Demografische factoren en de juiste investeringen in openbaar vervoer

Raymond Huisman – Goudappel Coffeng – rhuisman@goudappel.nl

Hugo Visser – RET – hvisser@ret.nl

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Samenvatting

In een hoogopgeleide en een verstedelijkte samenleving, zoals Nederland, is goed openbaar vervoer een must. Er is echter geen oneindig budget beschikbaar, waardoor er een toenemende focus is ontstaan op efficiency en effectiviteit van het openbaar vervoer. Ook moet er bij investeringsbeslissingen kritisch worden gekeken naar toegevoegde waarde voor nu en voor de toekomst. Door onderzoek te doen naar de economische en demografische ontwikkelingen in een gebied en de verplaatsingen die daardoor vanuit het gebied ontstaan, kunnen zowel (decentrale) overheden als mobiliteitsaanbieders inzicht krijgen in de mogelijke (waarde van de) toekomstige vervoerbehoefte in hun regio. Daarmee wordt inzichtelijk waar de veelgebruikte verbindingen kunnen komen te liggen en kunnen investeringsplannen daarop worden aangepast.

In dit paper wordt dat inzicht gegeven door NRM- en OVIN-data te combineren met demografische factoren en theorie over de verschillende doelen van een reis. Voor Nederland biedt de NRM-data inzicht in de demografische ontwikkeling tot en met 2030, waardoor voor een aantal scenario's bekend is hoeveel mensen er in een bepaald gebied zullen wonen. OVIN-data biedt inzicht in de verwachte hoeveelheid verplaatsen vanuit een bepaald gebied, uitgesplitst naar het doel van een reis. Door het verwachte aantal verplaatsingen te verrijken met demografische gegevens en het soort verplaatsingen, kan worden bepaald welke behoefte aan mobiliteit er vanuit een bepaald gebied zal gaan ontstaan in een bepaald scenario. Deze scenario's kunnen worden afgezet tegen bijvoorbeeld de huidige verplaatsingen vanuit een gebied, of diverse verschillende toekomstscenario's.

Deze gegevens kunnen worden geplot op een kaart, zodat ook grafisch zichtbaar is welke gebieden de komende jaren een toename aan vervoer kunnen verwachten. In dit paper wordt de rekenmethode voor combineren van de NRDM en OVIN-data beschreven en wordt ook aangegeven welke beperkingen er zijn in de datasets. Het paper wordt afgesloten met een grafische weergave van deze data. Het studiegebied betreft het gebied waarbinnen het vervoerbedrijf RET opereert.

1. Introduction

The main topic of this paper is the relationship between demography and the foreseen operations of public transport. Well-functioning public transport systems are crucial for densely populated and economic areas, such as the Randstad in The Netherlands (Raad voor Verkeer en Waterstaat, 2004). However, several developments do have an influence on these systems. In this paper, we address three of such developments: (1) a changing Dutch demography; (2) the demand for public transport operators to work more efficient and more effective; and (3) new (information) technology demanding public transport operators to change the supply of public transport. A research has been conducted to see what kind of effects apply on possible public transport operations in the future.

1.1 A changing Dutch society

Rural areas in the Netherlands face a shrinking population size; urban areas, however, face urban growth (Kooiman et al., 2016). The Randstad, the western part of the Netherlands, is one of the areas where the population size will rise (Ritsema van Eck et al., 2013). Another important changing demographic factor, is population composition. An ageing population, both education level and labour force participation are on the rise are only examples which lead to changes in transport usage. Studies (see for example Harms, 2008) show that higher educated people generally travel more often and do have a greater *daily urban system* than people who are less high educated. Even today's elderly travel more often than they did several decades ago. Obviously, these demographic changes influence trip generation and eventually lead to different public transport service demand. As is with changes in population size, changes within population composition differ per region, as well. Municipalities in the rural areas of the Netherlands have to deal faster with an older getting population than their counterparts within the Randstad area. Current forecasts (Ritsema van Eck et al., 2013) say that the overall demand for mobility in the Randstad area, and for public transport as well, will continue to rise slightly in the coming years.

1.2 Efficiency

Besides demographic changes, public transport operators are demanded by regional public transport authorities to work more effectively and more efficiently (e.g. Mouwen, 2016). Grants given by regional public transport authorities to operators decline. This leads to an increasing focus on vehicle occupancy and cost efficiency, and affects decision making processes on infrastructure investments. As a result, authorities and operators choose to invest in mass transit solutions, such as railways or BRT, that serve large amounts of passengers and connect dense urban areas.

1.3 New technologies

Amongst demographic changes, declining grants and cost efficiency, new mobility solutions, such as E-bikes and Uber, are on the rise. These mobility services will have an impact on existing public transport, and forces local authorities and operators to make strategic choices in transport services. Existing services may not be future-proof, and we expect that public transport tend to shift to either BRT-like solutions or solutions that

offer local mobility services.
Today's technology, such as smart card data and mobile apps, can give real time information on transport usage and actual transport demand. These technologies could help to start transport services on demand, reduce operating costs and optimise vehicle occupation.

1.4 Future transport demand

Therefore, research needs to be done to demographic variables and their influences on today's public transport demand to gain better understanding of (a) the mechanism between these variables and (b) to estimate changes in the next decades. This is highly relevant since operating public transport goes hand in hand with large investments, such as infrastructure (new, maintenance) as well as (financially) responsible fleet management. More insight in future transport demand could support decision making processes. This research has been conducted while fusing different data sources: OVIN, data about trip generations, and NRM, demographic data about population size and composition.

After this introduction chapter, a theoretical framework has been set up. The relation between demography and mobility and the preference for certain public transport characteristics in relation with different trip purposes, will be described in that chapter. Chapter 3 deals with the methodology in this paper. Chapter 4 contains research results. Finally, conclusions of this research have been described in the 5th chapter. This paper ends with a further reading section as well as some acknowledgements.

2. Theoretical framework

The content of this theoretical framework consists of two parts, eventually leading to a conceptual framework. First, influential variables will be described; focus lays on variables such as (a) demography and (b) spatial factors and their relationship with mobility. The second part of this theoretical framework briefly focuses on the mobility part. It is without question that the length of the forthcoming content is not even close to a brief summary of the published (and still unpublished) literature around.

From demography to mobility[1]

Several factors influence daily mobility, such as (a) the need for mobility to be beneficial; (b) personal characteristics; (c) spatial settings; and other factors, such as (d) economic growth. Mobility is a result of the need and desire of people to 'do things' at a different place from where they reside. Snellen (2001) states that: "Theories […] are mainly based on the notion that travel is the result of people's desire to engage in activities. Since activity locations are spatially distributed over a larger area, these activities cannot all be performed at the same location. The result is travel." According to Dutch studies described in the previous chapter, people in the Randstad tend to travel more often in the future. The motivation to travel differs from person to person. People must have a

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[1] This part is largely based on Huisman (2015).

(not necessarily financial) benefit from their travel, such as attending classes or going to work. The optimum between the costs of travelling and the value to go to a place different will finally result in mobility.

The cost/benefit optimum is different for every kind of person and it is influenced by personal characteristics. The most important characteristics are: age, education, participation in the labour force, gender, and the opportunity to travel. If a person has a driving license and a car, then s/he is possibly keen to travel by car; but if a person has no driving license; s/he is already *de jure* unqualified to drive a car. Being 'a member' of a certain age or date of birth cohort may show such an effect 'through time' (Van Dam et al 2013).

Cohorts can be sorted by age or by date (year) of birth. A fine example of an age cohort effect is that people in the group of 65-75 years old become more mobile. Whereas an example of a year of birth cohort is the variation of mobility by age through life, a person from the 1950s might be more mobile in the 1970s (his/her twenties) than in the 2000s (his/her fifties).

Besides characteristics such as age and education, cultural background might be a value characteristic as well. It can be argued that such a factor substantially influences individual desires and thus mobility. Literature (e.g. Harms 2008) states that some foreign cultures appreciate car travel more, whereas others (for instance, native Dutch people) are keener to ride their bicycles. Unfortunately, due to practical issues such as data availability, this characteristic is not being researched.

Other influential factors

Spatial settings of either the origin or destination do have an impact on travel as well. Ewing and Cervero (2010) mention five important D-factors: (a) **D**ensity, (b) **D**iversity, (c) **D**esign, (d) **D**estination accessibility, and (e) **D**istance to transit. Obviously, these D-factors intermingle and influence each other as well. According to Gim (2012), *density* is the most important one, since all the other factors correlate highly with density. From a more practical viewpoint, *density* is relatively easily measurable and even predictable.

Besides personal and spatial characteristics, the economical context is an important factor too. In general, the economic growth leads to several consequences: a) more people being employed leads to a growing commuting potential; b) the people who are being employed are more specialised – and thus have to travel further to their employer of interest; c) people earn more – and people with a higher income intend to travel longer distances. It is estimated that economic crises are insignificant for long term (mobility) forecasts. Changes in population composition seem to be more important regarding their effect on daily travel than, for example, the current economic crises.

Finally, it is concluded that both personal and spatial characteristics influence daily mobility. Not only regarding the lengths of trips, but also the mode choice depends of these characteristics. Hitherto the influential factors have been described, containing who generates mobility and how people travel, in the forthcoming part the characteristics of public transport characteristics have been further analysed.

Value of time

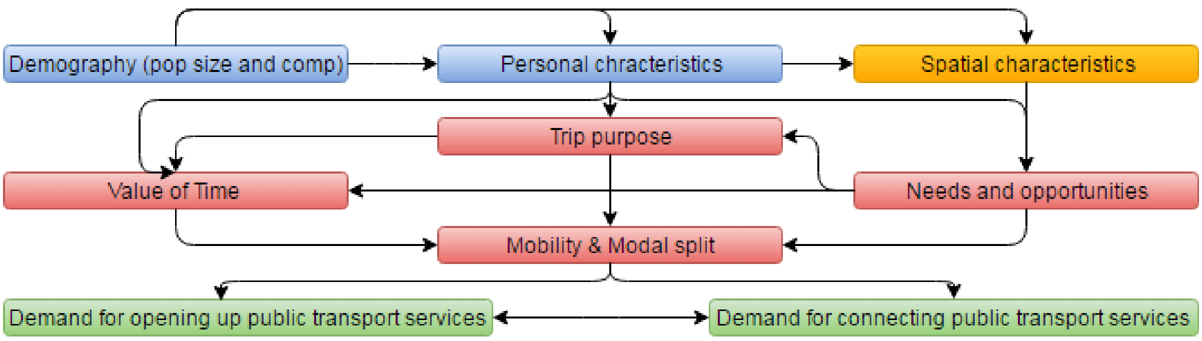
Common motives for travel are to commute, to travel for leisure of to travel for business purposes. Lots of research has been done on costs of time spend on transport and values of travel time reductions.
While each trip starts at a certain location and ends at a certain location, the trip itself consists of several elements, such as walking, waiting, time spend in a vehicle etc. People tend to evaluate their time spend on these elements differently. Wardman (2001) shows that people evaluate time spend while waiting 1,5 to 2 times higher than time spend in a moving vehicle. Although these numbers may vary among several studies, it points out that a single trip could not just be evaluated on time. Other factors, such as waiting facilities, speed or timetable quality (for public transport) counts as well.

2.1 Conceptual framework

The above described literature shows that population size and composition (aggregated level) or personal characteristics (individual level) as well as spatial characteristics highly influence daily mobility. Individual trips – each with its own purpose and value of time, created by needs and opportunities of the travellers – create mobility and modal splits for each m\odes. This information is of the uttermost importance when being confronted with questions such as 'where is a demand for public transport services?' or 'where do people rather have opening up public transport services?'

The figure below shows the conceptual framework to answer these questions.

Figure 1 Conceptual framework



This framework eventually leads to a map showing areas the demand for transport services in several areas in the Randstad. Since investments in transport services can be part of long-term planning strategies, we created a map showing the demand for transport services nowadays and future demand.

Future scenarios

In the Netherlands, many long-term policy decisions are based on a NRM-study that point out two different scenarios for the year 2030 and beyond, called reference scenario 2030 Laag and 2030 Hoog. Basically, these scenarios indicates demographic changes and economy growth, and these two developments will have an effect on mobility, climate, energy consumption, agriculture etc. The main transitions in the two scenarios are listed below.

Hoog – high economy growth and population growth, which also includes immigration and (consequently) a relatively high birth rate.

Laag – moderate economy growth and population growth, due to modest immigration and birth rate.

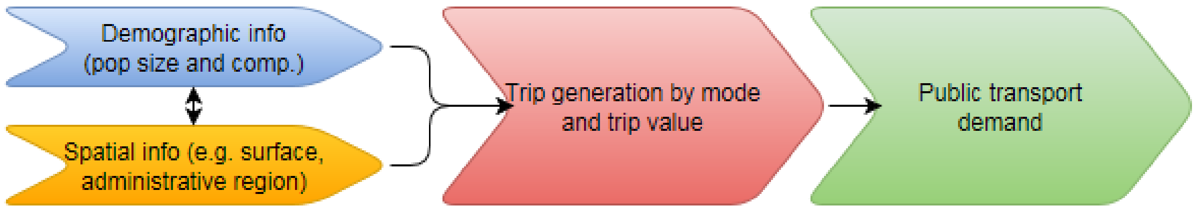
The scenarios differ on population growth in the whole country, but both scenarios predict population growth in de Randstad area. The demand for mobility rises in both scenarios as well. Not only car usage will rise, bus also public transport and bicycle usage will rise. There might be slightly more congestion in scenario Hoog.

Since one cannot 'know' the future, new policy makers and decision makers can make their choices based on these 'predictions', the future scenarios. In this paper, we will take both possible scenarios into account.

3. Research methods

As written in the previous chapter, trip information, demographic characteristics, and spatial diversion are considered of major importance within this field of research. The first element has a dependent relation with the other two elements, which are considered independent. Data should not only be available of the recent past, but also of the future, since a prediction has to be made. Trip related data is distracted from OVIN, whereas socio-economic data from the past and the future is distracted from NRM.

Figure 2 Demographic characteristics and spatial diversion



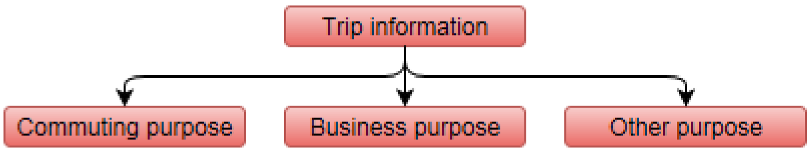
Obviously, not only the data demand has to be taken into account, also data availability has to be considered. Data has to be available for this research purpose and available data should be able to 'intermingle' with other data sources to the whole research scope can be covered. This chapter considers both the data demand for this research, as well as the data availability from a more practical viewpoint.

3.1 Trip information

Regarding trip information, since the mid-1970s the Statistics Bureau of the Netherlands (CBS) conducts research within the field of mobility. This longitudinal research, called OVIN from 2010 onwards, proves to be highly favourable when doing research within the mobility field. Especially when general trip characteristics can be taken into account. OVIN covers not only trip information, but also information about the person making the trip is stored within the dataset. This combination is highly valuable and therefore OVIN has been used to deal with the trip production and demographic part of this research. OVIN can specifically be used to answer more general research questions. Demanding data on a highly detailed level, both demographic and spatial wise, will, however, lead to problems regarding the amount of cases and therefore the validity of the research results. This problem can, however, be eliminated by stacking five years of OVIN-data (2010-2014) to calculate the public transport trip production for each demographic group, for each spatial group and for each trip purpose.

Besides information of both the person making the trip and the spatial context of the trip, the purpose of the trip is also taken into account. In line with earlier research to the Value of Time, a distinction has been made into: (1) trips with a commuting purpose, (2) trips with a business purpose, and (3) trips with other purposes, see Figure 3. Not every trip purpose is considered for each demographic group. An example is the lack of business and commuting trip purposes for people between 0-18 years old.

Figure 3 trip information

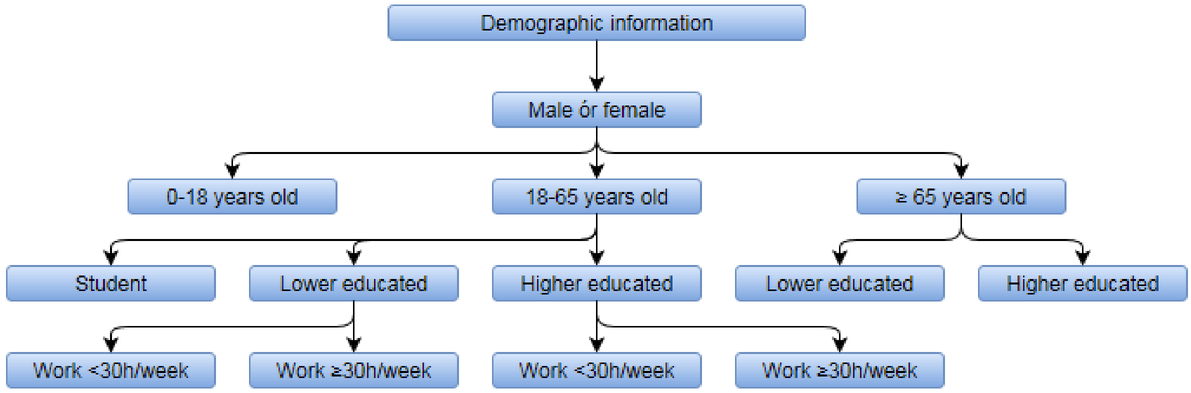


3.2 Demographic information

As written in this paper’s theoretical framework, personal characteristics highly impacts daily mobility. Age group, participation in the labour market, and level of education are major influencers. The aforementioned OVIN-research contains data of demographic characteristics, so data has simply been extracted from the OVIN-database to distinguish trip generation per demographic group.

Since distinguishing too many groups may lead to too less cases, population composition has been grouped. Furthermore, to be able to cooperate with other data sources, the population composition groups have to be in line with these data sources. Factors to derive population composition groups are shown in the forthcoming diagram. Although OVIN-data distinguishes level op educated, NRM-data unfortunately does not. Therefore, the percentage of higher and medium educated groups have been estimated using OVIN-data for the NRM-scenario’s.

Figure 4 Demographic information



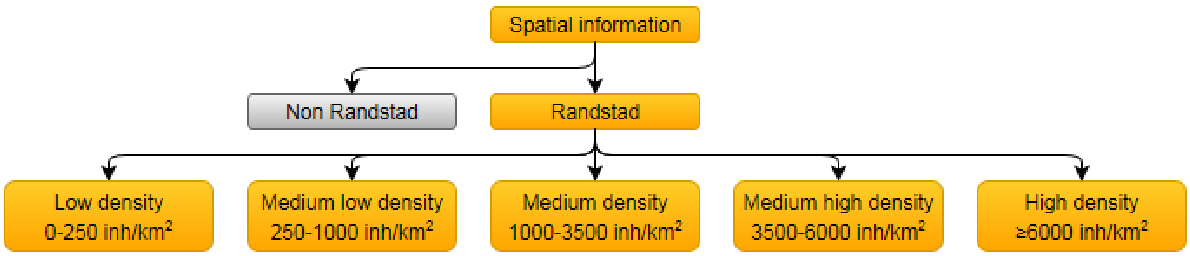
3.3 *Spatial diversion*

Trip generation in OVIN has to be researched for population composition groups, only then it is possible to connect trip generation with trip purposes and population size and composition forecasts. As written before, OVIN does not contain enough data to consider (a) all the different demographic groups; as well as (b) trip purpose; as well as (c) spatial diversion separately. Although stacking several years (2010-2014) reduces the problem, another measure is taken to enlarge the number of cases. This is done by enlarging the research area and merging equal spatial areas.

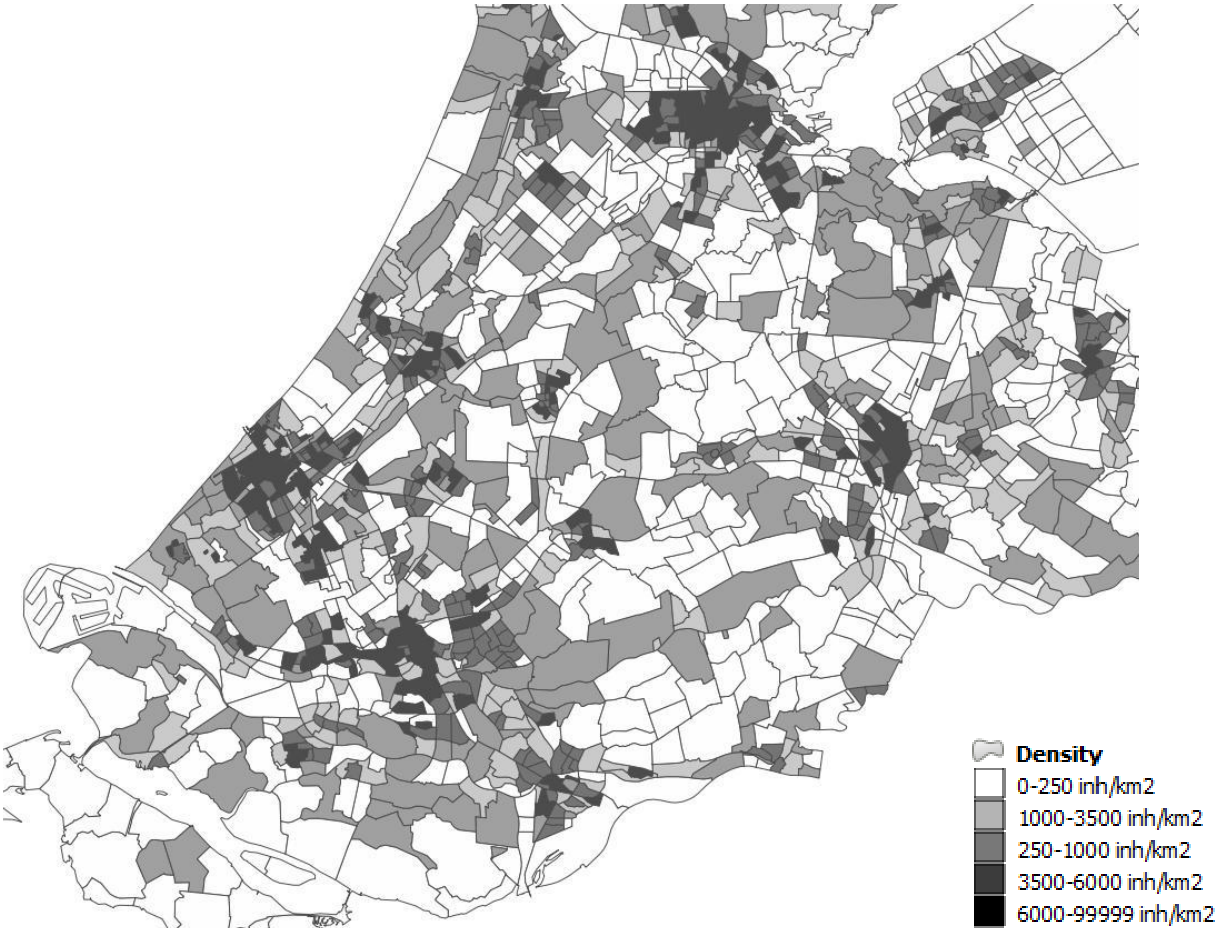
As written in the theoretical framework, amongst other spatial characteristics, density highly matters. Regarding the first, OVIN does not contain data of population density on any kind of spatial level. Therefore, data regarding density has to be imputed from other sources. The smallest spatial variable within the OVIN-data is the Postcode 4-level (PC4). The surface of these PC4 levels as well as the number of inhabitants have therefore been imputed from the NRM-data (see further on). These figures are simply divided by each other to calculate the density of the given PC4-area.

Although it is then possible to use density classes of PC4 level throughout the whole Netherlands, it can be justified that distinguishing spatial design on a macro level is needed to distinguishing different trip generation behaviour. Therefore, only information from the Randstad area is used: in this way the spatial dynamics around the four larger Dutch cities are being taken into consideration, thus justifying spatial design on a macro level, while still being able to derive enough data from the OVIN-dataset.

Figure 5 Spatial information



Figuur 6 density in the Randstad area



3.4 Today and tomorrow

The aforementioned part of this chapter is used to create a reference situation with total predicted mobility as a dependent variable and (a) population size, (b) population composition, and (c) trip generation by trip purpose within a given PC4-area as independent variables. To predict public transport usage of the future, independent spatial and population variables are thus needed. Available NRM-data contains the independent variables regarding population size and population composition. NRM-data does, however, not contain any information regarding trip generation originated by behaviour, and is thus kept constant. NRM-data involves the different future scenarios 2030 Laag and 2030 Hoog.

Although it is possible to assign trips to PC4-areas within the different NRM-scenario's, it does not give the possibility to gain understanding of the added value created by assigning trips to PC4-areas with extra independent variables. Assigning trip information data to PC4-areas is therefore done iteratively to create better understanding of the impact of each iteration. The first iteration deals with the population size and the trip generation per person, thus creating the amount of trips made by an 'average person' living in the Randstad. The first iteration does not take into account any other variable, such as spatial context (read: density) or the kind of people living in the PC4-area.

The second iteration, however, adds the spatial context to the assignments of the trips. It is likely that the denser areas will produce different kind of mobility than the lesser populated areas. The third iteration adds population composition data on top of the population size data (iteration 1) and the spatial context (iteration 2). Finally, in the fourth iteration trip purposes are added to the trip assignment. This fourth iteration does not necessarily create a different sum of trips, yet it enables the possibility to gain understanding of the value of trip created in the region. It is expected that adding information of the spatial context (iteration 2) and of the population composition (iteration 3) has the highest impact on trip generation within PC4-areas.

Figure 7 Iterations

The last iteration gives the Value of Travel time per minute for all trips generated in one area per day for each induvial PC4-area. Dividing this amount by the population size gives the benefit per inhabitant per minute travel time. When this amount is multiplied by the number of days in a year, the Value of a minute Travel time per capita is calculated for the inhabitants and trips generated in this PC4-area (see equation 1).

$$VoTt\ per\ capita_{(PC4\ i)} = \frac{1min_{(PC4\ i;\ it\ j)}}{n\ inh_{(PC4\ i)}} * n\ day$$

Equation 1: Calculating the Value of Travel time (VoTt) per capita for PC4-area (i), by dividing the Value of Travel time of 1 minute (1min) for the corresponding PC4-area (i) from one of the above mentioned iterations (j) by the population size (n inh) for the same corresponding PC4-area (i).

Leaving the 'per capita' factor and multiplying the Travel time per minute by the number of days may give a rough indicator of the corresponding holding value of the PC4's piggy bank (see equation 2).

$$Pb_{(PC4\ i)} = 1min_{(PC4\ i;it\ j)}\ n\ day$$

Equation 2: Calculating the holding value of the piggy bank for PC4-area (i), by multiplying the Value of Travel time of 1 minute (1min) for the corresponding PC4-area (i) from one of the above mentioned iterations (j) with the amount of days of the desired period of time.

However, larger areas with more inhabitants simply have a larger piggy bank. More people contribute to the PC4's piggy bank. This does, however, not mean it is ultimately more economical to save a minute travel time, since it also may be harder to save on travel time in a larger and/or denser populated area. Therefore, an indicator has been created to deal with the density and size of an area. (see equation 3)

$$StPb_{(PC\,4\,i)} = \frac{1min_{(PC\,4\,i)} * \frac{n\ inh_{(PC\,4\,i)}}{S_{(PC\,4\,i)}}}{S_{(PC\,4\,i)}}$$

Equation 3: Calculating the holding value of the standardized 'piggy bank' for PC4-area (i) to compare (i) with other areas (j-…), by multiplying the Value of Travel time of 1 minute (1min) for the corresponding PC4-area (i) with the population size divided by the surface of PC4-area (i).

To conclude, the value of time will calculated for each individual PC4-area and then standardized or multiplied according to the desired variable. The chapter 'results' further clarifies the above with illustrations.

3.5 Research validity

As mentioned previously, some crucial steps have been made in this research design. Besides the known (and unknown) errors that may possibly occur given the used data sources, it is important to have understanding that: (a) trip generation is based on population size and population composition; and (b) trip generation is based on certain aforementioned demographic groups and aforementioned assigned trip purposes.

Regarding the issue mentioned under 'a', it is unlikely that there will be a PC4-area with only population size and population composition that influence trip generation. Major other influencers will be labour market and student related variables. In the forthcoming displayed map, the homogeneity of PC4-areas are shown. The homogeneity of a PC4-area is calculated as follows:

$$HI_{(PC)} = \frac{I_{(PC)}}{I_{(PC)} + LM_{(PC)} + S_{(PC)}}$$

Equation 4: Where homogeneity of inhabitants of a PC4-area is displayed as HI, which is calculated by taking the proportionate size of the number of inhabitants (I) in the same PC4-area, the number of jobs (Labour Market, LM) and the number of student places (S).

The table below shows corresponding HI-figures for several places within the Rotterdam urban area. Please note that certain measures are not given for places with less than four PC4-areas. Certain places clearly are more homogenous than others, where the number of jobs or students places seem to prevail, at least in some of the included PC4-areas. Examples of the first are Bergschenhoek and Ridderkerk, whereas Rotterdam and Capelle aan den IJssel are definitively more heterogeneous.

Table 1: HI-figures for several places within the Rotterdam urban area.

Place	Inhabitants (x1000)	Surface (km2)	Population density	Number of PC4-areas	Average HI	StDev HI	Lowest PC4 HI	Q1 HI	Median HI	Q3 HI	Max HI
Barendrecht	46,8	21,7	2156	9	63%	26%	4%	43%	75%	81%	88%
Bergschenhoek	17,2	15,5	1110	5	61%	32%	22%	22%	83%	88%	91%
Berkel en Rodenrijs	25,9	18,9	1371	6	61%	31%	0%	32%	72%	88%	91%
Bleiswijk	10,9	22	498	3	38%	25%	14%	na	na	na	73%
Capelle aan den IJssel	66,2	15,4	4293	12	62%	30%	0%	54%	72%	84%	92%
Maassluis	31,9	10,1	3157	9	72%	22%	20%	57%	84%	88%	92%
Pernis	4,8	4,8	999	2	42%	41%	2%	na	na	na	83%
Poortugaal	9,9	6,8	1454	3	68%	20%	40%	na	na	na	89%
Rhoon	14,7	16,3	902	2	79%	13%	66%	na	na	na	93%
Ridderkerk	44,9	25,1	1788	9	71%	19%	27%	56%	79%	84%	87%
Rotterdam	549,4	143	3842	92	58%	30%	0%	31%	72%	83%	94%
Rotterdam Hoogvliet	34	10,7	3194	7	77%	15%	43%	71%	86%	89%	89%
Schiedam	75,8	19,9	3809	16	59%	35%	0%	15%	75%	86%	92%
Vlaardingen	71,3	26,7	2670	14	57%	34%	1%	14%	76%	88%	91%

Regarding the issue mentioned under ‘b’, the majority of population composition groups have taken into account in this research. The population composition groups, as mentioned earlier in this chapter, are mutually exclusive. This, however, does not prevent that the used datasets have data in it with some blank cells. Approximately 98% of the people are covered by the used population composition group differentiation. Regarding trip generation data, the same methods applies as to the population composition grouping. Approximately 97% of the generated trips are covered by the used grouping. Obviously, regarding this figure, underrepresentation of certain groups and/or trips within the OVIN-data itself, have not been taken into account.

Finally, it is important to realize this research deals with trip generation partially. Regarding spatial factors only density has been taken into account, leaving other influential variables, such as the distribution of the labour market or student places absent. Regarding population composition, the majority of cases has been taken account, leaving only a few percent absent. The same counts for trip generation as well.

3.6 To conclude

Data derived from OVIN gives a number of trips to be made on a daily base for a variety of demographic groups within a variety of PC4-areas, split by three trip purposes. These trip numbers have to be multiplied by the population size (of the same population composition group) in the PC4-area to get to finally know the amount of trips produced within a certain region. As earlier mentioned, PC4-areas are the smallest areas within the OVIN-data. The multiplied factor (population size, population composition) changes over time, when using different NRM-years. Two factors are kept constant, a) the trips generated by each individual, calculated from OVIN-data and b) the value of time. This suits this research topic for now, but should be investigated further on in forthcoming researches. Validity wise, there is an important remark that not all (public transport)trips are taken into account here, about 3% to 4% of the data derived from OVIN is missing. Further on, only trips related to residential places have been taken into account, thus leaving out business or attraction related trips.

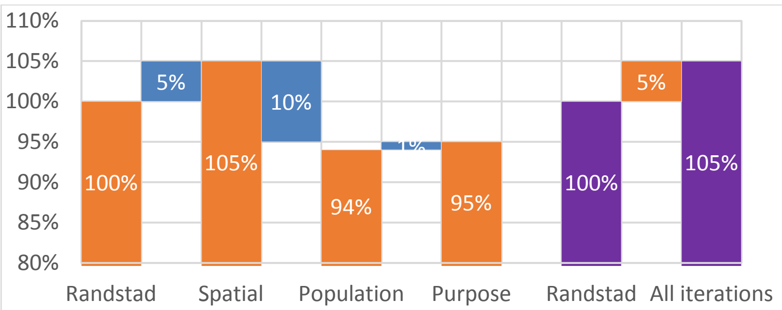
4. Results

The abovementioned iterations finally results in two illustrations. At first, we will show the impact of the different iterations on trip generations. Secondly, we will show a map of the Randstad area that indicates which postcode-areas are likely to have a high transport demand in 2030.

4.1 Demographic influences

As written in the previous chapter, four iterations are done to get a number for total trip generation. In the first iteration, trips are only generated by the population size, eventually leading an index of 100%. When adding a spatial context, which happens in the second iteration, the trip generation rises in any case (by 12% within the study area), but is declining by more or less the same percentage when population composition is taken into account. Adding trip purposes rarely has an impact on the total trip generation value. The displayed ‘waterfall diagram’ shows the difference in trip generation for each iteration for the area of study.

Figure 8 Iterations for Randstad area

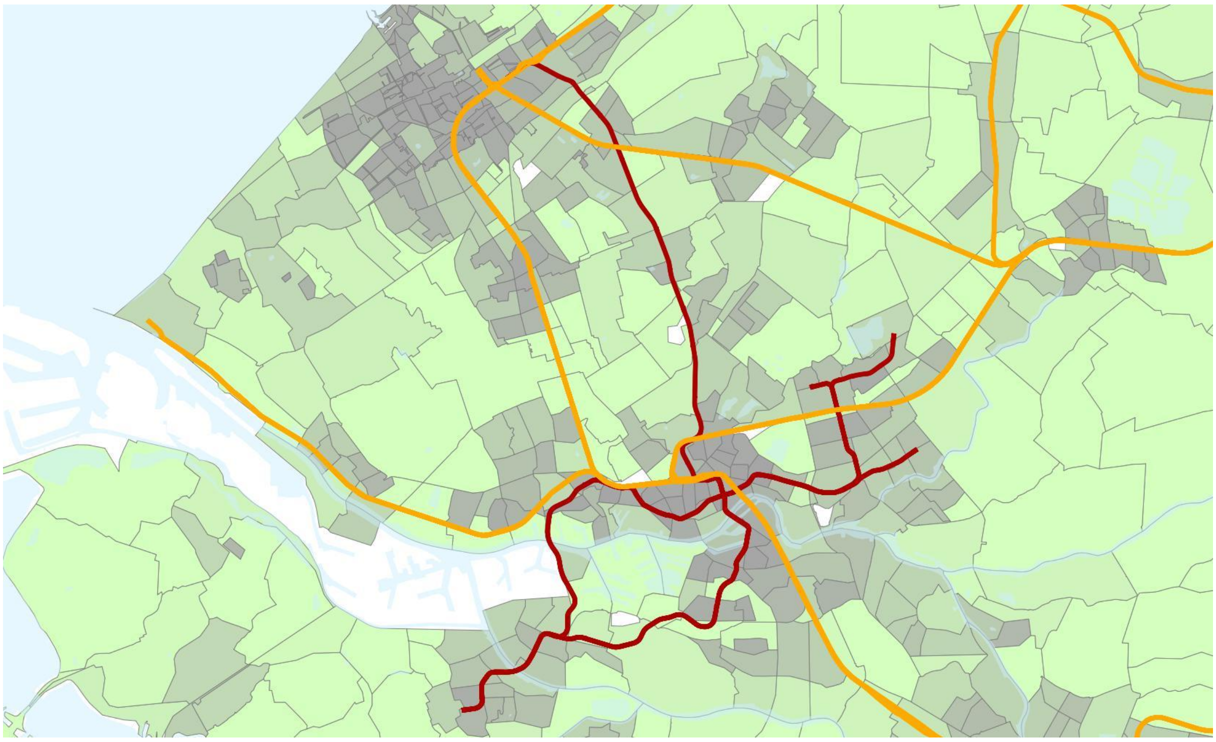


4.2 Trip value within Rotterdam area

The ‘waterfall diagram’ only shows the difference for each iteration regarding the amount of generated trips. The results from the final iteration are displayed on the figure below. This figure represents a map of the RET concession area and a geographical view of aforementioned iterations (see equation 3) for scenario 2030-Hoog. For each single PC4-area it has been calculated how much travel demand can be expected in one of the 2030-scenario’s. The amount of travel demand has then been multiplied by regular travel time cost savings to indicate which areas are worthwhile to invest in travel time reductions, e.g. by adding more infrastructure, or speeding up existing services.

Dark green areas are areas where the value of transport demand is higher than compared to the light green areas. Since the iterations are made for each PC4-area, even minor differences within the urban area are visible. These visuals could help policy makers or transport companies to choose which areas are worthwhile to invest in.

Figure 9 Geographical view of iterations



5. Conclusions

In this paper, we have combined data about trip information, demographic characteristics, and spatial diversion to forecast future transport demand. Several iterations have be done to combine and enrich current data. Adding spatial, demographic and travel purpose related information provides up to 10% more accurate forecasts. This could be helpful data for policy or decision makers. However, every single iteration is based on available data and proposed forecasts, and the latter could be determined by policy makers as well. The data only shows the potential for cost saving initiatives, it does not include feasibility nor does it suggest any type of investment.

The results mentioned above are just a very brief insight into the effects detailed demographic can have on outcome of public transport and in which area 'no regret' measurements are to be taken. Further research is definitely needed and should also focus on the connectivity to the labour market and educational institutes for the underprivileged ones among us. The cartographic displayed information shows in which PC4-area more benefits can be reached than in other areas. However, PC4-areas could be rather administrative and could thus give a distorted view. Another important factor that should be included in further research, is the impact of the Value of Travel time for several trip purposes.

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