



FONDEF  
Fondo de Fomento al Desarrollo  
Científico y Tecnológico

# Analysing route choice decisions on Metro networks

A comparison between Santiago and London

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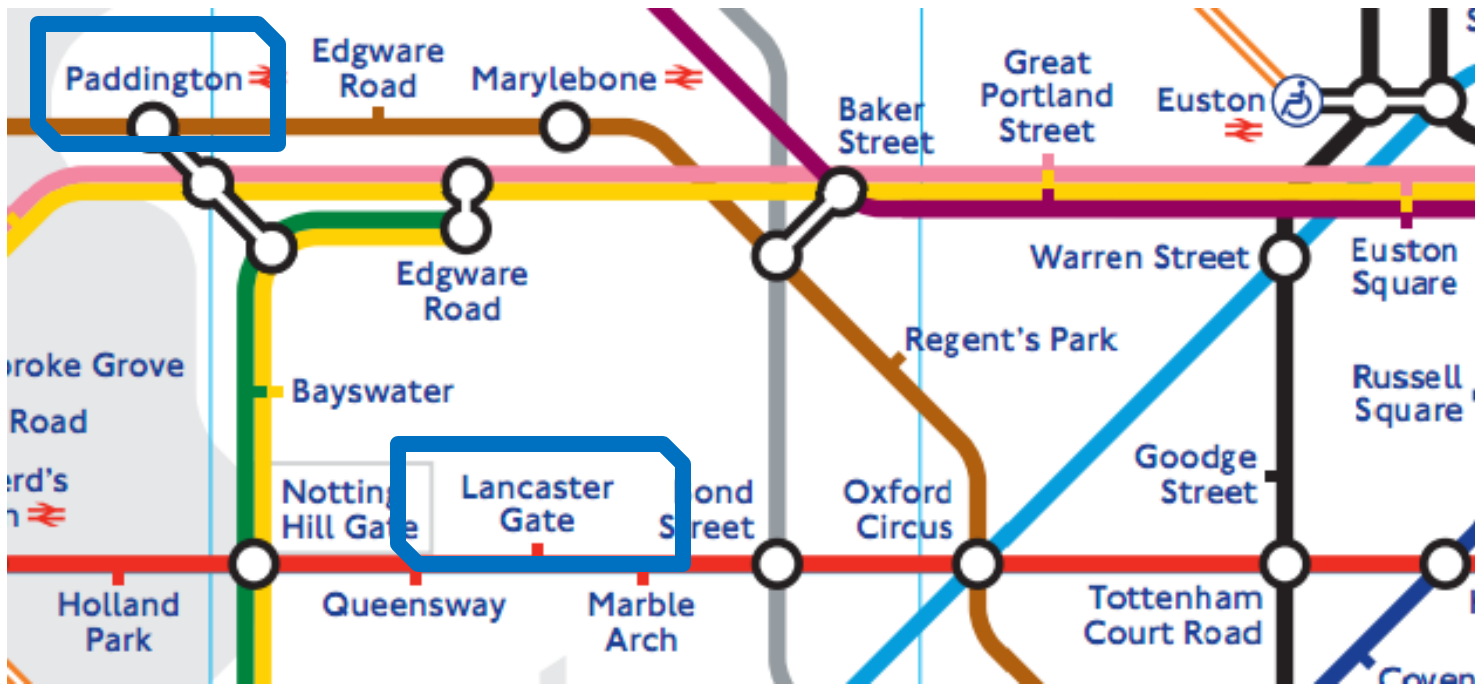
New York University

Juan Carlos Muñoz

Pontificia Universidad Católica de Chile

Nigel Wilson

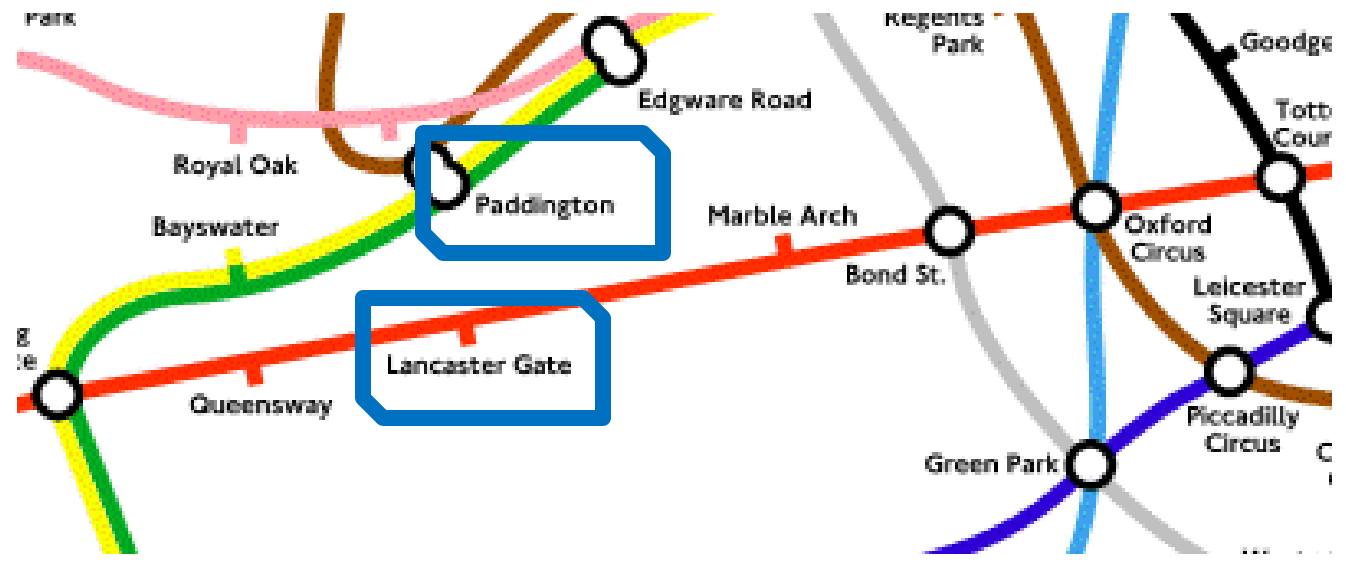
Massachusetts Institute of Technology



13 min



10 min



# Contents

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Modelling  
Variables

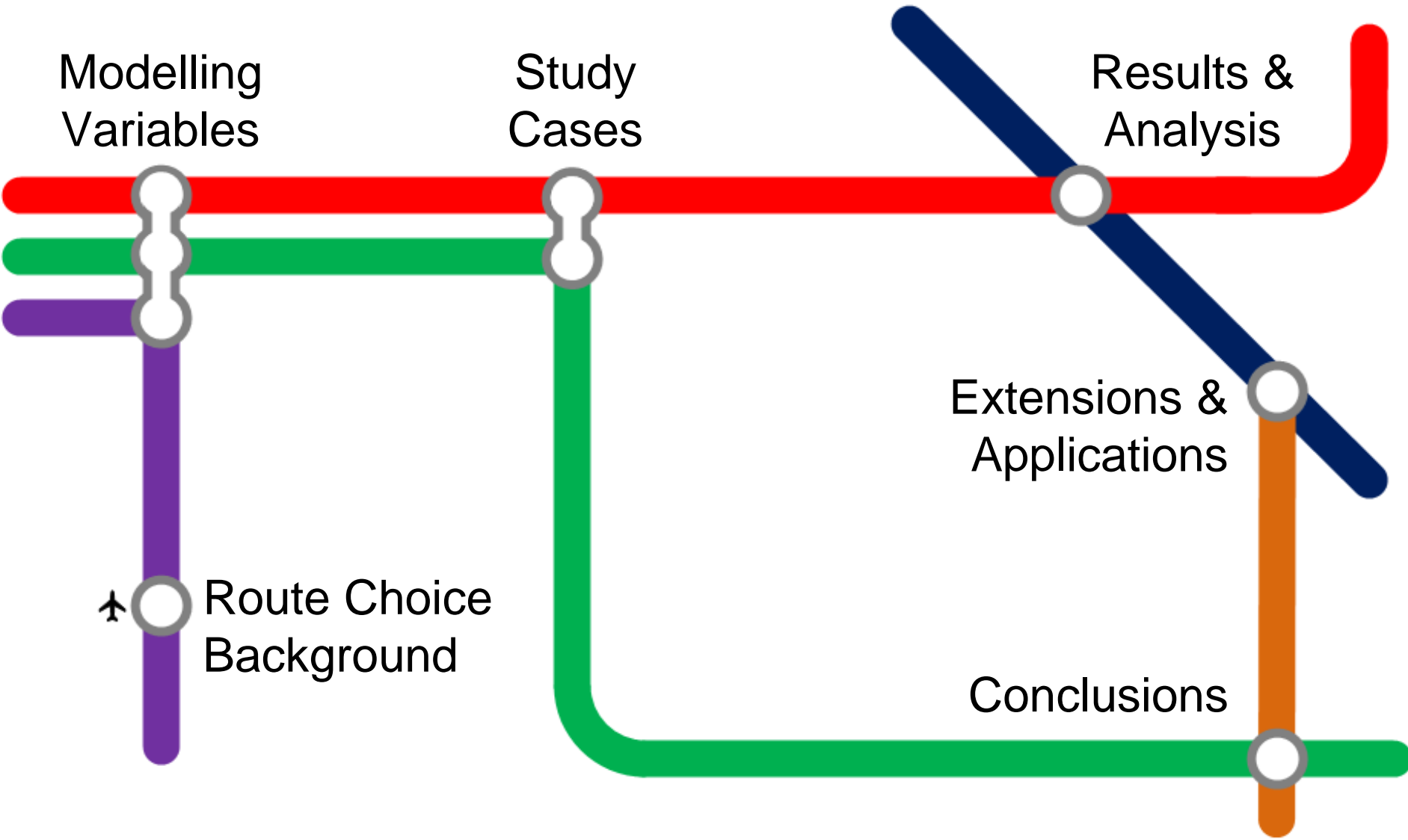
Study  
Cases

Results &  
Analysis

Extensions &  
Applications

↑  
Route Choice  
Background

Conclusions



# Route choice modelling

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Traditional route choice models usually consider just tangible variables related to the level of service

travel time

fare

number of transfers

These models are sometimes refined including socio-economic variables of the travelers

## Route choice modelling

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However, this approach ignores other relevant elements that influence route choice as:

comfort and safety

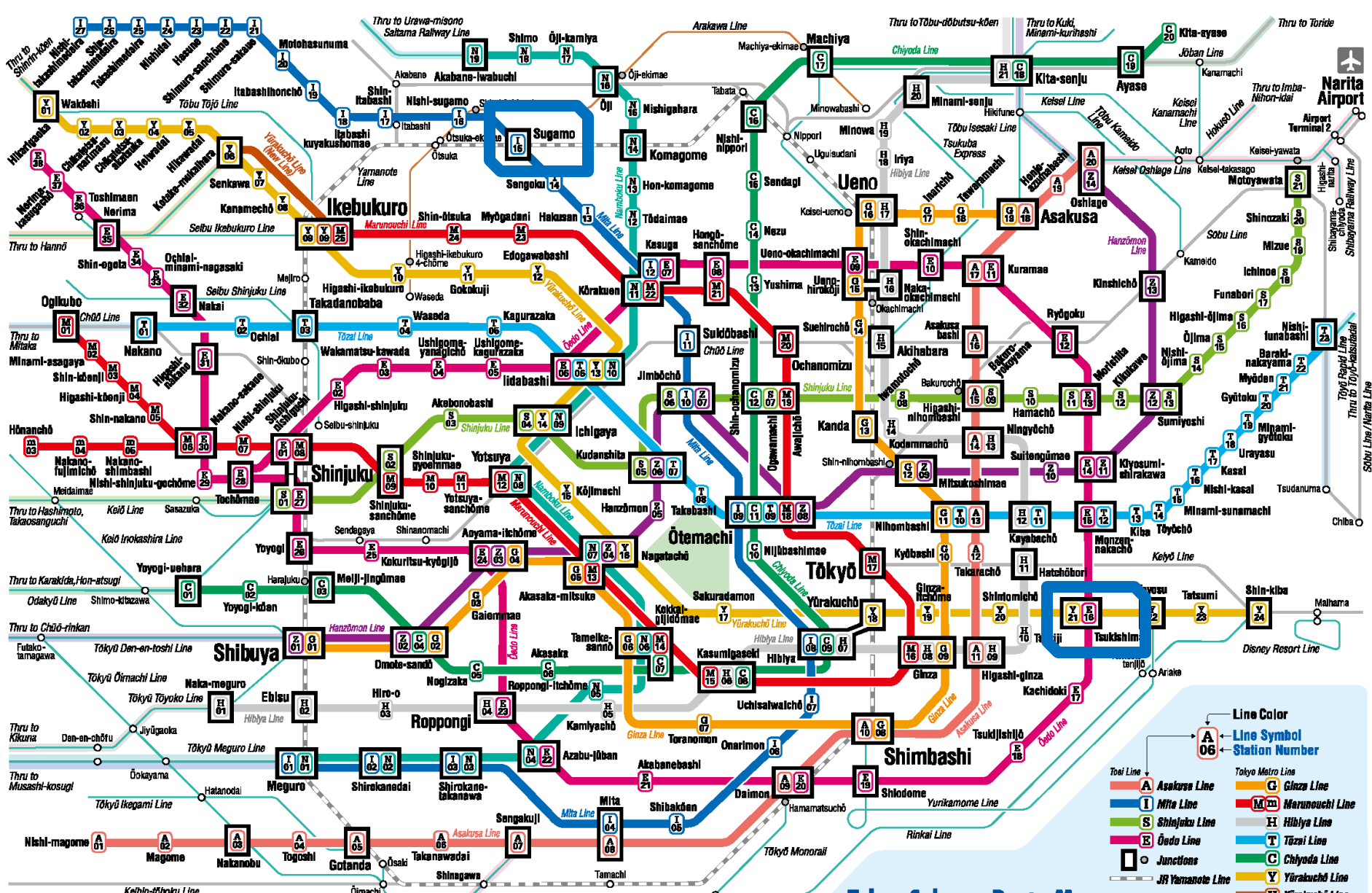
transfers accessibility

network topology

aesthetics

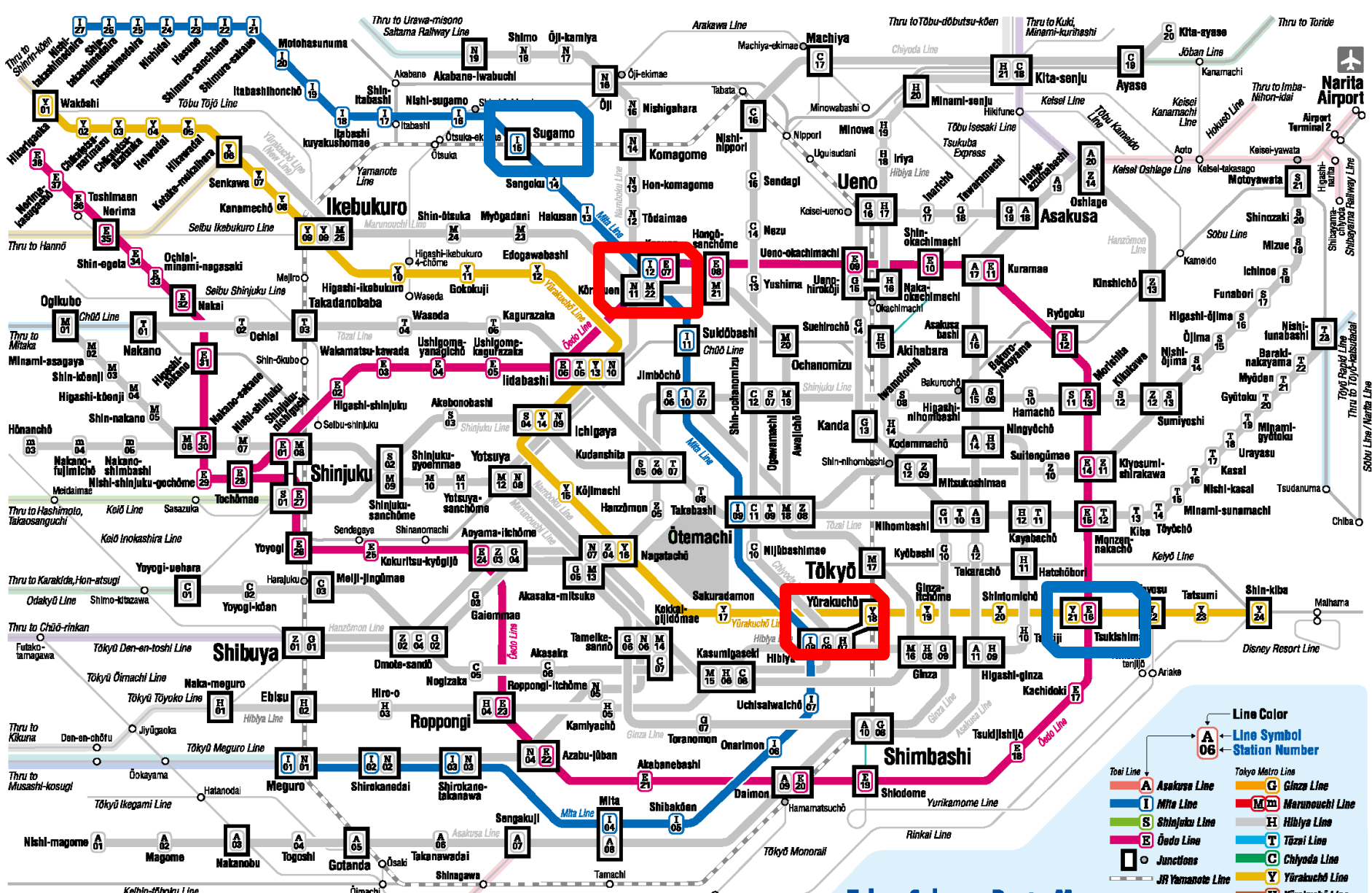
These variables are subjective and hard to quantify

# Pathfinding Criteria



Tokyo Subway Route Map

# Pathfinding Criteria



Tokyo Subway Route Map

## Pathfinding Criteria

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Some people follow different criteria when deciding how to get from one point to another

the fastest way

the cheapest way

In a transit context, there are some additional factors

avoid walking

avoid transferring

But most consider many factors at the same time!



## Study's objectives

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Understanding travelers is essential in Transportation Planning

**Identify** and **quantify** the factors that affect the transit users' behaviour

**Compare** the preferences of transit users in London and Santiago

# What do people take into account?

In-vehicle time  
Waiting time  
Walking time (when transferring)

travel time  
components

Number of transfers  
Transfer stations layout

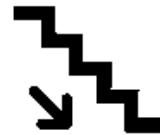
ascending



at level



descending



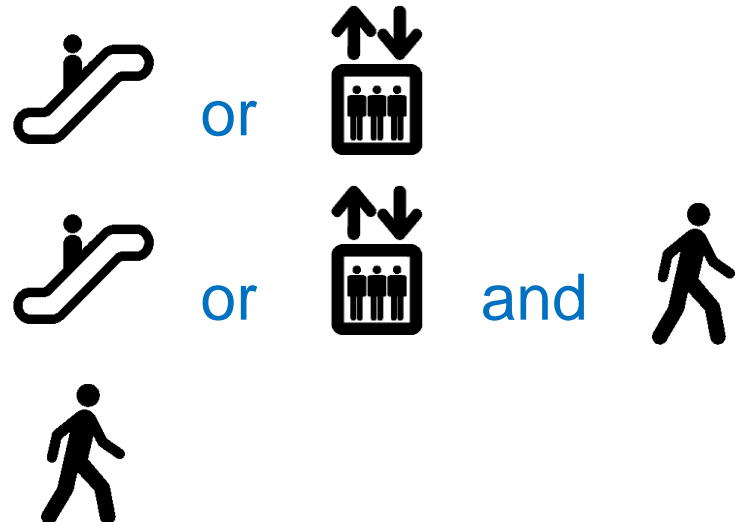
# What do people take into account?

In-vehicle time  
Waiting time  
Walking time (when transferring)

travel time  
components

Number of transfers  
Transfer stations layout  
Transfer stations infrastructure

assisted



## What do people take into account?

In-vehicle time	travel time components
Waiting time	
Walking time (when transferring)	
Number of transfers	transfer experience
Transfer stations layout	
Transfer stations infrastructure	
Mean occupancy	
Possibility of not boarding	

in London

in Santiago

initial occupancy  $\geq 70\%$

initial occupancy  $\geq 85\%$

## What do people take into account?

In-vehicle time	travel time components
Waiting time	
Walking time (when transferring)	
Number of transfers	transfer experience
Transfer stations layout	
Transfer stations infrastructure	
Mean occupancy	
Possibility of not boarding	
Possibility of getting a seat	

in London

in Santiago

initial occupancy  $\leq 20\%$

initial occupancy  $\leq 15\%$

## What do people take into account?

In-vehicle time	travel time components
Waiting time	
Walking time (when transferring)	
Number of transfers	transfer experience
Transfer stations layout	
Transfer stations infrastructure	
Mean occupancy	comfort and crowding
Possibility of not boarding	
Possibility of getting a seat	
Route distance	
Number of stations	
Angular cost	

## What do people take into account?

In-vehicle time	travel time components
Waiting time	
Walking time (when transferring)	
Number of transfers	transfer experience
Transfer stations layout	
Transfer stations infrastructure	
Mean occupancy	comfort and crowding
Possibility of not boarding	
Possibility of getting a seat	

Route distance

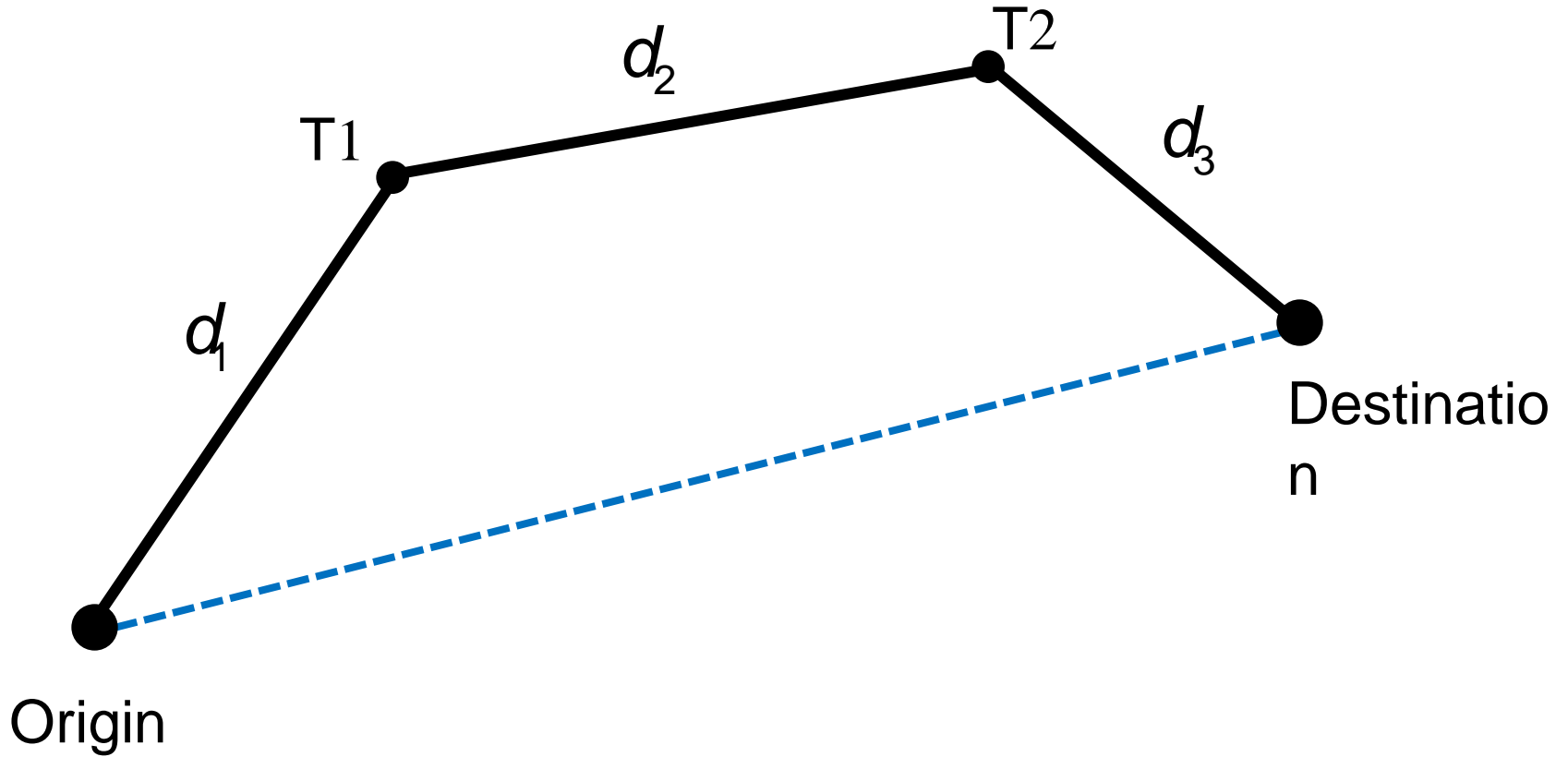
Number of stations

Angular cost

$$\sum d \cdot \sin\left(\frac{\theta}{2}\right)$$

# What do people take into account?

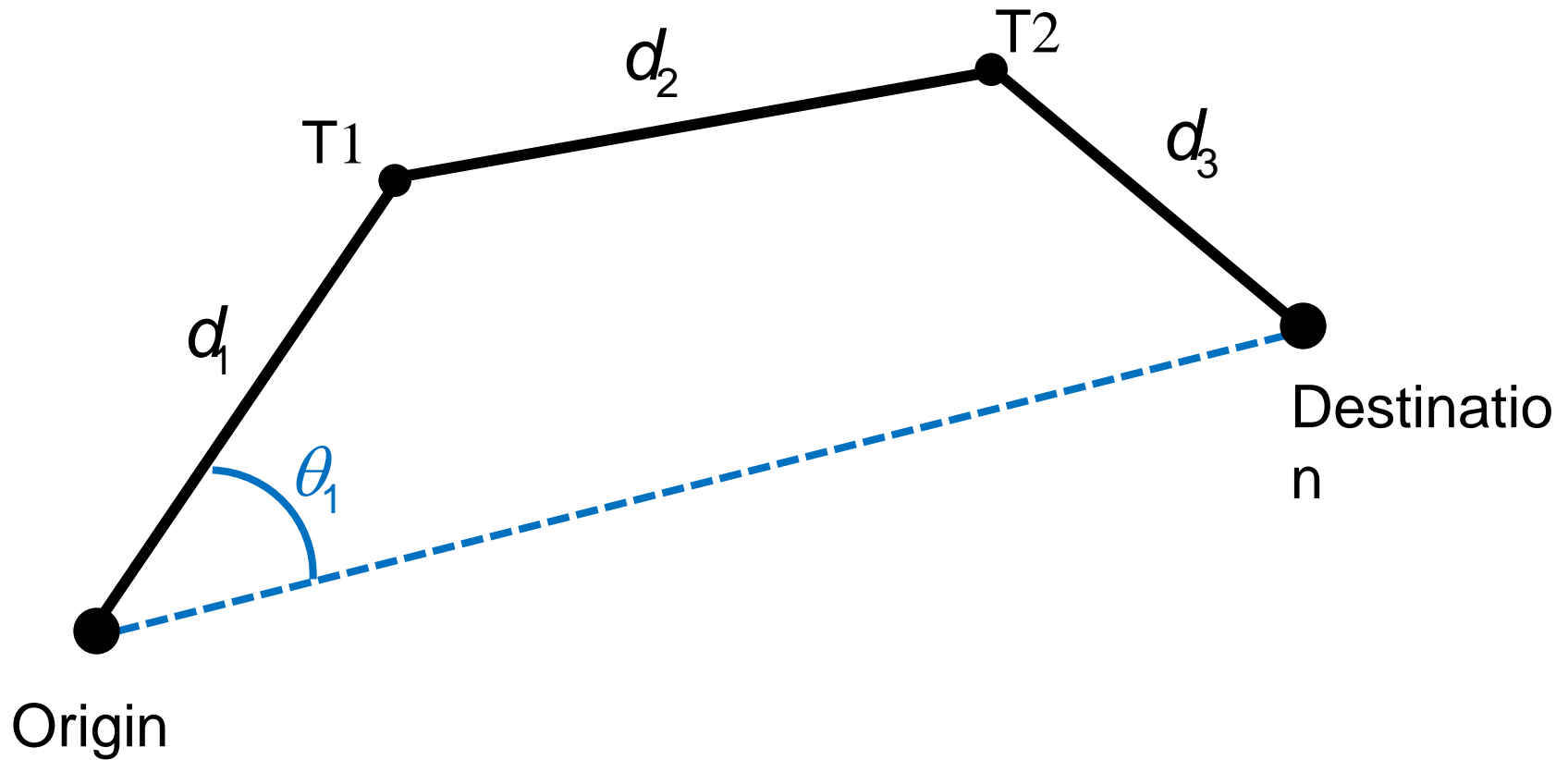
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Angular Cost =

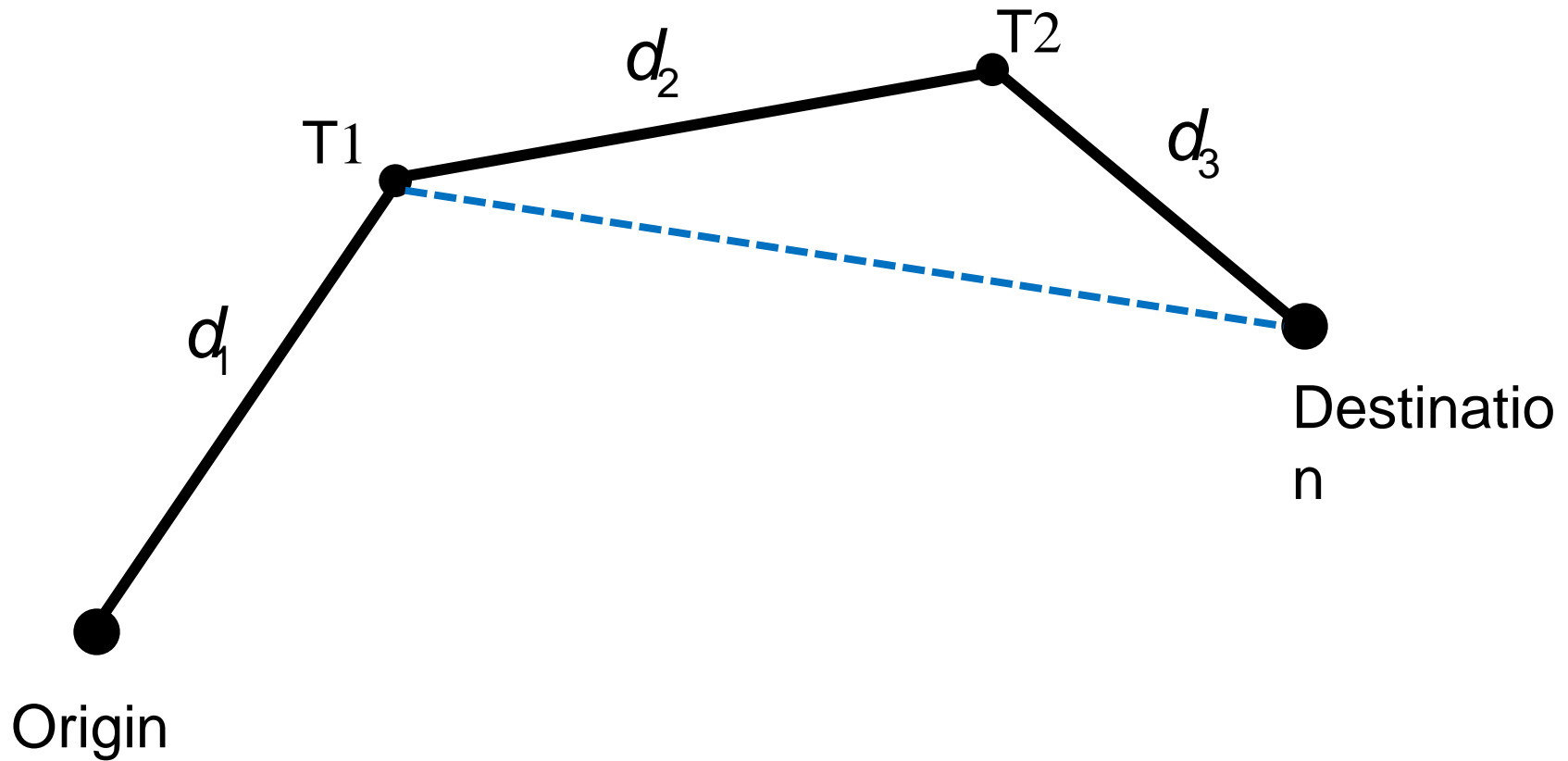


# What do people take into account?



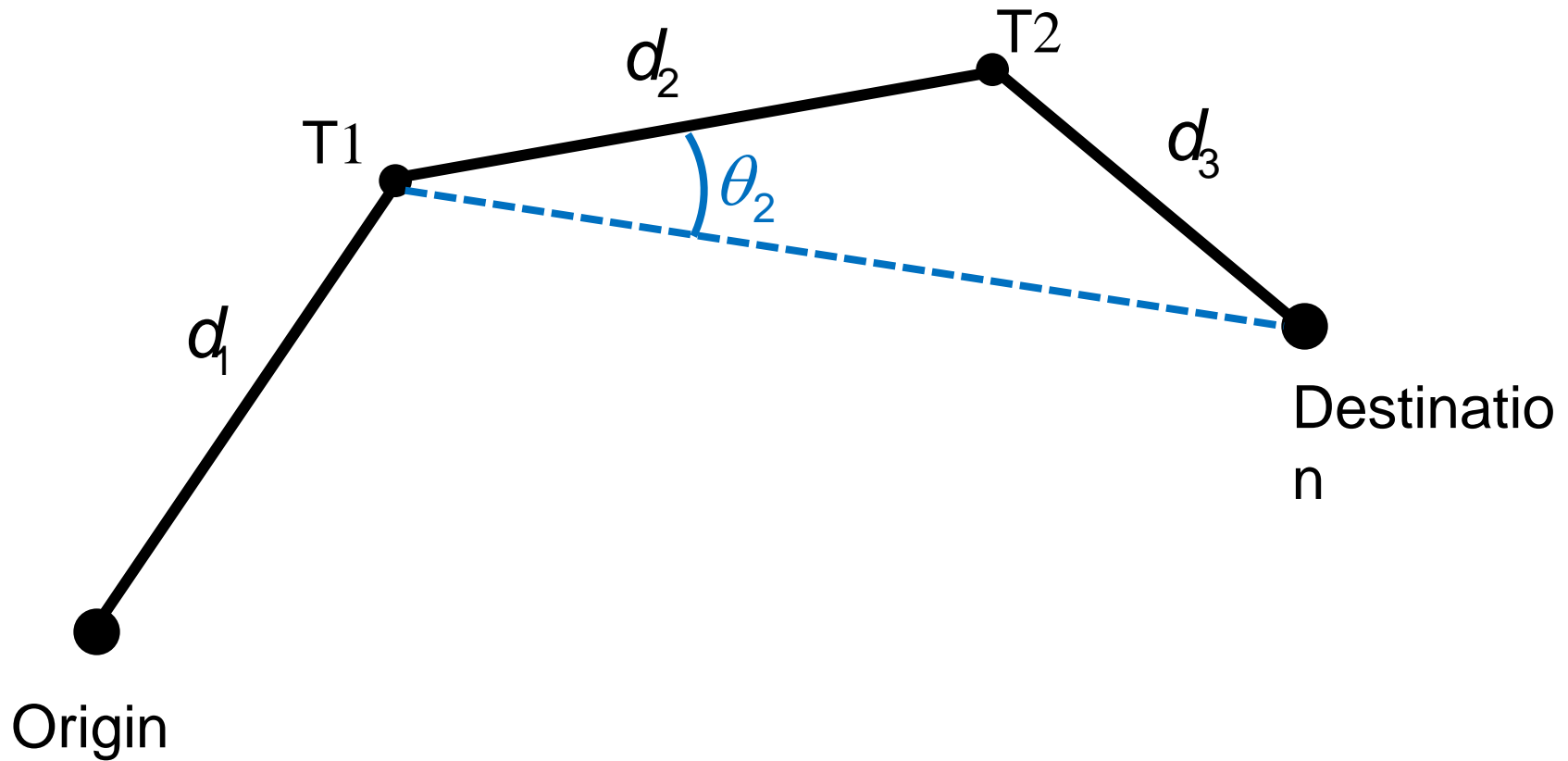
Angular Cost =

## What do people take into account?



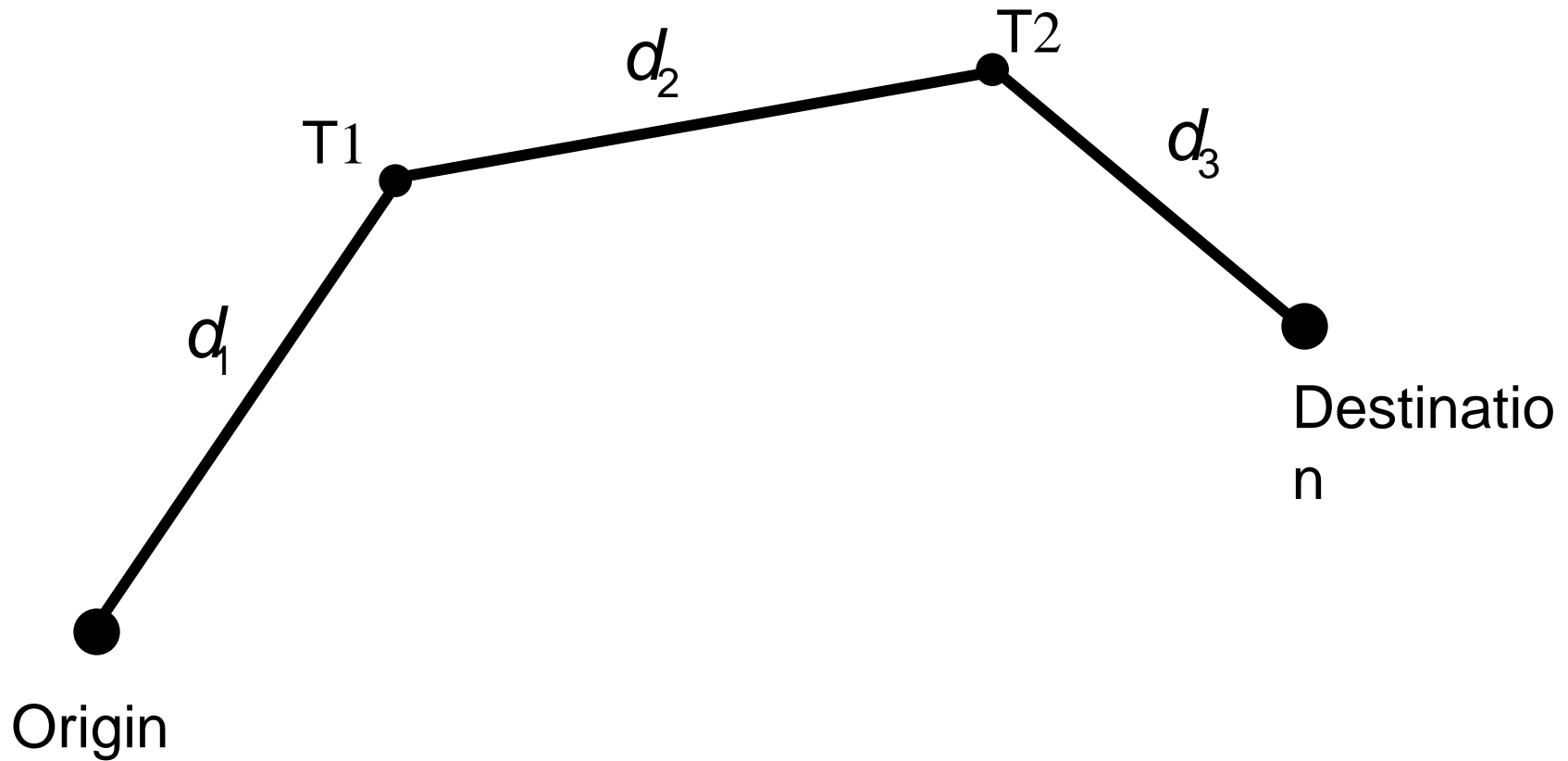
$$\text{Angular Cost} = d_1 \cdot \sin\left(\frac{\theta_1}{2}\right)$$

## What do people take into account?



$$\text{Angular Cost} = d_1 \cdot \sin\left(\frac{\theta_1}{2}\right)$$

## What do people take into account?



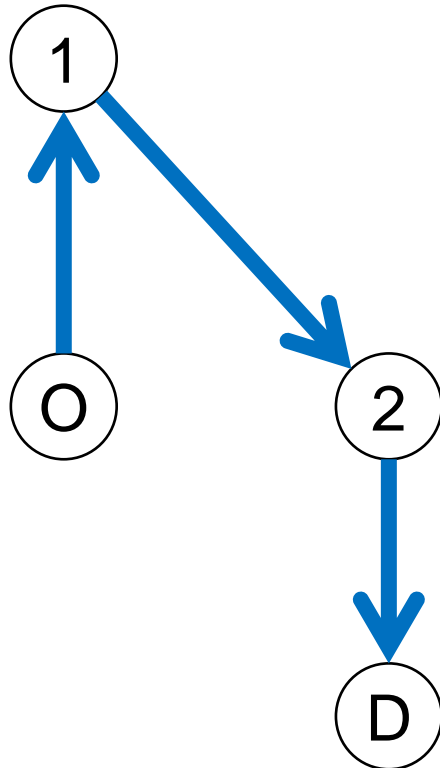
$$\text{Angular Cost} = d_1 \cdot \sin\left(\frac{\theta_1}{2}\right) + d_2 \cdot \sin\left(\frac{\theta_2}{2}\right)$$

## What do people take into account?

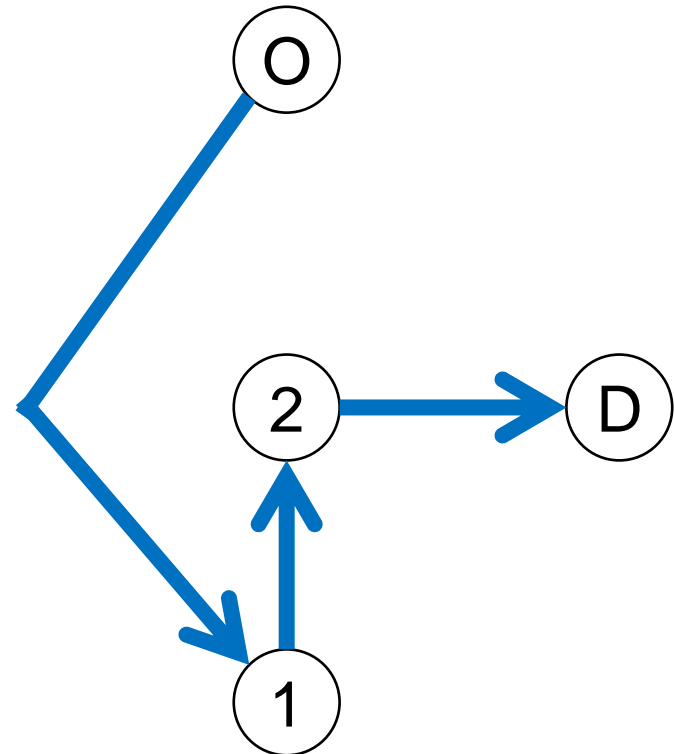
In-vehicle time	travel time components
Waiting time	
Walking time (when transferring)	
Number of transfers	transfer experience
Transfer stations layout	
Transfer stations infrastructure	
Mean occupancy	comfort and crowding
Possibility of not boarding	
Possibility of getting a seat	
Route distance	
Number of stations	
Angular cost	
Reasonable route	

# What do people take into account?

turning away from  
the destination



turning back to  
the origin



## What do people take into account?

In-vehicle time	travel time components
Waiting time	
Walking time (when transferring)	
Number of transfers	transfer experience
Transfer stations layout	
Transfer stations infrastructure	
Mean occupancy	comfort and crowding
Possibility of not boarding	
Possibility of getting a seat	
Route distance	topological variables
Number of stations	
Angular cost	
Reasonable route	based on schematic maps

# Comparing Santiago and London

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Santiago London 

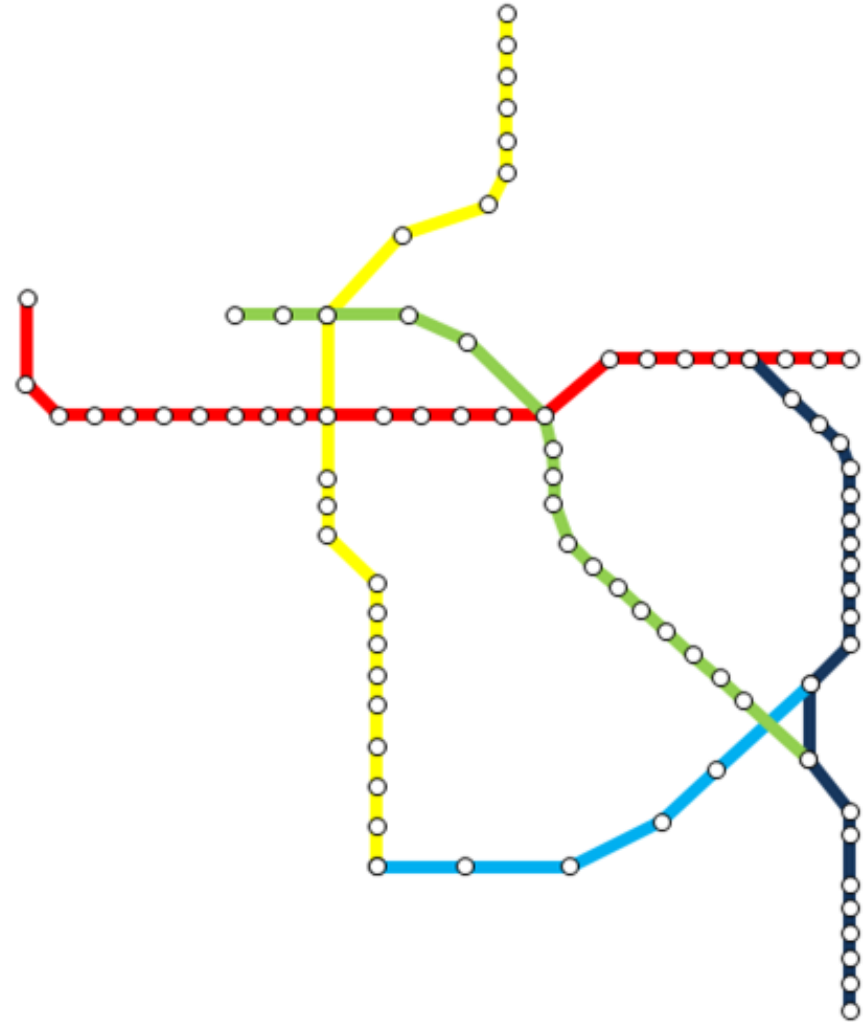
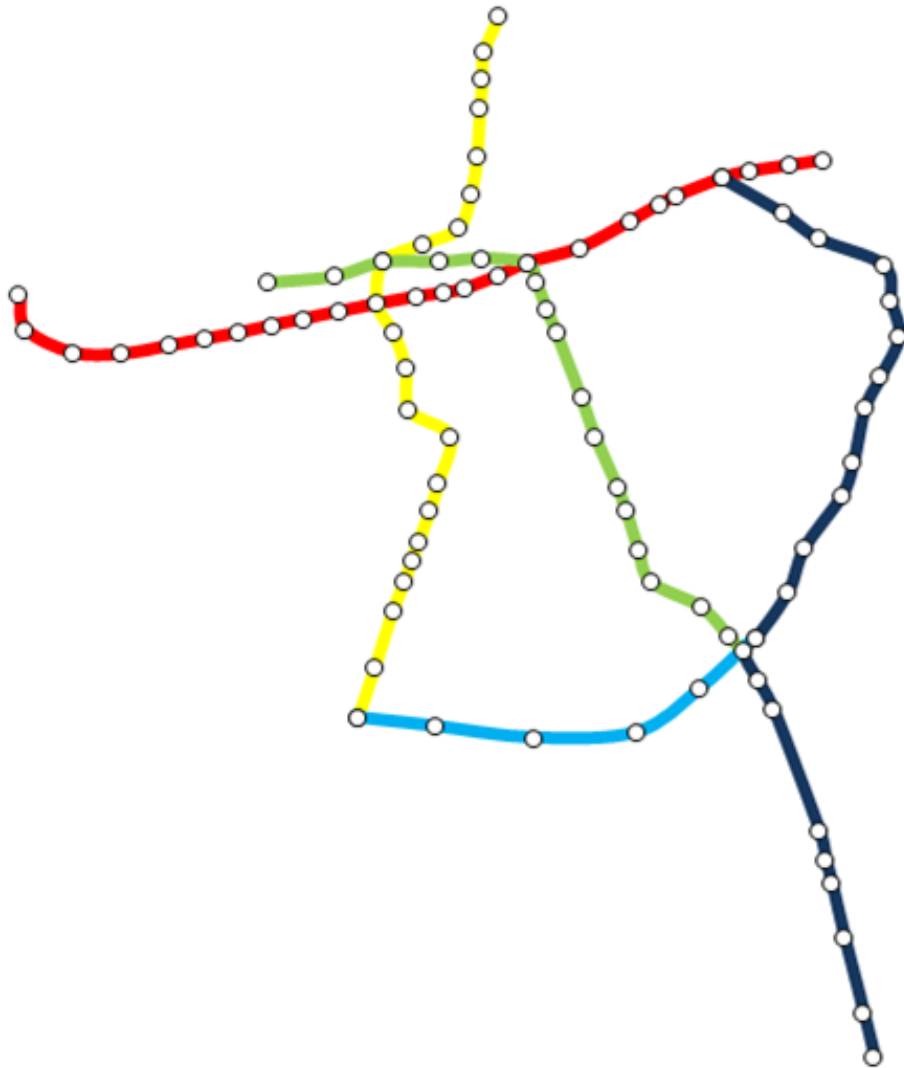
Survey date	2008	1998-2005
Length	78 Km	324 Km
Lines	5	11
Stations	85	255
Transfer stations	7	72
Daily trips	2,300,000	3,400,000
Survey size	28,961	16,300



# Comparing Santiago and London

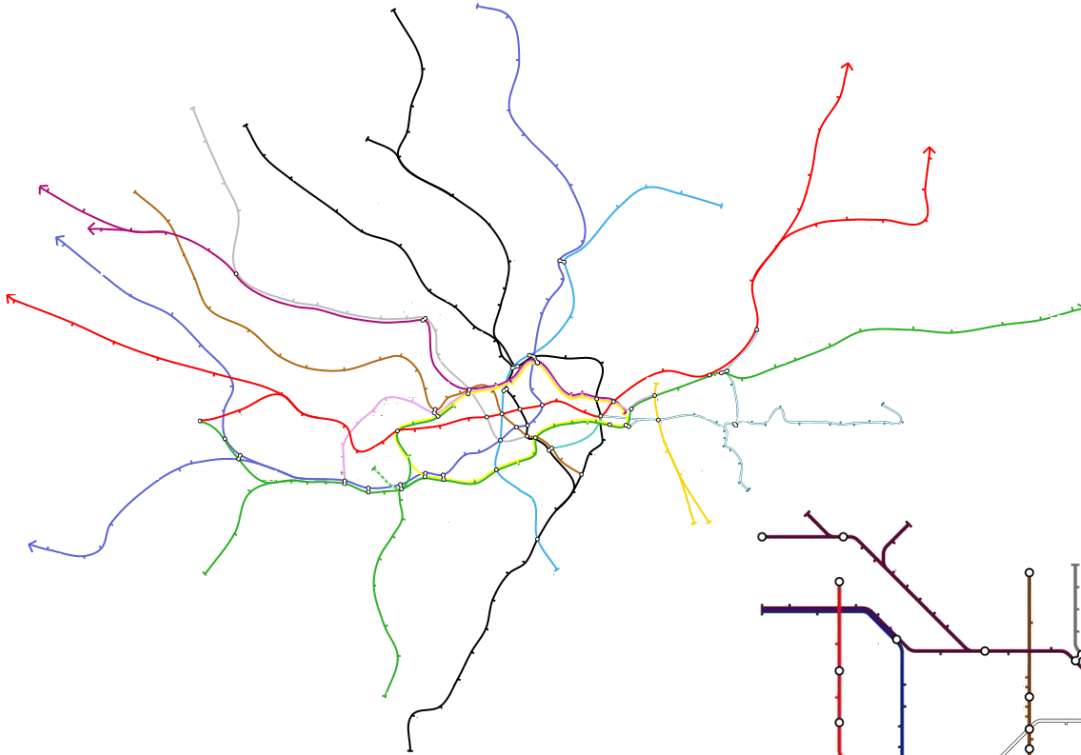
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## Santiago Metro

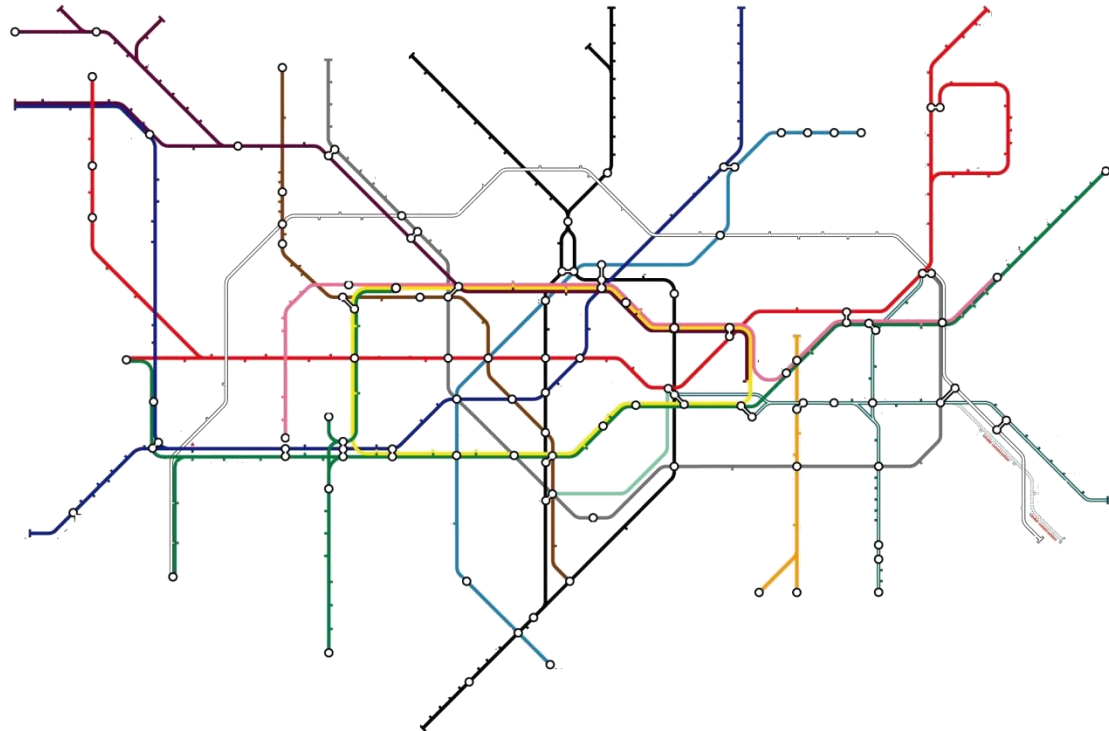


# Comparing Santiago and London

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## London Underground



## Set of alternative routes

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A key element when dealing with probabilistic route choice models is the definition of the **alternatives** for the OD pairs of interest

### Santiago

generated based on the actual choices

→ 2 to 4 alternative routes

### London

generated based on a labeling approach

→ 2 to 6 alternative routes

# Estimation results

Attribute	London Underground		Santiago Metro	
Travel Time	- 0.188	- 16.02	- 0.095	- 19.57
Waiting Time	- 0.311	- 7.39	- 0.139	- 5.07
Walking Time	- 0.216	- 6.14	- 0.155	- 8.23
Number of Transfers	- 1.240	- 4.37	- 0.632	- 4.06
<div style="display: flex; justify-content: space-between; align-items: center;"> <div style="font-size: 24px; font-weight: bold;">Parameter's signs</div> <div style="font-size: 36px; color: #0070C0;">😊 OK</div> </div>				
Semi-Assisted Transfers	- 0.328	- 6.83	n. a.	n. a.
Non-Assisted Transfers	- 0.541	- 6.79	- 0.262	- 6.23
Mean Occupancy	- 2.911	- 3.48	- 1.018	- 5.60
<div style="display: flex; justify-content: space-between; align-items: center;"> <div style="font-size: 24px; font-weight: bold;">Parameter's significances</div> <div style="font-size: 36px; color: #0070C0;">😊 OK</div> </div>				
Map Distance	- 0.358	- 5.76	- 0.274	- 5.69
Number of Stations	- 0.316	- 5.52	- 0.147	- 3.10
Turning Back	- 0.725	- 8.12	- 0.141	- 9.76
Turning Away	- 0.968	- 8.00	- 0.226	- 7.11
Adjusted $\rho^2$	0.566		0.382	

## Marginal rates of substitution

Attribute	London	Santiago
1 min waiting	1.65 min in-vehicle	1.46 min in-vehicle
1 min walking	1.15 min in-vehicle	1.62 min in-vehicle
1 (basic) transfer	6.60 min in-vehicle	6.63 min in-vehicle
1 % of occupancy	0.16 min in-vehicle	0.11 min in-vehicle
Seating	0.52 min in-vehicle	0.97 min in-vehicle
Not boarding	2.29 min in-vehicle	3.99 min in-vehicle
1 station	1.68 min in-vehicle	1.54 min in-vehicle
Turning back	3.86 min in-vehicle	1.48 min in-vehicle
Turning away	5.15 min in-vehicle	2.37 min in-vehicle

## Marginal rates of substitution

### Transferring valuations in London

Transfer Type		Getting a seat	Intermediate	Not boarding
Ascending	Assisted	6.81 min	7.33 min	9.62 min
	Semi-assisted	8.56 min	9.07 min	11.36 min
	Non-assisted	9.69 min	10.21 min	12.49 min
At level		3.35 min	3.87 min	6.15 min
Descending	Assisted	6.08 min	6.60 min	8.88 min
	Semi-assisted	7.82 min	8.34 min	10.63 min
	Non-assisted	8.95 min	9.47 min	11.76 min

## Marginal rates of substitution

### Transferring valuations in Santiago

Transfer Type		Getting a seat	Intermediate	Not boarding
Ascending	Assisted	9.05 min	10.02 min	14.01 min
	Non-assisted	11.80 min	12.77 min	16.76 min
Descending	Assisted	5.67 min	6.63 min	10.62 min
	Non-assisted	8.41 min	9.38 min	13.37 min

range in London

3.35 to 12.49 min

range in Santiago

5.67 to 16.76 min

## Information omission bias

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The omission of relevant information produces bias in the results

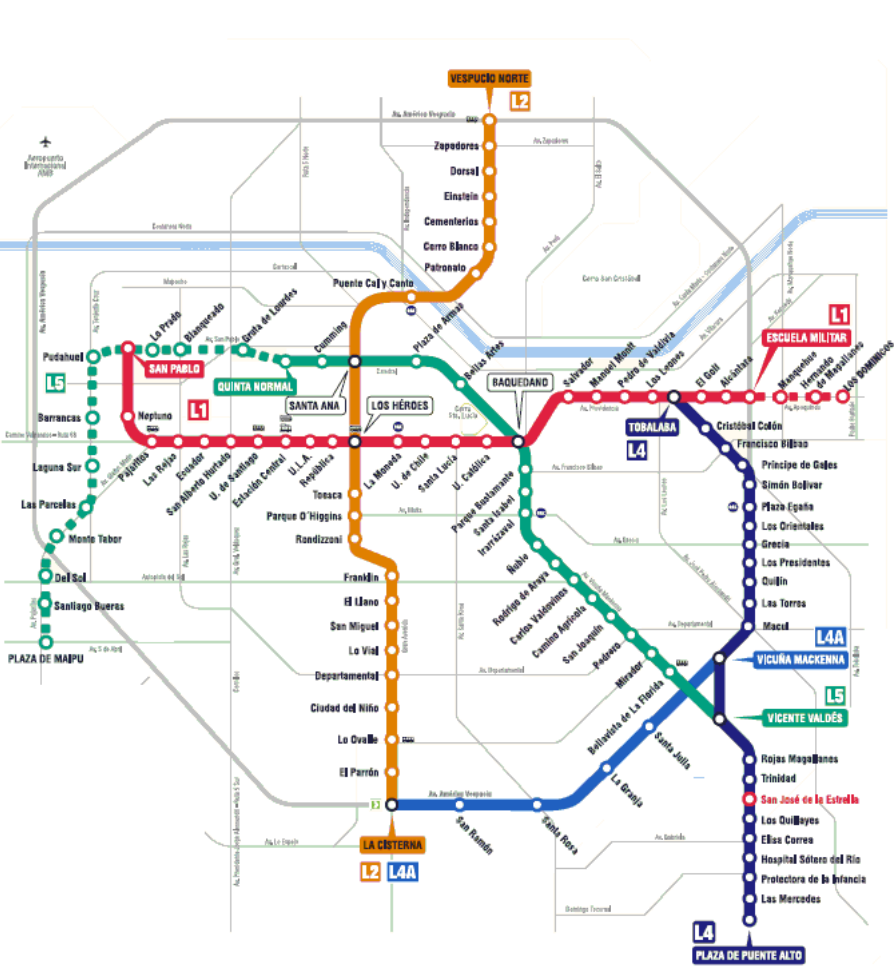
Model Specification	London		Santiago	
	$\theta_{\text{wait}} / \theta_{\text{travel}}$	$\theta_{\text{walk}} / \theta_{\text{travel}}$	$\theta_{\text{wait}} / \theta_{\text{travel}}$	$\theta_{\text{walk}} / \theta_{\text{travel}}$
Complete Model	1.65	1.15	1.46	1.62
without topological	0.61	0.46	2.36	2.09
without occupancy	1.67	1.17	2.48	1.81
without transfers	2.18	1.94	4.32	2.47
without all three	0.80	0.75	4.48	2.64

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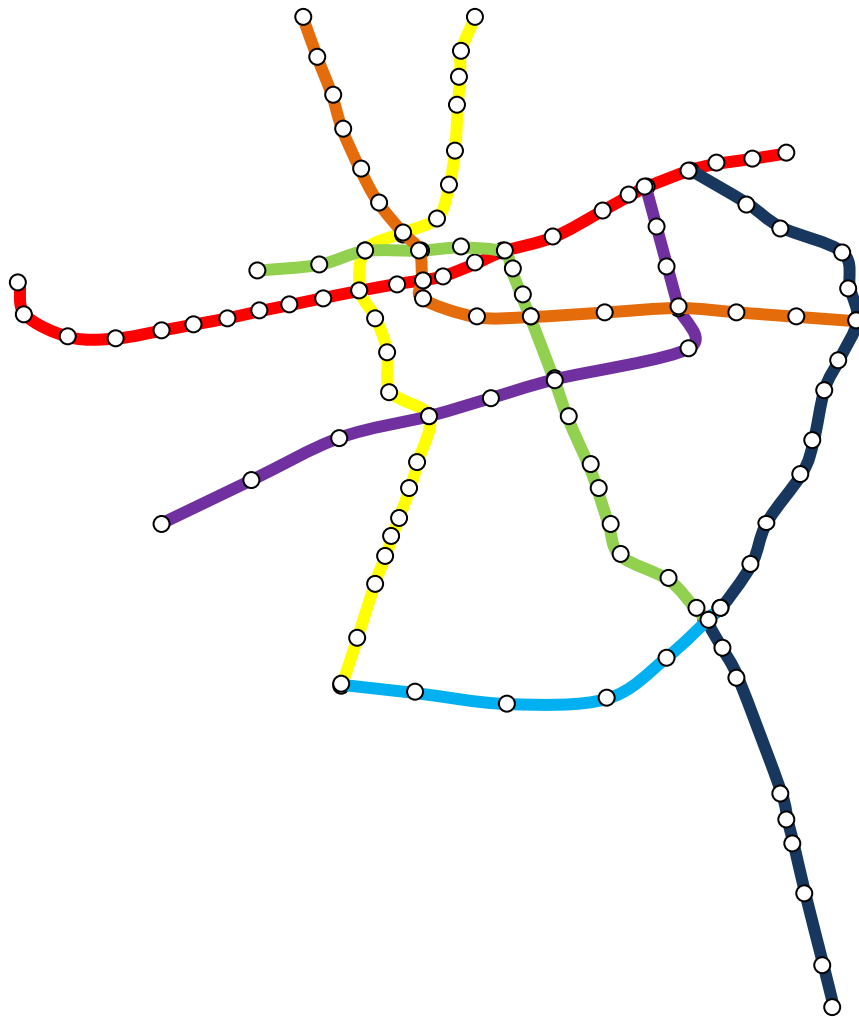
# So... what can we do with this?

## Change in the Santiago Metro schematic map



## So... what can we do with this?

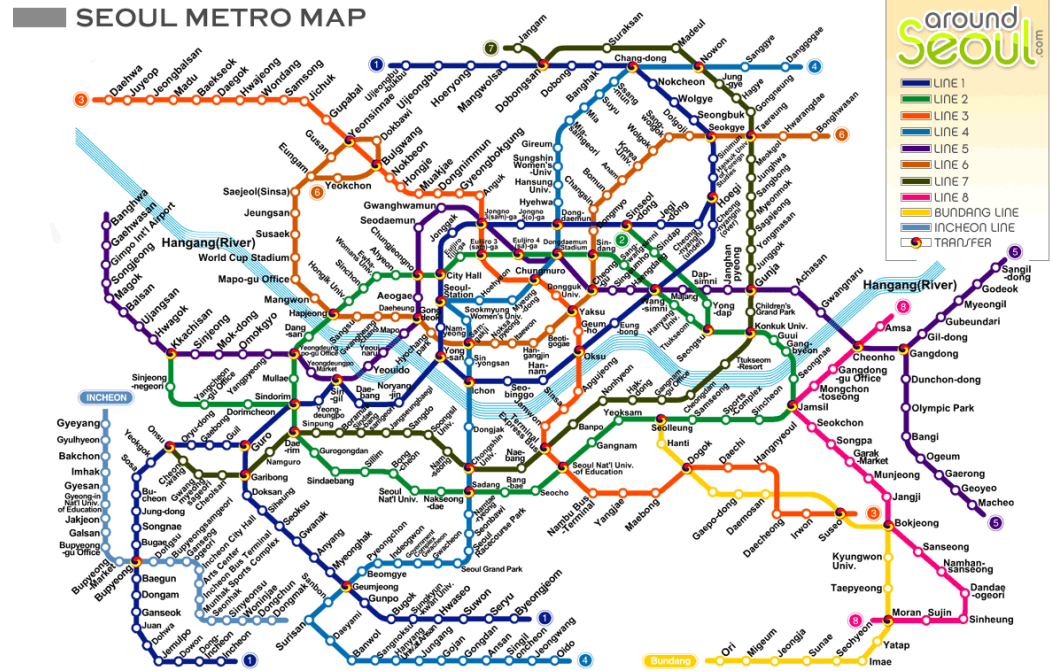
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Demand analysis for the  
design of transfer  
stations

# So... what can we do with this?

## Analyze and apply to any kind of transit network



# So... what can we do with this?

Create a trip planning that not only considers travel time, fare and/or transfers, but much more!

**Travelling from...** English Go

**From**

  
 Station or stop in:  
  
 Post code  
 Address  
 Place of interest  

---

For location help, try the following: [Tube map](#).  
[Street map](#)

**Travelling to...**

  
 Station or stop in:  
  
 Post code  
 Address  
 Place of interest  

---

For location help, try the following: [Tube map](#).  
[Street map](#)

I need to depart on 21 December 2011  
at: 17 : 49 hours

**Walking options**

---

I don't want to walk for longer than  minutes  
My walking speed is: Average  
 I'd rather walk if it makes my journey quicker

**Advanced options**

---

**Show me...**  
Select your preferred option:

The fastest routes  
 Routes with the fewest changes  
 Routes with the least walking between stops

I wish to travel via:

Station or stop in:   
 Post code  Address  Place of interest  
For location help, try the following: [Tube map](#). [Street map](#)

**My mobility requirements**

---

I cannot use stairs  
 I cannot use escalators  
 I cannot use lifts  
 I use wheelchair accessible vehicles  
Select any of the above statements that apply to you.  
For station access details [click here](#)

## What did you learn today?

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Public transport users take into account a **wide variety** of attributes when choosing routes

An incomplete model **specification** can result in biased results, such as attributes valuations

Network's **topology**, and specially the way it's presented to users on a daily basis, is relevant

## What did you learn today?

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Due to bigger distortions in the schematic map, the **topological variables** are more important in London

Londoners are more willing to **transfer**, as it is more common to them (bigger and denser network)

Londoners are less willing to travel in **crowded trains**, but care less about getting a seat



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