ACCESSIBILITY AND EQUITY
THE CASE OF SANTIAGO, CHILE

Ignacio Tiznado
Ricardo Hurtubia
Juan Carlos Muñoz
Outline

- Santiago, Chile
  - Urban segregation and income inequality
  - Accessibility to opportunities: evolution of activity center
- Employment accessibility
- New accessibility measures
  - Incorporating quality of service
- Application and case study
- Conclusions and future work
Santiago, Chile

- Surface: 640 km²
- Density: ~8000 people/km²

Socioeconomic segregation:
- 1970-1990: Low-income households expelled to periphery (Sabatini et al., 2009)
- East Zone: agglomeration of high-income (Rodriguez, 2008)

Average income per person, USD 2012 (Source: Niehaus, Galilea & Hurtubia (2016), based on O-D Survey (2012))
Santiago, Chile

- Gini coefficient: **0.503** (MDS, 2013)
  - High, compared with developed countries. Worst within OECD countries (2014)
- 9.2% of population live in poverty situation
  - Only 6.19% of them are located on east zone
- Increased car ownership

### Car ownership

<table>
<thead>
<tr>
<th>Year</th>
<th>Cars per household</th>
</tr>
</thead>
<tbody>
<tr>
<td>1991</td>
<td>0.3</td>
</tr>
<tr>
<td>2001</td>
<td>0.5</td>
</tr>
<tr>
<td>2012</td>
<td>0.6</td>
</tr>
</tbody>
</table>

Santiago, Chile

But 59% of households does not have access to car (captive public transport users)

Source: O-D Survey from 2012
Transantiago
Modal split evolution

Population distribution

Pudahuel 225,000
Maipú 525,000
Total 750,000
Population distribution
Population distribution

- Lo Barnechea: 97,000
- Vitacura: 84,000
- Las Condes: 283,000
- La Reina: 92,000
- Providencia: 126,000

Total population: 682,000
Activity center evolution

1970

- Population: 750,000
- Map showing urban areas and population distribution.

682,000

1,570,000
Activity center evolution

1980

750,000

682,000

1,570,000
Activity center evolution

1990

- 750,000
- 682,000

1.570.000
Activity center evolution

From 2000

750,000

682,000

1,570,000
Activity center evolution

¿Future?

750,000

682,000

1,570,000
Causes

- Land use planning instruments are often weak
- Lack of integrated land use and transport planning
- 37 communes, each with their own mayor, budget and regulations (Lack of metropolitan authority)
- Loose requirements for new real estate developments
  - Conditioned Urban Development Zones
  - Social housing (conditions to benefit from subsidies)
    - Less than 500 meters from public transport
Consequences

- **Low accessibility** to activities and urban services
- Travel time increase in lower-income communes due to peripheral location (Sabatini et al., 2001; Rodriguez, 2008)
- Big impact in terms of equity and social exclusion (Hidalgo, 2007; Rivera, 2012)
- Hard to overcome through just improvement of the transport system
Transit accessibility to employment

- Based on strategic four step model (ESTRAUS)
  - $E_j$: number of opportunities in $j$
  - $c_{ij}$: generalized cost (fare, travel, walking and waiting time)

- Similar to several accessibility measures found in the literature ((Handy & Niemeier (1997), Kwan (1998), van Wee et al. (2001), Geurs & van Wee (2004))

$$A_i = \sum_j E_j \cdot \exp(\beta \cdot c_{ij})$$

Source: Niehaus, Galilea & Hurtubia (2016)
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Average income per person, USD 2012 (Source: Niehaus, Galilea & Hurtubia (2016), based on O-D Survey (2012))
Public transport accessibility

- Few research on this topic (Martin et al., 2002)
- Most studies focus only on physical accessibility (Lei & Church, 2010)
- Quality of service is usually not taken into account
Quality of service

Transit stops

Santa Rosa  San Bernardo  Las Condes
Quality of service

Environment

La Pintana

Providencia
Quality of service

Environment

Peñaflor or Lo Barnechea
Quality of service

Comfort
We want to include all these aspects in an expanded accessibility measure.
Application

- **Physical accessibility** to 10 closer transit stops
  - Logistic function and speed of 3 km/hr
  - Calibration based on observed trips (O-D survey, 2012)
  - Values: 0 to 1 for each transit stop (Max value: 10)

- Infrastructure and environmental quality index
  - Index based on “perceived” cleanliness, security, streets/sidewalk’s quality, environment
  - All components are binary, except streets/sidewalk’s quality
  - Values for index: 2 to 20
Physical accessibility and LOS
Equity?

<table>
<thead>
<tr>
<th>Trips</th>
<th>Communes</th>
<th>Level of service</th>
</tr>
</thead>
<tbody>
<tr>
<td>21.01%</td>
<td>Las Condes, Huechuraba,</td>
<td>13.07 / 20</td>
</tr>
<tr>
<td></td>
<td>Providencia, Ñuñoa,</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Lo Barnechea, Vitacura</td>
<td></td>
</tr>
<tr>
<td>21.01%</td>
<td>Puente Alto, Maipú,</td>
<td>9.63 / 20</td>
</tr>
<tr>
<td></td>
<td>San Bernardo, Estación</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Central, La Pintana,</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Quinta Normal</td>
<td></td>
</tr>
</tbody>
</table>
What about the quality of service of public transport?
## Motivation

<table>
<thead>
<tr>
<th>Component</th>
<th>Trip 1</th>
<th>Trip 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>On board time (mins)</td>
<td>17</td>
<td>12</td>
</tr>
<tr>
<td>Waiting time (mins)</td>
<td>3</td>
<td>5</td>
</tr>
<tr>
<td>Walking time (mins)</td>
<td>5</td>
<td>8</td>
</tr>
<tr>
<td>Transfers</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Comfort (p/m²)</td>
<td>3</td>
<td>5</td>
</tr>
<tr>
<td><strong>Total (mins)</strong></td>
<td><strong>25</strong></td>
<td><strong>25</strong></td>
</tr>
</tbody>
</table>
Proposal

- Incorporate quality of service to accessibility measures
- Data coming from observed smartcard transactions
- Accounting for:
  - Disaggregate total travel time (waiting, walking, on board)
  - Penalty for bad quality of service (transfers, crowding, unreliability)
### How to do it?

**Travel time**

Wardman (2001): Times and quality of service ratings are measured in units of ‘in-vehicle time’ (IVT)

<table>
<thead>
<tr>
<th>Component</th>
<th>Equivalency</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>Walking and waiting time</td>
<td>1.6 times (average in UK studies)</td>
<td>Wardman (2001)</td>
</tr>
<tr>
<td>Reliability</td>
<td>CoV and percentile for travel and waiting times</td>
<td>Marguier &amp; Ceder, 1984; Chen et al., 2003</td>
</tr>
<tr>
<td>Transfers</td>
<td>Penalty: 2 to 22 minutes</td>
<td>Currie, 2005; Raveau et al., 2014</td>
</tr>
<tr>
<td>Comfort</td>
<td>Perceived time is 1 to 2.2 times IVT, depending on crowding level</td>
<td>Whelan &amp; Crockett, 2009; Tirachini et al., 2013</td>
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Example

- Trip to Santiago Centro from San Miguel and Las Condes
- What is the difference in terms of quality of service between this two communes?

Total travel times (not include walking and waiting times) to Santiago Centro and Providencia. Morning peak, April 2013
(Source: DTPM (2013))
Case study: Metro

Source: 2gis.cl
Case study: Bus
## Case study

<table>
<thead>
<tr>
<th>Quality of service</th>
<th>Las Condes</th>
<th>San Miguel</th>
</tr>
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<tbody>
<tr>
<td></td>
<td>Metro</td>
<td>Bus</td>
</tr>
<tr>
<td>Distance</td>
<td>9,4 km</td>
<td>10 km</td>
</tr>
<tr>
<td>Total travel time</td>
<td>31 mins</td>
<td>47 mins</td>
</tr>
<tr>
<td>Waiting time</td>
<td>1,78 mins</td>
<td>5,1 mins</td>
</tr>
<tr>
<td>Walking time</td>
<td>15 mins</td>
<td>16,3 mins</td>
</tr>
<tr>
<td>Comfort</td>
<td>4-5 p/m²</td>
<td>3-4 p/m²</td>
</tr>
<tr>
<td>Reliability</td>
<td>0,59</td>
<td>0,907</td>
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Source: 2gis.cl and data from DTPM & Metro (2015)
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Source: 2gis.cl and data from DTPM & Metro (2015)
What this means?

- In terms of accessibility and equity, the level of service may have a big impact.

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<tr>
<th>Component</th>
<th>Las Condes (Metro)</th>
<th>San Miguel (Metro)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Classic measure</td>
<td>Expanded measure</td>
</tr>
<tr>
<td>On board (mins)</td>
<td>14.22</td>
<td>14.22</td>
</tr>
<tr>
<td>Waiting time (mins)</td>
<td>1.78</td>
<td>2.85</td>
</tr>
<tr>
<td>Walking time (mins)</td>
<td>15</td>
<td>24</td>
</tr>
<tr>
<td>Comfort (multiplicator)</td>
<td>-</td>
<td>X1.2</td>
</tr>
<tr>
<td>Total (IVT)</td>
<td>31</td>
<td>49.3</td>
</tr>
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Conclusions

- Evident inequity in Santiago
  - Urgent need to address problems of land use and transport planning
  - Communal budgets are poorly distributed. Metropolitan government?
  - Need to invest in public transport quality

- Accounting for quality of service allows to observe real differences in terms of unequal access to opportunities.
  - Effect of environment and urban infrastructure
  - Effect of level of service
Recommendations

- If you are going to evaluate transportation projects, CBA may not be enough. Accessibility and equity indexes are needed.
- If you are going to measure accessibility for equity purposes, you should consider quality of service and users perception
- Land use planning should encourage new subcenters (but, how do we do this?)
Some questions

- Increased motorization rate is sustained over time. More and more people “leaves” public transport
  - Should we focus on benefiting captive public transport users or on discouraging car use?
  - Or should we allow people to “do whatever they want” and provide the required infrastructure

- What should we deal with first?
  - Waiting time? Comfort? Reliability?
  - Which changes would have the most impact and which are more feasible?

- Are we still in time to revert the poor land use policies from last 40 years?
References


- Niehaus, M., Galilea, P. and Hurtubia, R. (2015). Accessibility and equity indicators: approach for wider transport project assessment in Chile. International Conference Series on Competition and Ownership in Land Passenger Transport (THREDBO 14), Santiago, Chile, August 30 - September 3
References


DTPM (2013). Travel times to Santiago Centro

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Application

- Accessibility to 10 closer transit stops
- Logistic function and speed of 3 km/hr

\[ A_i = \sum_{j \in \varnothing} f(t_{ij}) \]

\[ f(t_{ij}) = \frac{1}{1+\alpha e^{-\beta t_{ij}}} \]