ERASMUS UNIVERSITY ROTTERDAM
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Bachelor Thesis BSc Economie & Bedrijfseconomie

The Relationship Between Accessibility and Subjective Well-being:

a case-study regarding a third riverbank connection in Rotterdam

Abstract

This research investigates the relationship between the accessibility of a district in the city of Rotterdam and the perceived well-being in the district, and how the construction of a third riverbank connection will affect well-being. Data from the districts in the municipality of Rotterdam is used for the years 2014, 2016, 2018, and 2020. This is done by regressing a random effect model. The results show that accessibility by car does have a significantly positive effect on the subjective well-being of people, but accessibility by bike and public transport do not. Furthermore, the districts being located close to the new riverbank connection are likely to benefit from it, while the districts further away are expected to experience lower well-being.

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Table of Contents

Table of Figures

Introduction

The city of Rotterdam is characterised by the major differences between the districts: prosperous neighbourhoods alternate with heavily derelict areas. Some parts of the city flourish with rising housing prices and descending crime rates, while other districts undergo the opposite trend (Gemeente Rotterdam, 2019). One of the main objectives of the municipality council of Rotterdam is to mitigate the contrasts that exist between the neighbourhoods in the city, as has previously successfully been done with the 'Kop van Zuid' area. For example, the 'Nationaal Plan Rotterdam-Zuid' (NPRZ) has been created by the municipality of Rotterdam, in order to stimulate the development of Rotterdam-South. The goals that are provided include increasing safety, stimulating high educational attainment, and building new houses (NPRZ, 2019). Eventually, the municipality, the Dutch government, and various other stakeholders aim to improve the overall well-being in Rotterdam-South.

Furthermore, the Dutch government has recently agreed to invest in the construction of a third riverbank connection in the vicinity of Rotterdam (Rijksoverheid, 2017). The principal reason for this is to relieve the other connections crossing the Meuse. The city of Rotterdam officially has two riverbank connections (i.e. the 'Erasmusbrug' and the 'Willemsbrug'), but two other connections are located close to the city as well (i.e. the 'Maastunnel' and the 'Van Brienenoordbrug'). The 'Maastunnel' will be less congested as a result of the construction of the 'Blankenburgtunnel' that is planned to be completed in 2022. The other connections have to be relieved by the construction of a third riverbank connection. Out of three possible options, the municipality council of Rotterdam has chosen to further elaborate the possibility of either a bridge or a tunnel between the districts of Feyenoord and De Esch (Gemeenteraad Rotterdam, 2019). This new connection will have only one lane in either direction, but will contain a high-frequency transitway for public transport. Although the new connection is not likely to be completed before 2035, for the scope of this paper, it is assumed that there is no construction time for the new connection.

Although these two projects are currently being considered two separate objectives, it is likely that they are able to influence each other. The new riverbank connection could give a boost to the area and, by this means, regenerate a disadvantaged part of the city. Therefore, the main question of this research is how a change in the accessibility of neighbourhoods affects the corresponding level of well-being and, subsequently, how the construction of a third riverbank connection in Rotterdam will affect the well-being throughout the city. In order to fully answer this question, the question will be divided into two parts. The first part is the question or the level of accessibility of a district is positively related to the perceived level of well-being. This would imply that when accessibility increases, well-being does so as well, and vice versa. The second part is determining how the levels of well-being in the districts will change as a result of a third riverbank connection.

As the construction of a new riverbank connection is a large investment by both the municipality of Rotterdam and the Dutch government, all the consequences regarding this decision have to be looked into. Although multiple reports have been written on this subject, they all fail to include the well-being of residents and are mainly targeted on traffic effects (MRDH, 2018a; 2018b). This makes the subject highly socially relevant. Furthermore, existing literature about the effects of an increase in transport infrastructure on welfare is lacking for most European countries. The researches that have been carried out mainly focus on the theoretical side of it, and do not empirically substantiate their statements. Therefore, the subject is academically relevant since it is the first empirical based research on this matter in The Netherlands.

Firstly, the existing literature will be discussed in this research, followed by the data and methodology section. Then, the results found will be presented. The discussion section and the conclusion are the final parts of the research.

Theory

The welfare effects of transport and traffic are fiercely debated over recent years. The construction of a third riverbank connection can affect the subjective well-being in the districts of Rotterdam both positively as negatively. The existing literature on this topic will be discussed.

Well-being

The well-being of people belongs to the most investigated areas of science, as one of the aims of morality, politics, law, and economics is to maximise this aspect of human life (Griffin, 1986). In order to fully understand the concept of well-being, it is vital to find out how the well-being of a person is influenced. The main problem in determining a person's well-being is that it is hard to measure it exactly. Well-being is a subjective measure and can basically only be provided by the person himself. It has been shown that the determinants of well-being even differ per individual, making it almost impossible to objectively measure well-being (Diener, Suh, Lucas, & Smith, 1999). Therefore, it is common practice in this field of research to use subjective well-being instead. However, even then it is important to specify the question about well-being properly since people may assume different definitions of well-being (Dodge, Daly, Huyton, & Sanders, 2012; Kahneman & Krueger, 2006). Although objective determinants are still considered relevant, over the last decades the emphasis of the determinants of well-being seems to shift towards comparative measures instead. Ross, Eyman, and Kishchuk (1986) mention that subjective measures, such as what people have achieved so far in comparison with their goals, are better predictors of well-being than objective measures. The objective determinants as found by many authors are not necessarily faulty, but should be looked at in a more comparative manner with regards to the expectations of individuals (Diener, Suh, Lucas, & Smith, 1999).

Despite these difficulties, plenty of research has been carried out into the determinants of well-being. In one of the earliest articles regarding this topic, Watson (1930) states that social connections and good health are related to high levels of happiness, but that the proximity of amenities is not. This is further confirmed by Wilson (1967), who also underlines the higher perceived well-being of married, religious, extraverted, and optimistic people in a summary of many different articles. Shields and Price (2005) state that people who are unemployed, living in poor households, or living in highly deprived areas are more likely to experience lower well-being. Dolan, Peasgood, and White (2008) conclude that income, ethnicity, and social connections are positively correlated with happiness, but that commuting time is negatively correlated. Ferrer-i-Carbonell (2005) argues that not only the individual income influences the happiness of people but also the income of people in the same neighbourhood. Higher income inequality within an area is likely to result in a lower average level of well-being. This relation is predicted to be relatively strong in The Netherlands in comparison with other OECD countries (Fleche, Smith, & Sorsa, 2012). The notion that ethnicity plays a role in well-being is confirmed by Spiers and Walker (2008), who found that Canadians with a British background experience a significantly higher happiness and quality of life than Canadians with a Chinese background do, suggesting that the background of immigrants is a determinant for well-being. Especially in the United States, major differences in the perceived happiness between black and white people are found (Blanchflower & Oswald, 2000). However, Martinez and Dukes (1997) also show that native residents have less ethnic identity and, as a result, experience lower general happiness. Regarding the amenities, Glaeser, Kolko, and Saiz (2001) show that people tend to value the presence of urban amenities in a city, which can have a positive influence on the well-being of people in that city. Furthermore, local amenities are considered to be a necessary – but not sufficient – condition for the attraction of human capital and, thus, the growth of a city, which is deemed beneficiary for the well-being (Glaeser & Saiz, 2003).

Effects of infrastructural projects

When it comes to transport infrastructure, the most obvious cause of the relationship between an improvement in the infrastructure and increasing welfare is the reduction of travel time. Especially commuting time is positively correlated with stress, and, as a result, negatively correlated with the well-being of people (Dolan, Peasgood, & White, 2008; Stutzer & Frey, 2008). It is the aim of many governments to reduce traffic congestion, for example by means of constructing new roads, improving public transport facilities, or road pricing (Stopher & Stanley, 2014). However, infrastructural improvements have more benefits than just reducing travel times. Lopez (2003) states that improvements in the infrastructure have a positive effect on growth and reduces income inequality between cities. This is empirically confirmed by Calderón and Chong (2004) by means of global data. According to Estache (2003), this trend mainly consists because infrastructural projects aim to improve the accessibility of the poor and underdeveloped regions in particular. Furthermore, Allen and Arkolakis (2019) substantiate mathematically that infrastructural projects reduce the generalised costs of travel in a region and that, as a result, the overall welfare increases.

In addition to the direct link with welfare, many articles have focussed on the positive relation between transport possibilities and housing prices, of which Alonso (1964) was probably the first. Later, this is empirically confirmed by for example Mathur (2008). Yiu and Wong (2005) show that housing prices in Hong Kong were already rising before the construction of a new tunnel was finished. Since higher housing prices are likely to attract residents with a higher income, an increase in the housing prices can result in higher well-being in the neighbourhood. Moreover, Gospodini (2005) exemplifies with a case study of 12 European cities that infrastructural projects can regenerate parts of a city. Although these researches are not necessarily valid for the city of Rotterdam, it does indicate that some relationship between infrastructure and well-being seems to exist.

Transport (dis)advantage and social exclusion

It is only since the end of the 20th century that the strong connection between badly accessible transport possibilities and negative welfare effects is emphasised, and that intervention by policymakers is deemed necessary. Church, Frost, and Sullivan (2000) were one of the first to construct a conceptual framework regarding this topic. They argue that there are always multiple circumstances causing the transport disadvantage. However, certain groups experience a greater risk of being transport disadvantaged, such as elderly, young, or disabled people (Dodson, Buchanan, Gleeson, & Sipe, 2006). Delbosc and Currie (2011a) show in a case study regarding the province of Victoria, Australia that people who are transport disadvantaged are more likely to be socially at risk and to experience low well-being. The same is concluded with data coming from the city of Melbourne, Australia (Currie, et al., 2010; Delbosc & Currie, 2011b), and the European Union (Bellani & D'Ambrosio, 2011). This underlines how important good infrastructure actually is for cities worldwide.

In addition to many articles stating that social connections are beneficiary for a person's well-being, the British government's Social Exclusion Unit (2003) recognises a lack of transport options as a cause of social exclusion, as people are not able to access certain services due to inaccessible or badly located public transport facilities. In his influential paper on this topic, Sen (2000, p. 5) describes social exclusion as "the difficulty experienced by deprived people in taking part in the life of the community". Examples of these difficulties are, amongst others, unemployment, finding suitable housing, low income, legal inequality, and a lack of democratic participation. Sen (2000) mentions that social exclusion is not a result of lacking social opportunities but of the inaccessibility of these opportunities. This implies that not the quantity of transport infrastructure, in particular, determines the level of social exclusion, but also the extent to which people are able to use this infrastructure. Currie et al. (2010) state that car ownership plays an important role in social exclusion since people that do not own a car make significantly fewer car trips and experience more difficulties with travelling. Stanley and Lucas (2008) mention that the availability of public transport plays an important role as well in the social exclusion of people. Furthermore, Preston and Rajé (2007) argue that the time-measured proximity of services and the cost of the trip to services are important determinants for social exclusion. These researches underline the suggestion that the quality and accessibility of the transport facilities are more important than the quantity.

Eisenberger, Lieberman, and Williams (2003) state that the feeling of being socially excluded evokes the same neurocognitive function as physical pain, which implies that social exclusion physically hurts the excluded. Additionally, Twenge, Catanese, and Baumeister (2002) show that social exclusion leads to unintentional self-destructive behaviour, such as taking irrational risks, choosing unhealthy behaviour over a healthier alternative, and spending more time to pleasurable activities instead of practising for an upcoming test.

Negative externalities of transport

Despite the clear benefits of an improvement in the transport infrastructure in a region, there can be negative externalities involved as well. Although many people are aware that travelling comes with negative externalities regarding the environment, they will not change their behaviour, as it is in their own best interest to travel to their destination by the fastest transport mode. Since the environment is in general not considered to be the property of people, traffic externalities are a clear illustration of Hardin's (1968) tragedy of the commons: the road users have no incentive to protect the environment. As a result, people will choose the mode of transport that they desire, denying any harm they do to properties that do not belong to someone in particular. Therefore, an increase in the capacity will improve the traffic flow in the short-term. On the long-term, however, traffic volumes will rise since this transport option has become more attractive and, thus, congestion will increase again. (Stopher & Stanley, 2014). This rise in traffic volumes will lead to an increase in pollution (Gualtieri & Tartaglia, 1998; Roorda-Knape, et al., 1998) and traffic noise (Li, Tao, Dawson, Cao, & Lam, 2002).

Regarding pollution, Chen and He (2014) show that especially particulate-matter exposure can be harmful. Kim (2004) indicates that children and infants are more vulnerable to exposure to air pollution than others. Brunekreef and Holgate (2002) state that air pollution is positively correlated with asthma, bronchitis, cardiac deaths, mortality, and hospital admissions and negatively correlated with lung function. However, well-being in general appears to be affected by air pollution as well. The World Health Organization (2005) argues that the state of the global ecosystem influences the well-being of people, implying that deterioration of this can lower the well-being. Luechinger (2010) states that there is a negative relationship in the EU member states between air pollution and life satisfaction. In addition to this, the average welfare loss in Europe in 2005 solely due to air pollution is estimated to be two percent (Nam, Selin, Reilly, & Sergey, 2010).

The notion that congestion influences human behaviour through transport costs was first made by Solow (1973). He argued that the optimal equilibrium between space for roads and housing is often deemed not desirable and, therefore, ignored. Later, plenty of research has been carried out into the effects of congestion, mainly focussing on residential choices and housing prices. An example of this is Gubins and Verhoef (2014), stating that less congestion will lead to residents spending more time at home and living in larger houses. Although many researchers have focused on the relationship between congestion and welfare factors during commuting travel (Gatersleben & Uzzell, 2007; Higgins, Sweet, & Kanaroglou, 2018; Stokols, Novaco, Stokols, & Campbell, 1978), the relation between congestion within a neighbourhood and the well-being of the residents has been unexplored. The researches that investigate the link between traffic noise and multiple psycho-social factors are the ones that probably come closest. Öhrström (1991; 2004) states that a reduction in traffic noise leads to a decrease in annoyance and an increase in general well-being. The main cause of this is that people need to have access to quiet indoor and outdoor areas, where they will be undisturbed by for example traffic noise (Gidlöf-Gunnarsson & Öhrström, 2007). Furthermore, significant health improvements were found to be related to less traffic noise (Öhrström, Skånberg, Svensson, & Gidlöf-Gunnarsson, 2006).

Theories on welfare distribution

On beforehand, it can be stated that the new riverbank connection will not have the same effect on all districts: some neighbourhoods are likely to benefit, while others might experience a lower average level of well-being. Therefore, it is vital to discuss some of the views on the distribution of welfare and inequality theories. Probably the oldest vision towards welfare distribution is the utilitarian approach, as brought forward by Bentham (1789) and Mill (1879). Utilitarianism can be best described by maximizing the welfare of the society as a whole and, thus, allowing for major inequalities between different societal groups. The utilitarian theory argues that the loss of welfare by people is justified as long as other people benefit at least as much from it. This inequality increasing argument can be traced back to the consequentialism that utilitarianism is based on, stating that only the consequences of an act are relevant for societal welfare and not the intentions of the act. However, different than at the time that the utilitarian theory was created, utility and welfare are currently being considered to be marginally diminishing, justifying the statement that utilitarianism supports a reallocation from the rich to the poor. Despite the fact that utilitarianism offers some good insights into the considerations with regards to the distribution of welfare, it is currently no longer being considered a suitable way of distributing welfare, which is mostly due to the fact that inequality problems are being deemed harmful for society (Sen, 1979).

Another point of view regarding the distribution of welfare is Rawls' theory of justice. Rawls (1971) argues that every person should have the same basic rights and liberties, and that people with the same resources and willingness should have the same societal chances, only allowing for inequalities if and only if it favours the worst off in society. Rawls' theory indicates that differences among society are of the utmost priority and that the government has an important task in preventing these differences. The most disadvantaged people in society are allowed to be supported but only under the condition that it is in the best interest of the society as a whole to help them, which is when it leads to more equality. This is in sharp contrast with the utilitarian theory that does not bother about societal differences but only about increasing the total utility of society.

A more unorthodox stance on the distribution of welfare is the libertarian entitlement theory created by Nozick (1974). The theory states that every distribution is fair as long as it does not harm the process in which people make voluntary choices and their rights are not violated. A person can possess anything he wants, as long as he has acquired it in a rightful manner. According to Nozick, society has to return to a moment in time where everything is acquired in such a way. A major problem regarding this theory is that it is virtually impossible to find out whether all belongings in the world have been acquired rightfully. So although Nozick's theory allows for the existence of inequalities in society and he offers a satisfying explanation for the existing inequalities, his ideas are above all impractical.

The last theory discussed is the capabilities approach by Sen (1993), which further elaborates Rawls' theory of justice. According to Sen, the resources as described by Rawls are only indirectly involved in determining the welfare of people. Sen states that the real determinants of welfare are capabilities and that they are required to achieve certain levels of prosperity. Resources can be converted to capabilities, but it is different per person how he does this and what sort of capabilities can be created out of the resources. This leads to a situation in which completely similar people may be able to achieve the same capabilities, but fail to do so due to a different personal utilization function. The disadvantaged person, however, will never notice since they are only aware of the capabilities they have realised and not of those that they could have realised. As such, inequality is seen as an inevitable process that can only be controlled by providing all people with the same resources. How they convert these resources into capabilities, however, cannot be controlled. This means that every person should have the same chances, but that inequalities will not seize to exist and are not necessarily a bad thing to happen. Despite this notion, Sen does not provide an answer to the question to what extent inequalities might be bad for the society, and does not offer a way to mitigate the inequalities.

Summary

In sum, the existing literature provides some important aspects that might affect subjective well-being due to the construction of a new riverbank connection. An improvement of the existing infrastructure is likely to increase the subjective well-being of people. In particular, the accessibility of transport facilities can play an important role in this relation, as this is the main determinant whether or not a person is transport disadvantaged, possibly resulting in social exclusion. However, negative effects, of which congestion, pollution, and traffic noise are the most evident, influence the subjective well-being in the districts as well. Especially pollution and traffic noise are found to negatively influence the welfare of residents. Lastly, as it is likely that the new riverbank connection will lead to a redistribution of welfare in the city of Rotterdam, it is important to compare a number of influential theories regarding welfare distribution. Although there is no thorough answer to the question of which theory is best, it is vital to determine which aspects of inequality have to be taken into account.

Data

The city of Rotterdam is divided into 14 areas, which are divided into multiple smaller districts. Appendix A provides a map of the districts and a list with its corresponding area. Data about the districts is gathered from multiple sources, with the 'Wijkprofiel Rotterdam' being the main source. For efficiency reasons, the 'Wijkprofiel Rotterdam' does not provide information about all districts, and combines some districts as well. The main reason for this is that in some of the districts the number of residents is too low. Furthermore, due to its size, the 'Wijkprofiel Rotterdam' considers the districts 'Groot IJsselmonde-Noord' and 'Groot IJsselmonde-Zuid' to be two separate regions, instead of just one district as it is depicted on the map. As mentioned earlier, this research assumes that there is no construction time involved with the building of a third riverbank connection. Therefore, it is assumed that the bridge is available in 2020, while it was not yet in 2018.

An overview of the sources is depicted in Table 1. As data from 2014, 2016, 2018, and 2020 is used, a panel data set with 284 observations is constructed. The subjective well-being, the ethnical distribution, the income distribution, the house value distribution, and the proximity of amenities are all provided per district for 2014, 2016, and 2018 by the 'Wijkprofiel Rotterdam'. This is a research institution supported by the municipality of Rotterdam. The subjective well-being is measured as the percentage of the people that are 15 years or older answering 'agree' or 'strongly agree' to the quote that they are satisfied with their life. The ethnical distribution provides what percentage of the residents in a district is native Dutch, a western immigrant, or a non-western immigrant. The income distribution states what percentage of the households in a district has an income belonging to the lowest 40% incomes in The Netherlands, the 40% middle incomes, and the 20% highest incomes. The distribution of the housing values tells what percentage of the houses in a district belong to the 20% of the houses with the lowest value in Rotterdam, to the middle 40% and the highest 40%. The value of a house is measured by means of the 'waardering onroerende zaken'-value (WOZ-value), which is the value of a house used for tax assessments. The proximity of amenities is determined based on the number of amenities and the distance to them. A district with many amenities located nearby has a higher score than a district with fewer amenities, or amenities that are located further away. The ethnicity, income level, housing prices, and amenities are all assumed to be unchanged by anything else than the construction of a third riverbank connection between 2018 and 2020.

An additional data source is the 'Metropoolregio Rotterdam Den Haag' (MRDH), which has data available about the accessibility by car, bike, and public transport of the districts, and the congestion per district. The accessibility is measured as the number of vehicle kilometres travelled (VKT) per district per transport mode. The level of congestion is the number of hours lost in traffic per day. Predictions about the change of these variables as a result of a third riverbank connection are provided in a report written by the MRDH. This report is based on traffic research and predicts the traffic volumes while accounting for different determinants, such as changes in the number of cars owned and fuel prices. As a result, the actual numbers for 2016 and the predicted numbers for 2030 considering the newly build riverbank connection are given for both the accessibility and the congestion. In order to have the numbers available for 2014, 2018, and 2020 as well, the provided numbers have to be discounted to avoid that other changes than a new riverbank connection influence the data. The MRDH states that the growth factor of car use is 13% over 14 years, the growth factor of public transport use is 12%, and the growth factor of bike use is six percent (MRDH, 2018a). This is based on the actual and predicted number of trips per vehicle per year. The numbers for 2014 and 2018 are calculated by discounting the actual data of 2016, while discounting the predictions for 2030 provide the data for 2020. The level of congestion is measured in less detail than the accessibility is. Congestion levels are provided for seven areas in the Rotterdam region (i.e. 'Prins-Alexander', North-West Rotterdam, South-West Rotterdam, South-East Rotterdam, 'IJsselmonde', North-East Rotterdam, and Rotterdam Centre), meaning that districts are assigned the level of congestion of the area that they are located in. Additionally, the congestion is not measured for some of the areas located far away from the city centre. Therefore, the districts of which the data is lacking (i.e. 'Hoek van Holland', 'Hillegersberg', 'Hoogvliet', 'Overschie', 'Pernis', and 'Rozenburg') are assigned the value of the closest area minus one standard deviation, as it is assumed that congestion declines further away from the city centre.

Lastly, the population change per district in 2014, 2016, and 2018 is taken from the municipality of Rotterdam. The population change is calculated as the percentual difference in the population compared to the year before. The population change in 2020 is estimated as the average of the yearly population changes of the last ten years.

Table 1: Overview of the variables and sources

Variable	Source	Description
Well-being	Wijkprofiel Rotterdam	The percentage of the people that are 15 years or older answering 'agree' or 'strongly agree' to the quote that they are satisfied with their life
Ethnicity	Wijkprofiel Rotterdam	The percentage of native residents, western immigrants, and non-western immigrants in a district

Variable	Source	Description
Income	Wijkprofiel Rotterdam	The percentage of the households having an income belonging to the lowest 40% incomes in The Netherlands, the 40% middle incomes, and the 20% highest incomes
Housing value	Wijkprofiel Rotterdam	The percentage of the houses in a district belonging to the 20% of the houses with the lowest value in Rotterdam, to the middle 40% and the highest 40%
Amenities	Wijkprofiel Rotterdam	The number of amenities in a district
VKT	MRDH	The number of VKT in a district by car, bike, and public transport
Congestion	MRDH	The number of hours lost in traffic per day in an area
Population change	Municipality of Rotterdam	The yearly percentual change in population per district

Methodology

All of the variables are continuous. The variables concerning the well-being, ethnicity, income level, and house value have to take a value between zero and one, as these are percentages. All other variables can be any positive number, except *population change* which can be negative as well. The variables regarding ethnicity, income level and house value are distributions and, thus, the sum of the three variables representing one distribution is equal to one. Therefore, the variables *native*, *high income*, and *high house value* are not included in regressions to avoid multicollinearity. As the timespan (T = 3) is smaller than the number of observations (N = 71) tests on the stationarity of the variables are not necessary (Park, 2011). In order to bring the data on a better scale with respect to the measured well-being, the VKT are used in millions, the numbers of hours lost due to congestion in thousands, and the level of amenities is rescaled by dividing through 100. The descriptive statistics of the variables are presented in total in Table 2 and per year in Appendix B.

Table 2: Descriptive statistics

Variable	Obs.	Mean	Std. dev.	Min.	Max.
Well-being	213	0.806	0.068	0.643	0.941
Car VKT (in millions)	284	0.924	0.113	0.442	1.108
Bike VKT (in millions)	284	0.257	0.219	0.019	2.005
Public transport VKT (in millions)	284	0.442	0.159	0.054	0.933
Congestion (in thousands)	284	1.423	0.422	0.578	1.998

Variable	Obs.	Mean	Std. dev.	Min.	Max.
Low income	284	0.491	0.152	0.150	0.770
Moderate income	284	0.327	0.063	0.196	0.454
High income	284	0.182	0.123	0.030	0.510
Low house value	284	0.191	0.209	0.000	0.870
Moderate house value	284	0.565	0.222	0.020	0.930
High house value	284	0.243	0.239	0.000	0.990
Native	284	0.513	0.192	0.060	0.900
Western immigrants	284	0.126	0.045	0.060	0.312
Non-western immigrants	284	0.361	0.188	0.029	0.804
Amenities	284	0.939	0.176	0.420	1.230
Population change	284	0.009	0.035	-0.364	0.289

Furthermore, the correlation between the variables has been tested, of which the results are shown in Appendix C. As expected, some of the variables regarding ethnicity, income level, and housing value show are highly correlated, as the sum of these variables is one, implying that one decreases as the other increases. Therefore, as mentioned before, the variables *native*, *high income*, and *high house value* are excluded from the regressions. *Non-western immigrants* and *low income* show a relatively high level of correlation, but since an absolute value of 0.80 is considered a widely recognised benchmark, it is not problematic. Other variables do not indicate to be correlated.

In order to provide a thorough overview of the effect of multiple variables, seven models will be presented in this paper. Since the aim of this report is to predict the change in the well-being of the different districts of Rotterdam due to the construction of a third riverbank connection, the model with the highest adjusted R^2 will be used to predict the well-being. Model 1 is an ordinary least square model (OLS-model), where a district effect is not taken into account. All other models do account for potential differences between districts, by means of including a district effect. For those models, a Hausman-test is carried out in order to determine whether a model with fixed or with random effects has to be used. All tests show that a model with a random effect is preferred, as shown in Appendix D. Furthermore, year dummies are added to every model to correct for year fixed effects. Model 2 to 7 will be of the form as shown in equation 1.

$$y_{it} = \alpha + X_{it}\beta + \mu_i + \gamma_t + \nu_{it} \quad (1)$$

In this equation, y_{it} is the subjective well-being of the i-th district at the t-th moment in time, α is the constant term for all districts, X_{it} and β are the independent variables and the coefficients, μ_i is the random effect of a district, γ_t is the year effect, and ν_{it} is the individual error term.

After the regression results have been determined, it is possible to predict the well-being levels per districts after the construction of a new riverbank connection. These predictions will be divided into three scenarios. The first scenario assumes that only the levels of accessibility and congestion change as a result of the new riverbank connection. Thus, the impact of only the change in traffic volumes on the well-being levels in the Rotterdam region is measured.

However, existing research of for example Mathur (2008) and Yiu and Wong (2005) suggests that infrastructural improvements affect housing prices. It is likely that housing prices rise in the districts that have become more accessible, while the prices fall in the districts that lose some accessibility. A district is said to be seriously affected by the new riverbank connection if the level of well-being changes with more than three percent points in either direction in the first scenario. It is assumed that housing prices only change in these particular districts since the change in the other districts is neglectable. As the exact change in housing prices is hard to estimate, a range is used to account for the changes. This means that for the well-being level as well a range is calculated with a minimum and a maximum expected level. In a district that considerably benefits of the new riverbank connection, the upper bound of the range is an increase of the percentage of high-value houses with 20 percent points, while both the percentages of low-value and moderate-value houses decrease with ten percent points. The lower bound shows an increase in the percentage of high-value houses of five percent points, with a decrease in the percentages of low-value and moderate-value houses of 2.5 percent points. Exactly the opposite will happen in the districts that are considered to be heavily disadvantaged by the new riverbank construction.

In addition to the change in housing prices, it is likely that the income level of the residents changes as well, as shown by Gospodini (2005). Therefore, the third scenario considers a change in the income level besides the changes in traffic volumes and housing prices. Again, the districts that benefit with an increase of more than three percent points in well-being, will be assumed to have an upper bound of 20 percent points more high-income residents, while the percentage of low-incomes and moderate-incomes both drop with ten percent points. The lower bound is that the districts will experience only five percent points more high-income residents and 2.5 percent points less low-income and moderate-income residents. Subsequently, the districts in which the well-being is heavily, negatively affected, will undergo the opposite transformations.

Results

Firstly, the effect of accessibility on well-being will be discussed. This will be done by means of seven regression models that estimate the effect of multiple accessibility variables on well-being. Table 3 provides the results of the different regression models.

Table 3: Regression results

Model **Variable**	**(1)**	**(2)**	**(3)**	**(4)** **Coefficients (std. err.)**	**(5)**	**(6)**	**(7)**
Car VKT	0.068** (0.024)	0.128 (0.076)	0.102 (0.077)	0.088** (0.032)	0.093** (0.031)	0.070* (0.031)	0.067* (0.032)
Bike VKT	-0.004 (0.007)	-0.047 (0.034)	-0.036 (0.034)	-0.014 (0.014)	-0.012 (0.014)	-0.005 (0.013)	-0.003 (0.014)
Public transport VKT	0.029 (0.028)	-0.117* (0.054)	-0.138* (0.055)	-0.040 (0.024)	-0.016 (0.026)	0.035 (0.030)	0.030 (0.032)
Congestion	-0.001 (0.007)		0.028 (0.020)	0.001 (0.008)	0.000 (0.008)	0.000 (0.008)	-0.001 (0.008)
Low income	-0.221** (0.066)			-0.371*** (0.025)	-0.223*** (0.065)	-0.231** (0.077)	-0.216** (0.081)
Moderate income	0.043 (0.087)			-0.016 (0.062)	0.141 (0.101)	0.020 (0.107)	0.056 (0.111)
Low house value	-0.074 (0.038)				-0.099** (0.037)	-0.061 (0.043)	-0.078 (0.045)
Moderate house value	-0.053 (0.029)				-0.069* (0.033)	-0.045 (0.035)	-0.058 (0.036)
Western immigrants	-0.123 (0.085)					-0.142 (0.093)	-0.123 (0.099)
Non-western immigrants	-0.083** (0.028)					-0.087** (0.031)	-0.082** (0.032)
Population change	-0.087 (0.077)						-0.118 (0.065)
Amenities	0.011 (0.029)						0.014 (0.028)
Constant	0.904*** (0.051)	0.747*** (0.061)	0.737*** (0.060)	0.928*** (0.044)	0.847*** (0.058)	0.916*** (0.063)	0.897*** (0.065)
Year effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes
District effect	No	Yes	Yes	Yes	Yes	Yes	Yes
Random or fixed effect	---	Random	Random	Random	Random	Random	Random
R^2	0.757	0.090	0.113	0.728	0.740	0.754	0.756
Adjusted R^2	0.739	0.068	0.088	0.717	0.727	0.740	0.739

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

It is visible that especially the accessibility by car has a significant effect on the well-being in the districts. The coefficient is strictly positive and significant in five of the seven models. This is an expected result, as the existing scientific literature already shows that there is a positive relation between good infrastructure and well-being. However, this relation is not so clear with regards to the accessibility by bike and public transport. The coefficients are both insignificant in almost all models. This result suggests that especially the accessibility by car is an important determinant of the well-being of residents in a district, while public transport and bike accessibility are less important.

There are two demographic characteristics that have a major impact on the well-being in a district: many low-income residents and many non-western immigrants living in a district. Both of these variables show a negative and highly significant relationship with the well-being of people. Moreover, the correlation table in Appendix C shows that the percentage of low-income residents and the percentage of non-western immigrants in a district are relatively highly correlated ($r = .79$). However, it is not necessarily the case that people with a low-income or a non-western background perceive lower levels of well-being. It can only be stated that districts with large numbers of residents with a low income or with a non-western background experience lower average levels of well-being. It could be the case that people value living in a neighbourhood with rich or native residents over living in a district with poor or non-western residents. In contrast to the distribution of the income and the ethnicity, the distribution of the housing prices does not seem to significantly affect the well-being, although there is a small negative effect.

An interesting side note next to the interpretation of the coefficients is the similarity between model 1 and the other models. The first model is based on OLS and does not account for district effects, while all other models do correct for these effects. For example, all coefficients of model 1 have the same sign as the coefficients in model 7 and the differences in magnitude are small. This indicates that the district effect is relatively small, which implies that the differences in well-being between the neighbourhoods are explained well by the variables and do not need an additional district effect to explain the variance in well-being. This is confirmed by a Breusch-Pagan Lagrange multiplier test, which shows that there is little evidence that a random effect is present in model 6 ($\chi^2(1) = 1.57$, $p = 0.10$) and model 7 ($\chi^2(1) =$

2.52, $p = 0.06$), which are the two most complete models. As such, it can be stated that the district effect and, thus, the difference between districts are relatively small.

Since it is now clear that the construction of a third riverbank connection has a positive effect on the well-being of people by means of the improvement of car accessibility in particular, the magnitude of this change will now be predicted. As mentioned earlier, this will be done by predicting three scenarios. For this prediction, the model with the highest adjusted R^2 is used, namely model 6. The first scenario assumes that only the traffic volume variables (i.e. accessibility and congestion) change due to the new riverbank connection. The second scenario also accounts for a shift in the housing value levels as a result of improvement or deterioration of the accessibility of a district. Lastly, the third scenario assumes that the distribution of the income levels in a neighbourhood changes as the accessibility and the housing values alter. An overview of both the absolute and percentual changes in well-being are provided per scenario in Appendix E.

Figure 1 depicts the change in perceived well-being when only the shift in traffic volumes is taken into account. With respect to this scenario, an average change in the well-being of -0.009 is found as a result of the newly constructed riverbank connection. The average percentual change of all the districts is -0.9%. This implies that the residents of the Rotterdam region experience a lower level of well-being after the construction of a new riverbank connection than before. As the regression results show that an improvement in the accessibility is related to a higher level of well-being, it is unexpected that the observed mean is negative. However, this could be the result of some districts located far away from the location of the new riverbank connection influencing the mean. For example, the district of 'Strand en Duin' in the area of 'Hoek van Holland' is situated approximately 50 kilometres away from the new connection, but has a predicted change in the well-being of -0.025. It can be considered unlikely that an infrastructural improvement results in a negative change in well-being due to increased congestion so far away. However, it is possible that the measured well-being in some of the districts is higher than predicted, for example due to a missing variable. Regarding the case of 'Strand en Duin', it could be that the residents perceive a higher level of well-being than expected since they are living near the sea. This is just one example of the many ways in which the predictions can turn out erroneous. In order to make some statements about the direct impact of the new riverbank connection, the averages are calculated for only the three areas that are located the closest to the new riverbank connection (i.e. ‘Kralingen-Crooswijk’, ‘Prins Alexander’, and ‘IJsselmonde’) as well. This results in an average absolute change of 0.009 and an average percentual change of 1.3%. Furthermore, Figure 1 shows that districts that are located relatively close to the new riverbank connection are likely to experience a higher level of well-being than the districts that are located further away. In sum, it can be stated that the construction of a new riverbank connection seems to turn out favourable for residents living close to the new connection, while the districts further away do not necessarily benefit from it.

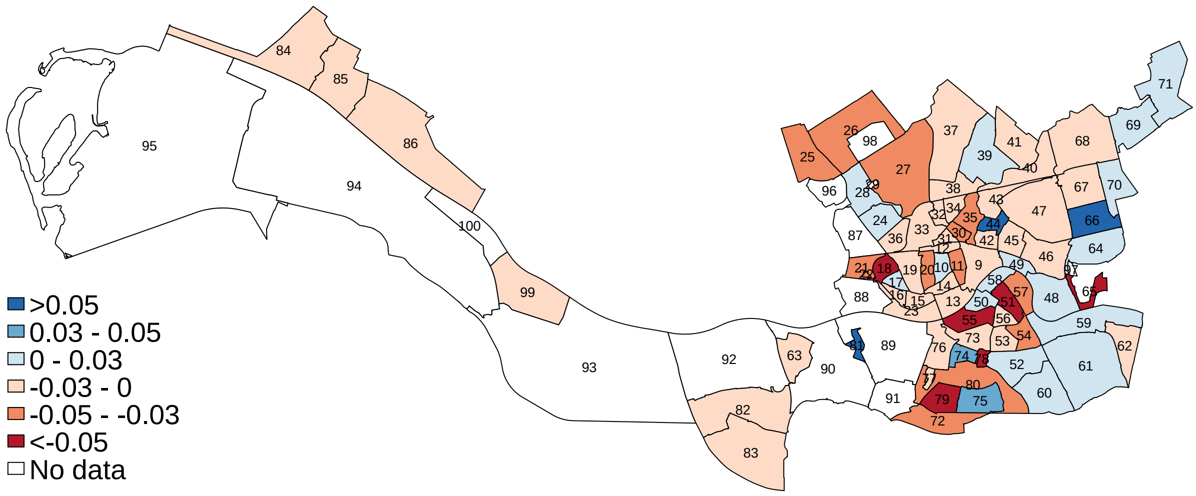

Figure 1: First scenario changes in well-being

The expected changes in well-being when taking into account that the housing prices are expected to change in some districts as a result of the new riverbank connection are presented in Figure 2. As a lower and an upper bound is constructed for this scenario, the values on the map are determined by taking the average of two extremes. Regarding the second scenario, the average change in well-being is expected to be between -0.011 and -0.008, while the average percentual change is between -1.2% and -0.9%. Again, this unexpected negative mean can be caused by the inclusion of districts that are unlikely to be affected by the new riverbank connection. The mean of only the three closest areas is between 0.008 and 0.010, while the average percentual change is between 1.3% and 1.5%. Although the addition of changing in housing prices does not have a major impact on the average change in well-being, the change in housing prices does affect the levels of well-being on a district-level. In the first scenario, the minimum change is -0.086, while the average of only the positive changes is between -0.097 and -0.089 in the second scenario. Regarding the maximum, the first scenario provides a maximum of 0.091, while the second scenario has a maximum between 0.094 and

0.101. This shows that the changes become larger and more extreme in either direction, indicating that the changes in the housing prices strengthen the change in well-being through better accessibility. The regression results and existing literature support this, as better accessibility tends to lead to higher housing prices, which is shown by the regressions to have a positive effect on the well-being of people.

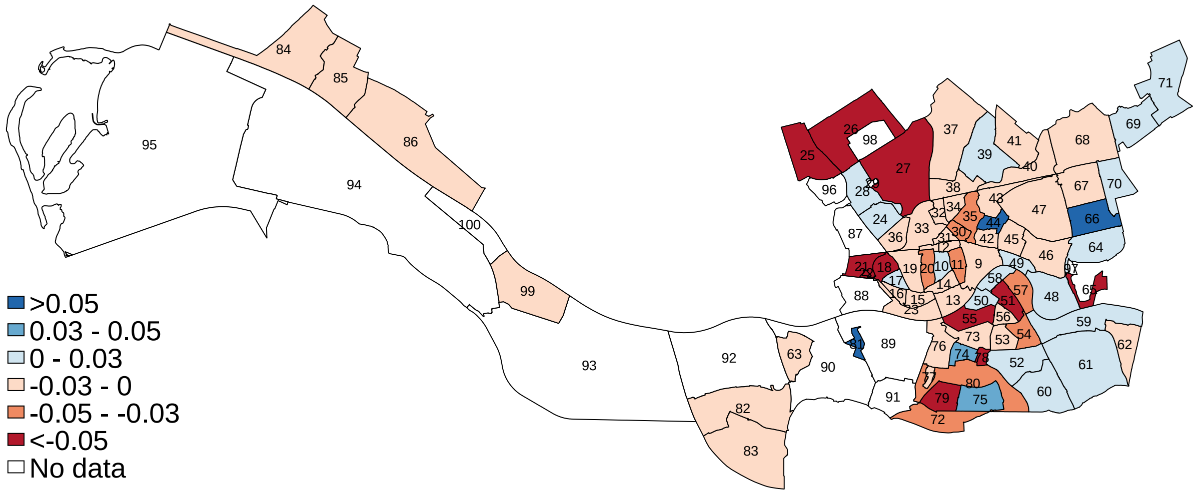

Figure 2: Second scenario changes in well-being

Regarding the third scenario, the changes in well-being per district are shown in Figure 3. Again, the values are calculated by taking the average of the lower and the upper bound. The third scenario assumes that also the distribution of the income in neighbourhoods changes as a result of the improved accessibility. This scenario causes an average change in well-being between -0.010 and -0.008, and an average percentual change between -1.0% and -0.7%. When only taking the three closest areas in consideration, the average of both the absolute and percentual change in well-being is positive, indicating that in those districts the well-being is expected to increase. Furthermore, it is also noted that the minimum decreases and the maximum increases even further with respect to the first and second scenario. This indicates that, as with the housing values, the effect of a changing income distribution strengthens the effect of a new riverbank connection on the well-being of people.

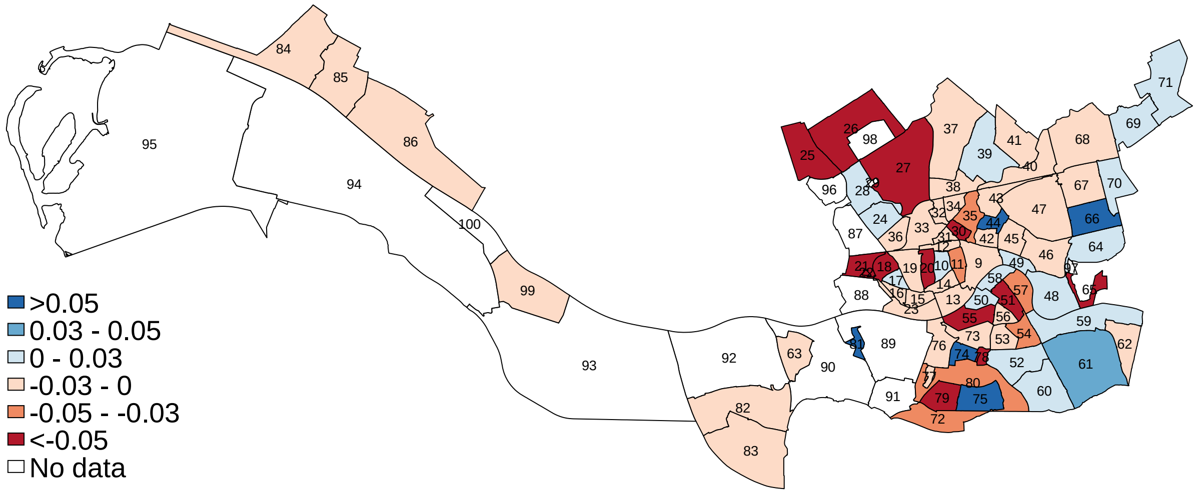

Figure 3: Third scenario changes in well-being

Discussion

The results found in the previous section show that improving the accessibility by car of a district significantly increases the well-being of the residents, which is in line with other scientific literature. Despite the fact that research has concluded that accessibility by public transport and bike influence the well-being of people as well, no evidence for this statement is found. A possible explanation for this is that earlier research has shown that especially travel time is important for people. When it comes to travel time only, the car is usually the quickest, possibly explaining why people favour using the car as mode of transport. However, as mentioned before, the tragedy of the commons – a situation in which every person handles in his own best interest without considering negative externalities – may eventually cause other modes of transport to be quicker.

Subsequently, this offers a number of policy implications that will be discussed. The finding that car accessibility has a positive effect on the well-being of residents is an important given when determining the urban and transport policy of a city. People seem to appreciate highly accessible places over places that are more difficult to reach. Obviously, this implies that if the municipality is interested in increasing the well-being only, it has to invest in a high level of car accessibility. Based on this information, it would be beneficial to build a bridge with as many lanes as possible. However, at the same time, it is impossible to ignore the existing literature that highlights all the negative externalities that come with increasing car use, such as congestion, pollution, and traffic noise. The municipality of Rotterdam has to think forward and is already investing in more sustainable modes of transport, such as transport by bike and public transport, but also innovative initiatives such as vehicle sharing are being considered. The point is that there is no evidence that these modes of transport have a positive influence on the well-being of people, and are often considered to be inferior to transport by car, potentially negatively affecting the well-being of residents. This faces the municipality with a dilemma: on one hand they want to improve the well-being in their city, but on the other hand, they want to promote sustainable modes of transport in order to prepare the city for the future. An imminent solution is the promotion of more sustainable modes of transport by the municipality, without harming the accessibility by car. When residents feel that car accessibility is deteriorating, this is likely to have a negative influence on their well-being. However, if it turns out that travelling by bike or public transport is actually a more attractive option, they are likely to favour these options over travelling by car. Thus, the municipality’s focus regarding the new riverbank connection will have to be on providing good travel possibilities by bike, public transport, and potentially other sustainable modes of transport, instead of just promoting car use. This can, for example, be achieved by creating wide bike lanes and high-quality public transport connections.

This immediately poses the question or a bridge or a tunnel would be more suitable. The imminent advantage of a bridge is that it is far less costly than a tunnel. However, when a bridge is built in that location, it has to be high enough for ships to pass underneath it. This is harmful to both the accessibility by bike and public transport: bikers will have to drive uphill for a long stretch, and public transport will have to drive through the city instead of through tunnels under the city, possibly harming the quality and frequency of the public transport connections. Although these might seem to be minor problems, these are the things that can make the difference between people travelling by car or by more sustainable modes of transport. Thus, the real question is or the municipality of Rotterdam is willing to do a somewhat uncertain and future-seeking investment when it comes to the choice between a tunnel or a bridge.

Besides to the main findings, it has also been found that ethnicity and income level play an important role in the perceived well-being of people. Districts with many poor residents or non-western immigrants experience a significantly lower average well-being than other districts do. This is in accordance with the existing literature. However, as also mentioned by Ferrer-i-Carbonell (2005), it is possible that this is not only due to individuals having a lower income, but also due to residents disliking living in a neighbourhood with many other poor residents.

When the predicted change in well-being is determined due to the construction of a new riverbank connection, the results show that the districts close to the new connection benefit, while the districts further away perceive a lower well-being. On average, the change in well-being is even negative. Although the numbers appear to be extremely small, an average change in well-being of -0.009 – as is the case in the first scenario – implies that approximately 5.500 people less will be satisfied with their life, under the assumption that all districts have the same number of residents. On the other hand, the three areas that are located the closest to the riverbank connection perceive an average change in well-being of 0.009. However, as only a fraction of the residents of Rotterdam lives in these areas, the absolute number of people being satisfied with their life will decrease as a result of the new riverbank connection. The same is happening in the other scenarios. This means that the construction of a new riverbank connection is not a way to create welfare, but to redistribute welfare. Under the utilitarian point of view that societal welfare should be maximized, this would be a completely unacceptable decision. However, it is defendable according to Rawls' theory of justice and the capability approach of Sen, both allowing for inequalities and redistributions, as long as it favours the worst off in society. Although it is known that some of the districts in the vicinity of the new riverbank connection are fairly derelict, it is unclear whether or not this redistribution would be justified.

There are some limitations that are important to take into notion when considering this research. Firstly, most of the results are based on predictions instead of real data, which highly increases the margin of error. Although it is good to investigate the effects of a new riverbank construction before it is built, it will have more scientific meaning when the same research will be carried out again when the new connection is constructed and actual data is available. Secondly, the research uses a number of rather unrealistic assumptions. For example, the demographic characteristics of districts is assumed to be unchanged, and the construction of the new riverbank connection is assumed to have no construction time, meaning that local residents do not suffer from inconveniences caused by the construction. Lastly, it would be better to use a larger data set. For example, only data of three years (i.e. 2014, 2016, and 2018) are available, which is a relatively short time span. Using a longer period by including data from more years might result in another conclusion, or clarify some of the aspects that are still somewhat ambiguous in this research. Also, data from a larger area than just the municipality of Rotterdam could be added, as the new riverbank connection is likely to have an effect far beyond the borders of the municipality. It is more likely that the residents of neighbouring municipalities located only 20 kilometres away from the new connection benefit, than that the residents of the area of 'Hoek van Holland' located 50 kilometres away do. Therefore, including other municipalities in the research is likely to influence the results.

Conclusion

The aim of this research has been to find out the relationship between the accessibility of different neighbourhoods and the corresponding level of well-being and, subsequently, how the construction of a third riverbank connection in Rotterdam will affect the well-being throughout the city. The first part of the question concerns the relationship between accessibility and well-being. It is found that especially the car accessibility has a significantly positive influence on the perceived level of well-being of residents. These results are not found when it comes to the accessibility by either public transport or bike. People seemingly favour transport by car over transport by bike or public transport. Furthermore, income levels and ethnicity of a district significantly affect the levels of well-being in that district. Districts with many residents with a low income or a non-western background perceive significantly lower well-being than other districts. However, whether this effect is because poor or non-western immigrants experience lower well-being or because people dislike living in a poor neighbourhood or with many non-western immigrants, cannot be stated.

The second part of the question consists of determining how the changed levels of accessibility affect the well-being in districts. The expected levels of well-being have been calculated based on three different scenarios, that differ upon the inclusion of the change in income levels and housing values in a district as a result of the new connection. For all these scenarios, it is found that the average level of well-being drops marginally after the construction of a new riverbank connection. However, when only taking into account the three closest located areas the average change of well-being happens to be small, but positive. This suggests that districts located closely to the new riverbank connection do benefit from it, but the districts further away do not, or even experience negative effects.

An obvious field of further research is whether or not the conclusions still hold with actual data of when the riverbank connection is actually built. By this means, a large number of assumptions can be relaxed, increasing the validity of the research. Furthermore, more attention can be paid to which population groups are affected by the accessibility of different transport modes, and what the effects of the redistribution of welfare will be. This research has not investigated or certain population groups are more dependent on certain modes of transport than others, nor has the cost of travel been included. These are both links that can be explicated further, especially when it comes to welfare redistributions.

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Appendix A: Map of areas and districts in Rotterdam

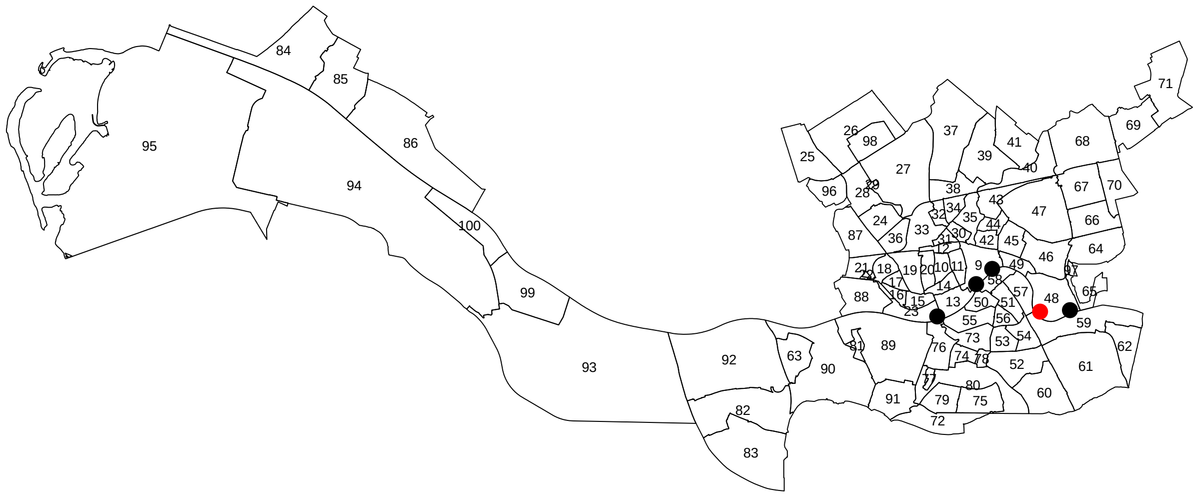

Figure 4: Map of the districts of Rotterdam

● *existing riverbank connection*

● *new to construct riverbank connection*

Table 4: Alphabetical list of the areas and districts of Rotterdam

Area	District	Number
Charlois	Carnisse	74
Charlois	Heijplaat	81
Charlois	Oud-Charlois	76
Charlois	Pendrecht	79
Charlois	Tarwewijk	73
Charlois	Wielewaal	77
Charlois	Zuiderpark en Zuidrand	72 + 80
Charlois	Zuidplein	78
Charlois	Zuidwijk	75
Delfshaven	Bospolder	16
Delfshaven	Delfshaven	15
Delfshaven	Middelland	20
Delfshaven	Nieuwe Westen	19
Delfshaven	Oud-Mathenesse/Witte Dorp	21 + 22
Delfshaven	Schiemond	23
Delfshaven	Spangen	18
Delfshaven	Tussendijken	17
Feijenoord	Afrikaanderwijk	56
Feijenoord	Bloemhof	53
Feijenoord	Feijenoord	57
Feijenoord	Hillesluis	54
Feijenoord	Katendrecht	55
Feijenoord	Kop van Zuid	50
Feijenoord	Kop van Zuid-Entrepot	51
Feijenoord	Noordereiland	58
Feijenoord	Vreewijk	52

Area	District	Number
Hillegersberg-Schiebroek	Hillegersberg-Noord	39
Hillegersberg-Schiebroek	Hillegersberg-Zuid	38
Hillegersberg-Schiebroek	Molenlaankwartier	41
Hillegersberg-Schiebroek	Schiebroek	37
Hillegersberg-Schiebroek	Terbregge	40
Hoek van Holland	Dorp/Rijnpoort	85 + 86
Hoek van Holland	Strand en Duin	84
Hoogvliet	Hoogvliet-Noord	82
Hoogvliet	Hoogvliet-Zuid	83
IJsselmonde	Beverwaard	62
IJsselmonde	Groot IJsselmonde-Noord**	61
IJsselmonde	Groot IJsselmonde-Zuid**	61
IJsselmonde	Lombardijen	60
IJsselmonde	Oud IJsselmonde	59
Kralingen-Crooswijk	De Esch	48
Kralingen-Crooswijk	Kralingen-Oost/Kralingse Bos	46 + 47
Kralingen-Crooswijk	Kralingen-West	45
Kralingen-Crooswijk	Nieuw Crooswijk	43
Kralingen-Crooswijk	Oud-Crooswijk	44
Kralingen-Crooswijk	Rubroek	42
Kralingen-Crooswijk	Struisenburg	49
Noord	Agniesebuurt	30
Noord	Bergpolder	32
Noord	Blijdorp/Blijdorpsepolder	33 + 36
Noord	Liskwartier	34
Noord	Oude Noorden	35
Noord	Provenierswijk	31
Overschie	Kleinpolder	24
Overschie	Noord-Kethel/Schieveen/Zestienhoven	25 + 26 + 27
Overschie	Overschie	28
Pernis	Pernis	63
Prins Alexander	Het Lage Land	67
Prins Alexander	Kralingseveer	65
Prins Alexander	Nesselande	71
Prins Alexander	Ommoord	68
Prins Alexander	Oosterflank	70
Prins Alexander	Prinsenland	66
Prins Alexander	‘s-Gravenland	64
Prins Alexander	Zevenkamp	69
Rotterdam Centrum	Cool	11
Rotterdam Centrum	CS-kwartier	12
Rotterdam Centrum	Nieuwe Werk/Dijkzigt	13 + 14
Rotterdam Centrum	Oude Westen	10
Rotterdam Centrum	Stadsdriehoek	9
Rozenburg	Rozenburg	99
---	Spaanse Polder*	87

Area	District	Number
---	Nieuw-Mathenesse*	88
---	Waalhaven*	89
---	Eemhaven*	90
---	Waalhaven-Zuid*	91
---	Vondelingenplaat*	92
---	Botlek*	93
---	Europoort*	94
---	Maasvlakte	95
---	Bedrijvenpark Noord-West*	96
---	Rivium*	97
---	Bedrijventerrein Schieveen*	98
---	Noordzeeweg*	100

* data of these districts is lacking and are, therefore, not considered
** the 'Wijkprofiel Rotterdam' considers these districts as two separate districts instead of just one as depicted on the map

Appendix B: Descriptive statistics

Table 5: Descriptive statistics per year

Variable	Year	Obs.	Mean	Std. dev.	Min.	Max.
Well-being	2014	71	0.801	0.683	0.650	0.920
	2016	71	0.804	0.070	0.670	0.941
	2018	71	0.812	0.066	0.643	0.935
	2020	0	-	-	-	-
	Total	213	0.806	0.068	0.643	0.941
Car VKT (in millions)	2014	71	0.912	0.112	0.442	1.079
	2016	71	0.920	0.113	0.446	1.089
	2018	71	0.928	0.114	0.450	1.098
	2020	71	0.937	0.114	0.454	1.108
	Total	284	0.924	0.113	0.442	1.108
Bike VKT (in millions)	2014	71	0.254	0.218	0.019	1.980
	2016	71	0.255	0.219	0.019	1.989
	2018	71	0.256	0.220	0.019	1.997
	2020	71	0.261	0.221	0.019	2.005
	Total	284	0.257	0.219	0.019	2.005
Public transport VKT (in millions)	2014	71	0.434	0.158	0.054	0.911
	2016	71	0.438	0.159	0.054	0.918
	2018	71	0.441	0.160	0.054	0.926
	2020	71	0.453	0.132	0.055	0.933
	Total	284	0.442	0.159	0.054	0.933
Congestion (in thousands)	2014	71	1.398	0.415	0.578	1.964
	2016	71	1.411	0.419	0.583	1.981
	2018	71	1.423	0.422	0.588	1.998
	2020	71	1.458	0.439	0.580	1.987
	Total	284	1.423	0.422	0.578	1.998
Low income	2014	71	0.491	0.153	0.160	0.770
	2016	71	0.491	0.151	0.150	0.760
	2018	71	0.491	0.153	0.163	0.770
	2020	71	0.491	0.153	0.163	0.770
	Total	284	0.491	0.152	0.150	0.770
Moderate income	2014	71	0.326	0.064	0.200	0.450
	2016	71	0.329	0.064	0.210	0.450
	2018	71	0.326	0.064	0.196	0.454
	2020	71	0.326	0.064	0.196	0.454
	Total	284	0.327	0.063	0.196	0.454
High income	2014	71	0.183	0.124	0.030	0.510
	2016	71	0.181	0.121	0.030	0.500
	2018	71	0.182	0.124	0.034	0.507
	2020	71	0.182	0.124	0.034	0.507
	Total	284	0.182	0.123	0.030	0.510
	2014	71	0.190	0.211	0.000	0.870
	2016	71	0.194	0.209	0.000	0.810

Variable	Year	Obs.	Mean	Std. dev.	Min.	Max.
Low house value	2018	71	0.190	0.211	0.000	0.870
	2020	71	0.190	0.211	0.000	0.870
	Total	284	0.191	0.209	0.000	0.870
Moderate house value	2014	71	0.563	0.225	0.020	0.920
	2016	71	0.571	0.219	0.050	0.930
	2018	71	0.563	0.245	0.020	0.920
	2020	71	0.563	0.245	0.020	0.920
	Total	284	0.565	0.222	0.020	0.930
High house value	2014	71	0.247	0.241	0.000	0.990
	2016	71	0.237	0.234	0.000	0.950
	2018	71	0.245	0.243	0.000	0.990
	2020	71	0.245	0.243	0.000	0.990
	Total	284	0.243	0.239	0.000	0.990
Native	2014	71	0.511	0.191	0.130	0.900
	2016	71	0.124	0.043	0.060	0.280
	2018	71	0.511	0.191	0.134	0.898
	2020	71	0.511	0.191	0.134	0.898
	Total	284	0.513	0.192	0.060	0.900
Western immigrants	2014	71	0.127	0.046	0.060	0.310
	2016	71	0.521	0.192	0.140	0.900
	2018	71	0.127	0.046	0.063	0.312
	2020	71	0.127	0.046	0.063	0.312
	Total	284	0.126	0.045	0.060	0.312
Non-western immigrants	2014	71	0.362	0.187	0.030	0.800
	2016	71	0.357	0.194	0.030	0.800
	2018	71	0.362	0.187	0.029	0.804
	2020	71	0.362	0.187	0.029	0.804
	Total	284	0.361	0.188	0.029	0.804
Amenities	2014	71	0.938	0.168	0.490	1.180
	2016	71	0.921	0.179	0.420	1.180
	2018	71	0.949	0.180	0.430	1.230
	2020	71	0.949	0.180	0.430	1.230
	Total	284	0.939	0.176	0.420	1.230
Population change	2014	71	0.011	0.023	-0.036	0.118
	2016	71	0.006	0.060	-0.364	0.289
	2018	71	0.012	0.018	-0.043	0.098
	2020	71	0.008	0.020	-0.067	0.105
	Total	284	0.009	0.035	-0.364	0.289

Appendix C: Correlation table

Table 6: Correlation table

Variable	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)
(1) Well-being	1															
(2) Car VKT	0.05	1														
(3) Bike VKT	-0.16	0.13	1													
(4) Public transport VKT	-0.18	0.53	0.12	1												
(5) Congestion	0.13	0.37	-0.13	0.39	1											
(6) Low income	-0.84	0.06	0.14	0.20	-0.11	1										
(7) Moderate income	0.49	-0.26	-0.13	-0.34	-0.11	-0.61	1									
(8) High income	0.78	0.06	-0.11	-0.07	0.19	-0.91	0.24	1								
(9) Low house value	-0.63	-0.06	0.02	0.05	-0.22	0.69	-0.43	-0.62	1							
(10) Moderate house value	-0.17	0.16	0.18	0.27	0.15	0.20	0.24	-0.37	-0.39	1						
(11) High house value	0.71	-0.10	-0.18	-0.30	0.06	-0.79	0.16	0.89	-0.51	-0.59	1					
(12) Native	0.69	-0.20	-0.24	-0.59	-0.07	-0.73	0.67	0.55	-0.52	-0.14	0.58	1				
(13) Western immigrants	0.10	0.29	0.47	0.47	0.31	-0.21	-0.06	0.29	0.07	-0.09	0.02	-0.20	1			
(14) Non-western immigrants	-0.73	0.14	0.49	0.49	0.00	0.79	-0.67	-0.62	0.52	0.16	-0.60	-0.97	-0.04	1		
(15) Amenities	-0.38	0.49	0.70	0.70	0.36	0.47	-0.47	-0.34	0.24	0.27	-0.46	-0.61	0.35	0.54	1	
(16) Population change	0.04	-0.00	0.02	0.04	0.02	-0.11	0.05	0.11	-0.14	-0.01	0.13	-0.01	0.12	-0.02	0.06	1

Appendix D: Hausman test results

Table 7: Hausman test results

Model	χ^2	Df	Effect
2	7.75	3	Random
3	7.60	4	Random
4	7.83	6	Random
5	10.05	8	Random
6	11.78	10	Random
7	14.18	10	Random

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Appendix E: Predicted change in well-being

Table 8: Predicted change in well-being

Scenario		1		2				3			
Bound		**---**		**Lower**		**Upper**		**Lower**		**Upper**	
Area	**District**	**Δ**	**% Δ**	**Δ**	**% Δ**	**Δ**	**% Δ**	**Δ**	**% Δ**	**Δ**	**% Δ**
Charlois	Carnisse	0,035	5,1%	0,038	5,4%	0,046	6,6%	0,059	8,4%	0,067	9,6%
Charlois	Heijplaat	0,069	9,7%	0,072	10,1%	0,080	11,2%	0,093	13,1%	0,101	14,2%
Charlois	Oud-Charlois	-0,005	-0,7%	-0,005	-0,7%	-0,005	-0,7%	-0,005	-0,7%	-0,005	-0,7%
Charlois	Pendrecht	-0,065	-8,1%	-0,075	-9,4%	-0,067	-8,4%	-0,080	-10,1%	-0,072	-9,1%
Charlois	Tarwewijk	-0,018	-2,5%	-0,018	-2,5%	-0,018	-2,5%	-0,018	-2,5%	-0,018	-2,5%
Charlois	Wielewaal	-0,010	-1,4%	-0,010	-1,4%	-0,010	-1,4%	-0,010	-1,4%	-0,010	-1,4%
Charlois	Zuiderpark en Zuidrand	-0,032	-3,8%	-0,043	-5,0%	-0,035	-4,1%	-0,048	-5,6%	-0,040	-4,7%
Charlois	Zuidplein	-0,061	-7,1%	-0,072	-8,3%	-0,064	-7,4%	-0,077	-9,0%	-0,069	-8,0%
Charlois	Zuidwijk	0,041	5,8%	0,044	6,2%	0,052	7,3%	0,065	9,2%	0,073	10,3%
Delfshaven	Bospolder	-0,016	-2,1%	-0,016	-2,1%	-0,016	-2,1%	-0,016	-2,1%	-0,016	-2,1%
Delfshaven	Delfshaven	-0,013	-1,7%	-0,013	-1,7%	-0,013	-1,7%	-0,013	-1,7%	-0,013	-1,7%
Delfshaven	Middelland	-0,039	-4,7%	-0,049	-5,9%	-0,041	-5,0%	-0,055	-6,6%	-0,047	-5,6%
Delfshaven	Nieuwe Westen	-0,018	-2,3%	-0,018	-2,3%	-0,018	-2,3%	-0,018	-2,3%	-0,018	-2,3%
Delfshaven	OudMathenesse/Witte Dorp	-0,043	-5,5%	-0,054	-6,9%	-0,046	-5,9%	-0,059	-7,6%	-0,051	-6,6%
Delfshaven	Schiemond	-0,027	-3,3%	-0,027	-3,3%	-0,027	-3,3%	-0,027	-3,3%	-0,027	-3,3%
Delfshaven	Spangen	-0,086	-10,5%	-0,097	-11,8%	-0,089	-10,8%	-0,102	-12,5%	-0,094	-11,5%
Delfshaven	Tussendijken	0,011	1,5%	0,011	1,5%	0,011	1,5%	0,011	1,5%	0,011	1,5%
Feijenoord	Afrikaanderwijk	-0,017	-2,3%	-0,017	-2,3%	-0,017	-2,3%	-0,017	-2,3%	-0,017	-2,3%
Feijenoord	Bloemhof	-0,007	-1,0%	-0,007	-1,0%	-0,007	-1,0%	-0,007	-1,0%	-0,007	-1,0%
Feijenoord	Feijenoord	-0,033	-4,5%	-0,044	-5,9%	-0,036	-4,8%	-0,049	-6,6%	-0,041	-5,5%
Feijenoord	Hillesluis	-0,035	-4,7%	-0,045	-6,1%	-0,037	-5,0%	-0,051	-6,8%	-0,043	-5,7%
Feijenoord	Katendrecht	-0,079	-9,2%	-0,089	-10,5%	-0,082	-9,5%	-0,095	-11,1%	-0,087	-10,1%
Feijenoord	Kop van Zuid	0,012	1,4%	0,012	1,4%	0,012	1,4%	0,012	1,4%	0,012	1,4%

Scenario		1		2				3			
Bound		---		Lower		Upper		Lower		Upper	
Area	District	Δ	% Δ	Δ	% Δ	Δ	% Δ	Δ	% Δ	Δ	% Δ
Feijenoord	Kop van Zuid-Entrepot	-0,051	-5,9%	-0,061	-7,2%	-0,053	-6,3%	-0,066	-7,8%	-0,058	-6,9%
Feijenoord	Noordereiland	0,001	0,1%	0,001	0,1%	0,001	0,1%	0,001	0,1%	0,001	0,1%
Feijenoord	Vreewijk	0,004	0,6%	0,004	0,6%	0,004	0,6%	0,004	0,6%	0,004	0,6%
Hillegersberg-Schiebroek	Hillegersberg-Noord	0,024	2,8%	0,024	2,8%	0,024	2,8%	0,024	2,8%	0,024	2,8%
Hillegersberg-Schiebroek	Hillegersberg-Zuid	-0,026	-2,8%	-0,026	-2,8%	-0,026	-2,8%	-0,026	-2,8%	-0,026	-2,8%
Hillegersberg-Schiebroek	Molenlaankwartier	-0,023	-2,4%	-0,023	-2,4%	-0,023	-2,4%	-0,023	-2,4%	-0,023	-2,4%
Hillegersberg-Schiebroek	Schiebroek	-0,015	-1,8%	-0,015	-1,8%	-0,015	-1,8%	-0,015	-1,8%	-0,015	-1,8%
Hillegersberg-Schiebroek	Terbregge	-0,001	-0,1%	-0,001	-0,1%	-0,001	-0,1%	-0,001	-0,1%	-0,001	-0,1%
Hoek van Holland	Dorp/Rijnpoort	-0,016	-1,9%	-0,016	-1,9%	-0,016	-1,9%	-0,016	-1,9%	-0,016	-1,9%
Hoek van Holland	Strand en Duin	-0,025	-2,7%	-0,025	-2,7%	-0,025	-2,7%	-0,025	-2,7%	-0,025	-2,7%
Hoogvliet	Hoogvliet-Noord	-0,007	-0,8%	-0,007	-0,8%	-0,007	-0,8%	-0,007	-0,8%	-0,007	-0,8%
Hoogvliet	Hoogvliet-Zuid	-0,011	-1,4%	-0,011	-1,4%	-0,011	-1,4%	-0,011	-1,4%	-0,011	-1,4%
IJsselmonde	Beverwaard	-0,003	-0,4%	-0,003	-0,4%	-0,003	-0,4%	-0,003	-0,4%	-0,003	-0,4%
IJsselmonde	Groot IJsselmonde-Noord	0,056	7,7%	0,059	8,1%	0,067	9,2%	0,080	11,0%	0,088	12,0%
IJsselmonde	Groot IJsselmonde-Zuid	-0,019	-2,4%	-0,019	-2,4%	-0,019	-2,4%	-0,019	-2,4%	-0,019	-2,4%
IJsselmonde	Lombardijen	0,020	2,7%	0,020	2,7%	0,020	2,7%	0,020	2,7%	0,020	2,7%
IJsselmonde	Oud IJsselmonde	0,029	3,5%	0,029	3,5%	0,029	3,5%	0,029	3,5%	0,029	3,5%
Kralingen-Crooswijk	De Esch	0,007	0,9%	0,007	0,9%	0,007	0,9%	0,007	0,9%	0,007	0,9%

Scenario		1		2				3			
Bound		---		Lower		Upper		Lower		Upper	
Area	District	Δ	% Δ	Δ	% Δ	Δ	% Δ	Δ	% Δ	Δ	% Δ
Kralingen-Crooswijk	Kralingen Oost/Kralingse Bos	-0,026	-2,8%	-0,026	-2,8%	-0,026	-2,8%	-0,026	-2,8%	-0,026	-2,8%
Kralingen-Crooswijk	Kralingen-West	-0,018	-2,2%	-0,018	-2,2%	-0,018	-2,2%	-0,018	-2,2%	-0,018	-2,2%
Kralingen-Crooswijk	Nieuw Crooswijk	-0,017	-2,1%	-0,017	-2,1%	-0,017	-2,1%	-0,017	-2,1%	-0,017	-2,1%
Kralingen-Crooswijk	Oud Crooswijk	0,091	14,1%	0,094	14,5%	0,101	15,8%	0,115	17,8%	0,122	19,1%
Kralingen-Crooswijk	Rubroek	-0,017	-2,1%	-0,017	-2,1%	-0,017	-2,1%	-0,017	-2,1%	-0,017	-2,1%
Kralingen-Crooswijk	Struisenburg	0,025	3,1%	0,025	3,1%	0,025	3,1%	0,025	3,1%	0,025	3,1%
Noord	Agniesebuurt	-0,039	-4,8%	-0,050	-6,1%	-0,042	-5,1%	-0,055	-6,8%	-0,047	-5,8%
Noord	Bergpolder	-0,011	-1,3%	-0,011	-1,3%	-0,011	-1,3%	-0,011	-1,3%	-0,011	-1,3%
Noord	Blijdorp/Blijdorpsepolder	-0,016	-1,8%	-0,016	-1,8%	-0,016	-1,8%	-0,016	-1,8%	-0,016	-1,8%
Noord	Liskwartier	-0,015	-1,8%	-0,015	-1,8%	-0,015	-1,8%	-0,015	-1,8%	-0,015	-1,8%
Noord	Oude Noorden	-0,030	-3,8%	-0,041	-5,2%	-0,033	-4,2%	-0,046	-5,8%	-0,038	-4,8%
Noord	Provenierswijk	-0,002	-0,3%	-0,002	-0,3%	-0,002	-0,3%	-0,002	-0,3%	-0,002	-0,3%
Overschie	Kleinpolder	0,011	1,4%	0,011	1,4%	0,011	1,4%	0,011	1,4%	0,011	1,4%
Overschie	NoordKethel/ Schieveen/Zestienhoven	-0,049	-5,2%	-0,059	-6,4%	-0,051	-5,5%	-0,064	-6,9%	-0,056	-6,1%
Overschie	Overschie	0,010	1,2%	0,010	1,2%	0,010	1,2%	0,010	1,2%	0,010	1,2%
Pernis	Pernis	-0,005	-0,6%	-0,005	-0,6%	-0,005	-0,6%	-0,005	-0,6%	-0,005	-0,6%
Prins Alexander	Het Lage Land	-0,019	-2,3%	-0,019	-2,3%	-0,019	-2,3%	-0,019	-2,3%	-0,019	-2,3%
Prins Alexander	Kralingseveer	-0,058	-6,4%	-0,068	-7,5%	-0,060	-6,7%	-0,074	-8,1%	-0,066	-7,2%
Prins Alexander	Nesselande	0,023	2,6%	0,023	2,6%	0,023	2,6%	0,023	2,6%	0,023	2,6%
Prins Alexander	Ommoord	-0,010	-1,1%	-0,010	-1,1%	-0,010	-1,1%	-0,010	-1,1%	-0,010	-1,1%

Scenario		1		2				3			
Bound		---		Lower		Upper		Lower		Upper	
Area	District	Δ	% Δ	Δ	% Δ	Δ	% Δ	Δ	% Δ	Δ	% Δ
Prins Alexander	Oosterflank	0,024	3,0%	0,024	3,0%	0,024	3,0%	0,024	3,0%	0,024	3,0%
Prins Alexander	Prinsenland	0,078	10,2%	0,080	10,6%	0,088	11,6%	0,101	13,3%	0,109	14,4%
Prins Alexander	s-Gravenland	0,001	0,1%	0,001	0,1%	0,001	0,1%	0,001	0,1%	0,001	0,1%
Prins Alexander	Zevenkamp	0,003	0,4%	0,003	0,4%	0,003	0,4%	0,003	0,4%	0,003	0,4%
Rotterdam Centrum	Cool	-0,033	-3,9%	-0,044	-5,1%	-0,036	-4,2%	-0,049	-5,7%	-0,041	-4,8%
Rotterdam Centrum	CS-kwartier	-0,012	-1,4%	-0,012	-1,4%	-0,012	-1,4%	-0,012	-1,4%	-0,012	-1,4%
Rotterdam Centrum	Nieuwe Werk/Dijkzigt	-0,009	-1,1%	-0,009	-1,1%	-0,009	-1,1%	-0,009	-1,1%	-0,009	-1,1%
Rotterdam Centrum	Oude Westen	0,003	0,4%	0,003	0,4%	0,003	0,4%	0,003	0,4%	0,003	0,4%
Rotterdam Centrum	Stadsdriehoek	-0,004	-0,5%	-0,004	-0,5%	-0,004	-0,5%	-0,004	-0,5%	-0,004	-0,5%
Rozenburg	Rozenburg	0,000	0,0%	0,000	0,0%	0,000	0,0%	0,000	0,0%	0,000	0,0%