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Better or Worse Job Accessibility? Understanding Changes in Spatial Mismatch at the Intra-Urban Level in Medellín

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The views expressed are those of the authors and not necessarily those of Banco de México.

Research Summary

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- **What we do**
  - We measure job spatial mismatch in Medellín, Colombia at the intra-urban level and analyze how it has changed over time.
- **How we do it**
  - We calculate mismatch by measuring access to jobs through different transportation modes using travel times and transportation costs.
  - We propose an adjusted accessibility measure that allows comparisons across places and over time.
- **What we find**
  - Spatial mismatch has increased in Medellín between 2012 and 2017.
  - Job accessibility is higher by using private transportation.
  - Investment in public transport has been insufficient to mitigate the increase in spatial mismatch.

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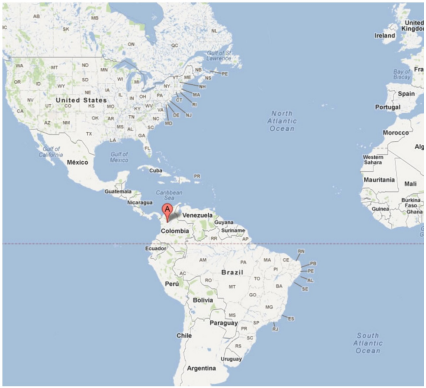
Motivation

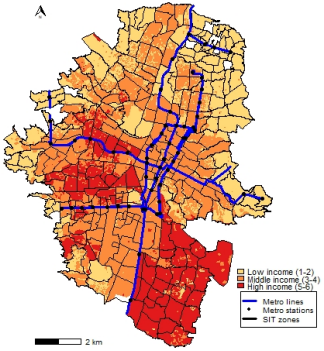
- **Why Medellín?**
  - It is the second-largest city in Colombia, with a population of 2'427,000 and a population density of 6568/km^2.
  - Only city in the country with a metro system.
  - High transport investment and policies to promote public transport in the last few years.



Source: Google Maps.

Motivation-Medellín

Figure: SIT zones and income



Source: Medellín OD survey 2017.

Contribution

- Show evidence of spatial mismatch at the intra-urban level in the context of a developing country.
  - Most other evidence is from developed countries.
  - Few studies that analyze mismatch within cities.
- Propose an adjusted accessibility measure that can be compared over time with incomplete data.

Related Literature

- **Spatial mismatch**
  - Kain (1968), Gobillon et al. (2007).
- **Consequences of spatial mismatch**
  - Job-education mismatch (Di Paolo et al., 2017; Hensen et al., 2009) .
  - Transportation costs and wages (Zenou, 2009; Dauth and Haller, 2019).
- **Examples of spatial mismatch**
  - Taylor and Bradley (1997), Stacy et al. (2019).

Accessibility We use a Hansen (1959) equation adapted from Di Paolo et al. (2017):

$$A_{i,m} = \sum_{j} \frac{emp_{j,t}}{r_{i,j,m,t} \times \bar{w}_t + c_{i,j,m,t}}, \quad r_{i,j,m,t} > 0, \tag{1}$$

Where:

- $A_{i,m}$: Job accessibility in zone i using transport mode $m \in \{private, public\}$.
- $emp_{j,t}$: Number of jobs in zone j.
- $r_{i,j,m,t}$: Travel time from zone i to j using transport mode m.
- $\bar{w}_t$: Average wage in period t.
- $c_{i,j,m,t}$: Transport cost going from i to j using transportation mode m in period t.

Data

- Travel data comes from Medellín's Origin-Destination survey ("Encuesta Origen-Destino", EOD) for 2012 and 2017.
- The survey provides information about travel times and trips in Medellín and its Metropolitan Area. It includes self-reported travel times and SIT zones geographies.
- For 2017, we have information for 310 zones and for 2012 we have information of 250 zones.

Employment

- The total number of jobs in Medellín increased from $1'655,000$ to $1'799,000$ between 2012 and 2017, an 8% increase
- We approximate the spatial distribution of employment at the SIT level by using the number of trips to work to each to each SIT zone inside a commune.
- We assume that the number of trips to work in the EOD is similar to the real distribution of jobs within commune in Medellín.

Data

- **Travel times**
  - For 2017, we use Google and Bing for public and private transport, respectively.
  - For 2012, we use information from the EOD to back-cast travel times.
    - We use reported travel time when data is available.
    - When data is not available, we use the mean travel time variation by zone between years.
- **Wage and transportation costs**
  - We calculate average wages for Medellín using data from the Life Quality Survey (Encuesta de Calidad de Vida)
  - We use the average city-wide wage for both years.
  - The cost for public transportation is the Metro fare in each year.
  - We assume that for travel distances larger than 10km, travelers pay for two rides.
  - Private transportation costs are a proportion of the public transportation costs. We calculate the proportion using the Income and Expenditure Survey.

- **Adjusted accessibility**
  Allows us to compare accessibility between years with different sample sizes because of missing data.

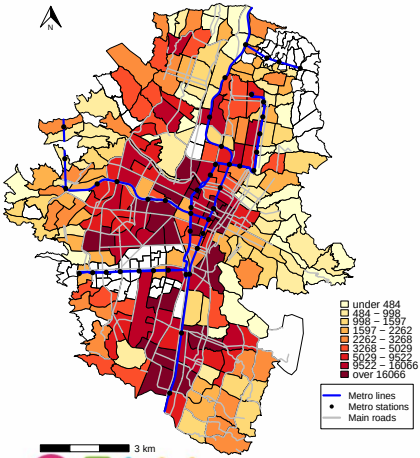
$$\hat{A}_{i,m} = A_{i,m,t} \times \frac{1}{n_t} \tag{2}$$

Where:

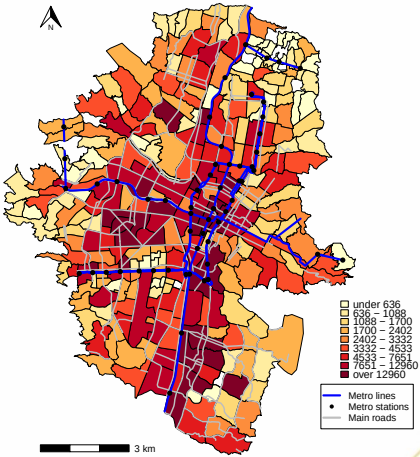
- $\hat{A}_{i,m}$: Adjusted accessibility in zone i.
- n_t: Sample size in period t. (Zones)

Descriptive Statistics

(a) Employment - 2012



(b) Employment - 2017



Source: EOD of Medellín 2012-2017 and authors' calculations.

Descriptive Statistics

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Table: Computed and Reported travel times (minutes)

Transport mode	Mean 2012	Mean 2017	Diff means 2017-2012	% Diff means 2017-2012
A. Computed travel times				
Private	20.20	24.87	5.28	23.1%
Public	51.64	55.08	3.45	6.65%
B. Reported travel times				
Private	24.86	30.14	5.29	21.26%
Public	39.14	45.44	6.30	16.08%

Note: Panel A shows computed travel times. These computed travel times come from an origin destination matrix where each trip is counted once. Panel B shows travel times reported by individuals in EOD, where only one trip is counted per person. The last two columns show the level and the percentage difference in mean travel times between 2017 and 2012. Computed travel times take into account all the possible trips in the origin-destination matrix, while reported travel times only consider the trips that are actually made.

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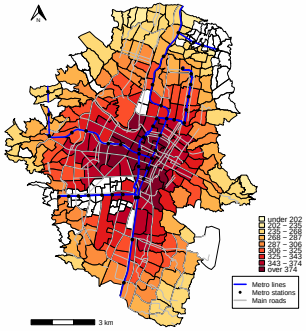
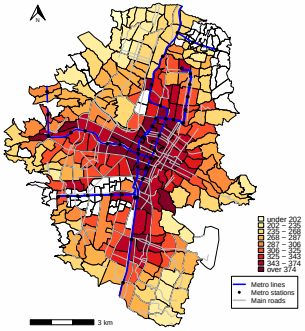
Results-Job Accessibility in 2012

(a) Private



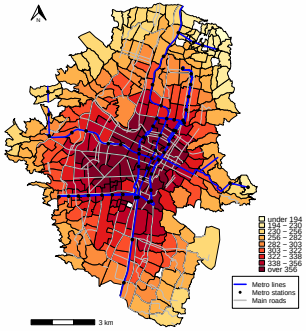
(b) Public



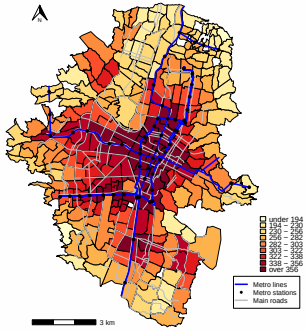
Source: EOD of Medellín 2012-2017 and authors' calculations.

Results-Job Accessibility in 2017

(a) Private



(b) Public



Source: EOD of Medellín 2012-2017 and authors' calculations.

Results-Changes in Adjusted Accessibility 2012 - 2017 (%)

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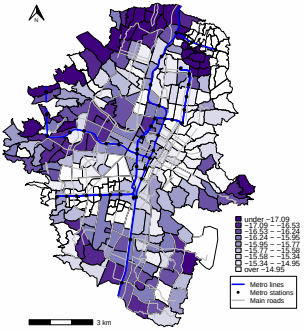
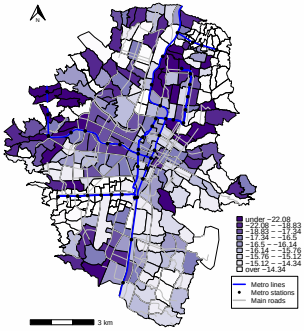
(a) Private



(b) Public



Source: EOD of Medellín 2012-2017 and authors' calculations.

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Results-Summary

Table: Accessibility

Transport mode	Mean 2012	Mean adjusted 2012	Mean 2017	Mean adjusted 2017	Diff adjusted	%Diff adjusted
Private	310.32	1.19	307.47	1.00	-0.19	-15.77%
Public	305.01	1.17	303.72	0.99	-0.18	-15.37%
Diff	5.31	0.02	3.75	0.01		

Conclusions

- Spatial mismatch increased indistinctly in Medellín between 2012 and 2017, and by a larger proportion for private transport.
- Accessibility to jobs through private transport is larger.
- Despite of the increases in employment and public transport investment, spatial mismatch increased.
- Possible policies: Telecommuting, housing near industrial centers.

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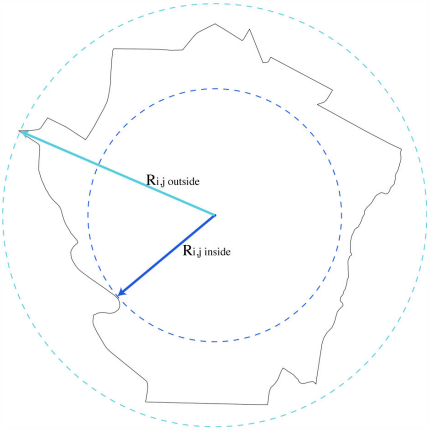
Travel Times Inside the Same Zone

- To calculate the travel time inside the same zone, we use the following formula:

$$t_{i,i,m} = \frac{R_{i,outside} + R_{i,inside}}{2} * AVS_m \tag{3}$$

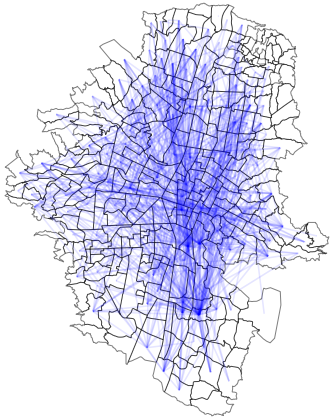
- For each zone and its centroid, $R_{i,outside}$ is the radio of the minimum circle that contains zone i and the center is the centroid. On the other hand, $R_{i,inside}$ is the radio of the maximum circle that can be contained in zone i which center is the same centroid. To convert to time we multiply it by AVS_m, which is the average speed per minute using the transport mode m.

Travel Times Inside the Same Zone

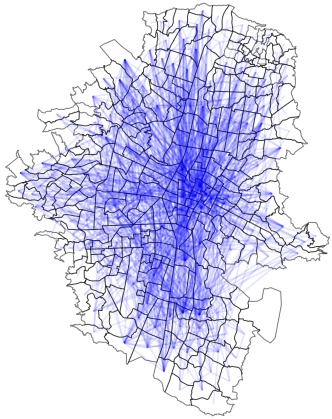


Desire Lines for 2017 and 2012

(a) 2012



(b) 2017



Source: EOD of Medellín 2012-2017 and authors' calculations.
Note: In order to get a clear picture of the trips, it considers combinations of trips which are repeated two times or more. Each line has an origin and a destiny.

Employment by SIT Zone

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We approximate the spatial distribution of employment with the next formula:

$$emp_i = empMed * \frac{W_h * empODC_{h(i)}}{\sum_h W_h * empODC_{h(i)}} * \frac{empOD_i}{\sum_{i \epsilon h} empOD_i} \quad (4)$$

Where:

- emp_i: Number of jobs in the zone i.
- $empMed$: Number of jobs in the city.
- W_h : Expansion factor at the commune h.
- $empODC_{h(i)}$: Number of trips to work to the commune h (where the SIT zone i belongs).
- $empOD_i$:Number of trips to work to the SIT i.

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Travel Times

- For 2017, we use Google and Bing for public and private transport respectively.
- For 2012, we use the next rule:

$$r_{i,j,m}(2012) = \begin{cases} r_{i,j,m}(2017) - (sr_{i,j,m}(2017) - sr_{i,j,m}(2012)) & \text{if data is available,} \\ r_{i,j,m}(2017)(1 + \Delta\overline{sr}_{m,h(i)}) & \text{if data is not available.} \end{cases} \quad (5)$$

Where:

- $sr_{i,j,m}(t)$: Reported times from i to j using m during period t.
- $\Delta\overline{sr}_{m,h(i)}$: The average difference of reported times in commune h using transportation mode m.