overschie (Schiedam Centrum). Another analysis taken from the questionnaire was that a majority of people walked to the stations before taking the Metro. This was made easy for them due to the large apartment complexes and dense housing developments located next to the stations. A final important piece of information gained from the riders was a preliminary finding of the car ownership. According to the results, citizens of Capelle a/d IJssel have an ownership of about 1/2 whereas Hoogvliet had an automobile ownership of about 2/3rds.

Figure 1

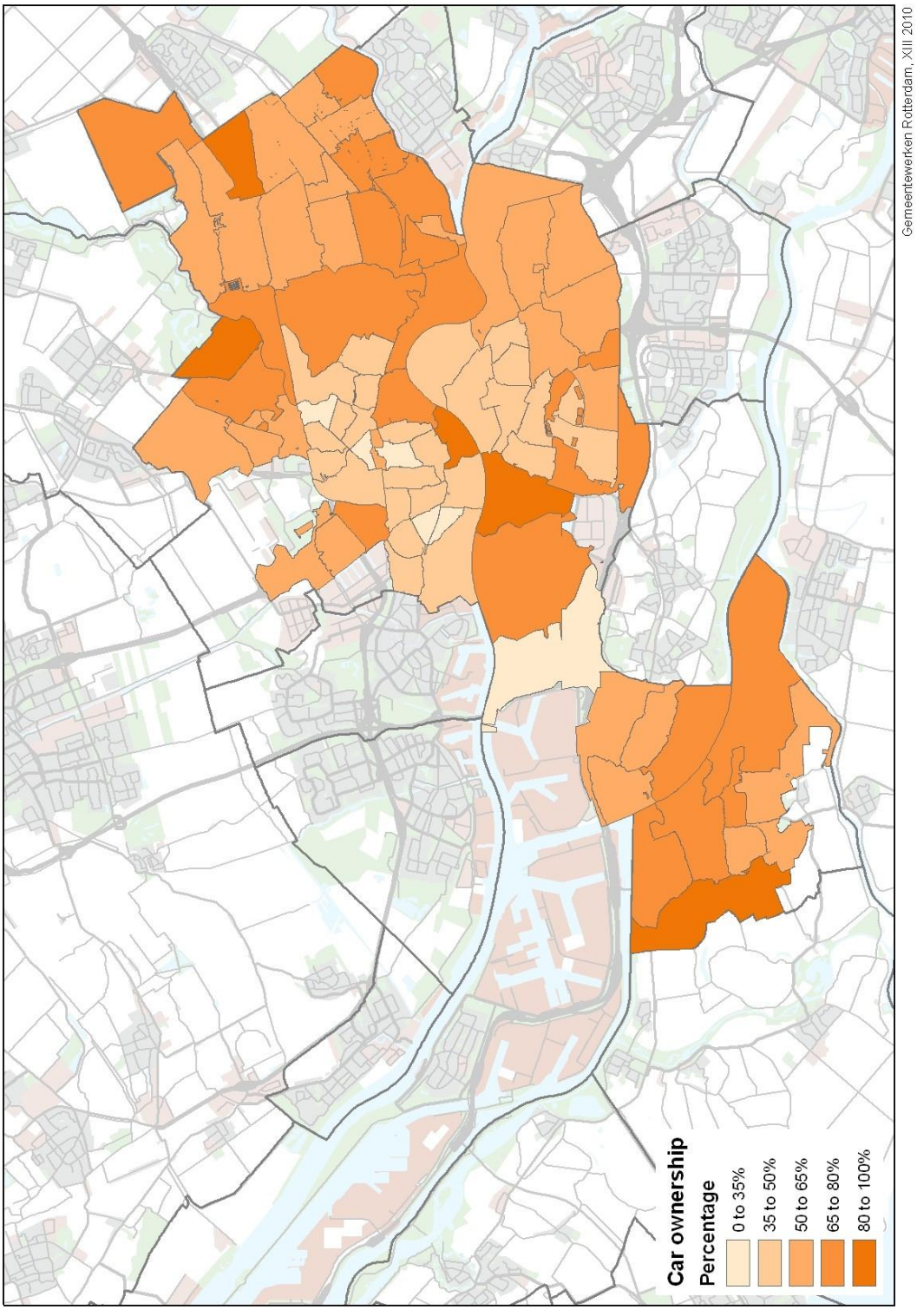


For the majority of the findings, the gravity model would be the method to determine the results of the research. To properly understand changes throughout the cities of Rotterdam, Spijkenisse and Capelle a/d IJssel were divided into their numerical postcodes. From here all the statistics collected earlier on such as employment opportunities, jobs available, automobile ownership, etc. could be divided into their appropriate postcode so as not to generalize the results over the entire city. These postcodes are not broken up into similar or equal shapes. For this study it would have been more accurate if these postcodes had been divided by neighborhoods. The variance in statistical area of the postcodes leads to some very diverse results and requires a thorough analysis of the area to actually understand what is happening there. It should be taken into account that this is the researcher's first experience with the gravity model so some hurdles were expected. Experts in the field of research and economics were consulted to help decipher the equation and the formation of the calculation and were instrumental in ensuring that the gravity model was used properly. The use of the gravity model was done under guidance from field experts.

Car Ownership

In this thesis, the idea of accessibility refers to the user-friendliness of the transport infrastructure for both car owners and those without the ownership of a car. Therefore car ownership is a critical piece towards determining the accessibility of each postcode. The data on car ownership is available through the Centraal Bureau voor Statistiek. The focus of the car ownership is on that of the working populations' ownership. There are also some workers who will be outside the realm of the data because they are either sharing a car with a spouse or partner other or they are carpooling to work with colleagues. While the values for car ownership were derived from CBS, the values for non-car ownership had to be derived by taking the population of citizens within working age located in a particular postcode and then subtracting the number of car owners in the postcode. This equation leads to a clearer picture of where car ownership is highest and lowest within the cities, as can be seen by Figure 2. A list of postcode names and the location of postcode numbers can be found in the annex.

Figure 2.



As can be expected, areas located further away from the city center have a higher car ownership rate than postcodes closer to the center. There were some findings that ran a bit out of the ordinary when compared to other postcodes nearby.

One of the starkest examples of this is postcode 3016 which is the location of Het Park, Euromast and Spido boat. This is the most southern tip of the city center on the north side of the river. While the working population of the area is one of the lowest in the city center, the percentage of car owners is in the same bracket as postcodes 3087 and 3208 located in Waalhaven and Western Spijkenisse, respectively. Another result askew of its neighbors is postcode 3195 which is the town of Pernis. Pernis itself is a small Shell community built mainly for the workers of the Shell refinery right across the road. Pernis demonstrates a remarkably small percentage of car owners when compared to its distance from the city center. This can be explained by the employment center for Pernis being located directly next to the town. The town is also small enough that the one Metro stop located near Pernis is quite easy to access anywhere in the town. There are other postcodes which show a slight alteration from the norm around them but not nearly as severe as Pernis and Het Park. These include: Melanchthonweg (3052), Molenlaankwartier (3055), Ahoy (3084), De Akkers (3206), North Oostgarde (2905), Hoofdweg (2908) and the city center postcodes. Melanchthonweg is located in the Hillegersberg-Schiebroek district which means it should have a much higher car ownership level in line with the rest of the district. However, Melanchthonweg has an ownership level of 50.3%. This can be explained by the postcodes extreme proximity towards the Melanchthonweg Metro stop on line E. On the opposite end of the spectrum, Molenlaankwartier has the second highest car ownership at 92.3% but this can be explained by the isolation of the postcode which is around 4 km from a Metro station. Ahoy demonstrates a much higher car ownership at 76.3% than its neighboring postcodes which are around 50%. This difference is harder to explain because the Ahoy postcode lies directly between the two Metro stops of Zuidplein and Slinge. An important bit of data to know about the area is that it has a working population of only 1135 people, whereas its neighbors have working populations of about 7000 people. So for the Ahoy postcode, the data may be skewed based on the sample population. De Akkers postcode is the furthest southwest postcode in this study, yet it has a car ownership of 55.2%. De Akkers is surrounded by postcodes with some of the highest percentages in the study, but it is also the end of the C and D lines. By surrounding this terminus station and being a less prosperous neighborhood, De Akkers has lowered its car ownership substantially. The postcode of North Oostgarde has a similar situation to De Akkers. While North Oostgarde is much better off financially than De Akkers it does also surround a terminus station of the C Metro line. This allows North Oostgarde to rely much less on automobile transportation. Hoofdweg is in a similar situation to Molenlaankwartier in that it is geographically isolated. Located between the A20 highway and the railroad, Hoofdweg is generally an industrial area and located far from a Metro stop. The variations in the city center have been saved till now because the seven postcodes (one of which, Het Park, has already been covered) it consists of five different levels of car ownership. Two of the postcodes located on the western portion of the city center, West Kruiskade (3014) and Middellandstraat (3021), have very low car ownership percentages. These two are located in areas with a high level of immigrants who would often have difficulty with the legal proceedings of acquiring a driver's

license and a car. The postcodes of Beurs (3012), Rotterdam Centraal (3013) and Erasmus MC (3015) all lie directly over a Metro stop, have a lower working population and all have car ownership percentages near 50%. The one postcode left is that of Blaak (3011). Blaak is similar to 3012, 3013 and 3015 in that it lies directly over a Metro stop, yet it has a large working population of 10,245 people and a car ownership percentage of 65.8%. This number is much harder to decipher and requires delving into other areas of the research.

Household Income

The best way to analyze the trends that are occurring within the realm of car ownership within the cities is to compare it to the data on income for each district, as in Figure 3.

Figure 3

	Total		Single Parent Family		Family W/ Children		Family W/O Children		Living Alone	
District Name	Households	Income	Households	Income	Households	Income	Households	Income	Households	Income
City Center	14924	25500	1111	23800	1363	33400	3430	36700	8471	19400
Delfshaven	30926	20600	3819	19900	5451	28700	5346	25900	14380	14600
Overschie	7372	25300	641	21700	1771	36400	1838	29100	2832	15600
Noord	25174	23100	2285	21100	3375	32000	5466	31100	12926	16800
Hillegerberg-Schiebroek	18989	31400	1433	24400	4622	45300	4801	38500	7557	19200
Kralingen-Crooswijk	23635	25600	2561	21600	3530	36500	5250	33900	11181	18200
Feijenoord	31018	22200	4115	20400	6375	29700	6189	26100	12098	15300
Ijsselmonde	27336	24200	2827	21400	5521	33300	6999	28300	10846	16400
Pernis	1955	27000	133	29500	467	36800	606	30000	700	16800
Prins Alexander	39743	28200	3111	24400	9409	39800	11300	32700	14930	17600
Charlois	31841	20700	3400	19500	4875	29100	6749	25600	15141	15200
Hoogvliet	15544	26000	1424	22100	3772	36100	4570	28700	5160	16100

According to the data on income of the districts, the most affluent districts are that of: Hillegersberg-Schiebroek, Prins Alexander and Pernis. Whereas the districts at the other end of the spectrum are: Delfshaven, Charlois and Feijenoord. The makeup of the family is also highly important to the information on income. In all districts except the City Center, there was a trend of Families With Children representing the largest income followed by: Family Without Children, Single Parent Family and Living Alone. In the City Center's case the Families Without Children made more than the Families With Children. Part of the reason for this is that the Families With Children account for 9.1% of the make up in the City Center, whereas Families Without Children account for 23%. The percentage for each demographic tells a lot about the types of people that live there. In all districts the highest percentage of residents belonged to the Living Alone category. The more suburban lifestyle of family and kids could be found in the more suburban neighborhoods of Hillegersberg-Schiebroek, Prins Alexander, Pernis and Hoogvliet. Single Parent

Families often have their income hit the hardest because they are feeding multiple mouths with one paycheck. According to the data, these areas are located in some of the rougher neighborhoods such as: Feijenoord, Charlois, Delfshaven and Kralingen-Crooswijk (as a note the neighborhood of Kralingen is typically much wealthier than Crooswijk).

Looking back at the data on car ownership and applying those results towards the information gathered from the income in districts, correlations can then be made on the level of income and its relation to car ownership. For areas with a higher percentage of Families With Children and a further distance from the city center there is also a higher percentage of car ownership. The Prins Alexander district is a perfect example of this as around 66% of the residents own a car and 23.7% of the households are Families With Children. Although it must be said that a higher percentage of Families With Children does not appear to be the key factor in determining the affluence of a district, that factor appears to be the percentage of Single Parent Family households. The higher the percentage of Single Parent Families, the lower the income level of the district and in correlation the lower the percentage of car ownership (except again in the Pernis case, which is proving to be an anomaly in this study). This trend can again be explained with the reasoning of one paycheck to feed multiple mouths and less money and time to spend on purchasing a car and driving (Blumenberg 2004). Of all the districts, Delfshaven has some of the lowest car ownership rates in the city (only Pernis was lower). Delfshaven also had the highest percentage of Single Parent Family households and the lowest total average income. According to this study then, Delfshaven is the most underprivileged district in Rotterdam. Other disadvantaged districts include: Charlois, Feijenoord and Noord. It is these depressed districts that will be most influential towards determining the spatial mismatch within Rotterdam because it is these districts that will be the most at risk based on their demographics. There is one other collection of neighborhoods that is in danger of becoming truly spatially mismatched. These districts are located far enough away from the city center that adequate public transport will be extremely important to the survival of their car-less residents. These districts include: Hoogvliet, Overschie and IJsselmonde. All of these districts have high auto accessibility through a direct link towards highway infrastructure but only Hoogvliet has direct access to the Metro system.

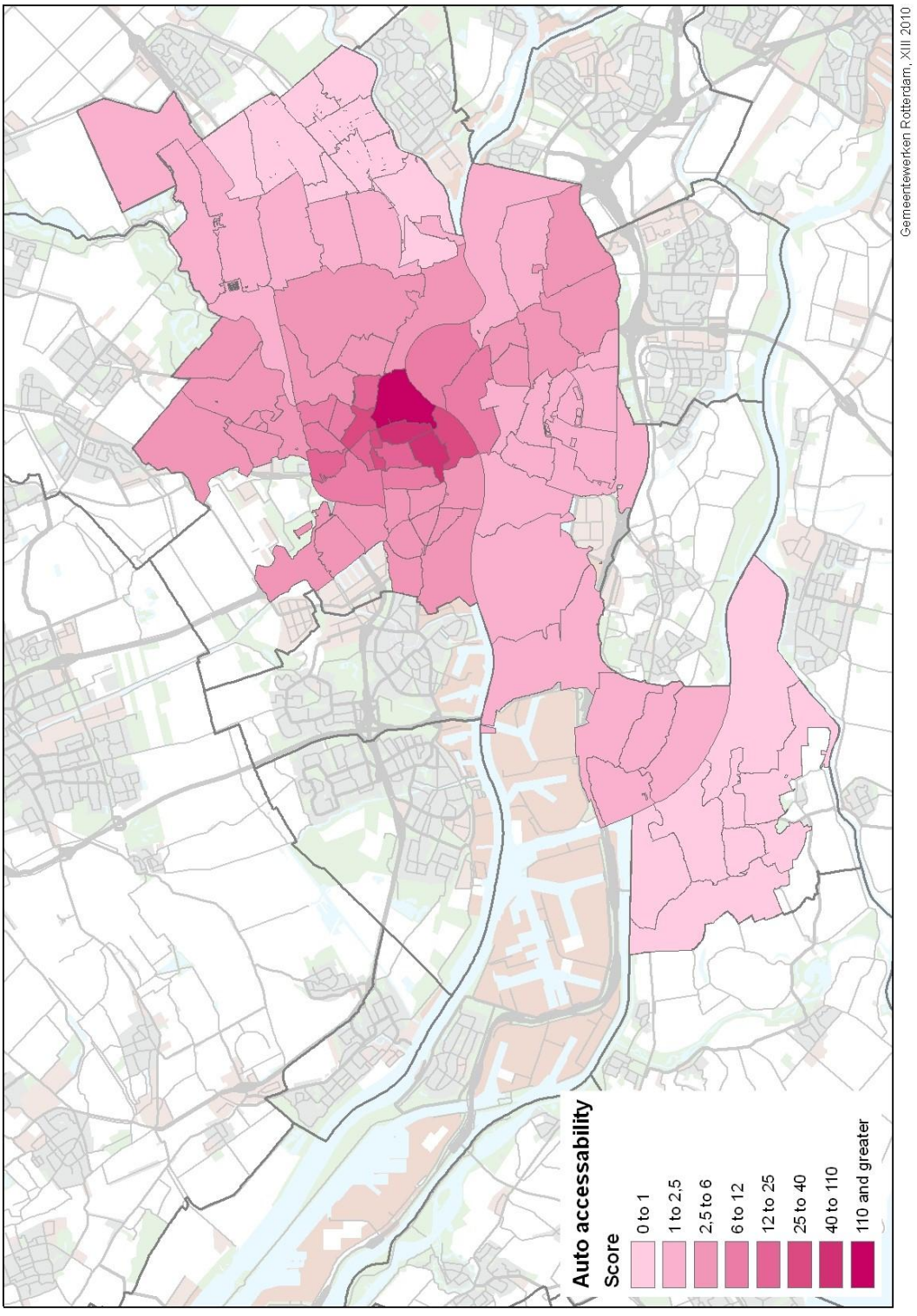
Accessibility

The measure that determines the accessibility mainly hinges on the value given by the impedance function. For this research, value of time multiplied by the time it takes to go between zones was used to determine the significance of each postcodes impedance function. The value of time the Dutch use is different for each mode of transport and quantifies how much a person is willing to spend for an hour using a specific method of travel. The value of time for automobile is €8.84 per hour and for urban rail is €8.29 per hour (Rijkswaterstaat 2006a & Rijkswaterstaat 2006b).

When broken down into minutes these values of time become €0.147 and €0.138 for car and metro respectively. These values can then be multiplied by the time in minutes it takes to go between zones. From here the impedance function works through very easily and each of these new figures will be input into the full equation of the gravity model. For this equation, it was important that the postcodes be organized based on the distance from the center; otherwise there would be no epicenter for the gravity model to work towards. The gravity model is not a brand new equation and has been around for around a century. The current form of the gravity model used in this thesis is only twelve years old, though, and is far more complicated than the original equation developed one hundred years ago. The form of the gravity model used in this study was chosen because it relates car ownership towards both automobile and public transport accessibility. It is important to note that the model does require an understanding of the calculus involved and that further expertise was sought for the running of this model.

The gravity model used in this research provides information on the accessibility for both automobiles and public transport within a particular postcode. The only methods used for public transport in this study are principally the Metro line and walking. On occasions where the walking distance was immense and would have taken an unreasonable amount of time to reach the Metro, bus transport was used to reach the Metro station. The focal point for the entire study was Beurs station due to its central location and high proximity to the highest amount of jobs. Google Maps was used for calculating time and distance to reach Beurs station from each postcode via auto, with the central portion of each postcode as the starting point. RET was used for calculating the time and distance for people travelling by Metro and walking only. For inputting all the statistical data gathered, Excel spreadsheets were developed to store the statistics and then calculate the values of accessibility via car or public transport. When the model was initially run there were some severe differences in the results done by Grengs (Grengs 2010) and the results my model was concluding. The differences were due to the distance from the center not being taken into account during the portion of the equation where zones were summed together from *i* to *j*, as Grengs had intended. After some recalibrating of my calculations and some readjusting to the method through which the calculus was supposed to be performed, values became more in line with those found in Grengs' and Shen's research. With the properly calculated values it became much easier to determine the areas of highest accessibility throughout the cities of Rotterdam, Capelle a/d IJssel and Spijkenisse. The results of the research can be found in the following figures. Figure 4 demonstrates auto accessibility, Figure 5 displays public transit accessibility and Figure 6 displays general accessibility for each postcode.

Figure 4

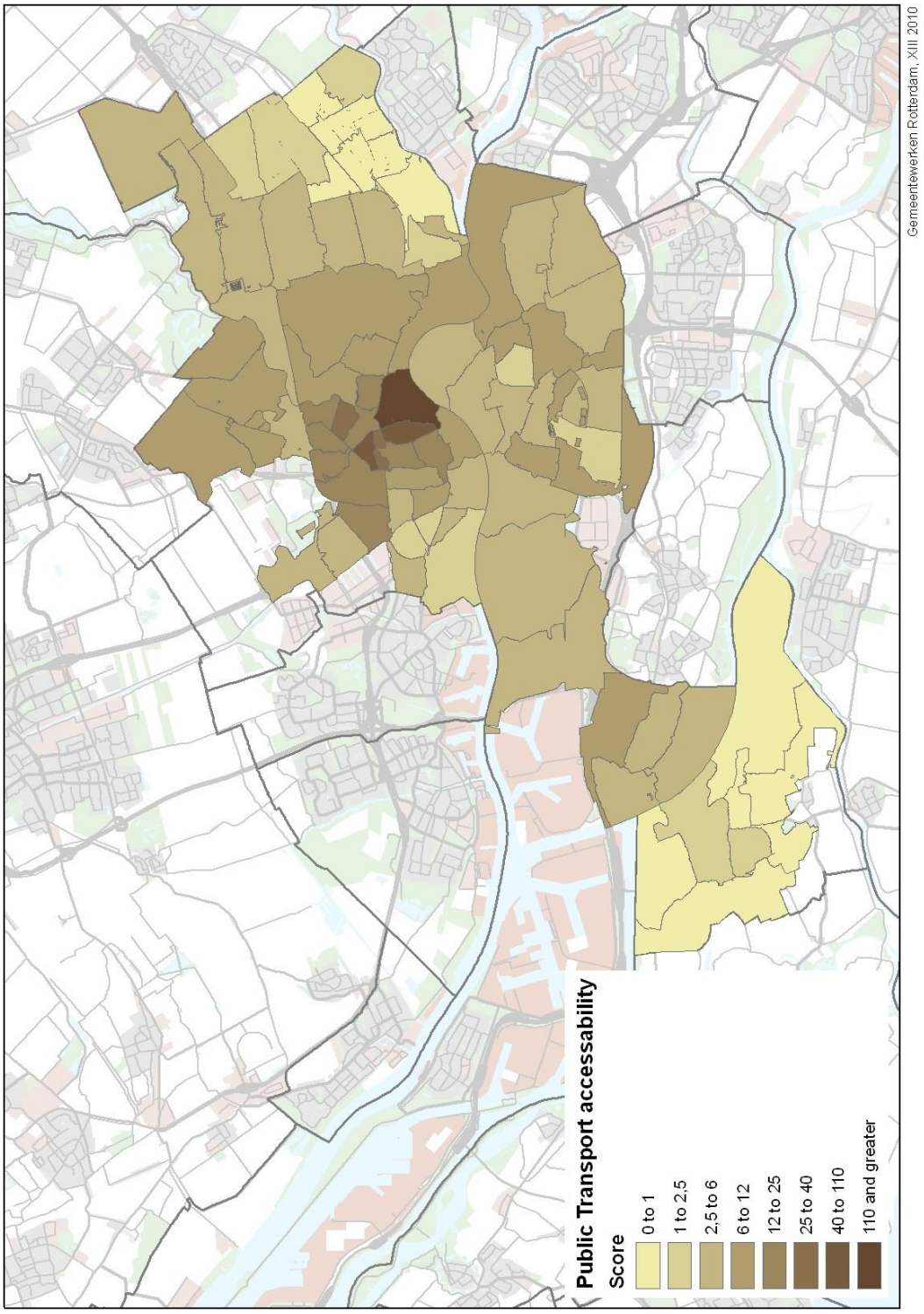

Auto accessability
Score
0 to 1
1 to 2,5
2,5 to 6
6 to 12
12 to 25
25 to 40
40 to 110
110 and greater
Gemeentewerken Rotterdam, XII 2010

Automobile Accessibility

The fastest way to reach Beurs station from within the city center is by car due to the main roads of Coolsingel and Westblaak which intersect with the station. The most auto-accessible to Beurs is postcode 3011, Blaak. The proximity of Blaak to Beurs is practically unfair from a driving standpoint. The two are 350 m apart so in the approximately 30 seconds it takes to reach the center by car a person walking will have taken about 40 steps and only gone about 40 m. It is important to note that when calculating the distance from Blaak to Beurs via public transport, the Metro was not used because it would have taken more time to reach the station travelling the 350 m by rail than it would have to walk. This was also the case for Beurs postcode of 3012. In 3012's case reaching the Metro station was well within walking distance but still the car was faster. For the West Kruiskade, Erasmus MC and Het Park postcodes (3014-3016), auto accessibility remained higher than public transport accessibility but just slightly. Two city center postcodes did have a lower automobile accessibility than public transport. These two postcodes were for Rotterdam Centraal (3013) and Middellandstraat (3021). Rotterdam Centraal can be explained easily because the center of the postcode sits directly upon the train station and therefore directly next to the Metro station. Driving from Rotterdam Centraal is much more time consuming because it requires going through the Hofplein roundabout which has to account for tram, bicycle, pedestrian and automobile traffic in four different directions. Middellandstraat is a little harder to explain as it is 1 km away from the nearest Metro station. However, travelling from Middellandstraat to Beurs also requires traveling through the Hofplein roundabout and therefore more time. Upon leaving the city center automobile accessibility began to drop off quickly with public transport accessibility climbing quickly in its place. There are still some areas where auto accessibility trumps public transport accessibility beyond the city center. In the district of Delfshaven, the postcodes of Tussendijken (3026) and Spangen (3027) experience a higher automobile access than public transport access despite being a kilometer away from the Marconiplein station. Moving to the Noord district there is only one postcode that experiences greater auto accessibility and that is the Hofplein (3032) postcode. This is not the same area as the Hofplein roundabout, but instead about 800 m northeast on the other side of the railroad tracks. Due to the Line D and E Metros not being connected yet, the time it takes to walk from the Hofplein station to the Stadhuis station causes enough of a delay for a car to beat a public transit rider. Beyond Hofplein, public transport in the Noord district becomes much more accessible. In the Feijenoord district postcodes Feijenoord (3071) and Strevelsweg (3073) experience more auto accessibility. Feijenoord's auto accessibility is so high due to its proximity to the Erasmusbrug which creates a much more direct access to the Beurs station than crossing Willemsbrug would. Strevelsweg also benefits from being close to the Erasmusbrug but it also benefits by being surrounded on all sides by major roads. In the district of Charlois no postcode shows great auto accessibility however one gets very close, West Slinge (3086). West Slinge may not be as close to the Maastunnel as some of its neighbors, but it is quickly accessible via major roads.

In the city of Capelle a/d IJssel only Capelle Centrum (2903) scored higher auto accessibility, but only slightly. Finally in the city of Spijkenisse only Maaswijk (3207) was more auto accessible due to it being a suburban neighborhood farther away from any of the Spijkenisse Metro stops. Something to note about Spijkenisse that is different than the other parts of the Rotterdam Stadsregio is that leaving the municipality can be quite a laborious exercise. Spijkenisse has two main bridges that connect it towards Rotterdam, the Hartelbrug connecting Spijkenisse to the A15 highway and the Groene Kruisweg bridge connecting Spijkenisse to Hoogvliet. The reason for the struggle with these bridges is that they are draw bridges that must yield to water traffic. In a country where there isn't much water traffic this would be less of a problem, but in the Netherlands water traffic gets first priority at an intersection. When calculating the accessibility for automobiles, the cost of petrol in the Netherlands has been placed into the Dutch Value of Time, which is the general reason why the further a car is from the city center the more costly it will be to drive to the center. It is important to note that the travel times used in this study do not account for traffic conditions which play a significant role in affecting travel times. However, traffic can vary dramatically depending on the road conditions. An area that is not as affected by traffic is that of public transport whose accessibility is shown in Figure 5.

Figure 5

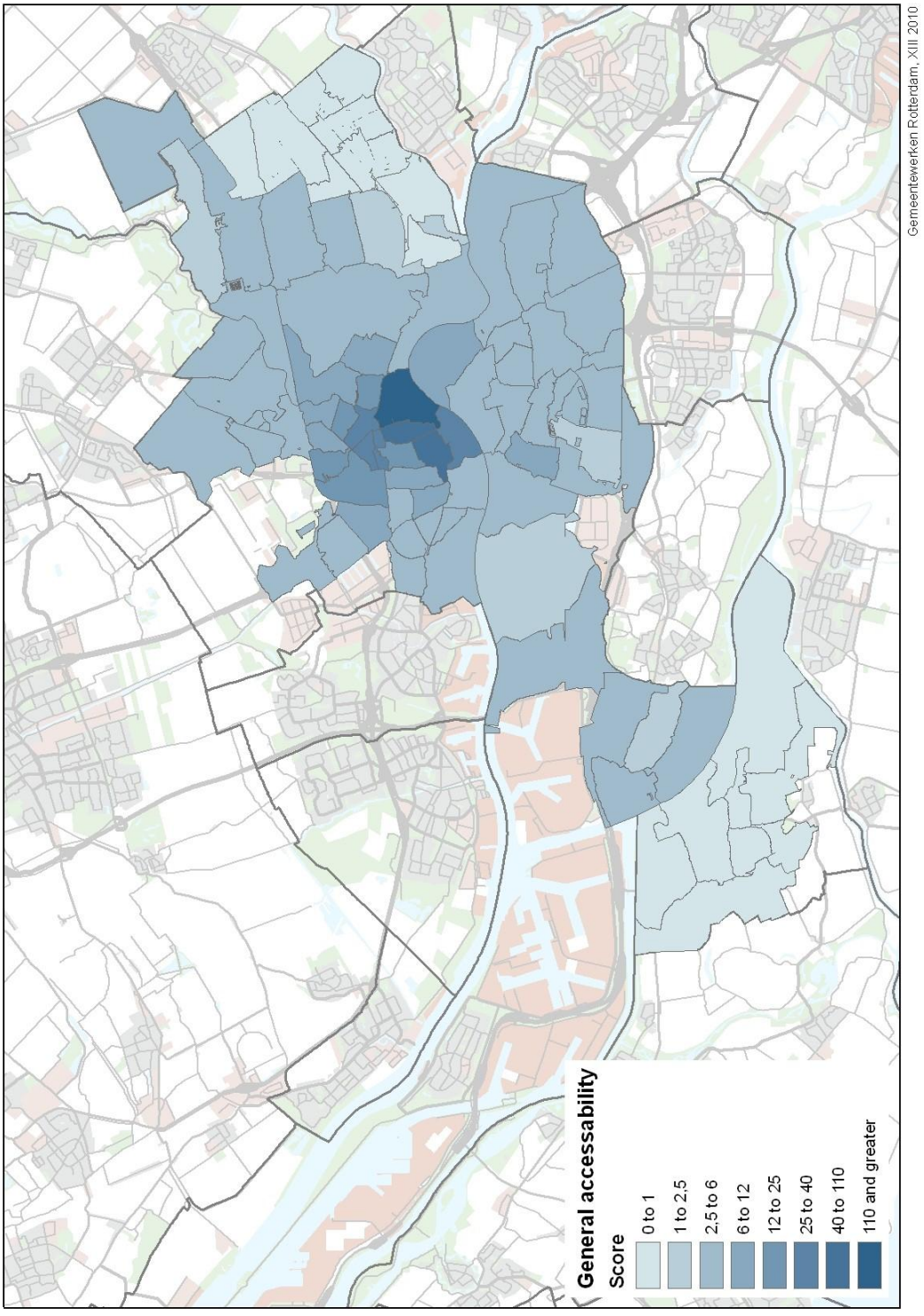

Public Transport accessability
Score
0 to 1
1 to 2,5
2,5 to 6
6 to 12
12 to 25
25 to 40
40 to 110
110 and greater
Gemeentewerken Rotterdam, XIII 2010

Public Transportation Accessibility

As hoped for, using public transit became a much more effective means to travel the further from the city center. There were certain parts located near the city center that were actually highly accessible by public transport. The best example of this was at Rotterdam Centraal (3013). Being the main railway terminal in a Dutch city means lots of connections with other forms of transport infrastructure. As such, Rotterdam Centraal provided immediate access to the Metro for 3013 but also for postcode Provenierswijk (3033) which is located just north of Centraal Station. The location of Provenierswijk gives it a dramatic uptick in public transport accessibility as opposed to its other Noord district brethren. For the rest of the Noord district, accessibility for public transport stays about 10 points higher than that of auto accessibility. In Delfshaven, there is a large dip in the accessibility as opposed to Noord and the City Center. The dip is so severe in fact that for the majority of Delfshaven accessibility by public transport is only slightly better than in Spijkenisse and Capelle a/d IJssel. Overall though, riding the Metro is a better alternative in Delfshaven especially in postcodes Coolhaven (3023) and Oud-Mathenesse (3028). These two postcodes are very close to the Coolhaven and Marconiplein Metro stations, respectively. In the district of Overschie, postcodes such as Blijdorp (3039) and Roel Langerakpark (3041) are close to Centraal Station so they enjoy the same type of accessibility as Provenierswijk. Once the transition is made from east of the A20 highway to the west side, public transport accessibility and auto accessibility become almost synonymous. Hillegersberg-Schiebroek is one of the more isolated sections of Rotterdam. Located on the north end of the A20 highway and separated from the problems of the city, Hillegersberg-Schiebroek is a quiet suburban community. This suburban isolation should make it a very auto accessible district, but on the contrary auto accessibility is rather low throughout the district. In a twist, public transport accessibility is relatively high with some of the further postcodes such as Hillegersberg, Molenlaankwartier and Terbregge (3054-56). While these areas are much further away from Metro stations than the rest of the Hillegersberg-Schiebroek, they are in close proximity to bus stops. It is these bus stops that trend the data towards higher public transport accessibility because otherwise the distance to a Metro station would have been ludicrously time consuming. Using the bus is somewhat cheating for these postcodes but it is well within the scope of this study so the values will be allowed. Moving on to the Kralingen-Crooswijk district, there is a dichotomy of the district just like the dichotomy of the name. The Crooswijk section (postcodes 3031 and 3034) has a high public transport accessibility thanks mainly to the proximity of the Oostplein Metro station which is only two stops from Beurs. Kralingen (postcodes 3061-3064) experiences much lower public transport accessibility than Crooswijk. A tremendous drop happens in the eastern most portion of Kralingen, Kralingse Veer (3064). Here the isolation of being surrounded by the IJssel river, A16 highway and Abram van Rijckevorselweg causes Kralingse Veer's public transport accessibility to plummet. Further east in the Prins Alexander district, accessibility for the Metro line is much higher than in Kralingse Veer. There are

seven Metro stations that run through the Prins Alexander district which give it a relatively good accessibility. The postcodes that experience the greatest access are located closest to the stations like: Nesselande (3059), Prinsenland (3066) and Zevenkamp (3068). The south of Rotterdam has long been a troubled area for the municipality to deal with. A high level of immigrants, a limited number of crossings to the north shore and the expansion of the port have historically led to a large number of civil issues to deal with. As far as accessibility towards the Metro goes, it is typically less of an issue for the municipality to deal with. The northern most part of the south shore is that of Feijenoord and its location close to the City Center causes the postcodes along the shore of the Maas (Feijenoord (3071), Katendrecht (3072) and Strevelsweg (3073)) to be more car accessible than Metro accessible. Just a few hundred meters past the edge of Strevelsweg, public transport accessibility shoots past car accessibility thanks in large part to bus access to Zuidplein. IJsselmonde is located at the very southeast corner of Rotterdam and in a different direction than the path of the Metro line; however it has the benefit of public transit access because of the bus stops. Charlois experiences a higher level of public transport accessibility because of the D Metro line forming just about the eastern border of the district. Heading to the furthest southwest district of Rotterdam is Hoogvliet and Pernis. Pernis has marched to the beat of its own drum throughout the course of this research, but in the realm of accessibility to both automobile and public transport, it falls in line with the rest of its neighbors. Both Hoogvliet and Pernis experience a higher level of Metro accessibility than car accessibility due to the distance from the city center and to the relatively small dimensions of the neighborhoods. The public transport accessibility numbers for these two neighborhoods are similar to those for IJsselmonde and Prins Alexander. Finally there are the suburban cities of Spijkenisse and Capelle a/d IJssel which have the lowest accessibility scores of both modes of transport. Capelle a/d IJssel's most Metro accessible postcode is Fascinatio Circle (2909) which is located closest to Rotterdam. Spijkenisse follows a similar pattern with its most accessible postcode, Spijkenisse Centre (3201), located closest to Rotterdam's center. Now that the accessibility of each mode of travel has been determined it is time to find the general accessibility of each postcode. This can be viewed in Figure 6.

Figure 6



General Accessibility

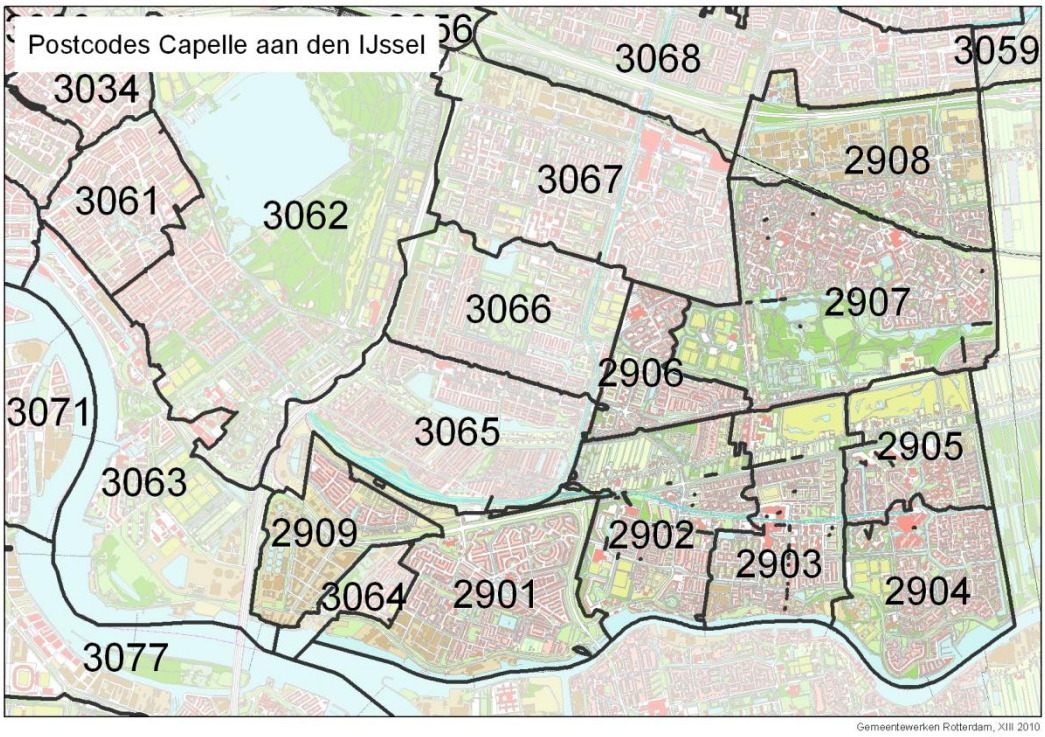
The general accessibility score displays the accessibility of both car and public transport while adding extra weight to one or the other based on car ownership or lack

thereof. While this number is practically in the middle of the two other accessibility scores, car ownership does alter the direction to which the general accessibility score gravitates. A prime example of this is that of the Blaak postcode (3011) which has the highest level of auto accessibility and much lower transport accessibility. The general accessibility score more closely approaches the auto side than the public transport side once automobile ownership is taken into account. The opposite can be said for the Delfshaven and Noord districts. In these districts their low car ownership rates gravitates the general accessibility scores towards public transport accessibility instead of automobile. The general accessibility scores for Rotterdam do not stray from the previous trends found in the accessibilities of cars and public transport. That is to say, that the City Center, Noord, the eastern portion of Overschie and the Crooswijk section of Kralingen-Crooswijk all have the highest general accessibility in the city. Those postcodes further from the City Center experience a drop off in accessibility with an increase in distance.

Site Analysis

The distance drop off is the spatial divide that is the heart of spatial mismatch research. In this study, a gravity model was used to determine the accessibility of the city based on automobile and Metro transport. While the results are just numbers and they cannot lie, they can be altered. Since this is the case it is also important to physically see the real life environment and conclude whether it matches up with the world of the numbers. To do this, neighborhoods had to be physically walked around to determine whether there were structures that prevented access. Since the neighborhoods of Capelle a/d IJssel and Hoogvliet are the main subjects of this work it is important to start with them, with Capelle a/d IJssel (as seen in Figure 7) being first.

Figure 7.

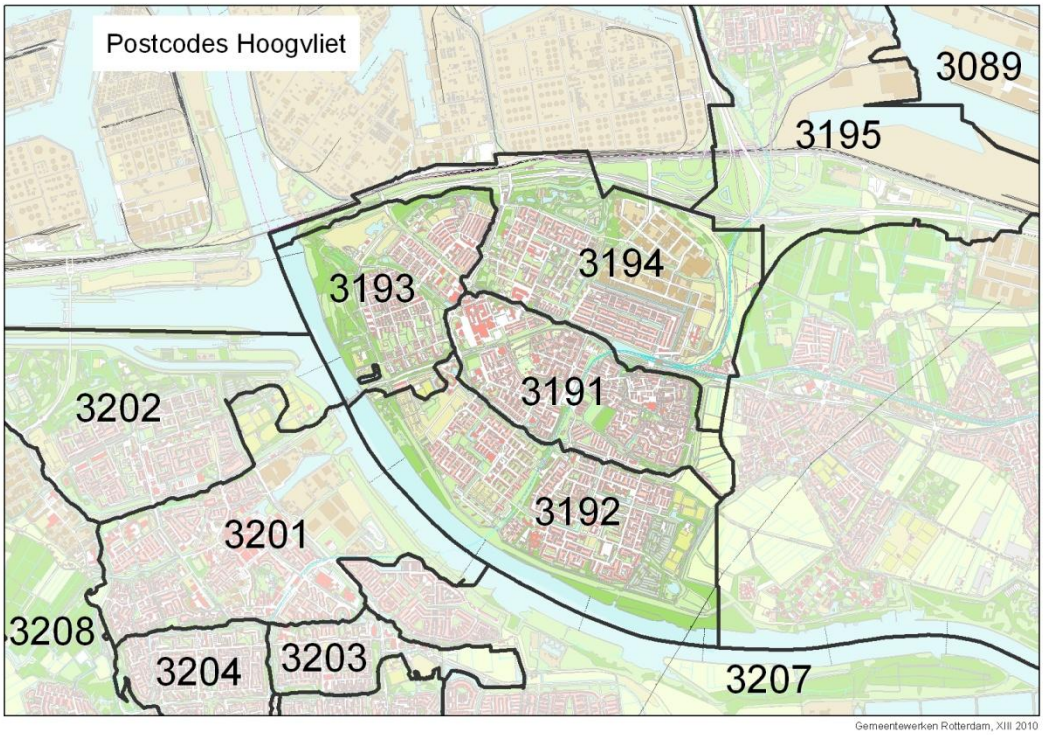


The city of Capelle a/d IJssel has three main borders: the A20 highway to the north, the IJssel river to the south and Prins Alexanderlaan to the west. Postcodes Capelle West (2901) and Fascinatio Circle (2909) are located west of Prins Alexanderlaan, however they are confined by the A20 highway and Metro track. While Fascinatio Circle is confined by the Metro, the heart of Capelle a/d IJssel has the Metro running through it almost like the spine in a fishbone. A majority of the streets in Capelle a/d IJssel run perpendicular to the Metro line forming the ribs of the fishbone. There are very few roads that run parallel to the Metro line, still fewer of the roads travel an extensive distance through the city. The center of Capelle a/d IJssel is actually quite different than its northern Schollevar sections. In Capelle Schollevar, roads such as Caplseweg and Hoofdweg become the axis and development is built around them. The development is not built in an orderly grid manner either; instead it is built in a twisty windy suburban pattern that is easy to get lost in. There are multiple Metro stops on the west of Capelle Schollevar, however that is only on the western side.

Hoogvliet (as seen in Figure 8) is built in a much more round form than that of Capelle a/d IJssel, which should provide better access throughout the municipality. The big difference is that instead of the Metro running through the center like in Capelle a/d IJssel, a major road (the N492) runs through. The history of Hoogvliet actually explains why this happened. When the town of Hoogvliet was originally developed there was a tram line that traveled through what is now the N492 towards

Spijkenisse. Since that tramline has been removed the only public transportation link has been the Metro. While the Metro is much faster than the tram, it is also in a much less central location of the municipality. There is no question that the Metro runs through the highest population postcodes of Hoogvliet Centre (3191) and Zalmplaat (3192) but the still relatively large populations in the northwest corner of Hoogvliet remain distanced from the Metro line by the N492. It is these north and western regions of Hoogvliet that also house higher percentages of non-car owners.

Figure 8.



There are some redevelopments going on towards more middle class incomes which should push the car ownership percentage higher, but a large amount of the housing in the area is outdated, poorly designed and owned by lower income groups. So while Hoogvliet remains a largely auto dependant municipality (all postcodes are above 60% car ownership) certain areas are being isolated. Although it was not in the original scope of the research Spijkenisse did have a very good example of why public transport is desperately needed for lower income neighborhoods. For Spijkenisse, automobile ownership is much higher than practically any other district in this study, except for one postcode De Akkers (3206). De Akkers is the terminus station for both Metro line C and D and the station itself is actually quite large. What is most important about De Akkers is the type of neighborhood it is. De Akkers is a densely packed region with winding streets that all eventually lead to the Metro station. De Akkers is also not a very good neighborhood, which was visible from the dense conditions and trash lying around the place. It also has an extremely low car

ownership rate of 55.2%. This may not seem like much since it is still over 50%, but in comparison to its surroundings which are 62-89% car ownership, De Akkers is more on the same level as the south of Rotterdam which is about 18 kilometers away. This is not just some population error because De Akkers has the second highest working population in Spijkenisse at 7,255 people.

Limitations

It is important to remember that this study is done with the accessibility of reaching the City Center, Beurs station, by car or Metro. The reason for this location is that it was where the most job opportunities are located. What should be noted though is that the Beurs area is not the only location with job opportunities. Going back to the rider graph in Figure 1, there are obvious nodes of business activity located within Rotterdam. These nodes are situated almost exclusively above the C Metro line, mainly because C line riders were a majority of the questionnaire. What doesn't come across in the questionnaire but is evident from getting off at these stops and looking around is that the Metro stations Schiedam Centrum, Marconiplein, Dijkzigt, Beurs, Blaak and Kralingse Zoom are right next to the hubs of business activity in Rotterdam. Despite the huge economic impact of the port of Rotterdam on the city itself, the manual labor demand for that region has just about dried up which leaves it practically outside the business nodes discovered earlier. The closest nodes to the port are that of Overschie and Europoint who actually have industries that take part in the port process. With the expansion of the port westward, many of these engines of commerce will travel towards the North Sea with the port, thus creating a new section of land for redevelopment. So while the port will continue to spatially divide itself from the heart of the city, the six stations mentioned earlier will provide the necessary occupations for job seekers. With that mentioned, it is worth noting that the level of spatial mismatch would be better determined by calculating the accessibility of these six stops as well. This added information would truly give the accessibility for some of the farther reaches of Rotterdam. For residents in a city such as Spijkenisse, reaching Schiedam Centrum or Marconiplein is much more logical than traveling all the way into the City Center. The same can be said for much of the Prins Alexander district who would be better served traveling to Kralingse Zoom. In the case of traveling on the Metro it is understood that there will be a proportion of the riders who own a car and are still riding the Metro for a variety of reasons. It is also understood that those individuals that own a car may also be sharing the car or be carpooling non-owners, creating a margin of error. The scope of this study did leave out some major employment areas in Rotterdam, mainly the Alexandrium and Winkelcentrum Zuidplein. These two massive malls provide a large section of the commercial opportunities in the east and south of Rotterdam respectively. They pose a difficulty because they provide job opportunities in the opposite direction than where common thought process dictates the options for occupation should be, in the center. These two shopping malls create a large spectrum of jobs for some of the more remote areas of Rotterdam. There are also the surrounding municipalities of

Dordrecht, Schiedam, Ridderkerk, Barendrecht, Vlaardingen and other towns who constitute a good chunk of the Stadsregio of Rotterdam. These communities also have many job seekers headed towards occupations in and around Rotterdam. Their populations are better served by the NS train lines than Metro lines. In relation to the train lines two Metro stations are very imperative to the limitations of this study. These stations are not just Metro stops but also train stations, Rotterdam Centraal and Schiedam Centrum. Why these stations are significant is because of the Netherlands' extensive train network which enables an employee to live in Rotterdam and work in a distant city, such as Den Haag. Affording this type of transportability allows workers to have more options for job employment than may be available in the city they live in. There is a distinct possibility that within this study a small percentage of the population does in fact commute between cities instead of commuting from the suburb to the cities.

There are also two other modes unaccounted for so far within this study: trams and bicycles. Both of these forms of transportation come with their own set of benefits and limitations. Trams are relatively cheap, faster than walking and their network does not necessarily coincide with that of the Metro. Trams, however, must deal with road traffic at intersections and travel slower than other forms of rail transport. Bicycling in the Netherlands is one of the easiest, cleanest and cheapest forms of transportation thanks to a high level of cycling infrastructure. Yet a person is only willing to travel so far on a bicycle and they are more exposed to the elements of the ever-changing Dutch weather. Omitting these forms of infrastructure does skew many of the results in this study, especially areas served heavily by tram. For every hole in the research there is a good reason for omitting the form of transport. In the case of cycling, many of the distances are far too great to be traveled by bicycle in a reasonable manner of under an hour. For trams, their infrastructure does not extend as far as that of Metros and leaves many outer areas subserviced. Buses are only used in this study to reach Metro stations because the bus network travels in many directions often times with multiple connections required to reach the center of the city. Finally trains offer some of the fastest travel to the City Center but their infrastructural impact is quite small considering only a small portion of Rotterdam has access to a train station. Metros and cars cover the most places in the city faster than any other form of transportation available to be used in this study. In comparing the situation in the United States to that of Rotterdam, more Metro infrastructure has been put into place than train, tram and bicycle. A lot of the United States light rail infrastructure is done in a different form than that of Europe. For Metros in the United States, the infrastructure is often at the street level. This makes it easily accessible for anyone walking along the street. However, it then must interfere with all the other infrastructure and buildings that already exist at the street level. This form of light rail planning would be better as a tram line because it would be able to share the road infrastructure if needed. Unfortunately the alternative to street level Metros is building a Metro above or below street level which is much more costly. The problem with going cheap and building on ground level is that the infrastructure that was built to

connect the community now has a chance to split the community. This type of problem is very prevalent in cities with railroads. In the United States coming from "the other side of the tracks" is synonymous with coming from a downtrodden neighborhood. Rotterdam does not have this kind of issue with their Metros because only one section (the eastern part of the A and B line past Capelsebrug) is actually on street level. This ground level section is already showing signs of "other side of the tracks" deprivation. The homes directly next to the Metro have become degraded because property values have dropped due to the noise from the Metro going by.

The use of the gravity model in this research was in itself both important to the research but also a limitation. The model is a very useful tool to display spatial mismatch as it demonstrates focal points and distance very well. It is however a complicated process. The delicacies of the model were a bit unexpected for the researcher. The model is typically used by traffic engineers and requires a good dose of calculus to work properly, both of which are not my backgrounds. These hurdles were crossable but would have been easier with proper training. The collection of the data for each variable came with its own challenges as well. It is important to know when collecting statistics within the Netherlands that if any cannot be acquired via the internet it is best to not try and gather them from people during the summer because they will most likely be out of the office on holiday. The Dutch are a very helpful people and are more than willing to assist you, if they are in the office. Acquiring the data was only half the challenge of the gravity model, the other half was making sure the function was correct. While many days were spent working out the equation in Excel and adjusting where need be, many days were also spent asking professionals with greater expertise in mathematics and formulas. It would be recommended that if attempting this model that a mathematics professional looks over it first or that the attempter has a thorough understanding of the workings of the gravity model. There is also the possibility that your professional advisor may also find a more practical way to word the equation or may find fault in the equation itself.

Chapter Five: Conclusions

The purpose of this study was to determine the accessibility of areas of Rotterdam, Capelle a/d IJssel and Spijkenisse towards two modes of transportation: Metro and automobile. The main Metro line that was focused upon was that of the C line with endpoints in Capelle a/d IJssel and Spijkenisse. Data for Metro lines A,B and D are also included in this study although not to the same extent as Metro line C. This research looks into how effectively communities with limited car ownership are given access to public transport thus providing them with a quick and efficient method for their residents to reach their employer. For the conclusions section the chapter will first be broken up into individual deductions related to: car ownership, car accessibility and transport accessibility. Then the chapter will come to conclusions based on combining the data and how this information can answer the research questions of:

- What is the effect of accessibility to public transport towards the socioeconomic position of people?
- Does the accessibility of public transport and socioeconomic status affect spatial structure?
- Can this process be recognized in the neighborhoods of Capelle a/d IJssel and/or Hoogvliet?

Chapter Five will then end with relating the conclusions towards the literature review, offering planning policy options and recommendations for further study.

Car Ownership

In the realm of car ownership, it was intriguing to note that the areas east of the Kralingen postcode (3061) through the Prins Alexander district had a much higher car ownership percentage than most of the south which was about the same distance. Car ownership was also extremely high in the northern sections of Rotterdam, especially in the Hillegersberg-Schiebroek area across the A20 highway. It would appear that being further away from the City Center would lead to higher car ownership, in which it often does, but the higher car ownership is also located in the more affluent neighborhoods of Rotterdam. These well off neighborhoods don't have to worry about becoming spatially mismatched because they can afford to own a car and therefore their travel options remain very open. The neighborhoods along the south bank are more at risk of becoming spatially mismatched than many of those along the north bank. They are especially at risk because most of the employment opportunities are located along the north bank. There are four road access points that connect the south shore to the north shore. These include the Erasmusbrug, Willemsbrug, Maastunnel and A16 highway. One of these, the Maastunnel, is not accessible by bikers and pedestrians. The location of the Maastunnel is actually extremely important because it provides access to the Erasmus MC directly and quick

access to Europoint and Overschie. The district closest to this vital artery is Charlois, yet Charlois's car ownership percentage hovers under 50% which means that a majority of the working population in Charlois must take a 20 minute Metro ride to go 3.3 km to Erasmus MC. This same 3.3 km trip could be done by a car in 5 minutes. With most of the port industries that were once the lifeblood of the south moving to the west, the opportunities on the southern bank still remain low compared to that of the north.

Car Accessibility

Car accessibility over the region of Rotterdam, Capelle a/d IJssel and Spijkenisse showed that once outside of the Blaak postcode, car accessibility drops and often at a rapid pace. The three wide boulevards of Westblaak, Weena and Westzeedijk all intersect with the main artery of Coolsingel to provide for the City Center. Those streets provide in the City Center to the west of Beurs station whereas Oostzeedijk, Maasboulevard and Blaak provide for the eastern end. These giving streets practically stop upon exiting the boundaries of the City Center. On the eastern side, Oostzeedijk combines with Blaak to form just Oostzeedijk and along with Maasboulevard they connect the east of Rotterdam to the center. There is a problem with Maasboulevard though. Since it is located along the edge of the river, it is peppered with drawbridges which must allow access to the boats located in some of the old harbors. Another issue is location because it mainly serves only one side of the road, which also happens to be the side served easily by Oostzeedijk. Meanwhile on the western edge of the City Center, accessibility drops almost immediately once Gravendijkwal is crossed. On the north side of the City Center, the Coolsingel traverses Hofplein and is renamed Schiekade. Luckily for Schiekade, it doesn't lose any of the accessibility once crossing Hofplein and gives the Noord district high auto accessibility. Finally along the south of the City Center, auto accessibility is low despite three main arteries into the heart of Rotterdam. The problem with these three is that the Maas River is so wide that it takes a longer time to cross over. Couple this distance with the already further distance to travel and it's easy to see why auto accessibility drops along the southern side. On the southern shore there are areas that tend to be at a higher car accessibility score but most of this is due to two things: their proximity in location to the bridges (Erasmusbrug and Willemsbrug) or their proximity to the roads that feed into those bridges. This is all despite the fact that a large number of car owners live on the Southside and the vast amount of car friendly infrastructure. The same car friendly infrastructure exists in the eastern portions of Rotterdam and makes getting around the district of Prins Alexander easy by car.

Transport Accessibility

Transport accessibility does not follow the same pattern as that of car accessibility. When judging it, distance to Beurs station does play a part of it, but it is the distance to the Metro itself that also determines the accessibility. Instead of

leaving the house, walking to the car and driving away; a public transport rider must commute to the Metro Station before taking the Metro into the city. For some of the postcodes this commute was relatively simple: Blaak (3011), Beurs (3012), Schiemond (3025), Zuidplein (3072), Capelle Centrum (2903), etc. The heart of these postcodes is located right next to a Metro station giving them great access. The inclusion of buses for certain postcodes that were incredibly distant from the nearest Metro did skew the results a little, but the data would have been outside the realm of plausible possibility if other alternatives had not been provided.

Combining Results

So after comparing the effect that public transport accessibility, car accessibility and car ownership have on a neighborhood it is now time to turn attention to the neighborhoods themselves. In this study certain districts around Rotterdam were identified as troubled areas. These districts include: Delfshaven, Charlois and Feijenoord. To better answer the first research question of whether accessibility to public transport has any effect on the socioeconomic position, the districts were then broken down into postcodes. From here the postcodes of Delfshaven could be identified as 3022 to 3029, Charlois as 3081 to 3089 and Feijenoord as 3071 to 3075. This allowed the data to be matched up and results to be identified. Delfshaven, the disadvantaged district on the north side of the Maas River showed a low car ownership. Unfortunately for them, they also had a low public transport accessibility that should have landed in the Prins Alexander District, and in some cases all the way into Spijkenisse or Capelle a/d IJssel. Delfshaven did have a lower automobile access than what was expected for living so close to the City Center yet the auto accessibility was similar to other districts about the same distance from Beurs station. Therefore owning a car would prove advantageous to living in Delfshaven yet only a little over one third get that opportunity. The opportunities provided by car ownership would help the large amount of single parent families who live in Delfshaven since they are not as flexible in traveling as they would be owning a car. Delfshaven's average income is also the lowest of any of the districts which has most certainly led to the low amount of cars being owned. Feijenoord's experience is similar to that of Delfshaven but slightly better off. Feijenoord has the highest average income of the three but that can be attributed to the recent developments around Wilhelminaplein that cater to a more upscale socioeconomic status. Much of Feijenoord has a higher auto accessibility score and fortunately those areas also have a higher car ownership rate. Some postcodes do elude this advantage namely Katendrecht and Strevelswijk. These two neighborhoods still have much lower car ownership and only have decent public transport access scores. Feijenoord also has the distinction of having the highest percentage of single parent families, which means living in these two neighborhoods is disadvantageous to them. Finally, the district of Charlois has higher public transport accessibility in its distant regions except this area has a higher car ownership. Car ownership is less of an advantage in Charlois though because the district has low automobile accessibility scores

throughout. Charlois is in between Delfshaven and Feijenoord in the realm of average income but below both when it comes to single parent family level of income. So while having a car would help the single parent families to be more flexible, their low income and low auto accessibility in the area means it wouldn't be worth it. It does appear that for many of the postcodes in these three districts owning a car would allow for a better socioeconomic status, yet the results make it difficult for that statement to become fact.

For answering the second research question of does the accessibility of public transport and socioeconomic status effect spatial structure, there were some neighborhoods whose spatial structure had an adverse impact on the socioeconomic status and accessibility. An example of a neighborhood spatially devoid from access is Katendrecht. Katendrecht is typically the go-to-name for bad neighborhoods in Rotterdam. However, there are good reasons why its name is so often on the top of "neighborhood in need of improvement" lists. The old port that once made up the very existence of the peninsula is long gone. The only ways from one end of the peninsula to the other is by car, bus, long bike ride or even longer walk. The very structure of the peninsula cuts it off from the rest of the city. There are no bridges from the tip to any other near pieces of land, such as Wilhelminapier or Charlois. Instead, there is one bus line that if missed does not come for 15 minutes or the option to drive. Driving is a severe challenge since less than 40% of the working population has ownership of a car. The redevelopments being done on Katendrecht have brought in more middle class residents which will come with car ownership. There is still a majority of the peninsula that remains carless and poor yet they are enviably close to the City Center. Another display of car ownership playing a heavy part in the livability of an area is on the Noordereiland. As the only island in the Maas River, Noordereiland is its own unique location in Rotterdam. Noordereiland is also extremely isolated. The island has two bridges, one on the north and one on the south. These bridges do have bike paths and sidewalks but would not be fun to cross in bad weather. They are very car friendly bridges and this is evident since almost the entire edge around Noordereiland is a parking lot. This ring of parking spaces best serves those people that live along the outside of the island but as for those on the inside; their access is much more limited. These examples answer whether space affects public transport access and socioeconomic status but as far as the opposite being true results were not as obvious. What became apparent was that economic development affected public transport access and the spatial structure within Rotterdam, but once outside of Rotterdam city limits the access to public transport affected the spatial structure and thereby the socioeconomic status. Within the city proper, Rotterdam's Metro stops were not located in the middle of large scale housing projects. Instead these Metro stops were located around large scale businesses and government buildings. The Metro stops that provided greater access for lower socioeconomic statuses based on the residential buildings being much closer were located in Spijkenisse and Capelle a/d IJssel. In these cities using the Metro provides a more consistent yet still fast option to reach work without having to drive. These riders

travelling to work are precisely the reason why economic centers are located along the Metro within Rotterdam. Many of the people that live within Rotterdam are often close enough to where they work that they do not need the Metro as much to reach their jobs. For the further areas, even up to Hoogvliet and Prins Alexander, the Metro is used to bring people into the city to work not from the city to the outskirts to work. Therefore socioeconomic status and public transport accessibility do not affect spatial structure the closer to the center of Rotterdam you are. They do affect spatial structure the further out from the center of Rotterdam one is.

To answer the final research question of whether the process just mentioned in the last paragraph can be visible in Hoogvliet or Capelle a/d IJssel, it is important to know the makeup of the two communities. Hoogvliet is only four postcodes big with a working population of 20,205 people. Capelle a/d IJssel is made up of nine postcodes with a working population of 40,395 people. Automatically it is evident that Hoogvliet is much smaller. In fact Capelle a/d IJssel is about twice the size of Hoogvliet in just about every way (population, density, area) except distance from the City Center. Much of Capelle a/d IJssel's size can be contributed to its acquisition of Schollevar which doubles the size of the city. Despite these differences, lower socioeconomic development within the communities has focused around public transport access. Capelle a/d IJssel is practically two towns with two different types of design. The original portion of the city located along the IJssel is built around the Metro line. As stated earlier the city is designed like a fishbone with the Metro forming the spine. This is a bit unique because the Metro line runs high above ground which allows major roads to cross by the stations. In the Schollevar section of Capelle a/d IJssel, development is again centered surrounding a public transport node but it is train not Metro. Much of Capelle Schollevar is also higher income and more car-oriented with more parking to accommodate this need. Hoogvliet's story is different than that of Capelle a/d IJssel. When Hoogvliet was just forming its development focused around the then existent tram line that ran through the center of town. Once the tram line was turned into a road, development moved south towards the new Metro line. This caused much of the older developments located away from the Metro to fall into decay. There has now been a program run by the municipality called WiMBY! (WiMBY! 2010) to redevelop these neighborhoods into higher class housing. This gentrification has pushed much of the lower socioeconomic class towards the main road and towards the Metro line. The gentrification taking place throughout some of the poor neighborhoods in Rotterdam such as Katendrecht and northern Hoogvliet may be looked at as a travesty towards lesser income groups but it can be used to help push them to locations where they will be better served. For these neighborhoods, it is important to realize that much of the new development is taking place at the furthest edge of the neighborhood. At this distance the gentrification taking place squeezes lesser income groups instead of pushes them away. While it sounds horrible for the poor, it can be used to give them cheaper housing in the form of denser apartments and it can also push them in the direction of the public transport they will be better served by.

Final Conclusions and Recommendations

Relating the findings to those in the literature review, there were few areas in Rotterdam where having a car would have been the best alternative as opposed to the cases of Los Angeles and Detroit. In those cases, providing residents with cars would have been a much better alternative than placing public transport such as light rail or trams simply because of how spread out the populations were. Rotterdam does not have the problem of spreading out that the United States does because in the Netherlands there is nowhere to spread out too but the sea. The urban planning of dense structures has severely limited the ability of Rotterdam to become a spatially mismatched city. As stated previously though, there were some locations that did show signs of spatial mismatch. The solution for Rotterdam is not an increase in car ownership as would be the case in the United States but a restructuring of where the car owners live. The areas with high car ownership were often highly accessible and if they weren't they had public transportation options to service them. The compact design of Dutch cities does not allow for them to easily expand their streets or highways. Instead they must become more creative. Fortunately, this lack of expansion room means that incorporating public transport is much easier because the population density of the city is much higher and less space is needed to build massive parking lots at Park-n-Rides, which take up valuable space. Rotterdam also has experimented with a unique policy to try and prevent disadvantaged neighborhoods from getting any worse. This "Rotterdam Law" prevents continued immigration of lower income individuals into the housing market of a low class neighborhood (Ouwehand & van der Laan Bouma-Doff, 2007). This type of stopping the faucet buys the neighborhood more time to deal with their societal problems. This time can be used to develop an effective strategy to service those in spatially disadvantaged communities with transport they can access or other policies to assist them.

According to this study, a lower access to public transport due to spatial disadvantages and a lack of car ownership in the area can lead to a continued lowering of socioeconomic status. If the area has a high level of car ownership, it should also have a higher level of socioeconomic status which means spatial disadvantages accompanied with a low access to public transport will be less of an issue. In short, the people that have the cars can afford the cars and can afford to live in a car-friendly environment. These car oriented neighborhoods must be lived in by car owners or the scale necessary to make the neighborhood car-friendly can lead to a disadvantage in space for workers without an automobile. For Rotterdam, car ownership typically went hand in hand with higher auto accessibility. The south of Rotterdam and Delfshaven did not get to experience this plus to their environment. Also unfortunate for these neighborhoods was that they scored relatively poorly for public transport accessibility when related to the Metro. It seems as though the Metro map for the south of Rotterdam is set for many years to come and unfortunately many of the neighborhoods in Charlois and Feijenoord remain spatially mismatched from their

Metro access. Rotterdam is already taking steps to improve this by a process of selective gentrification. By improving the south banks of the Maas, Rotterdam is redefining who lives in the area. The selective gentrification will push those in need of public transport access closer to the Metro line, once a clientele that does not require high public transport access moves in. This process has already begun in Hoogvliet and seems to have been planned for in Capelle a/d IJssel. These areas may have both low automobile access and low public transport access to the City Center but they are not cut off from the rest of the city.

The scope of this study gave an entirely different view to the literature of spatial mismatch. Since most spatial mismatch literature is almost entirely centered in the United States, the concept and the solutions to solving the problem are limited to American examples. By broadening the concept of city design to that of a country like the Netherlands, more options can be identified and more solutions can be found. The biggest recommendation for further research is to test the spatial mismatch of many other cities around the world to determine whether their city design has limited the effects of spatial mismatch. A vast array of worldwide experience would be invaluable to finding solutions to spatial mismatch. As far as transportation, it seems as though it can be a solution to solving the problem of spatial mismatch. Transportation by itself is not capable of the change but with the right location and proper access for lower socioeconomic classes it can be an effective remedy.

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Annex

Postcode Names

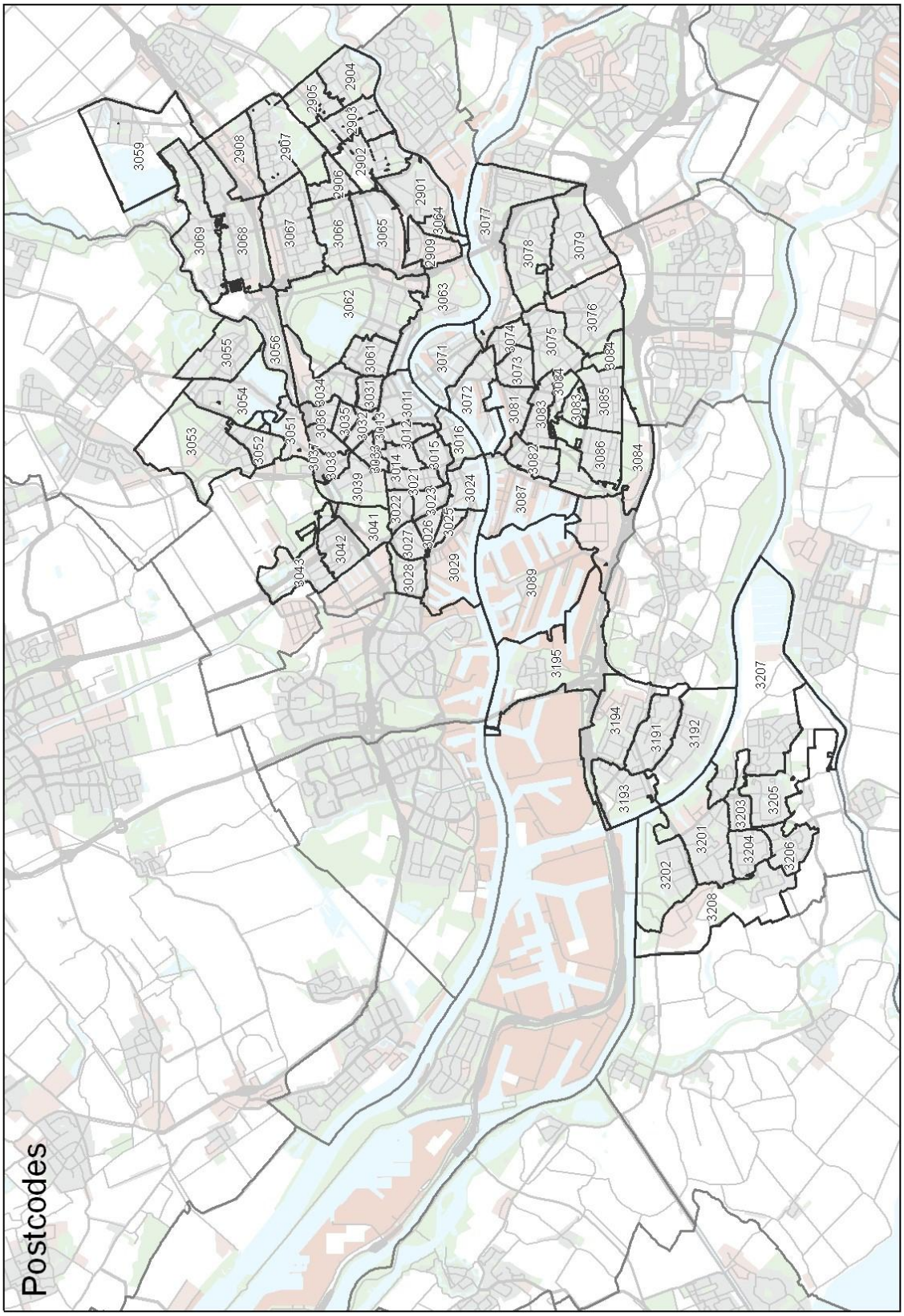
Capelle a/d IJssel	
City Center	
Delfshaven	
Noord	
Overschie	
Hillegersberg-Schiebroek	
Prins Alexander	
Feijenoord	
Charlois	
Hoogvliet	
Pernis	
Spijkenisse	

2901	Capelle West
2902	Slotlaan
2903	Capelle Centrum
2904	S. Oostgarde
2905	N. Oostgarde
2906	Ijsselland Hospital
2907	Schollevaar
2908	Hoofdweg
2909	Fascinatio Circle
3011	Blaak
3012	Beurs
3013	Centraal Station
3014	West Kruiskade
3015	Erasmus MC
3016	Het Park
3021	Middellandstraat
3022	Beukeldijk
3023	Coolhaven
3024	Delfshaven
3025	Schiemond
3026	Tussendijken
3027	Spangen
3028	Mathenesse
3029	Mathenesse Harbor
3031	N. Oostplein
3032	Hofplein
3033	Provenierswijk
3034	Crooswijk
3035	Noord Centre
3036	NE Noord
3037	Liskwartier

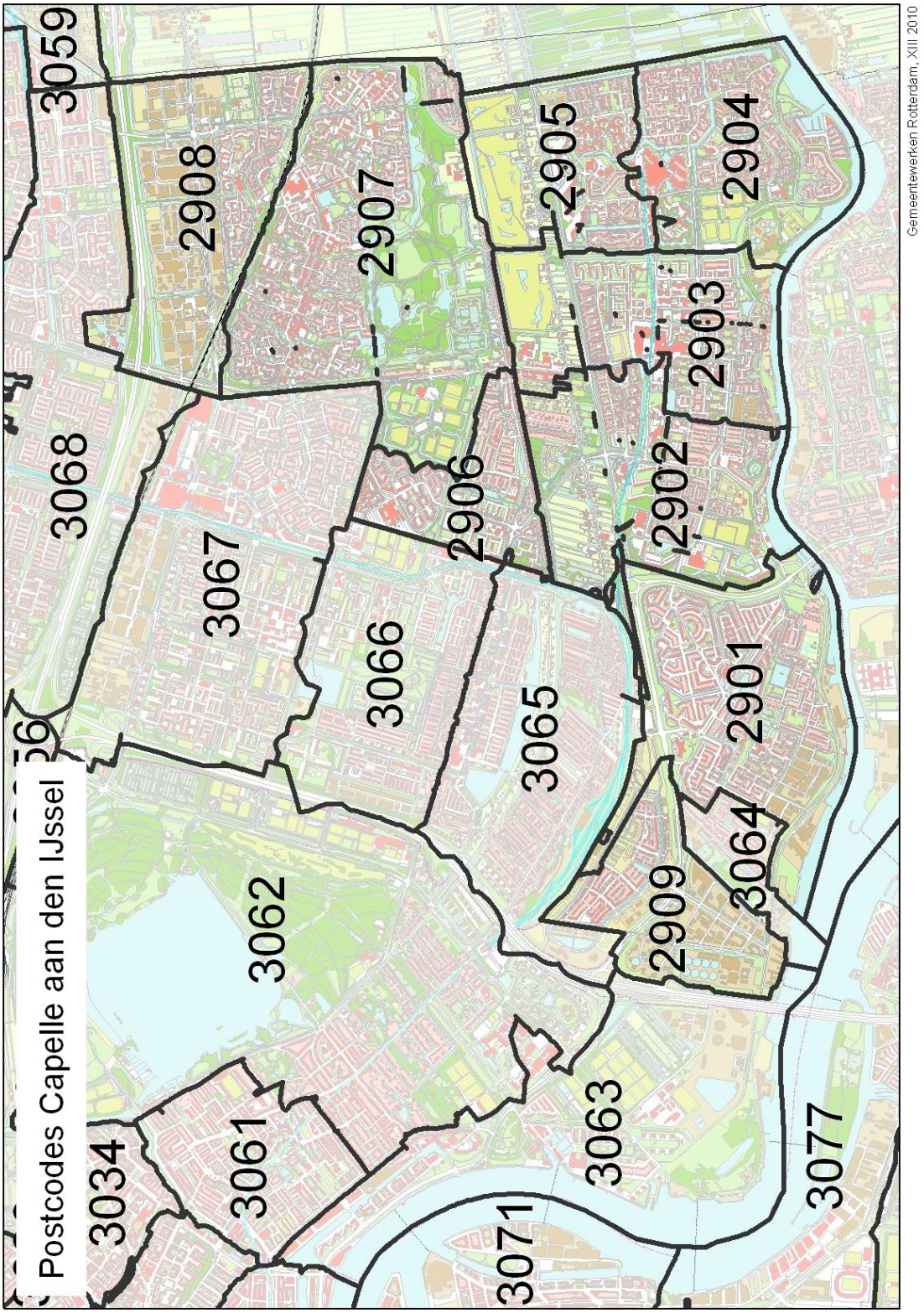
3038	Schieweg
3039	Vroesenpark
3041	Zoo
3042	Spaanse Polder E.
3043	Almost Airport
3051	N. Noord Station
3052	Melanchthonweg
3053	Schiebroek
3054	North Ismuth
3055	Molenlaankwartier
3056	Paintball area
3059	Nesseland
3061	Kralingen
3062	Kralingse Zoom
3063	De Esch
3064	Kralingscheveer
3065	S. Prinsenland
3066	Prinsen Park
3067	Lage Land
3068	N. Alexander
3069	Ommoord
3071	Wilhelminaplein
3072	Rijnhaven
3073	Maashaven
3074	Feijenoord District
3075	South Hospital
3076	Lombardijen
3077	Oud Ijsselmonde
3078	Ijsselmonde North
3079	Ijsselmonde South
3081	Tarwewijk
3082	Charlois
3083	Zuidplein
3084	Ahoy
3085	E. Slinge
3086	W. Slinge
3087	Waalhaven
3089	Heijplaat
3191	Hoogvliet Centre
3192	Zalmplaat
3193	NW Hoogvliet
3194	NE Hoogvliet
3195	Pernis
3201	Spijkenisse Centre
3202	N. Spijkenisse
3203	E Heemraadlaan

3204	W Heemraadlaan
3205	Waterland
3206	De Akkers
3207	Maaswijk
3208	W. Spijkenisse

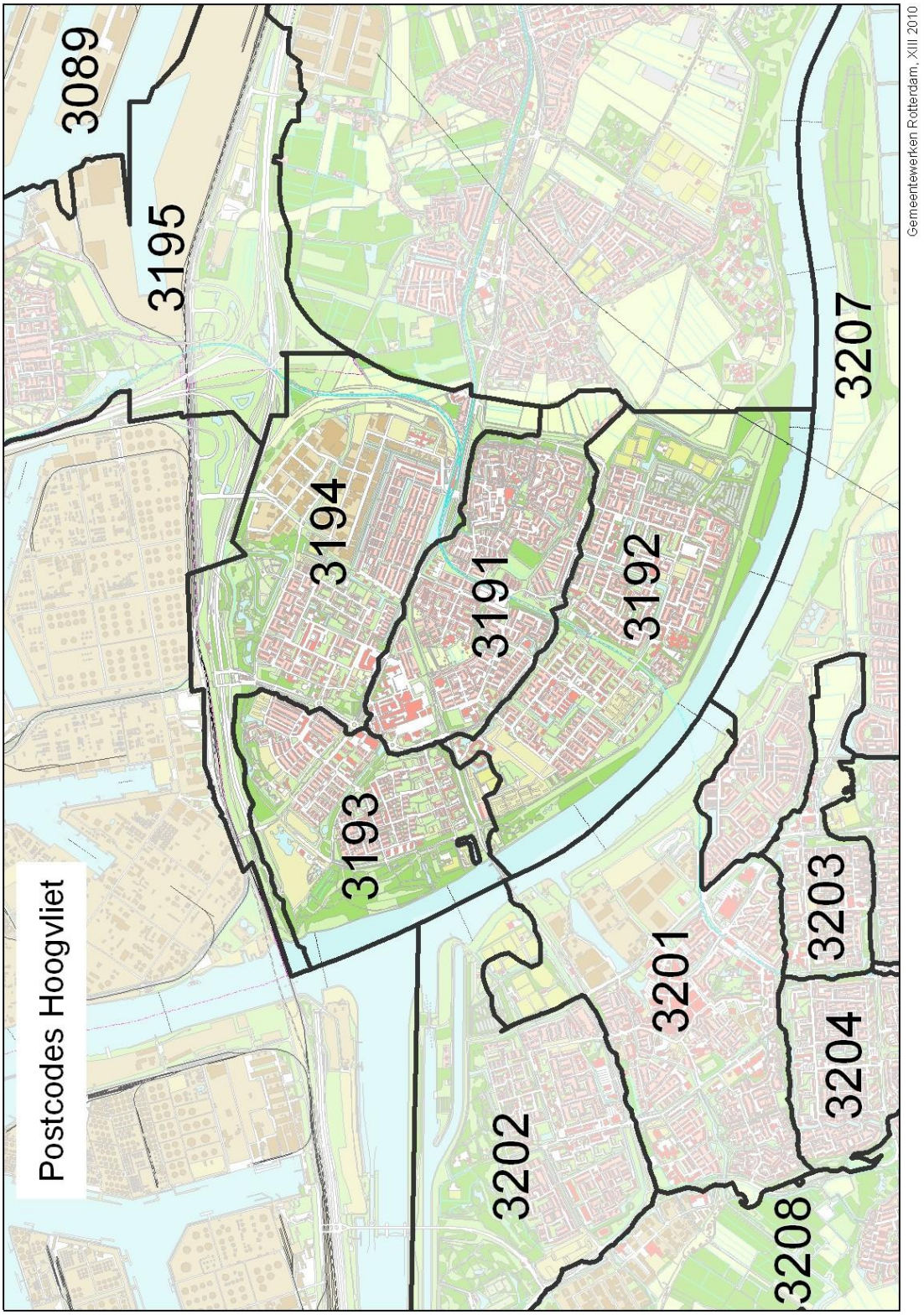
Postcode Map



Enlarged Capelle a/d IJssel Map



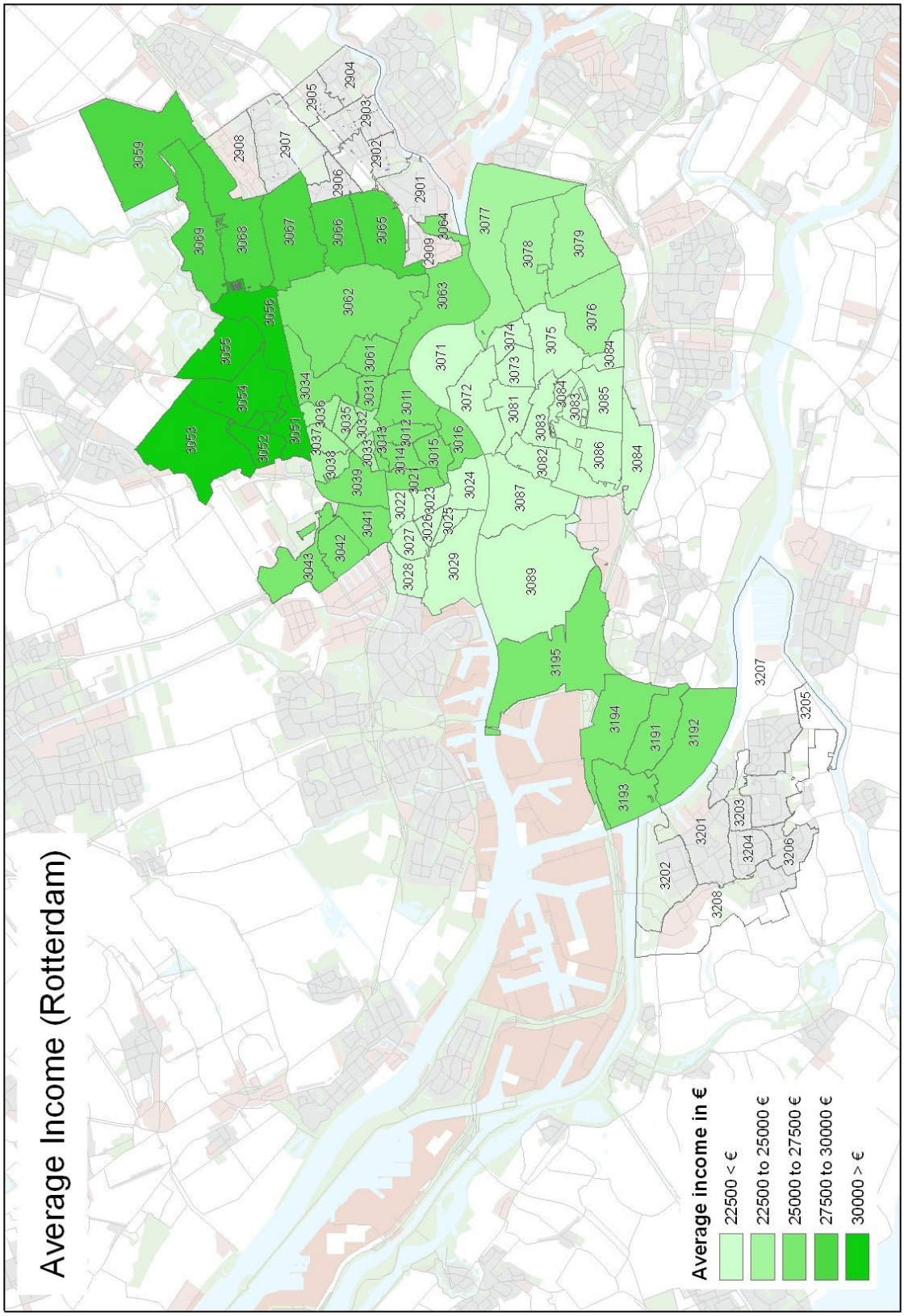
Enlarged Hoogvleit Map



Questionnaire

Are you taking the Metro to work?	Bent u met de metro naar het werk?
Yes No	
What stop will you be getting off at?	Wat stop je uitstappen bij?
Do you own a car?	Heeft u een eigen auto?
Yes No	
How long does it take you to reach your job?	Hoe lang duurt het voordat u uw baan te bereiken?
<5 5-10 10-20 20-40 40+	
How did you reach the Metro station?	Hoe bent u op het metrostation?
Walk Bike Bus Metro Car Other	

Average Income Map



Average Single Parent Income Map