The University of Hong Kong, 20 May 2019

Habit and Latent Constructs in Bicycle Demand Modelling:

a combined structural equation-ordinal logit model

Juan de Dios Ortúzar
Department of Transport Engineering and Logistics
Institute in Complex Engineering Systems,
Pontificia Universidad Católica de Chile

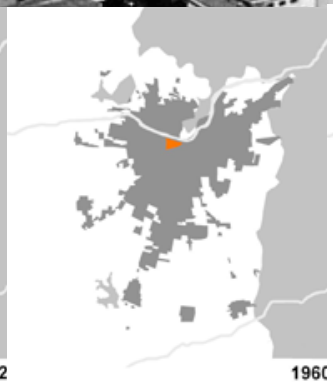
This presentation is based on work done as part of the PhD dissertation
by Margareth Gutierrez,
supervised by Dr. Ricardo Hurtubia and myself,
at the Department of Transport Engineering and Logistics,
Pontificia Universidad Católica de Chile.

CONTENTS

- Study context
- Research stages
- Results and conclusions
- Further work


1940


1952

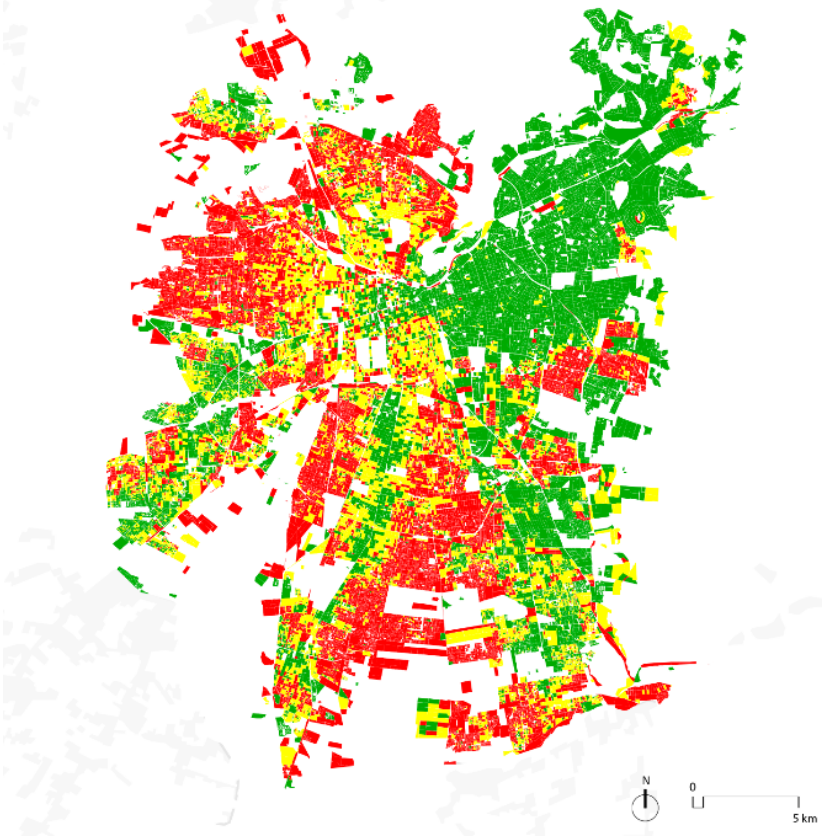

1960


1970


1982


1992

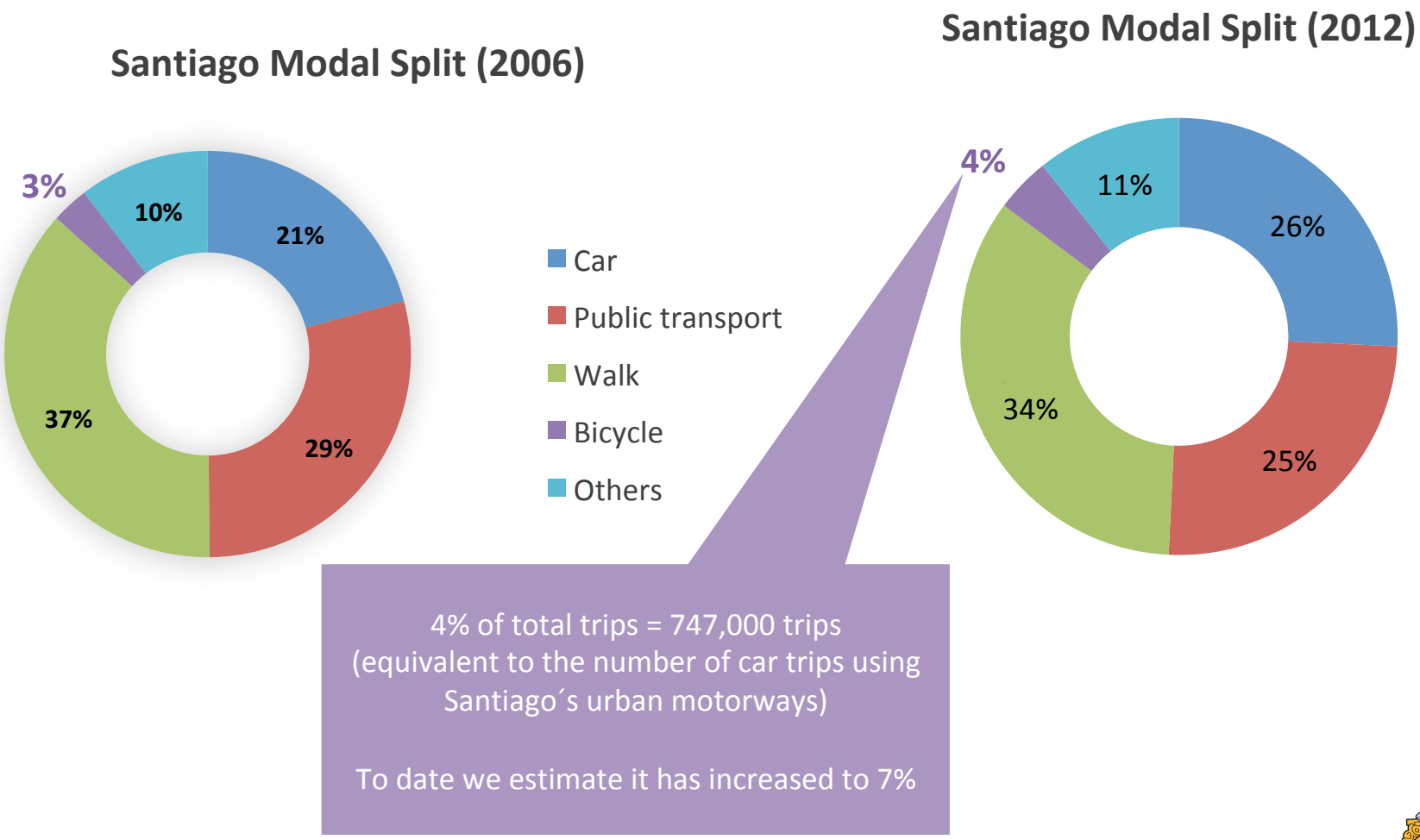
A SOCIALLY SEGREGATED METROPOLIS



Presence of D and E groups

- Less than or equal 25%
- Between 25 and 50%
- Over 50%

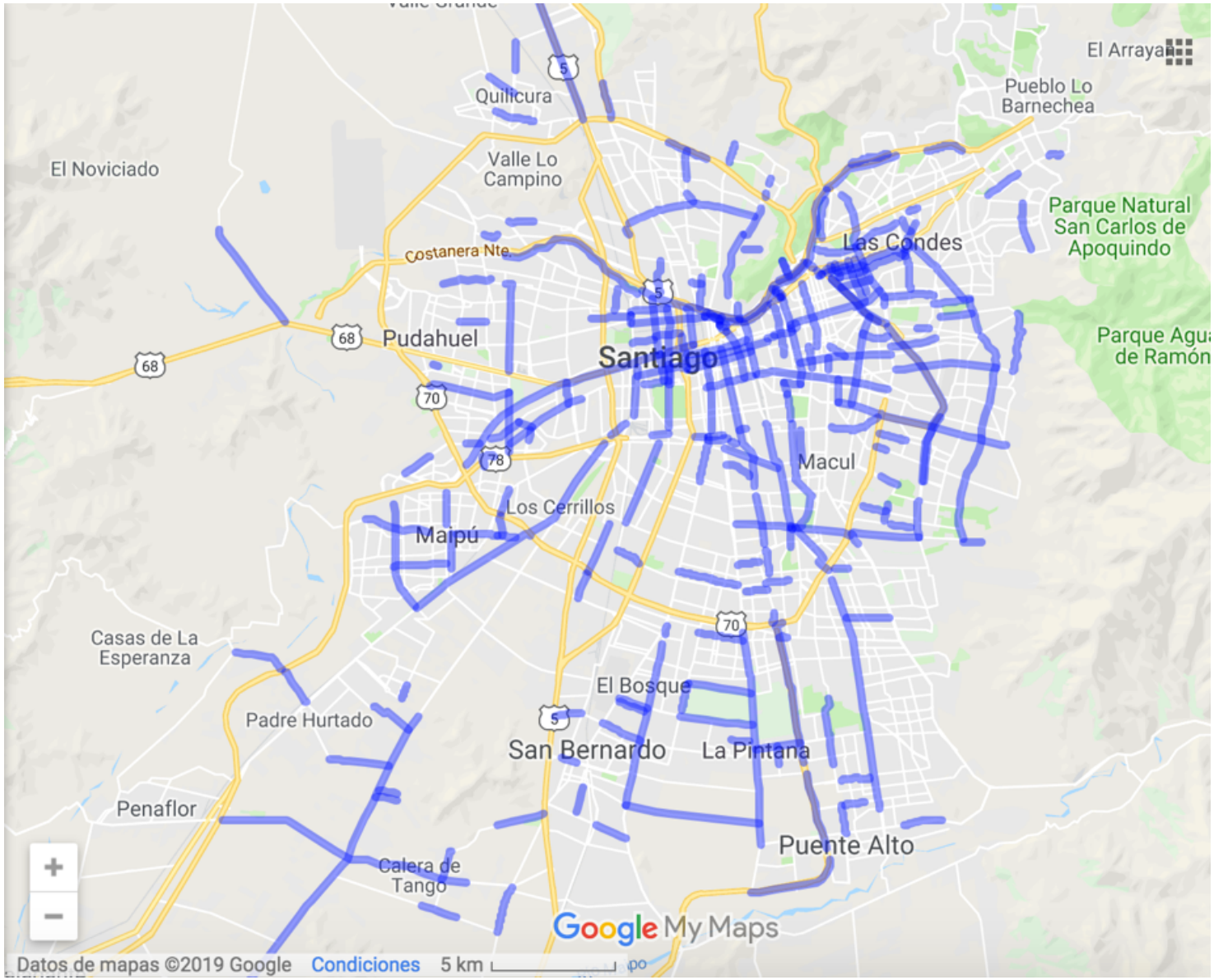
Study context



Study context

- Lack of up-to-date statistics about the current number of trips by bike
- Non reliable data about the construction or adaptation of bike-only infrastructure, and whether it is associated with the real demand at each municipality

Cicleways in Santiago

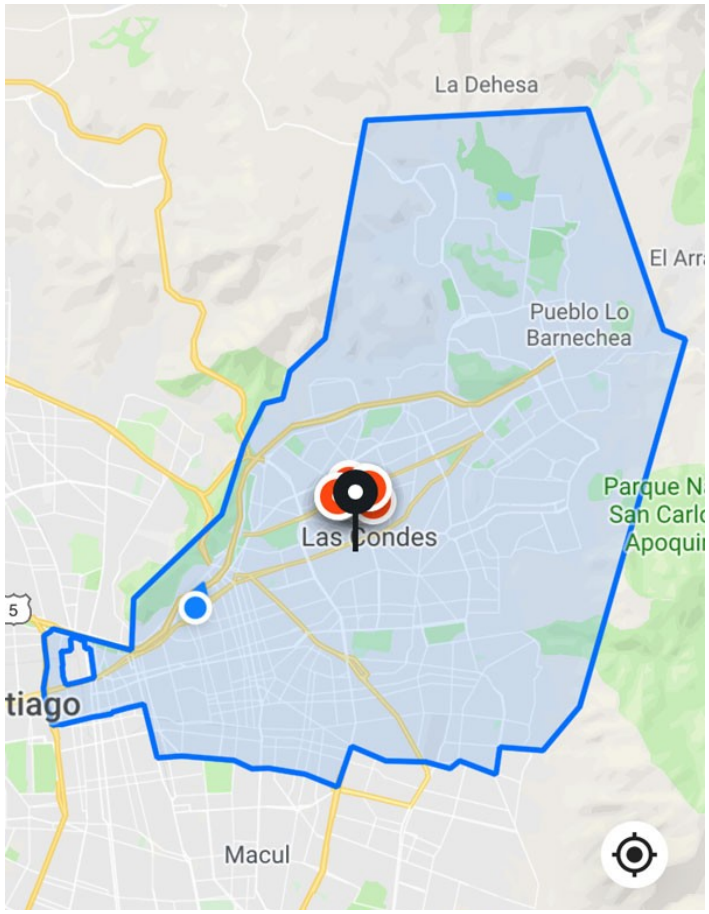


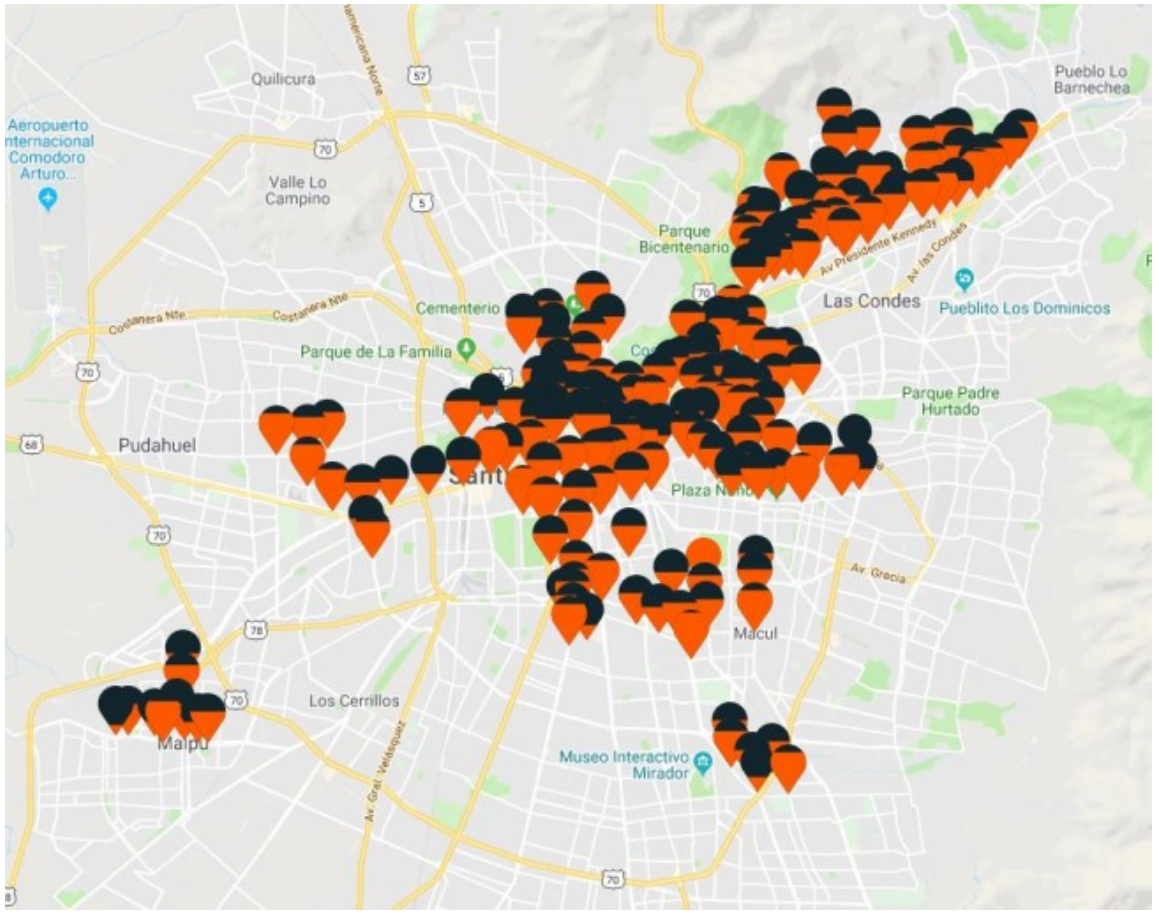
Study context

- Lack of up-to-date statistics about the current number of trips by bike
- Non reliable data about the construction or adaptation of bike-only infrastructure, and whether it is associated with the real demand at each municipality
- Lack of integration of public bikes in one key municipality, but encouraging appearance of a bike sharing system in the highest income municipalities.

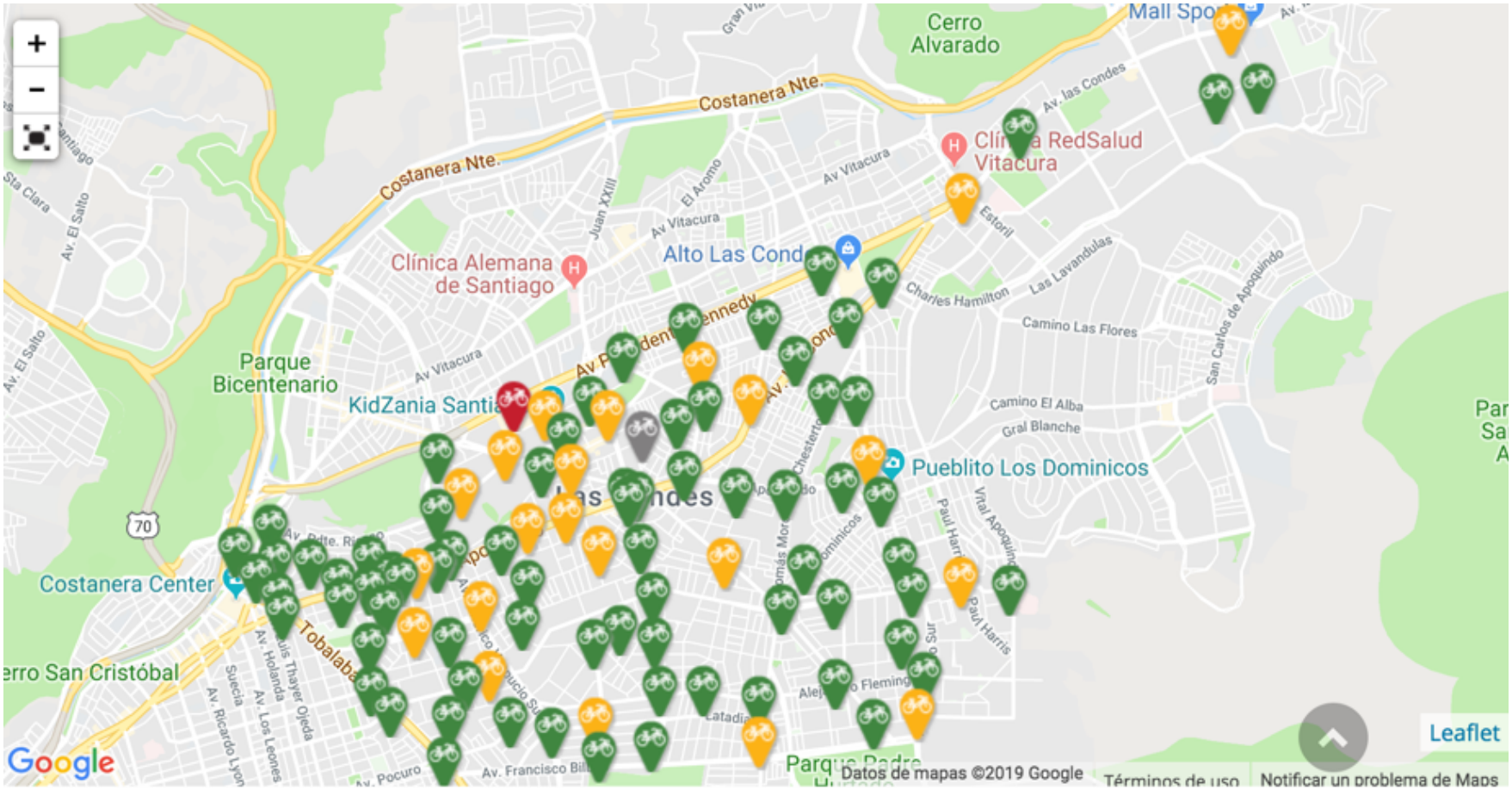
BikeSantiago

Mobike vs BikeSantiago





Bici Las Condes



Research Stages

- Aim is to identify potential bike users
- People who are prepared to use bikes in some of their daily trips
- Which factors could influence a change from their current mode?
  - Habit
  - Attitudes and perceptions (risk aversion, being “green”)

Research Stages

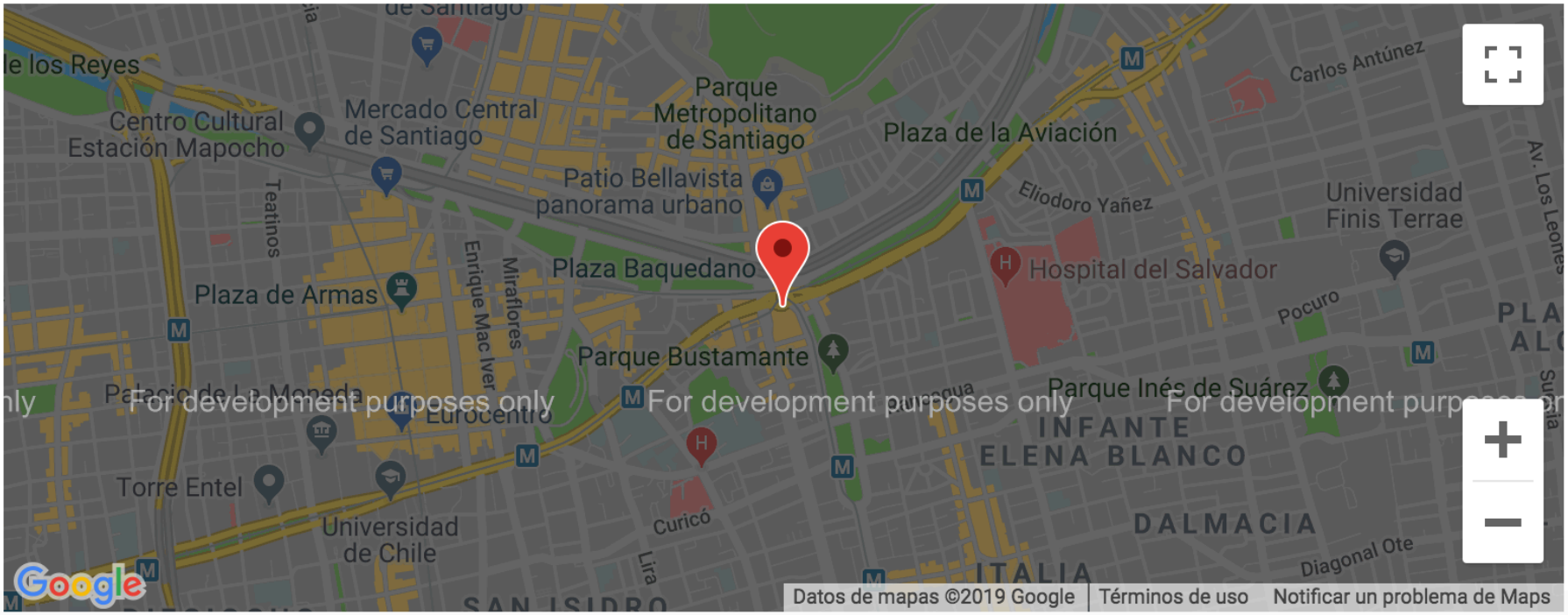
- Online web survey to two distinct groups:
  - Academics and administrative staff at the four Campuses of Pontificia Universidad Catolica de Chile in Santiago
  - Unknown social network users
- Data about journey to work/study in the morning peak (home-based trip)
- We surveyed users of all transport modes

Survey Contents

- Personal and household data, including a filter question:
  - Do you know how to ride a bike?
- Data about the morning peak journey to work or more habitual trip:
  - Starting and finishing hour of the trip
  - Number of stages of the trip
  - Modes used
  - Attributes of the mode used (travel and access time, cost)

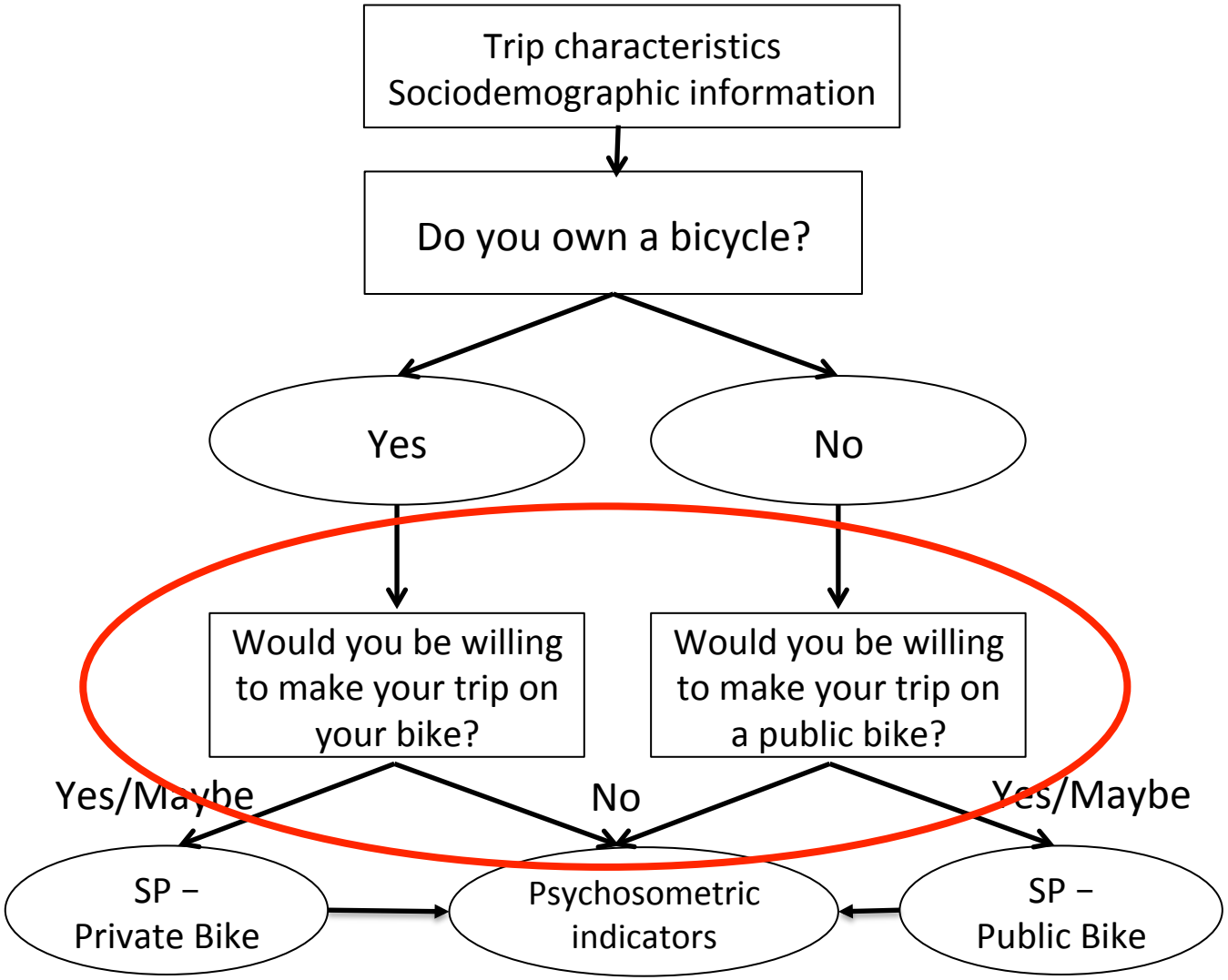
Survey Contents

Individuals were asked to register their trip's origin and destination:

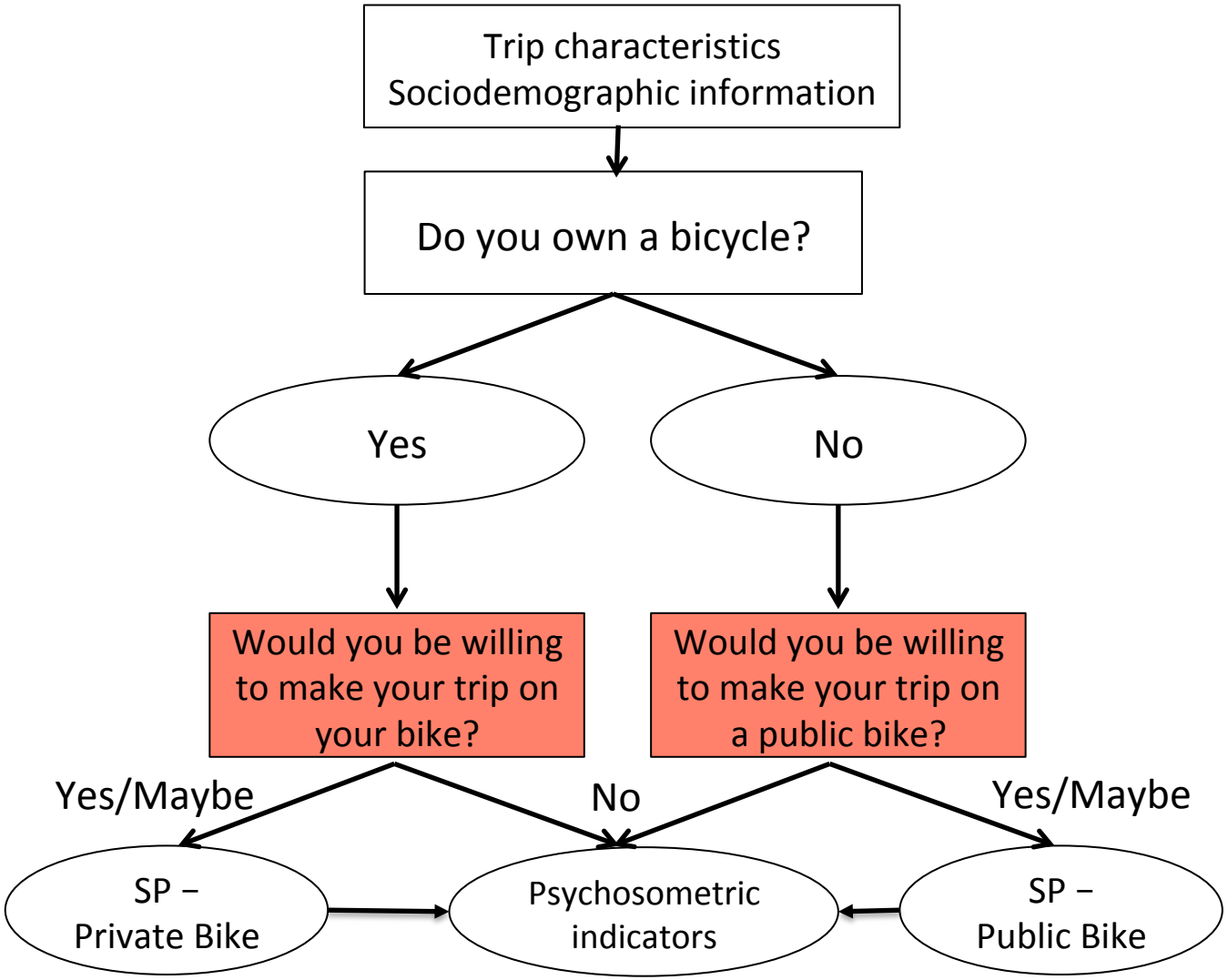


And from these data, we derived *built space* variables, such as distance to bus stops and cycleways, and others.

Survey Stages



Survey Stages



Psychometric Indicators

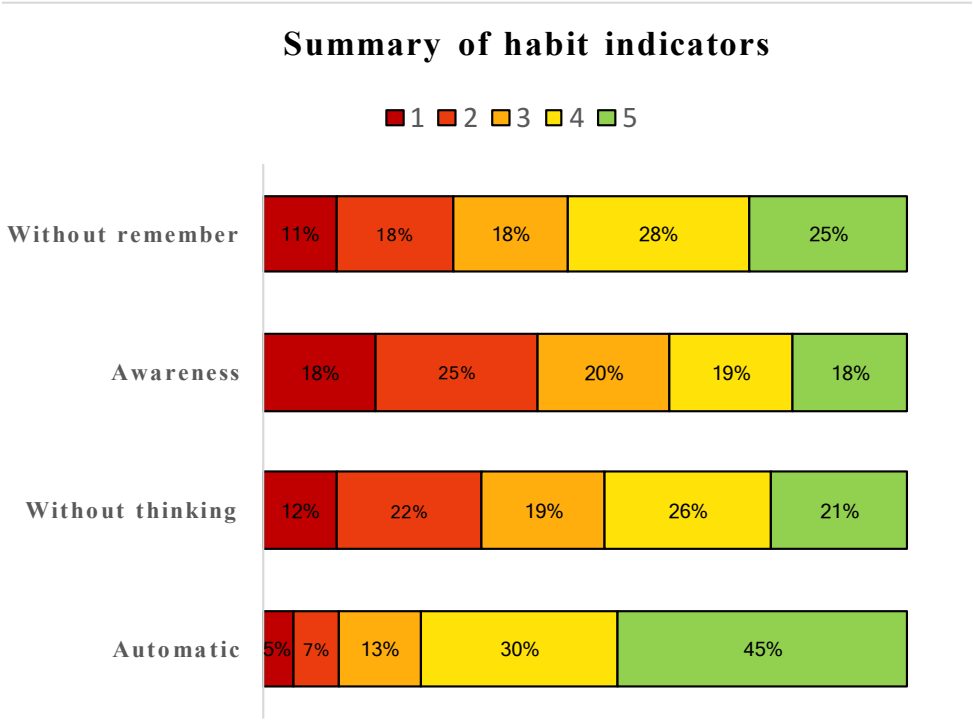
- Attitudes
- Perceptions (incentives/ barriers)
- Hábit
  - Using a reduced versión of the Self-Informed Habit Index (Verplanken and Orbell, 2003), and a 5-point Likert scale.

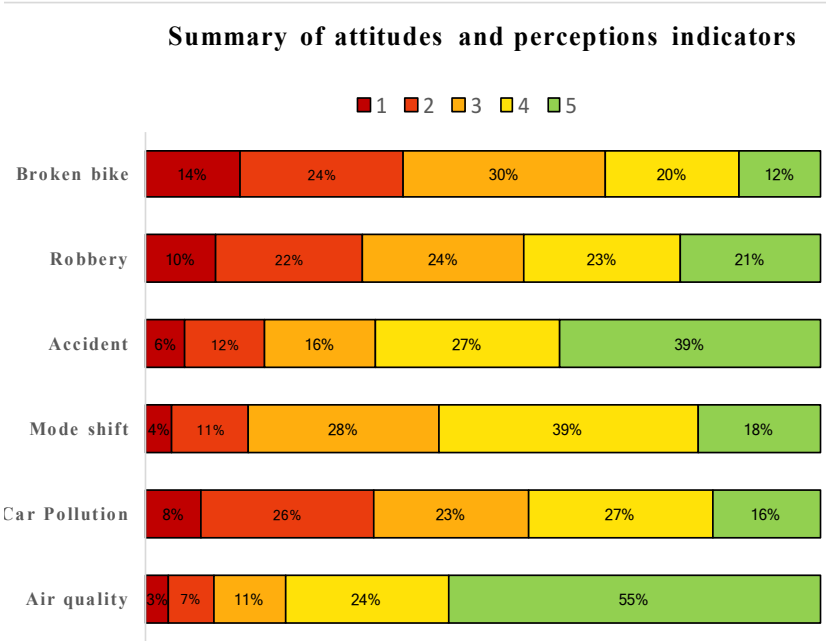
Principal Components Analysis

Statements	Indicators	Latent Variable
I do without having to consciously remember	Without remember	**Habit**
I start doing before I realize I'm doing it	Awareness	
I do without thinking	Without thinking	
I do automatically	Automatic	
I am worried about having a technical problem and not knowing what to do	Broken bike	**Insecurity**
I am worried about being mugged	Robbery	
I am worried about the possibility of having an accident	Accident	
I am prepared to change mode if that helps the environment	Mode shift	**Green**
Car use is the major cause of air pollution in urban areas	Car pollution	
Increasing public transport use would help air quality in Santiago	Air quality	

Principal Components Analysis

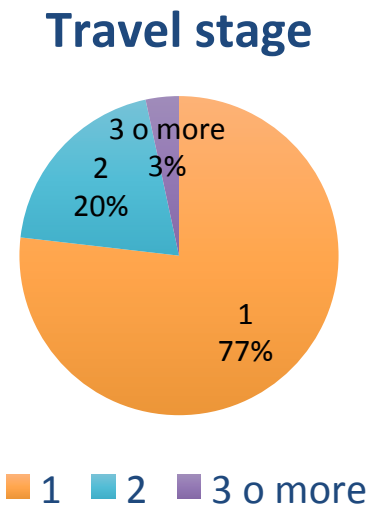
- Latent Variables: Spontaneity (i.e. the reverse of Habit), Pro-environment attitude (Green), Insecurity and Cyclo-inclusive infrastructure (not in the model)

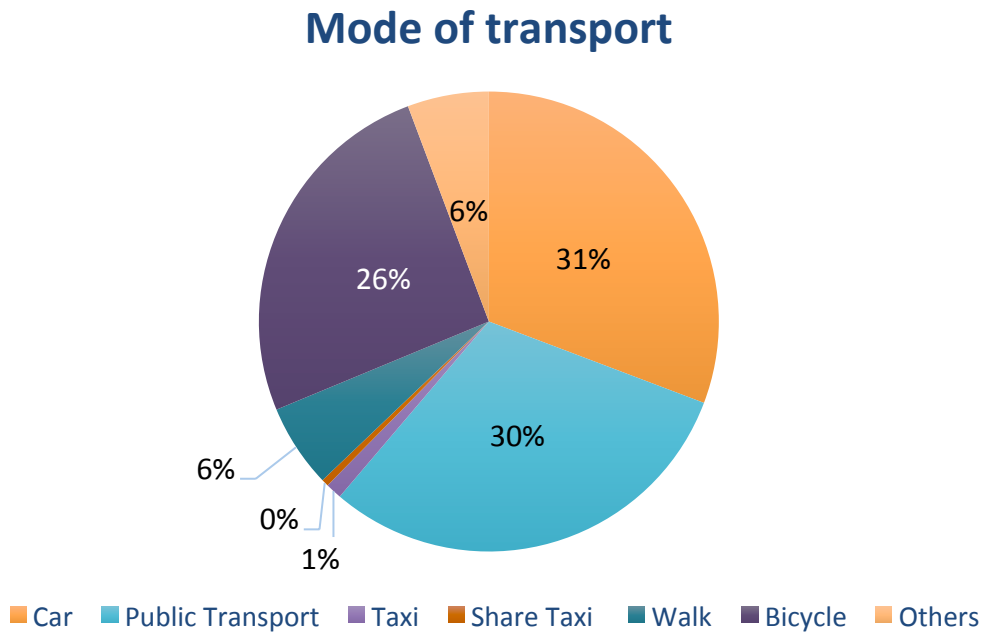




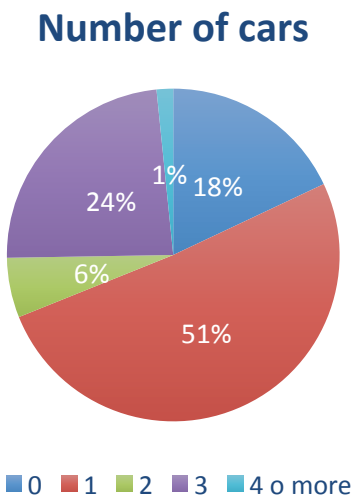
Data Analysis

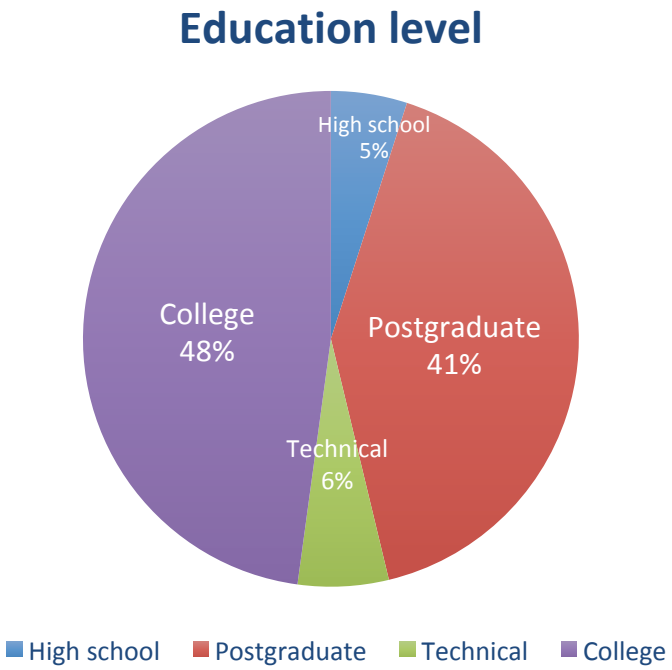
- 1432 survey forms collected (1398 depurated):
  - 380 academics/staff of the four PUC Campuses in Santiago
  - 1018 contacted through social networks (i.e., Twitter)
- 43% female

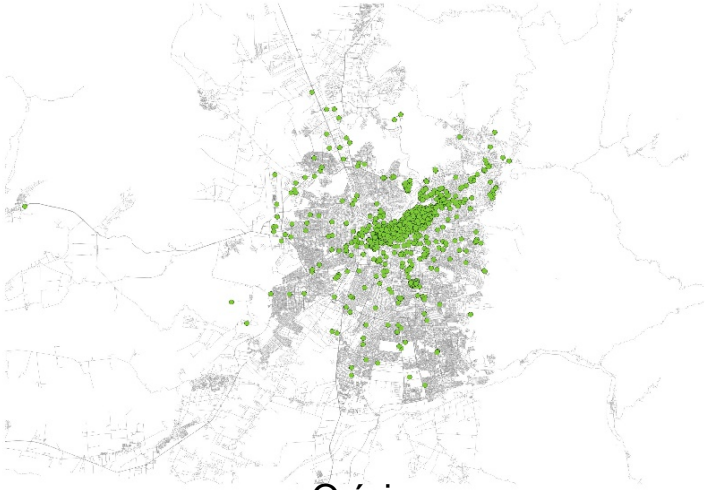




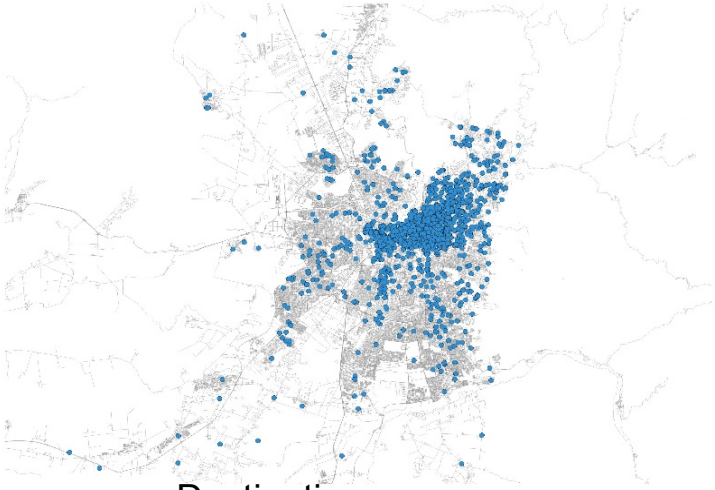
Data Analysis





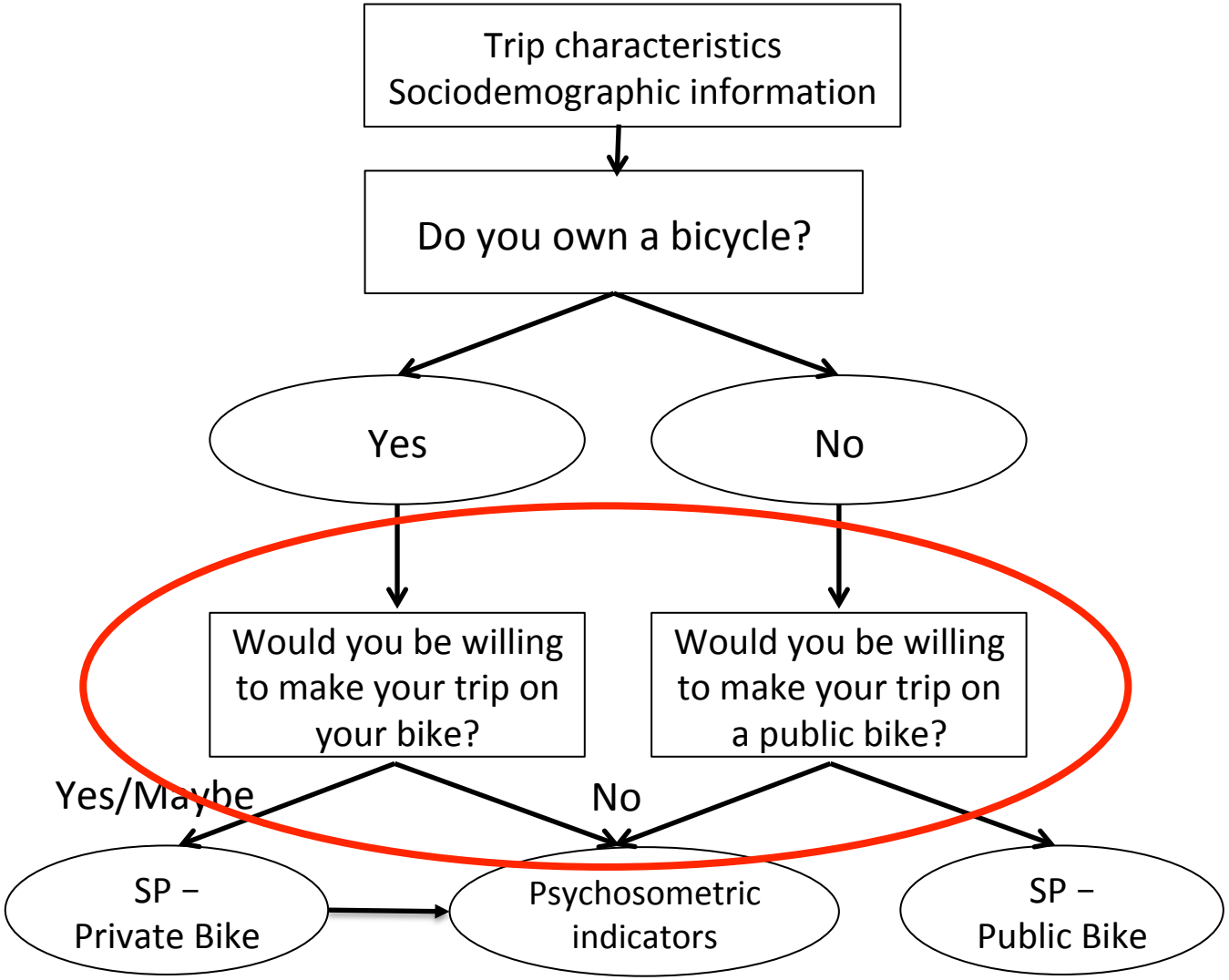


Orígins



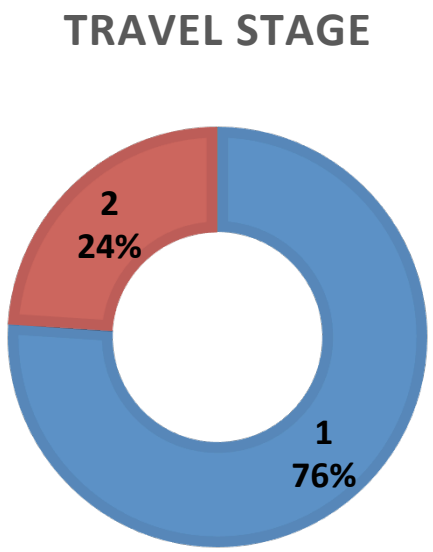
Destinations

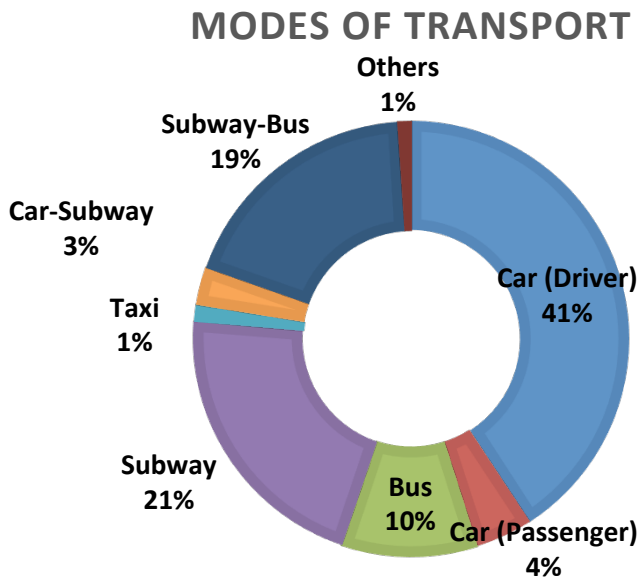
Survey Stages



Data Analysis

- 805 participated in the willingness to use bike survey
  - Yes, I would be prepared to use a bike in that trip: 21.5%
  - May be / It depends: 40.2%
  - No: 38.3%





Ordinal Logit Model with Latent Variables

$$F(\varepsilon)=\exp\square(\varepsilon)\ /(\ 1+\exp\square(\varepsilon)\ )$$

$$Z\downarrow i=h(X\downarrow i;\lambda)+\omega\downarrow i$$

$$I\downarrow i=m(Z\downarrow i;\alpha)+v\downarrow i$$

$$I\downarrow i\uparrow*=1 \quad if \quad \mu\downarrow 2<I\downarrow i\leq\mu\downarrow 1\ ,$$

$$=2 \quad if \quad \mu\downarrow 1<I\downarrow i\leq\mu\downarrow 2\ ,$$

$$=\ldots$$

$$=J\ if\ \mu\downarrow J-1<I\downarrow i\leq\mu\downarrow J$$

Model Estimation

- Basic OL Model

$$U\downarrow W\_Cycle = \theta\downarrow Fem \cdot \text{Female} + \theta\downarrow Age \cdot \text{Age} + \theta\downarrow Cars \cdot \text{No\_Cars} + \theta\downarrow Bk \cdot \text{No}\downarrow \text{B}ike + \theta\downarrow Per \cdot No\downarrow Per + \theta\downarrow Stages \cdot No\downarrow Stages + \theta\downarrow Length \cdot \text{L}\text{ength} + \theta\downarrow Stops \cdot Distance\downarrow Stops + \theta\downarrow Cycle \cdot Distance\downarrow Cicleway + \theta\downarrow mlCycle \cdot Cycleway\ meters + \varepsilon\downarrow i$$

- OL Model with Latent Variables (Hybrid OL)

$$U\downarrow W\_Cycle = \theta\downarrow Age \cdot \text{Age} + \theta\downarrow Bk \cdot \text{No}\downarrow \text{Bi}ke + \theta\downarrow Per \cdot No\downarrow Per + \theta\downarrow Stages \cdot No\downarrow Stagess + (\theta\downarrow Length + \theta\downarrow Spon. \cdot Spontaneity + \theta\downarrow Green \cdot Green) \cdot \text{L}\text{ength} + \theta\downarrow Stop \cdot Distance\downarrow Stop + \theta\downarrow Cycle \cdot Distance\downarrow Cycle + \theta\downarrow Insec \cdot \text{Insecurity} + \varepsilon\downarrow i$$

Modelling Results

Basic OL Model

Attribute	Parameters (t-test)
Female	-0.375 (-2.72)
Age	-0.028 (-4.12)
No. of cars	-0.163 (-2.20)
No. of bikes	0.189 (3.40)
No. of persons	-0.137 (-2.07)
Trip stages	0.604 (3.61)
Length of trip	-0.091 (-6.23)
Distance bus stop	0.051 (3.95)
Distance Cycleway	-0.062 (-2.81)
Cycleway meters	0.158 (1.35)

Hybrid OL Model

Attribute	Parameters (t-test)
Female	----
Age	-0.020 (-2.30)
No. of cars	----
No. of bikes	0.175 (2.59)
No. of persons	-0.173 (-2.41)
Trip stages	0.720 (3.54)
Distance bus stop	0.065 (4.09)
Distance cycleway	-0.074 (-2.97)
Length of trip	-0.082 (-4.02)
Spontaneity	*0,019 (2.14)*
Green	*0.063 (4.71)*
Insecurity	*-0,682 (-2.54)*

MIMIC Results

Attribute	Parameter (t-test)
$\lambda_{Frequency\_Spont.}$	-0.159 (-4.70)
$\lambda_{No\_Persons\_Spont.}$	0.125 (2.33)
$\lambda_{Children\_Spont.}$	-0.446 (-2.89)
$\lambda_{No\_Cars\_Green}$	-0.201 (-4.69)
$\lambda_{Student\_Green}$	0.265 (1.75)
λ_{Age_Green}	-0.014 (-2.72)
$\lambda_{Female\_Insecurity}$	0.548 (7.11)
$\lambda_{No\_Bikes\_Insecurity}$	-0.067 (-2.35)
$\lambda_{Age\_Insecurity}$	0.007 (2.07)

Conclusions

- Availability of cycle infrastructure plays a key role
- Need for educational campaigns to reduce feelings of insecurity
- Need for up-to-date information for cyclist, such as mapas with bike repair shops, rent-a-bike points,and cycleway maps, among others
- An app or system enabling the programming of the trip by bike (Google Maps).

Conclusions

- Spontaneity (i.e., less Habit) has a significant effect in the decision to move to bike
- The more “willing to change” people are younger, students, with far away bus stops or Metro stations

Further Work

- Investigate if there are behavioural differences among people having a bike at home and those who would need to use public bikes
- Estimate a joint model with the SP data gaathered and apply it to the Santiago population with similar characteristics to that oif our sample
- Estimate latent class models with the combined data

MANY THANKS FOR YOUR ATTENTION

QUESTIONS ?