Data driven sustainable mobility analysis in the city of Amsterdam

P5 presentation –

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TNO innovation for life

TU Delft

Contents

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Introduction

Introduction

- With rapid growing populations and cities, need for sustainable transportation methods is growing.
- Transportation has a negative impact on the environment:
  - Air polution
  - CO2 levels
  - Degradation of urban landscape
- In order to change policies, travel behavior needs to be well understood
- This research is aimed at investigating the use of FCD data to analyse the sustainable travel behavior in the city of Amsterdam

Research Questions

- Research Question
- Research Sub-questions

Research Question

To what extent can floating car data be used to give an insight in the sustainable mobility behavior in Amsterdam?

Research sub-questions

1. What is sustainable travel behavior and why is it important?
2. Which data sets are commonly used and available to analyze travel behavior?
3. What are the differences between these data sets and which ones suited best?
4. Which short distance car trips in Amsterdam could be replaced by more sustainable opportunities like walking or cycling ?
5. Which long distance car trips in Amsterdam could be replaced by more sustainable opportunities like public transportation?

Related Work

-Literature review
-Ethics

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Sustainable Mobility *(European Council, 2001)*

"A sustainable transport system [is] defined as one that:

- allows the basic access and development needs of individuals, companies and societies to be met safely and in a manner consistent with human and ecosystem health, and promotes equity within and between successive generations;
- is affordable, operates fairly and efficiently, offers choice of transport mode, and supports a competitive economy, as well as balanced regional development;
- limits emissions and waste within the planet's ability to absorb them, uses renewable resources at or below their rates of generation, and, uses nonrenewable resources at or below the rates of development of renewable substitutes while minimizing the impact on the use of land and the generation of noise." *([European Council, 2001] pp.15-16)*

Sustainable Mobility

General objectives	Specific objectives
Hazards reduction	Reduce CO2emissions
	Reduce air pollution
	Reduce land consumption
	Reduce urban landscape degradation
	Reduce noise
	Reduce accidents
Travel reduction	Reduce energy consumption
	Reduce congestion
	Reduce distance travelled
	Reduce need to travel
Modal shift	Reduce car use in urban areas
	Increase walking and cycling
	Increase share of public transport
	Replace medium and long distance car travel by rail
Accesability	Maintain or increase accessibility (while reducing mobility)
	Narrow the accessibility divides

Table 2.2: Summary of the objectives of sustainable mobility [Gil, 2016] based on the work of [Banister, 2005; Black, 2010; Bruun et al., 2012; Centre for Sustainable Transportation, 2002; European Commission, 2007; World Business Council for Sustainable Development, 2001]

Modal Shift

Mode	Seats/space	MJ/vehicle km	MJ/seat km	MJ/passenger km
Air Boeing 727	167	243	1.45	2.42
Rail electric/diesel	377	168	0.45	1.65
Metro underground	555	141	0.25	1.69
Tram light rail	265	79.8	0.30	0.90/1.20
Bus	48	14.7	0.34	0.92/1.53
lorry				2.94
car	4	3.7	0.92	2.10
Motorcycle	2	1.9	0.95	1.73
Cycling	1	0.06	0.06	0.06
Walk	1	0.16	0.16	0.16

Table 2.1: Impact of different modes of transportation on the environment [Banister, 2009]

model shift	**Indicators**	**Sustainability direction**
Non-motorised share	Neighbourhood walking share share Neighbourhood cycling share City cycling share	increase
car share	Neighbourhood car share City car share Regional car share	decrease
Public transport share	Neighbourhood transit share City transit share regional transir share	increase

Table 2.3: Selected sustainable mobility indicators related to modal shift [Gil, 2016]

Sustainability direction based on :

- Distance of the trip
- Duration of the trip
- Modality

Classification Method (Gil, 2016)

- indicators to the sustainabiliy direction.
- Walking and cycling are considered the more sustainable options followed by train and public transport options.

Indicator	Sustainability Direction
Share of short walk journeys	+ + +
Share of walk journeys	+ + +
Share of short1cycle journeys	+ + +
Share of medium cycle journeys	+ + +
Share of cycle journeys	+ + +
Share of short car journeys	- - -
Share of medium car journeys	- -
Share of long car journeys	-
Share of car journeys	- - -
Share of car distance	- -
Share of car duration	- -
Share of medium local transit journeys	+ +
Share of local transit journeys	
Share of long train journeys	+ +
Share of train journeys	+ +
Share of transit distance	+ +
Share of transit duration	+ +
Mean journey distance	-
Mean daily distance per person	-
Mean daily journeys per person	-

Table 2.4: classification method [Gil, 2016]

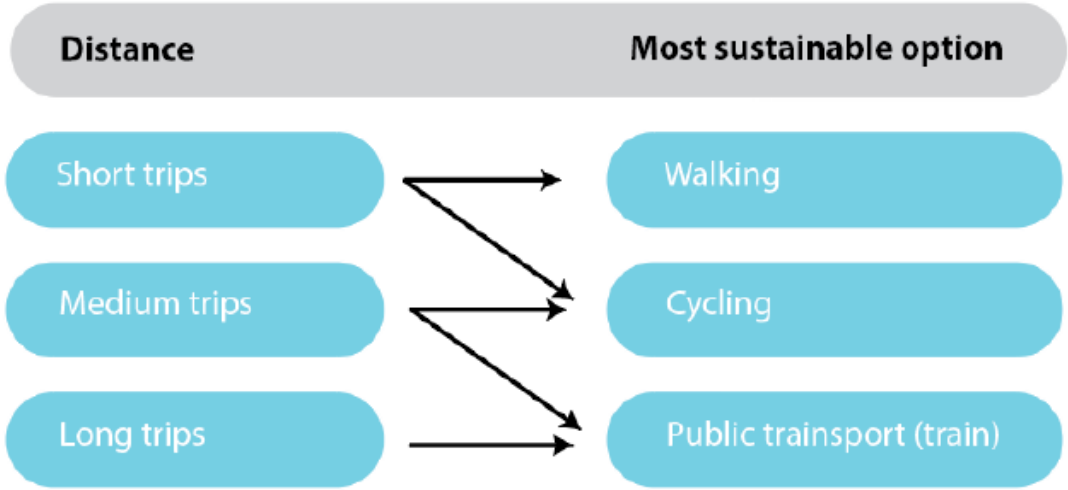


Figure 2.1: Sustainable option for the different classes in distance

Ethics of used data and privacy concerns

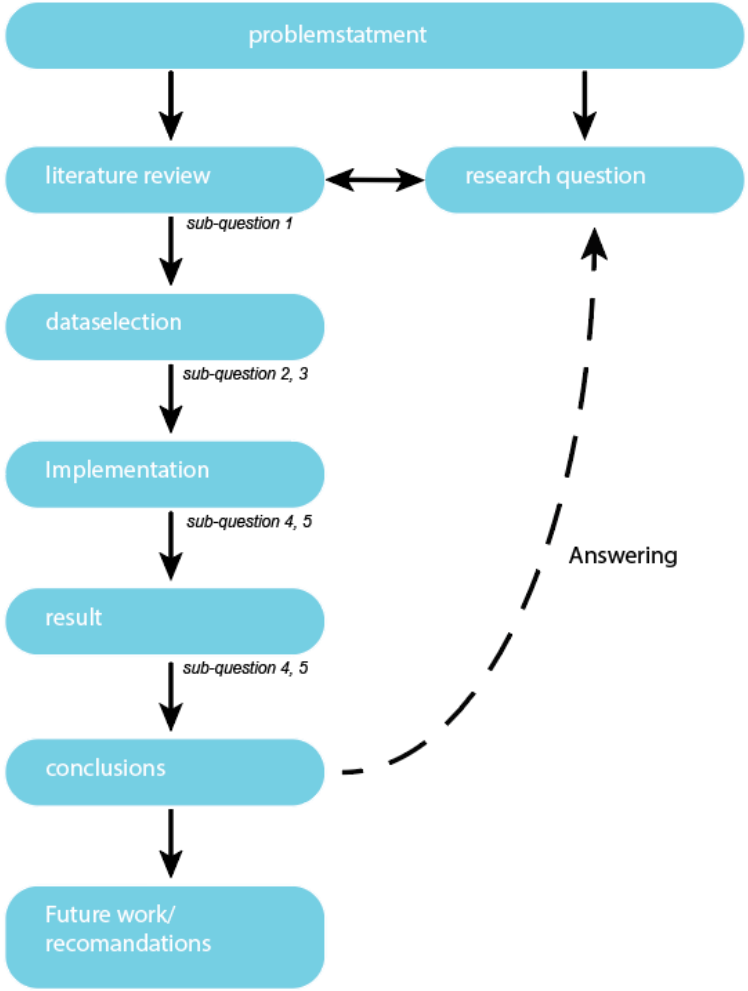
- As Geo-tagged data is considered personal data, the data should be handled carefully
- This means that data of individual trips is not availalbe. There are different ways to circumvent this issue:
  - Data is provided in an aggregated manner (such that individuals can not be tracked)
  - Begin and end points of individual trips have been cut off.
  - General Data Protection Regulation (GDPR) was not a limitation in time of this research.

Methodology

Methodology

After the literature review and stating the research questions, the next steps are depicted in the figure:

- Data selection: analysis of available data sets and picking the data sets which are best suited to answer the research question
- Implementation: methods of calculating and processing the data
- Results: making the results of the processed data visible
- Conclusions: drawing the conclusions from the results



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Data selection

Requirements

- The dataset must be available and free of use for this research.
- The data must show origin and destination information
- The dataset is sufficiently documented for the use in the experiments.
- The data should cover at least the area of Amsterdam, but preferable available for a larger area.

Available datasets

- **Flitsmeister** – Data is obtained from user of the Dutch app Flitsmeister which provides traffic jam and traffic trap information for car users
- **Ring Ring** – Mobile application targeted for cyclists
- **Google Flow** – Aggregated data from Google Maps users based on road segments
- **Google OD** – Aggregated data from Google Maps users providing origin and destinations based on zones
- **Landelijk Model Systeem (LMS)** – Data provided by Rijkswaterstaat based on different inputs and calculation methods
- **TU Delft** – GPS tracks of a group of housholds in the Netherlands

Requirements

requirement	Flitsmeister	Ring Ring	TU Delft GPS	Google Flow	Google OD	LMS
Availability	v	v	v	v	v	v
OD information	x	x	v	x	v	v
documentation	v	v	v	v	v	v
research area	v	v	x	v	v	v

Google OD and LMS are chosen to be further analyzed in the experiments.

Implementation

Distance classification

Short distance:

- Selection short distances
- Distance and duration

Long distance:

- Selection long distances
- Situation
- Region of Interest (ROI)
- Accessibility of Public transport
- Calculations trips
- Selection data
- Decision tree

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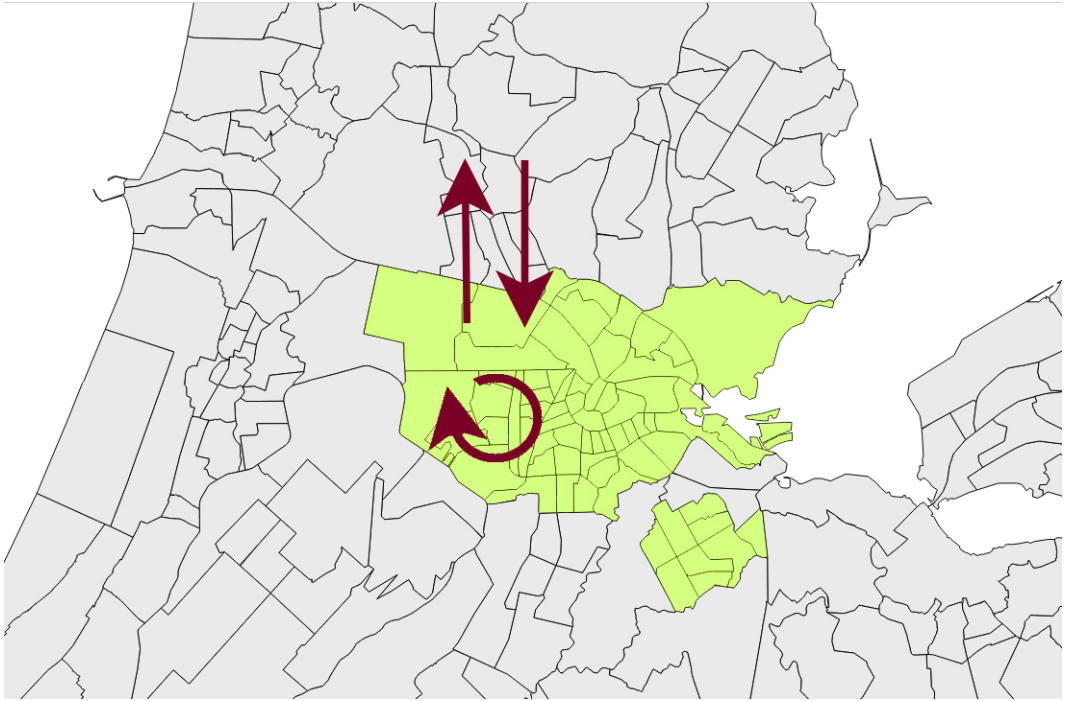
Research area

Trips that have a connection with an area in the municipality of Amsterdam

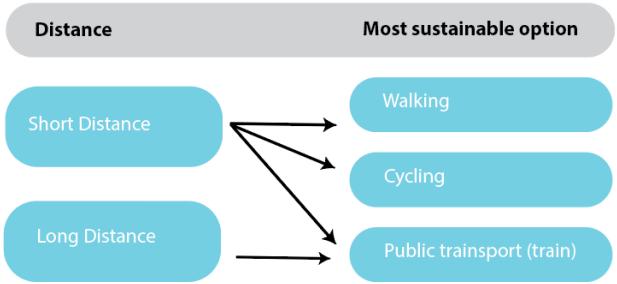


Distance classification

Based on the classification method by Gil, for different distances, the most sustainable option is identified.

In this research :

- Short distance trips (Medium and short)
- Long distance trips



Indicator	Sustainability Direction
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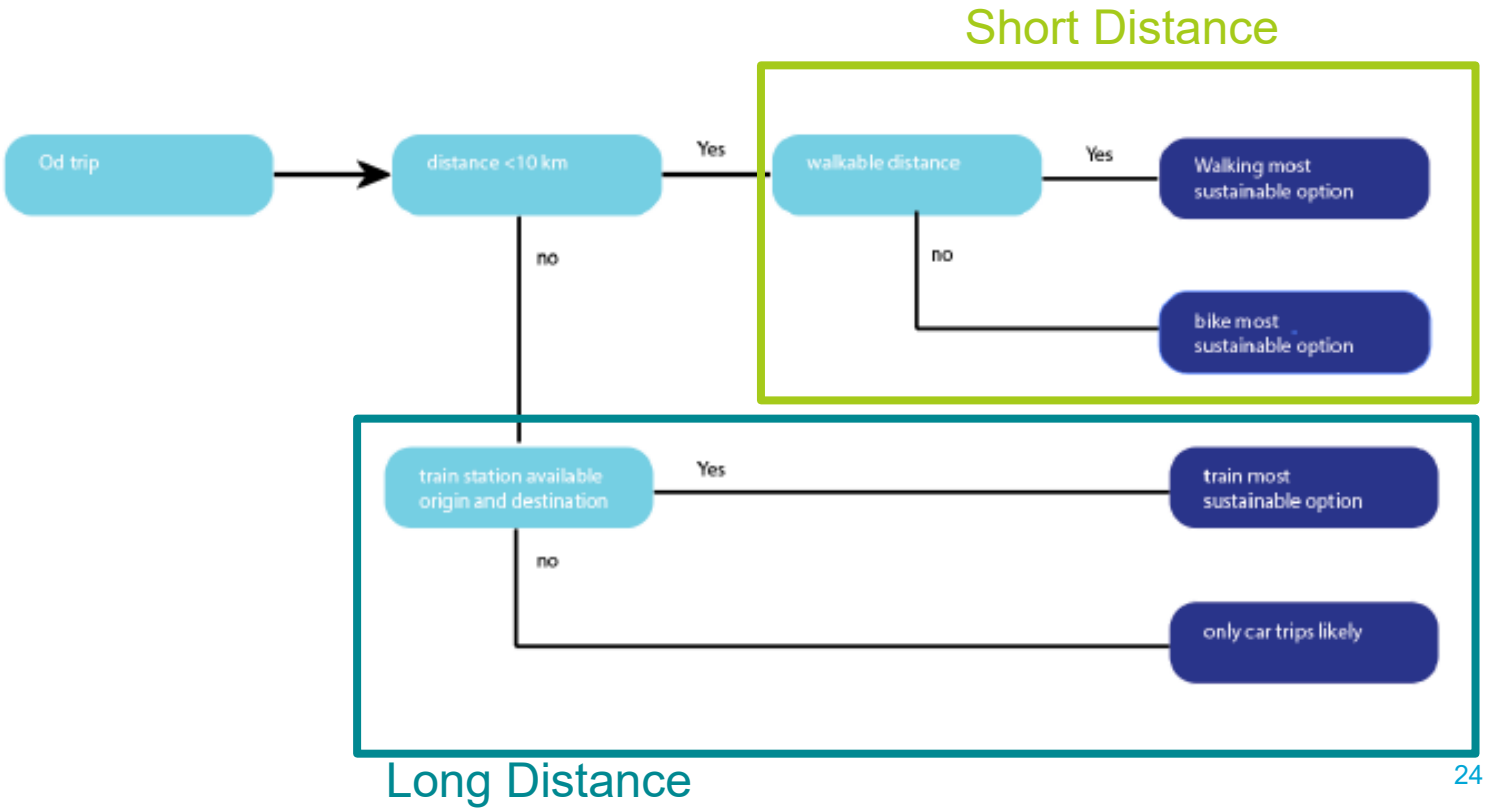
Share of long car journeys	-
Share of car journeys	- - -
Share of car distance	- -
Share of car duration	- -
Share of medium local transit journeys	+ +
Share of local transit journeys	
Share of long train journeys	+ +
Share of train journeys	+ +
Share of transit distance	+ +
Share of transit duration	+ +
Mean journey distance	-
Mean daily distance per person	-
Mean daily journeys per person	-

Table 2.4: classification method [Gil, 2016]

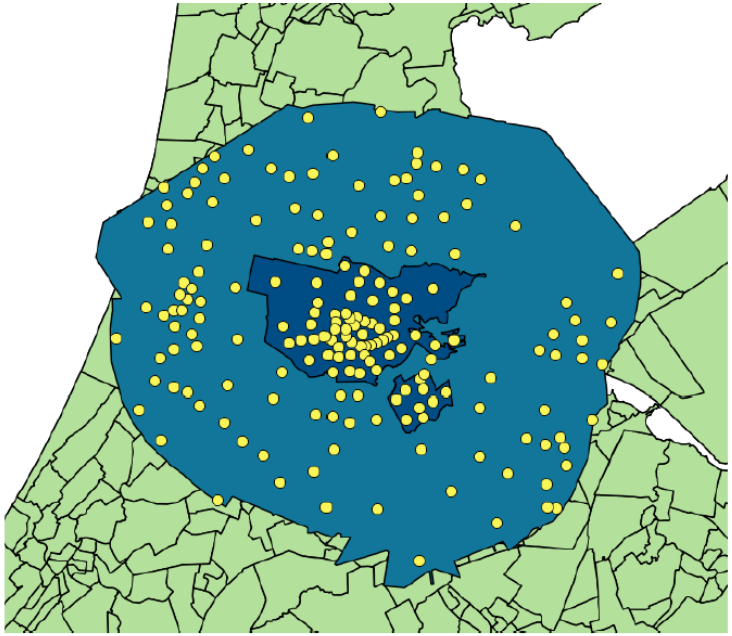
Distance classification



Selecting short distance

Process used to select the short distance trips:

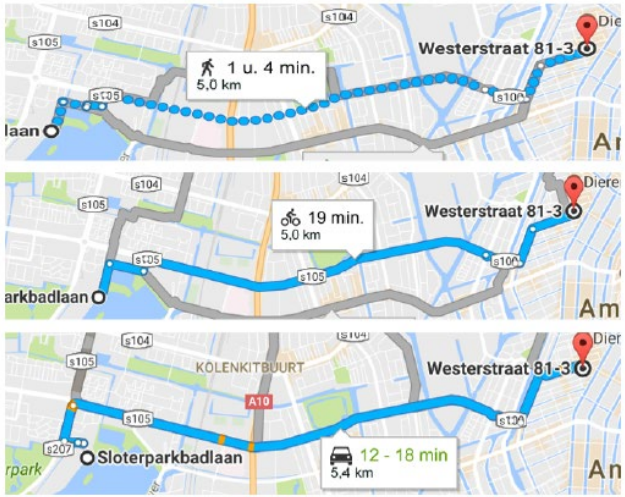
- Calculation all midpoint
- Create a buffer 10 km of Amsterdam
- Make selection
- Define al combinations
- Calculate distance/duration for all modalities



Selecting short distance: travel time and distance

Process for selecting travel time and distance for three modal types

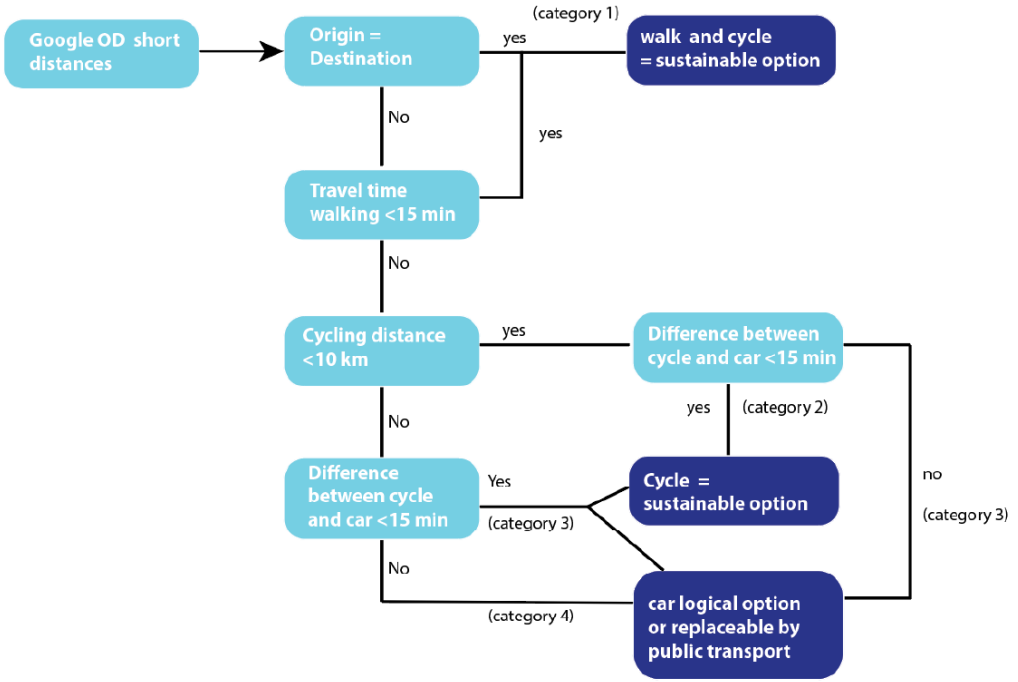
- Calculation for all combinations from midpoint to midpoint
- Determine duration and distance
- Modalities: walking, cycling and car



Selecting short distance: Travel time and distance

Sustainable replaceable alternative for car trips based on:

- Travel distance
- Travel time



Long distance trips

Selection long distance

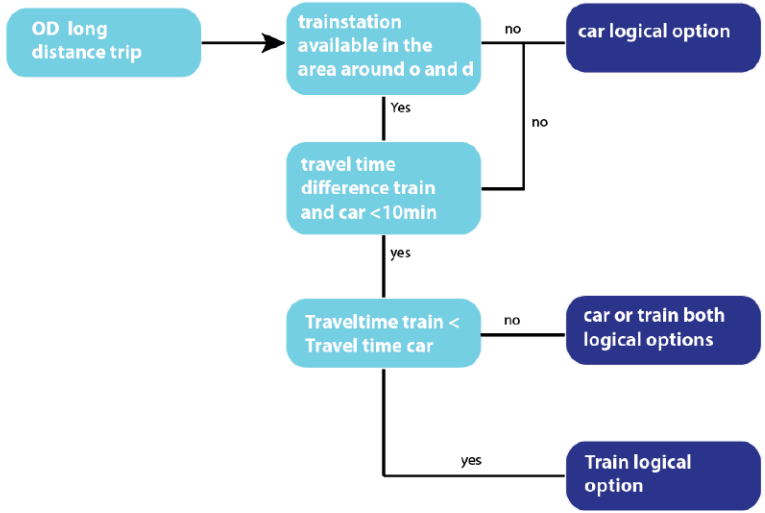
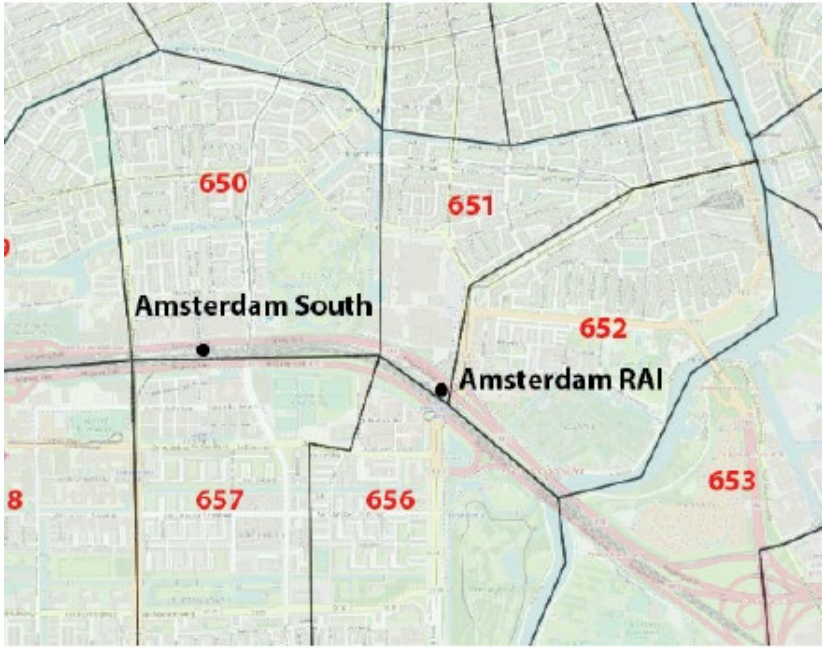


Figure 6.9: Decision tree long OD distances

Long distance trips

Challenge assigning train stations to LMS area's :

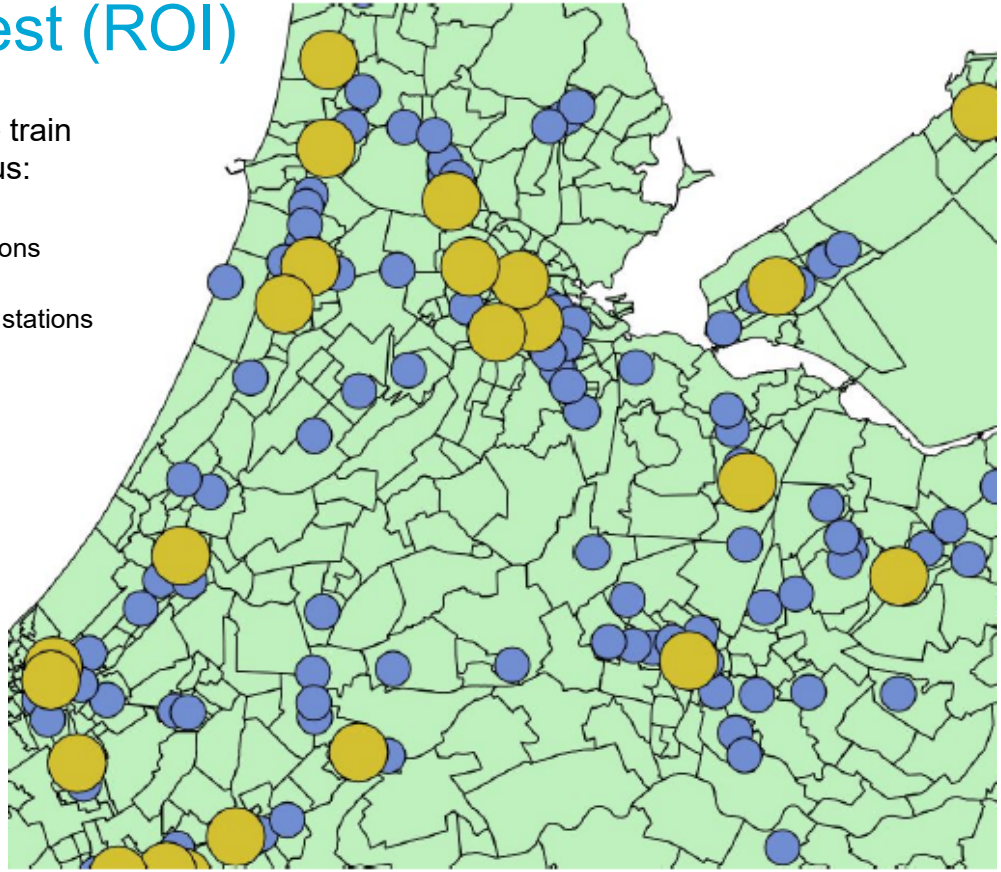
- The train stations can not be related to one area
- Station has an entry at 2 different areas
- Pre-transportation to station mostly by bike in the Netherland



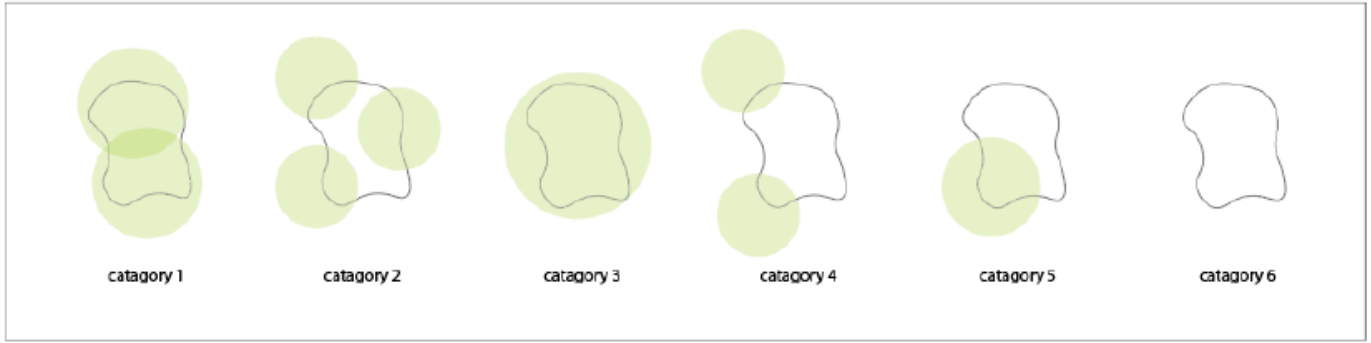
Region of Interest (ROI)

A ROI is introduced around the train stations with the following radius:

- 2,5 Km for intercity stations (yellow circles)
- 1,5 Km for non-intercity stations (blue circles)

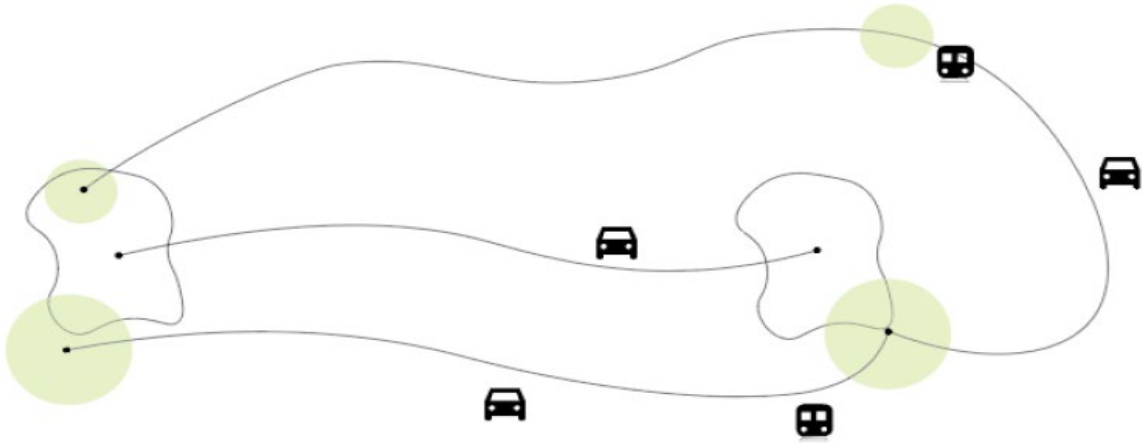


Accessibility of train stations in different areas



- Category 1: ROI from multiple stations overlapping > 75% of the area
- Category 2: ROI from multiple stations partially overlapping (between 25% and 75%) the area
- Category 3: ROI from one station is overlapping at least 75% of the LMS area
- Category 4: ROI from one or multiple stations overlapping a very small part (<25%) of the area
- Category 5: ROI from one station is overlapping partly (between 25% and 75%) the area
- Category 6: No ROI from any station are overlapping the LMS area (no station available)

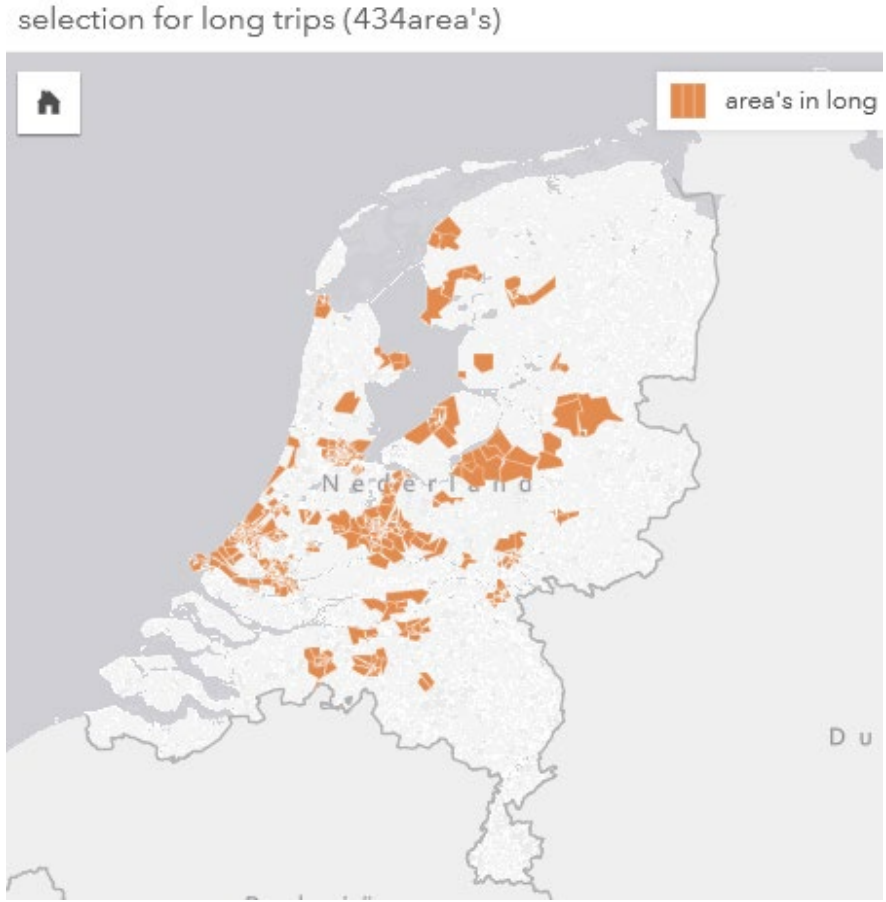
Calculation of long trips



- Category of every area based on the ROIs
- Distance and duration from midpoint to midpoint
- Distance duration for car and train from ROI to ROI

Selection of the dataset

- Improve the performance google API
- Manageability of the dataset
- Areas from different categories chosen
- Combinations of cities and rural areas



Results

Short distance :

- Walk : Google
- Cycle: Google
- Car : LMS and Google

Long distance :

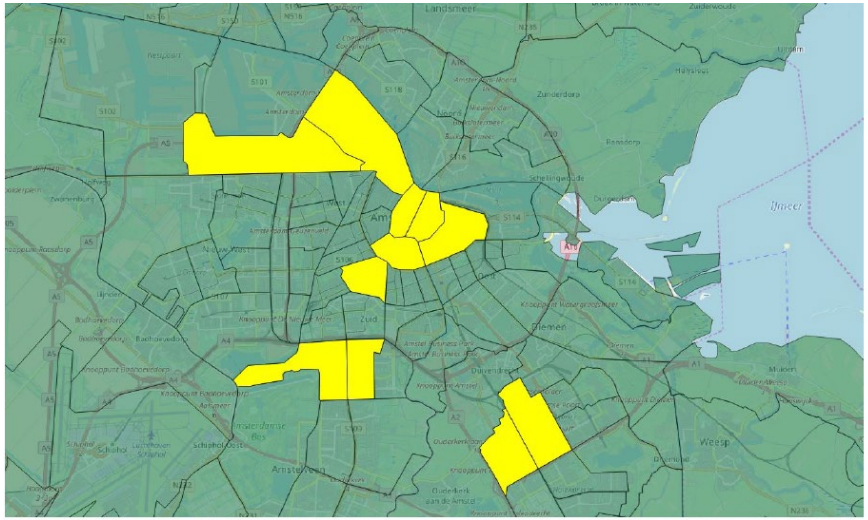
- car: LMS and Google

Short Distance

Short distance trips – Walking (Google)

Analysis shows areas of high walking intensities are near important places in Amsterdam

- Historical centre
- Museum Square
- Zuidas, business area
- Ziggodome, Arena, AFAS live

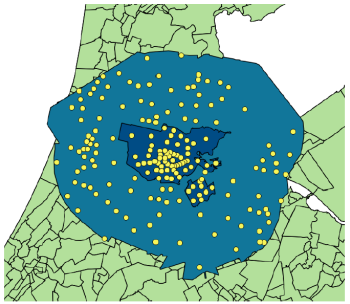


Favorite modality in google	Count origin-destination pair
Walk	96
Car	13
Cycle	2

Table 6.4: walkable distance vs favorite in the google od dataset

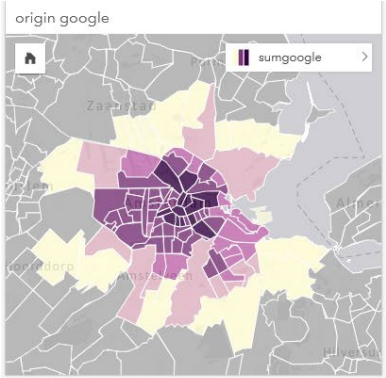
Short distance trips – Cycling (Google)

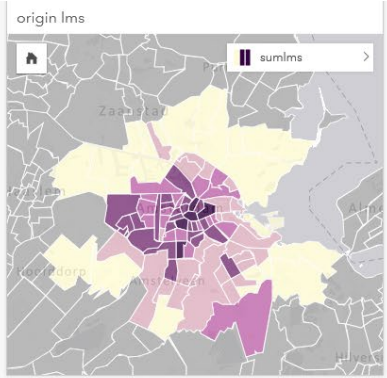
Bike is option	Favorite in Google OD	Appearance OD pairs
Yes	Walk	180
Yes	Cycle	724
Yes	Car	2116
Yes	all	221

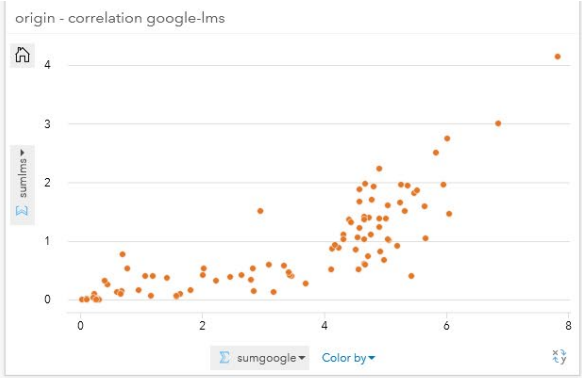


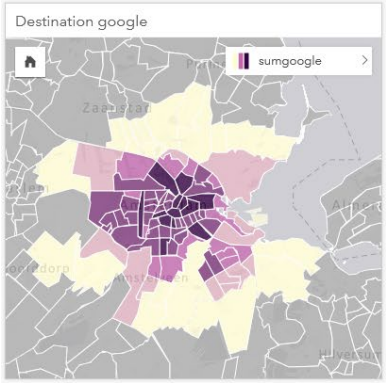
duration_bike-duration_car	count	bike is aternative	min distance_bike	max distance-bike	avg distance_bike	amount of biketrips >10 km	biketrips <10km
-15 tot -10 min	11	+++	1,508	5,116	2,98	0	100%
-10 tot -5 min	45	+++	0,96	6,418	3,48	0	100%
-5 tot 0 min	458	+++	0,57	7,955	3,41	0	100%
0 tot 5 min	1132	++	0,651	23,52	4,92	8	99,3%
5 tot 10 min	931	++	2,17	24,308	7,50	64	93,1%
10 tot 15 min	993	+/-	4,27	26,474	9,44	324	67,4%
>15 min	16898	-	6,054	50,502	23,51	16597	1,9%

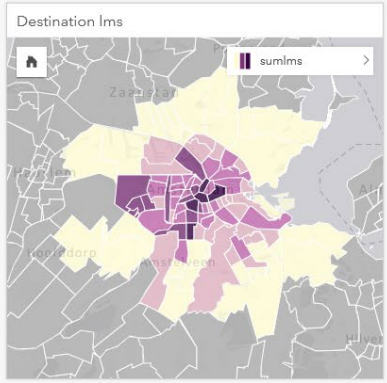
Short distance trips – Car (Google & LMS)

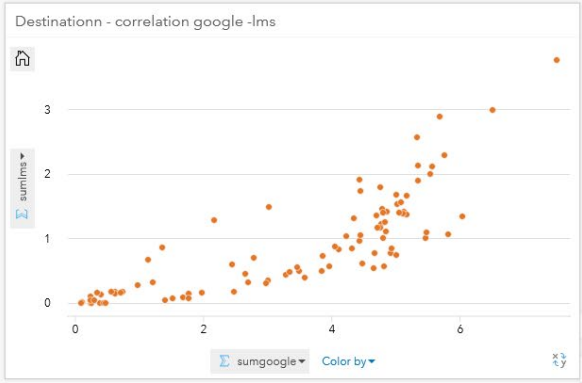




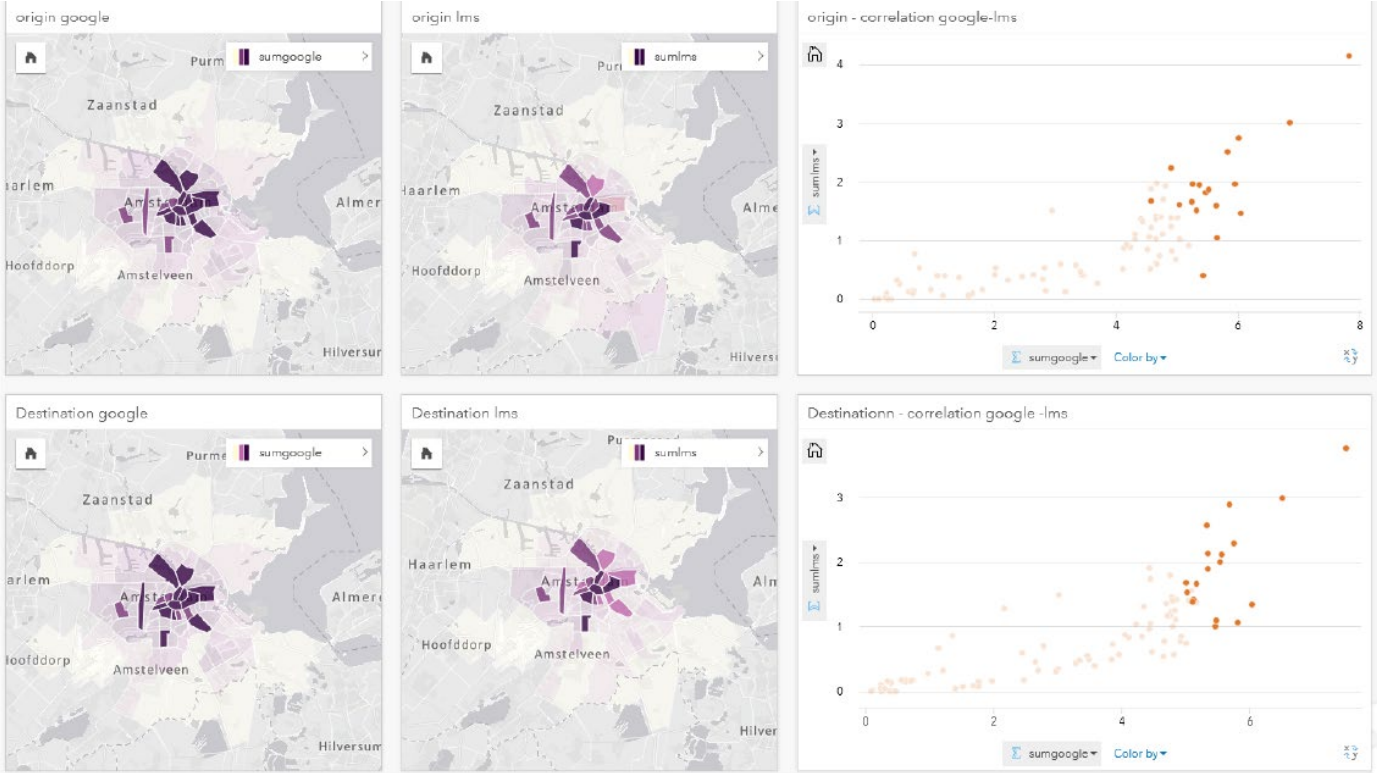








Short distance trips – Car (Google & LMS)



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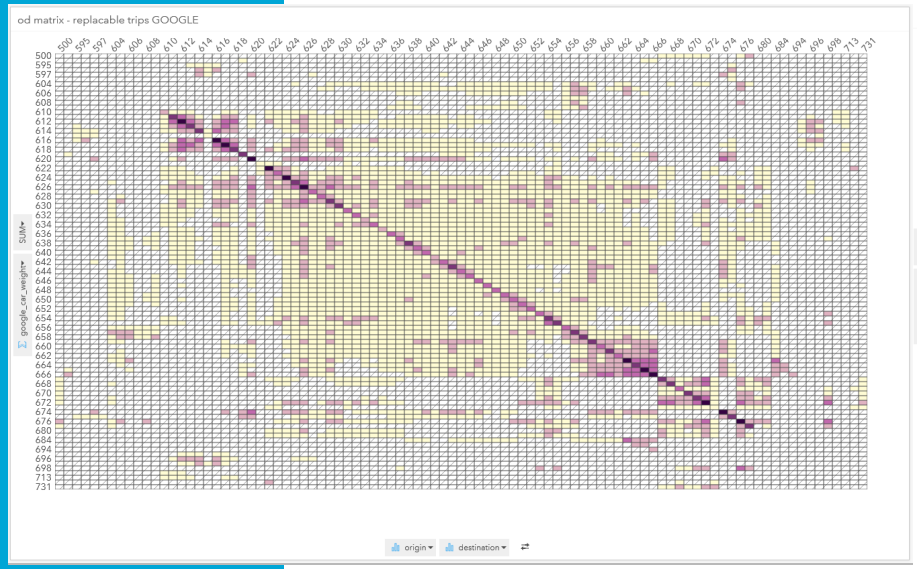
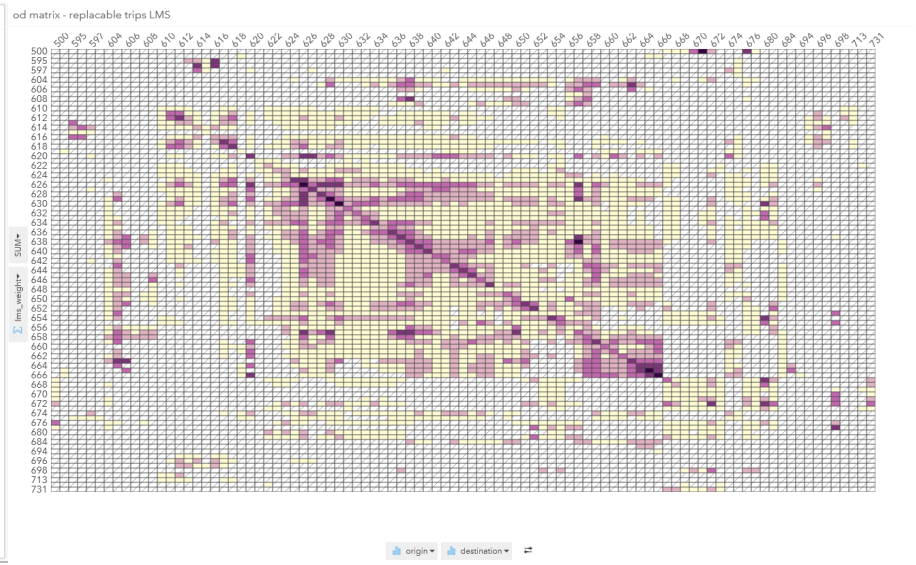
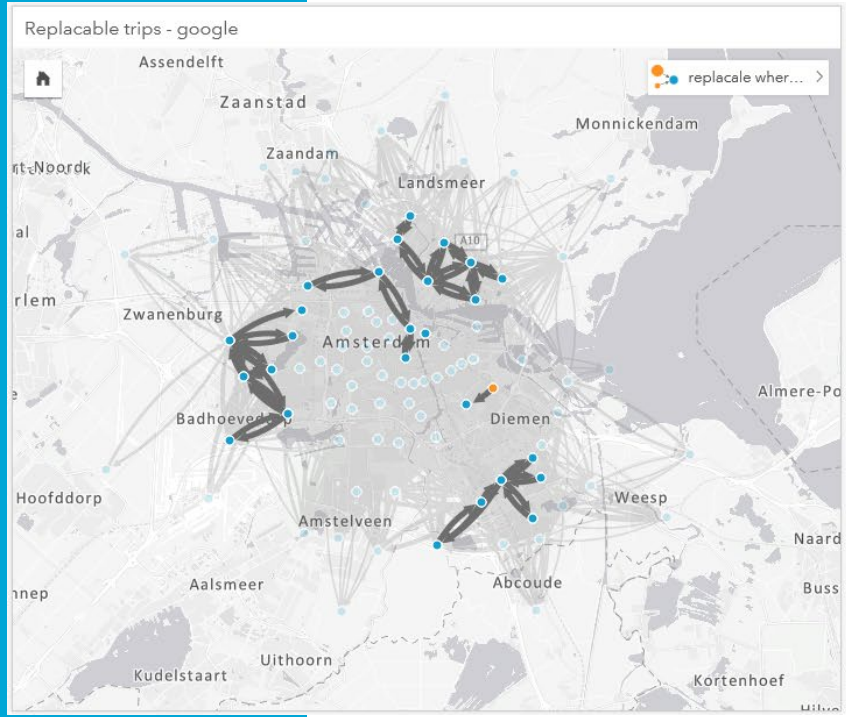


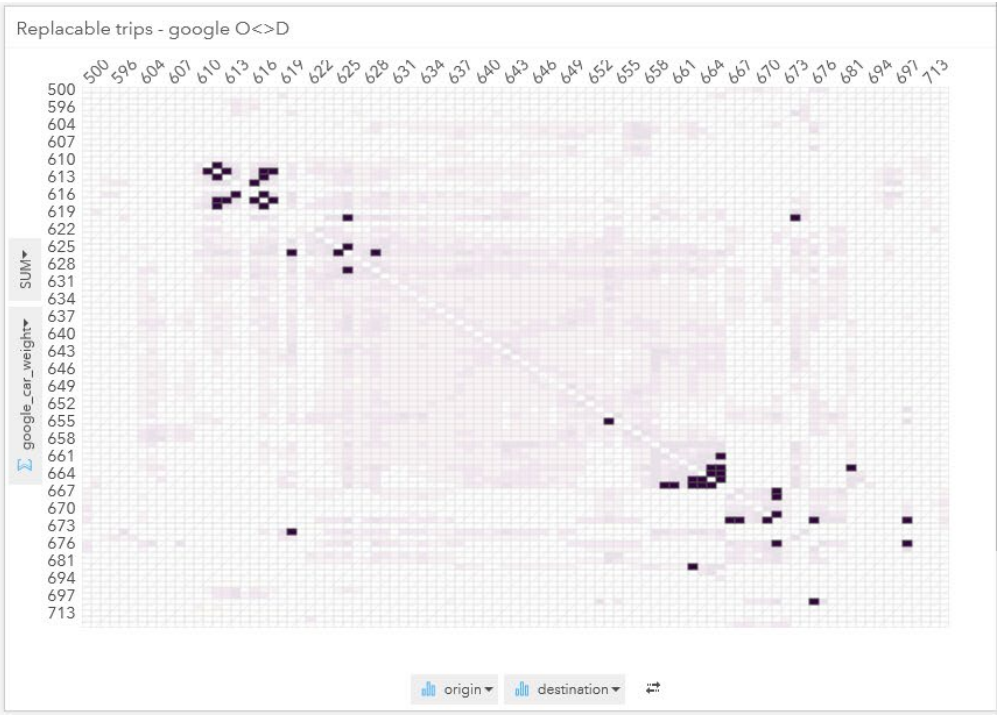
Google



LMS

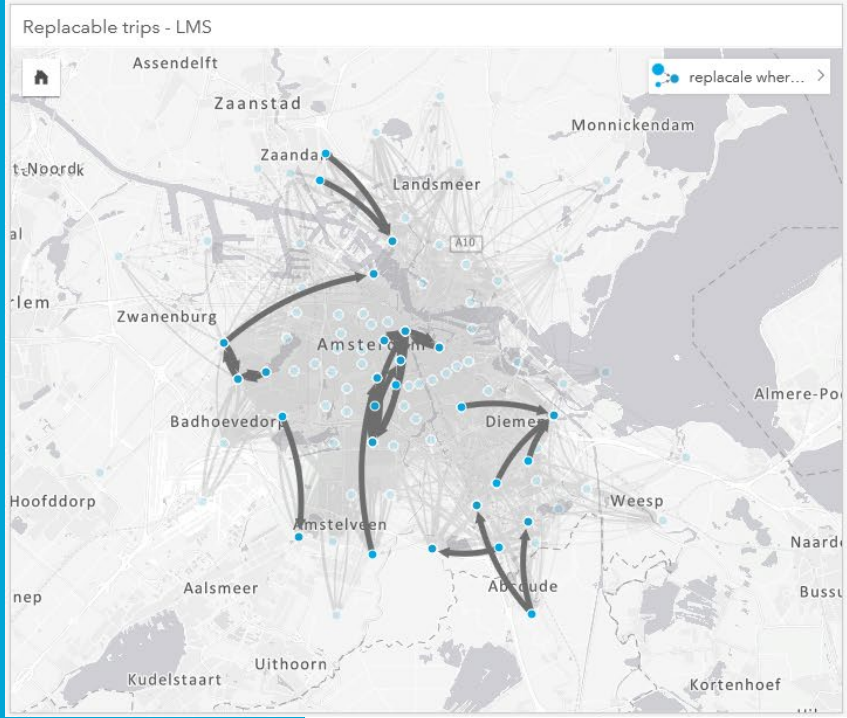
Short distance trips – Car (Google)

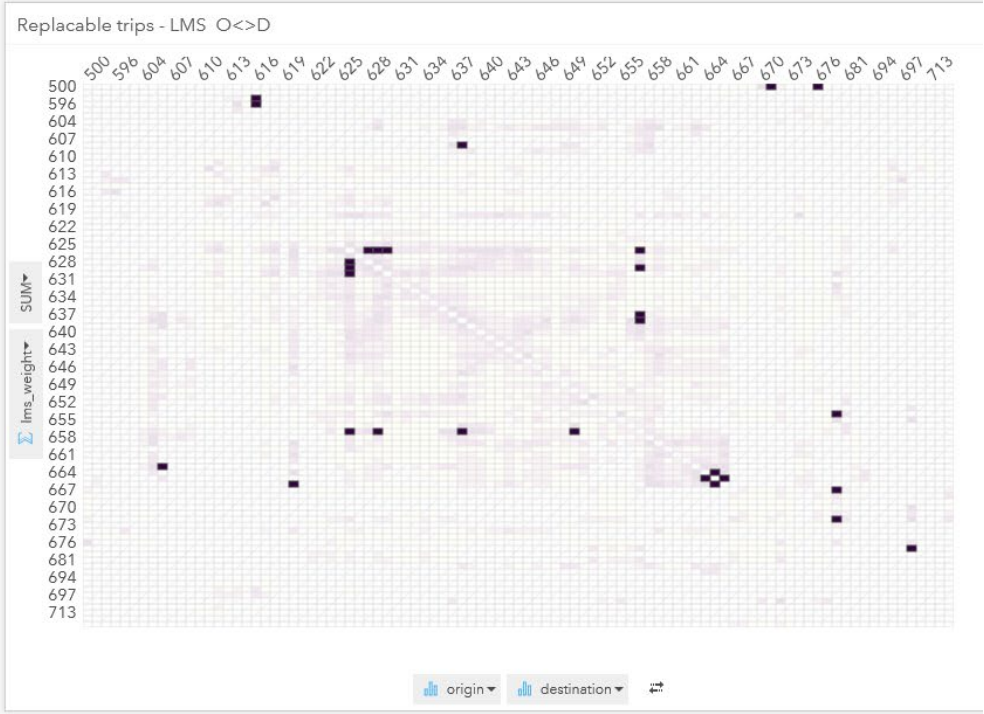




High in Google O<>D

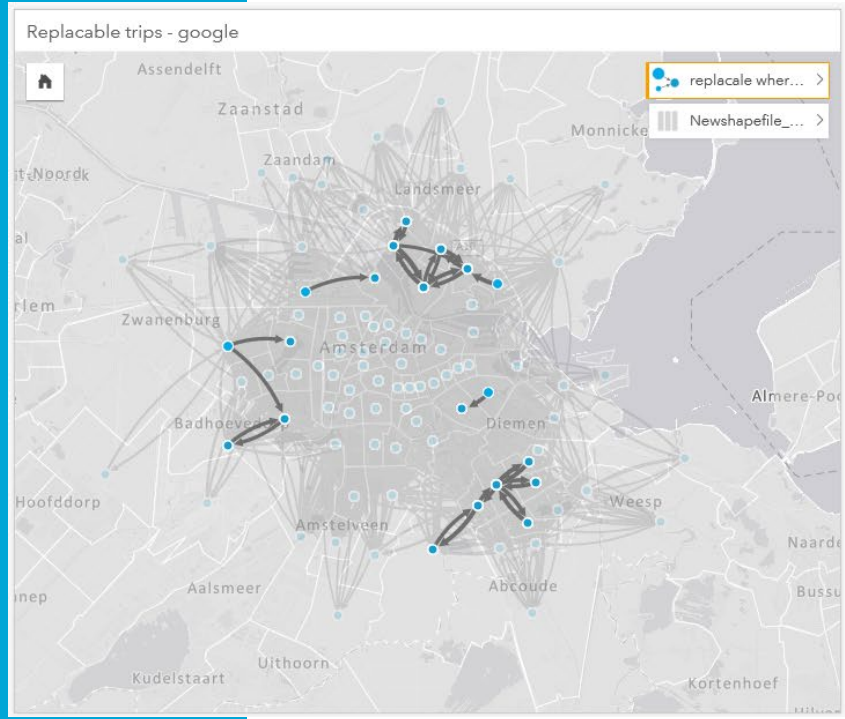
Short distance trips – Car (LMS)

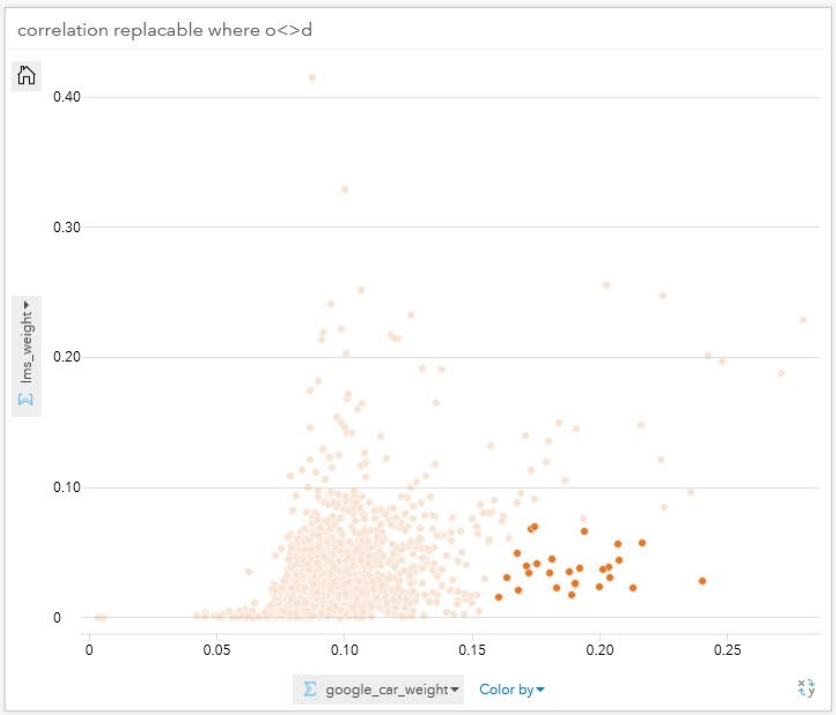




High in LMS O<>D

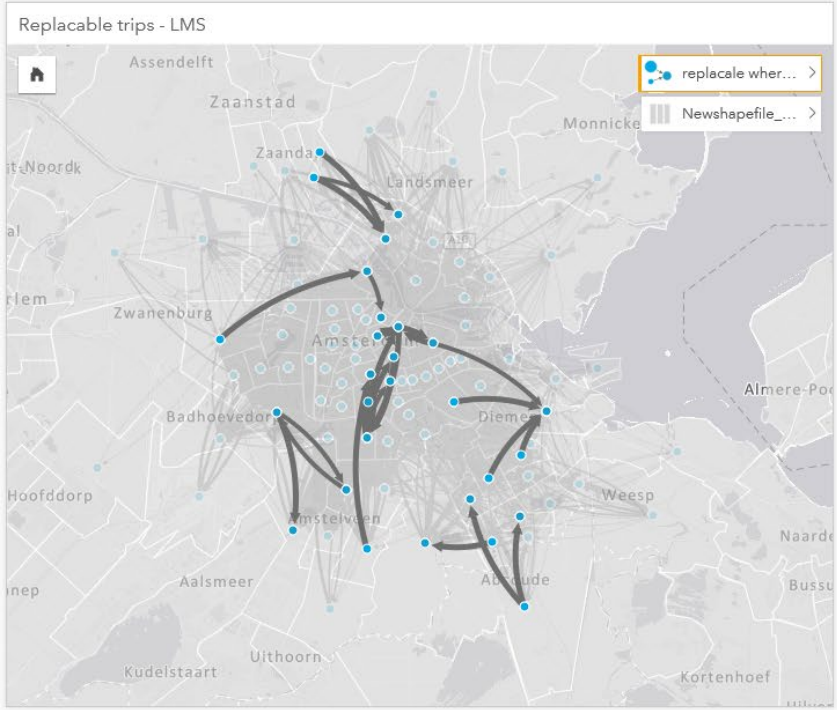
Short distance trips – Car (google)

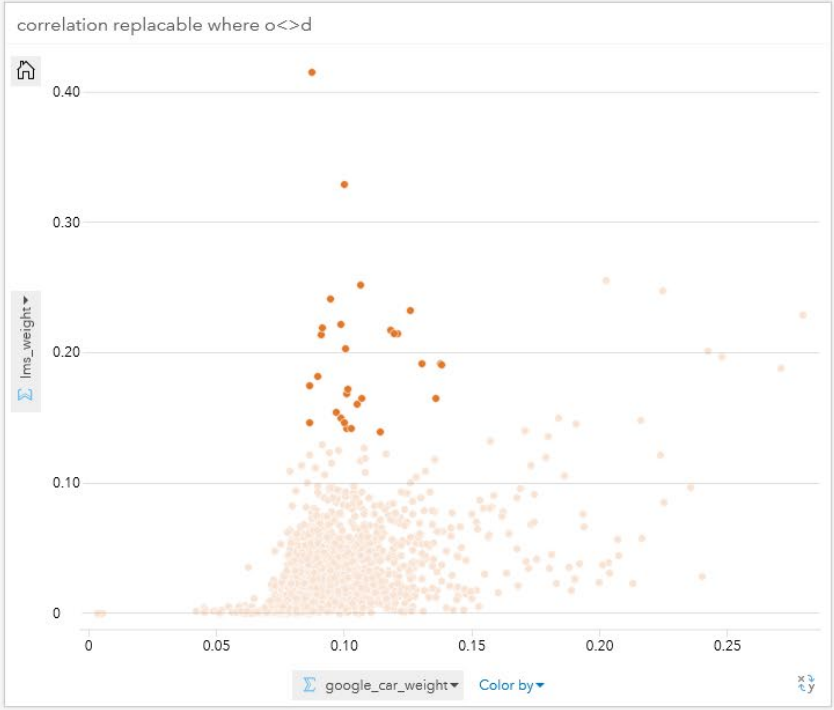




High in Google low in LMS (O<>D)

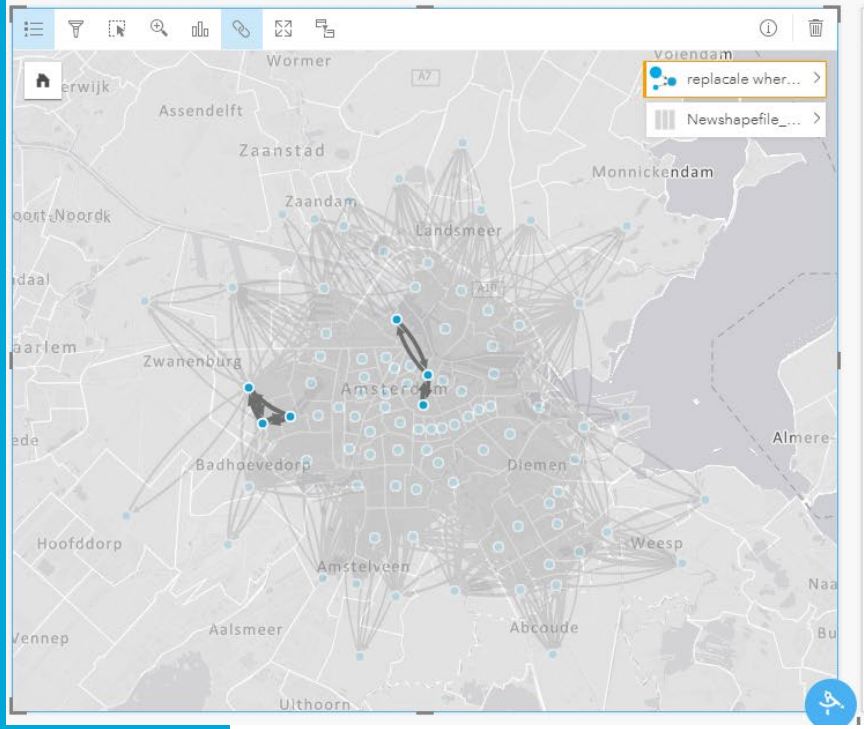
Short distance trips – Car (LMS)

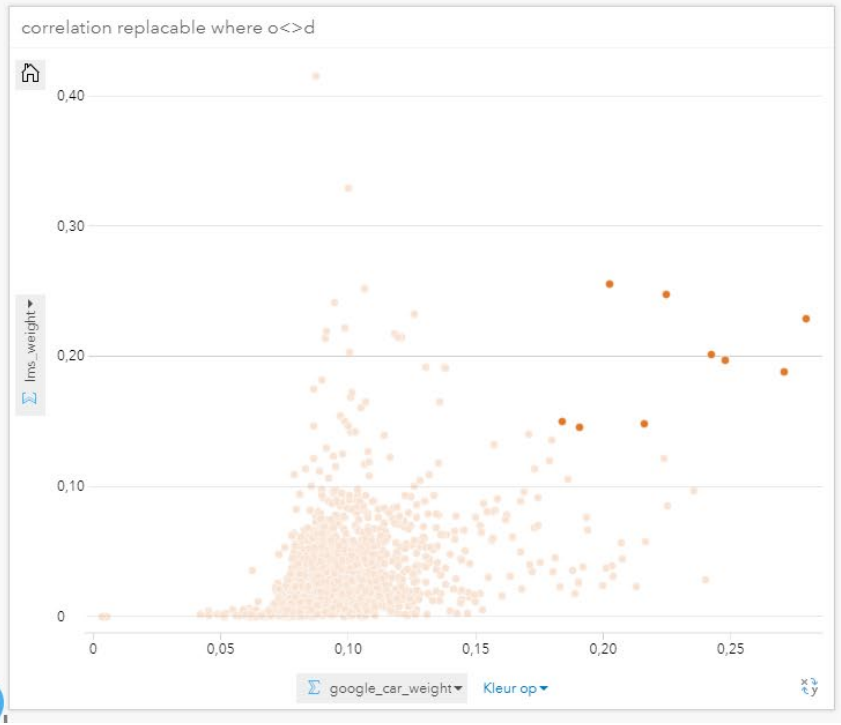




High in LMS low in Google (O<>D)

Short distance trips – Car (LMS)

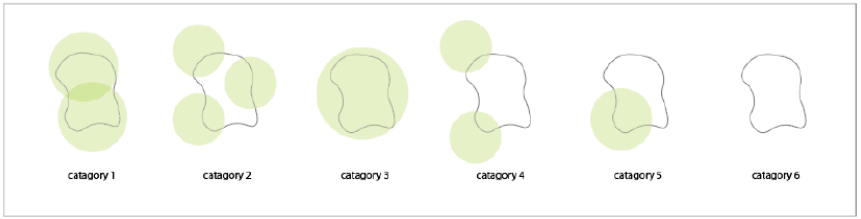




Both in LMS and Google High (O<>D)

Long Distance

Long distance trips – Accessibility Trainstations



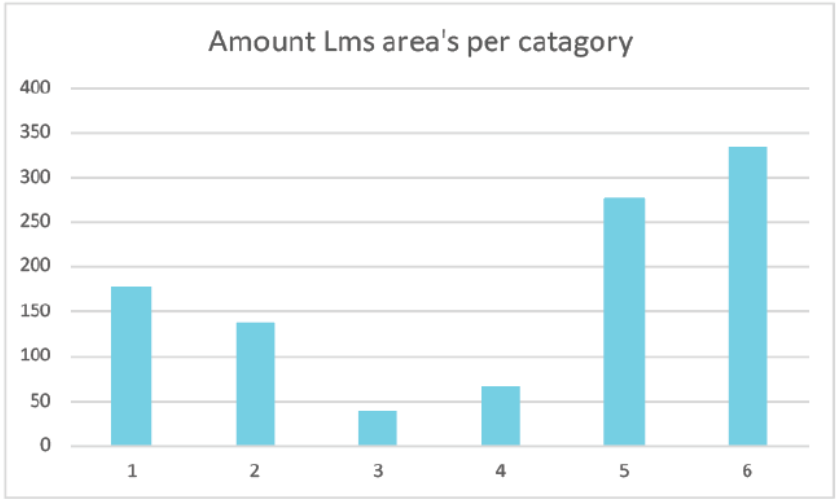


Figure 6.12: amount of area's per catagory for all 1030 area's

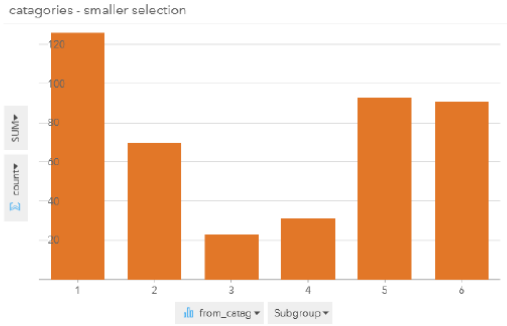


Figure 6.13: amount of area's per catagory for the subset that is used for long distances

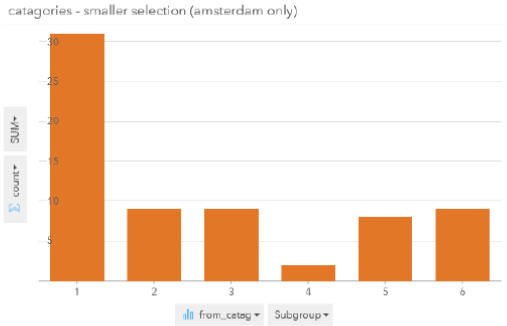


Figure 6.14: amount of area's per catagory for all area's in Amsterdam

Long distance trips – Accessibility Trainstations

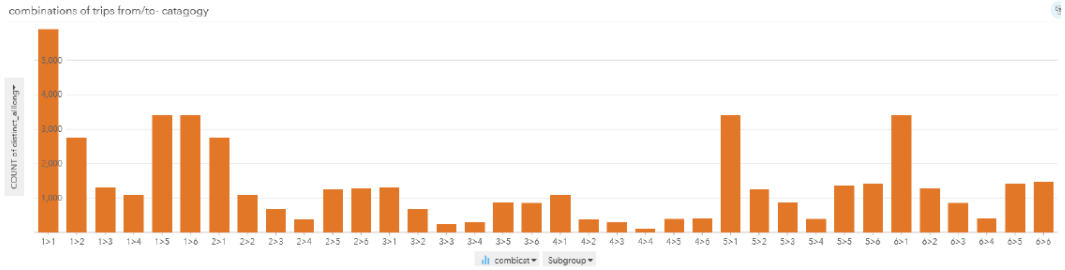


Figure 7.15: Amount of OD combinations per catagory combination in the long data set

LMS

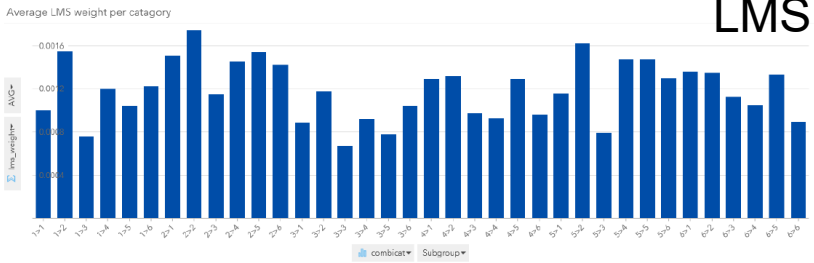


Figure 7.16: LMS average weight per category combination

Google

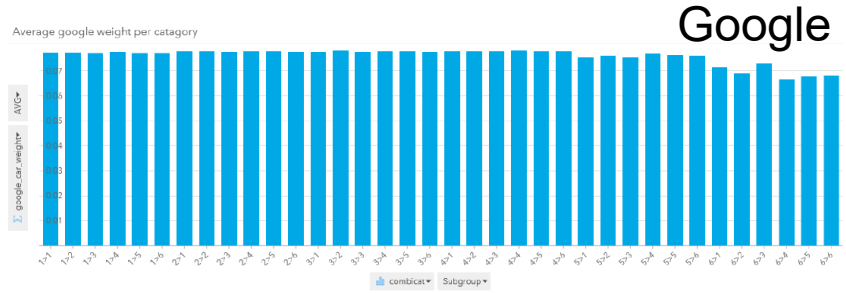
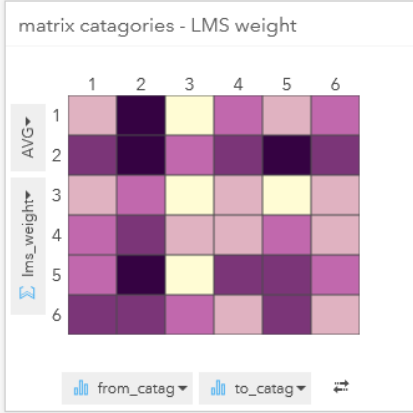
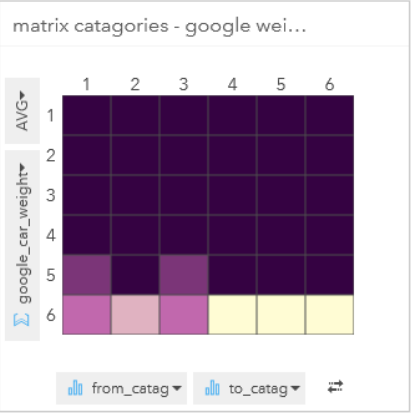


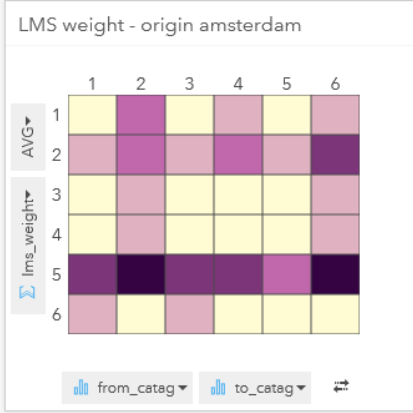
Figure 7.17: Google average weight per category combination

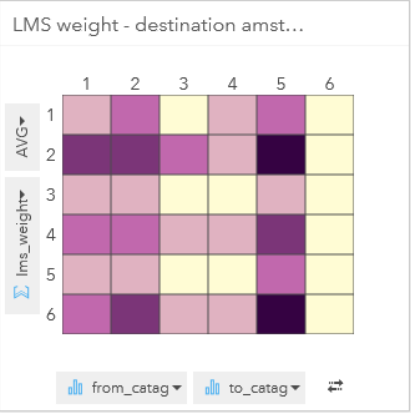
Long distance trips – Accessibility Trainstations

- LMS variation between combinations
- Google similar average for all combinations
- LMS: from Amsterdam to category 5 destination, average car weight is highest
- LMS: from category 5 to Amsterdam, average car weight is highest









TU Delft

Long distance trips – Replaceability

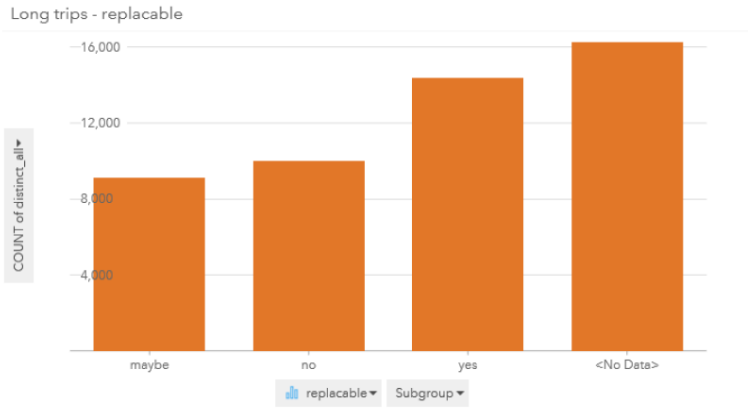
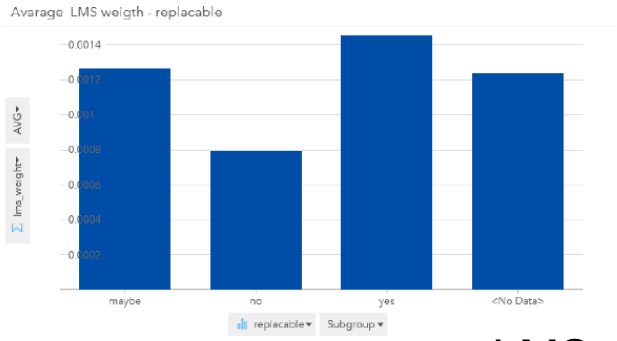
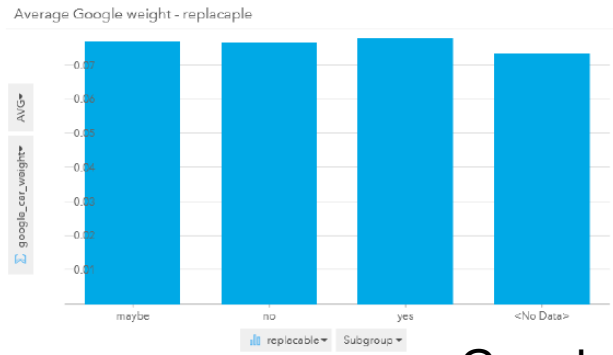


Figure 7.21: Amount of trips replaceable by a sustainable aternative



LMS



Google

Long distance trips – Replaceability (LMS)

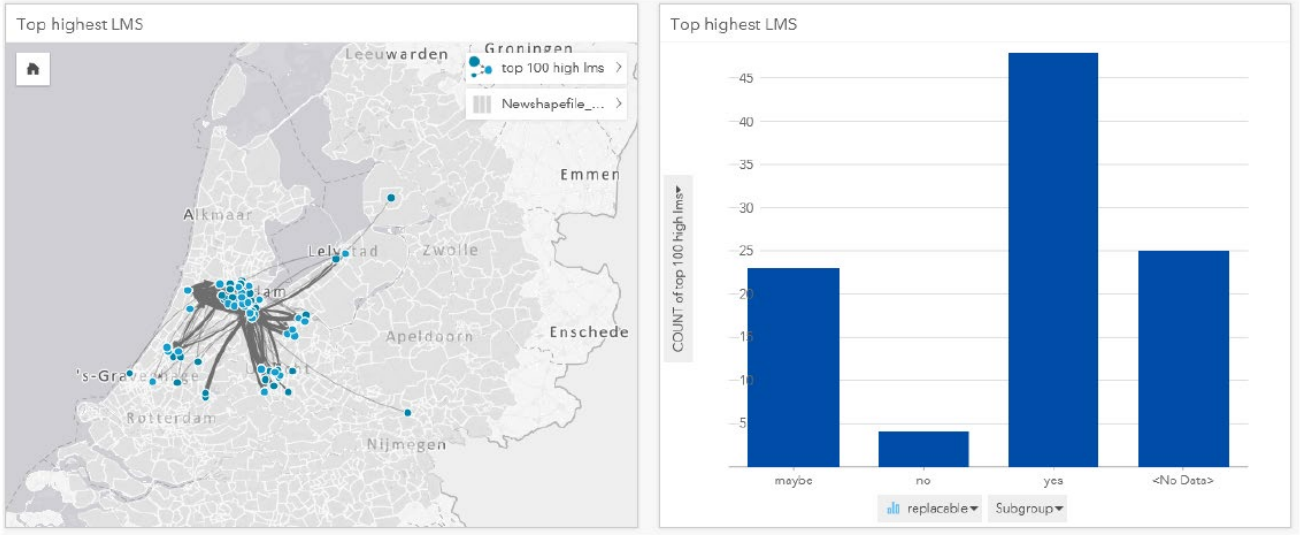


Figure 7.28: Top100 highest LMS weights in the longsdistance dataset

Long distance trips – Replaceability (Google)

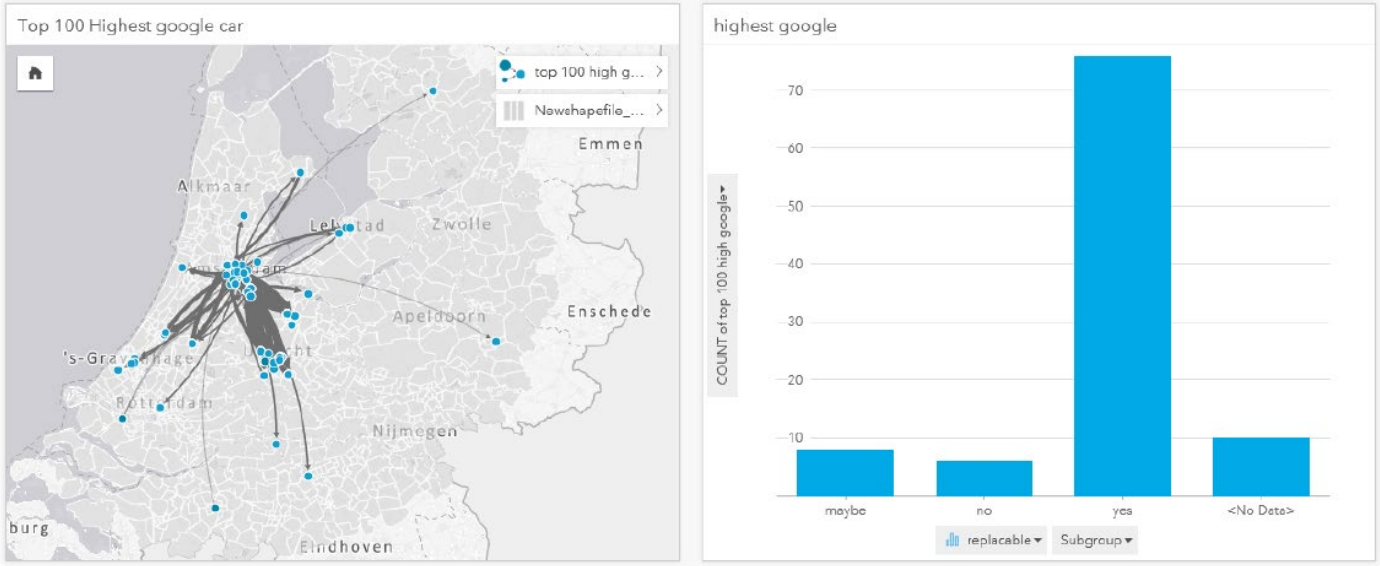


Figure 7.29: Top100 highest google weights in the longsdistance dataset

Long distance trips – Replaceability (Google & LMS)

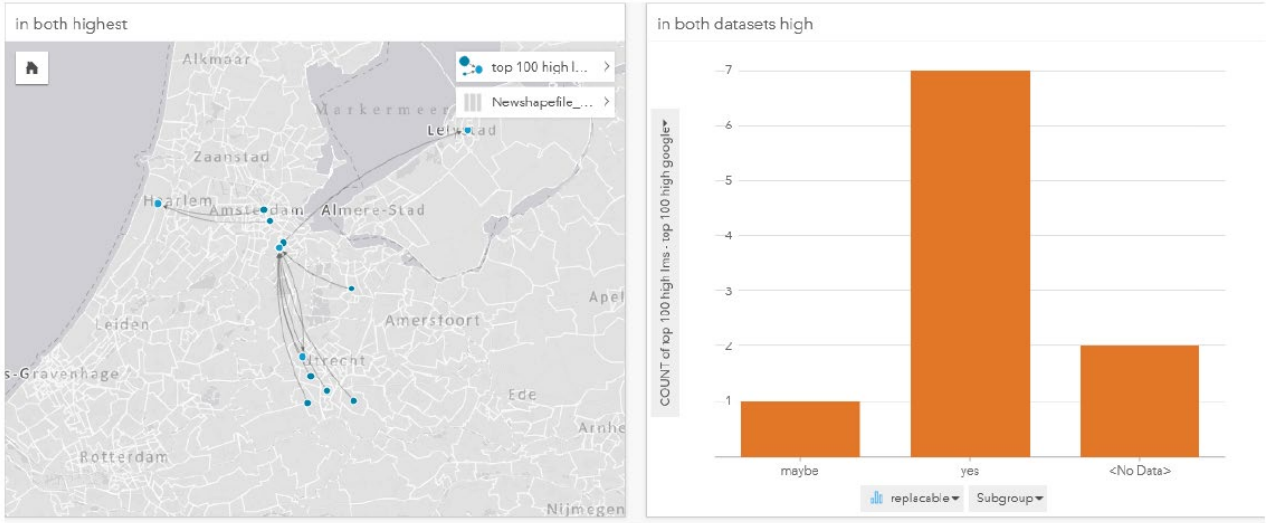


Figure 7.30: Corresponding trips in Top100 highest LMS weights and Top 100 higest Google trips in the longsdistance dataset

Long distance trips – Replaceability (LMS)

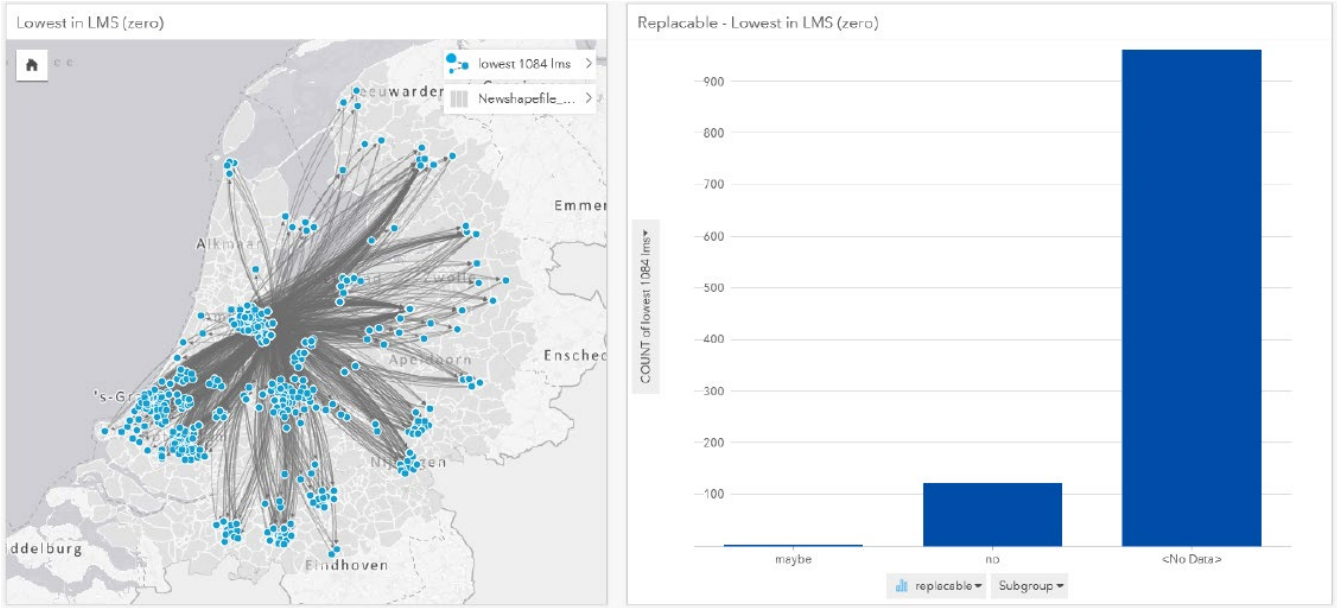


Figure 7.31: Lowest LMS weights in the longsdistance dataset

Long distance trips – Replaceability (Google)

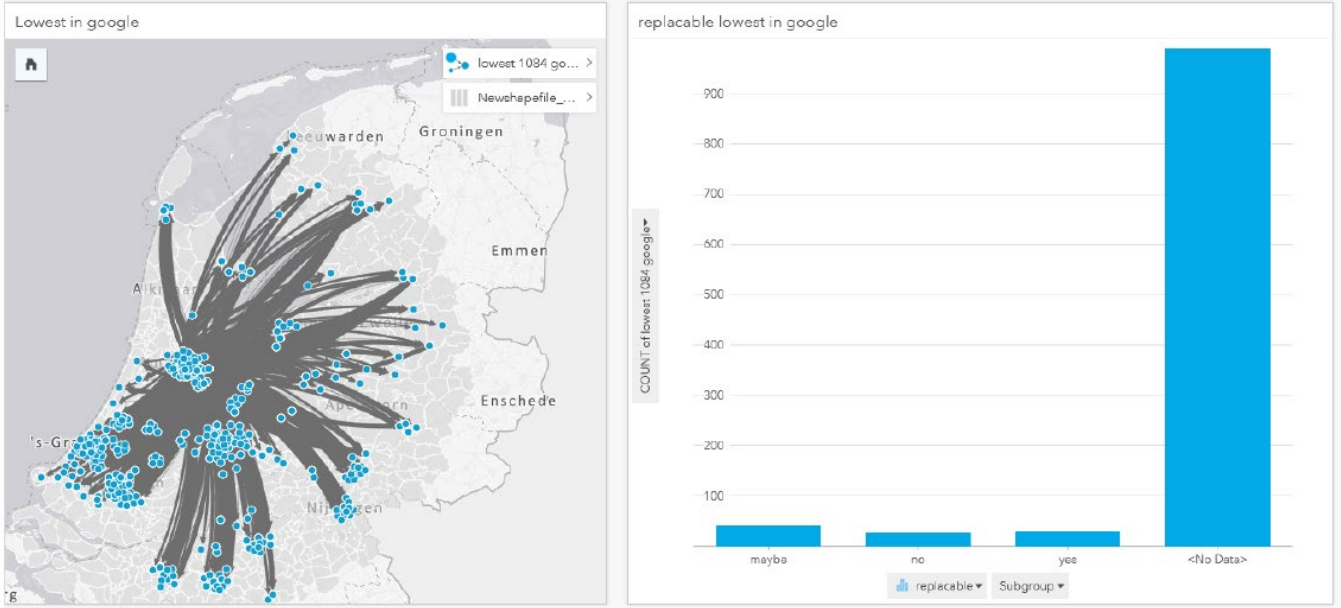


Figure 7.32: Lowest google weights in the longsdistance dataset

Conclusions and recommendations

1. What is sustainable travel behavior and why is it important?

- Sustainable mobility aims at promoting better and healthier ways of meeting individual and community transportation needs. It also reduces the social and environmental impacts of current mobility practices
- Different transportation methods have different impacts on society and the environment
- Analysis of travel behavior is important to understand why people make decisions for their modes of transportation
- This analysis can be used to influence decision making of people to steer towards more sustainable modes of transportation

2. Which data sets are commonly used and available to analyze travel behavior?

- There are many types of data which can be used to analyse travel behavior
- Traditional methods of coutings, diaries and statistics
- Modern methods include Floating Car Data, WiFi Tracking, GPS tracking

3. What are the differences between the FCD datasets and which ones are suited best?

- Differences between the available FCD data sets are captured in the table below
- Based on the requirementes, Google OD and LMS are best suited for this research

requirement	Flitsmeister	Ring Ring	TU Delft GPS	Google Flow	Google OD	LMS
Availability	v	v	v	v	v	v
OD information	x	x	v	x	v	v
documentation	v	v	v	v	v	v
research area	v	v	x	v	v	v

4. Which short distance car trips could be replaced by more sustainable opportunities like walking or cycling?

- Analysis of the data show that 15,7% of the trips could be easily replaced by either walking or cycling
- The corresponding OD combinations have been identified and visualised

category	walk-option	bike-option	in short data-set	percentage	reparable
1	yes	yes	111	0,5%	easy, by bike and walk
2	no	yes	3130	15,2%	easy, by bike
3	no	slow but short	320	1,6%	maybe by bike (or public transport)
4	no	maybe	384	1,9%	maybe by bike (or public transport)
5	no	no	16591	80,8%	not by walk or bike (public transport most sustainable option)

5. Which long distance car trips could be replaced by more sustainable opportunities like public transportation?

- Analysis of the data show a significant amount of trips replaceable by a sustainable alternative
- The corresponding OD combinations have been identified and visualised

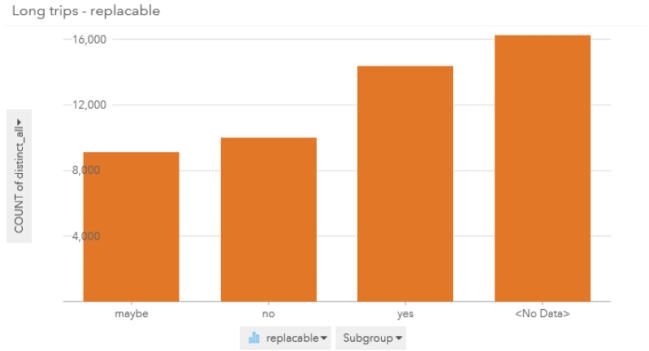


Figure 7.21: Amount of trips replaceable by a sustainable aternative

Recommendations - Long distance trips – Google dataset

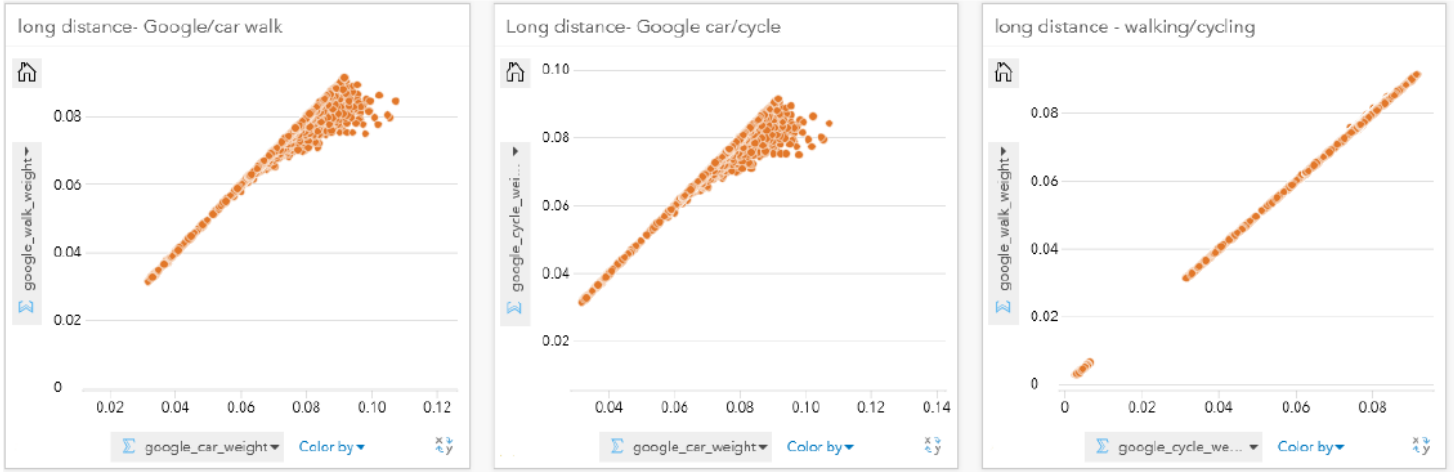


Figure 7.34: Correlation between: Google car/Google walk, Google car/Google cycle, Google walk/Google cycle

Recommendations

- Case study analyses
- Add demographic data for analyses
- Public Transport FCD data
- Trip purpose
- Weather conditions

Questions?