

IAPS 2020 - 26th conference

June 21-26 - Québec

Relationships to time and space in a context of urban change: some findings from “space-time of action” analysis in Bogotá (1993-2009)

Symposium 09 - Autonomy and independence in urban environments. Between youth and old age, what inequalities and opportunities over life cycles?



Florent Demoraes, Vincent Gouëset



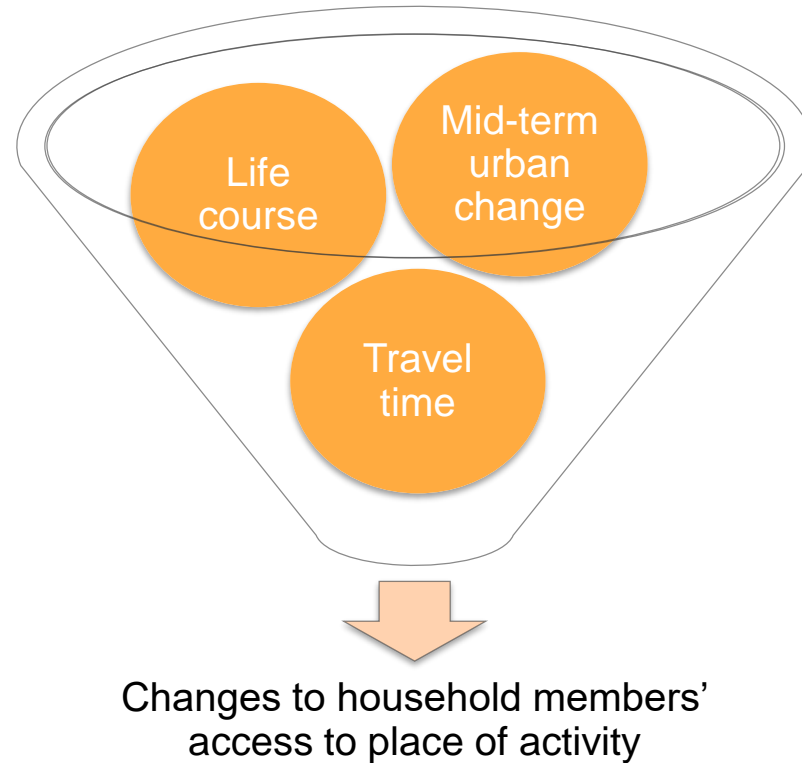


Household trips and joint changes

- ▶ Benefits of studying jointly the mobility of household members
→ Daily trips originate in the same dwelling whose location influences each members' mobility practices (children)
- ▶ Some may benefit to the detriment of others in terms of daily travel distance or time. Indeed the times and modes of transport of each individual tend to influence those of the others (Pratt, Hanson, 1991; Singell, Lillydahl, 1986)
- ▶ Few exceptions (Aguiléra et al., 2010; Berger, Beaucire, 2002; Fyhri et al., 2011), these studies examine joint mobility practices at a given point in time → no information about how they change over the course of one or two decades
- ▶ Inspired from time-geography (Hägerstrand, 1970) and from spatial analysis, we examine mid-term changes to household members' access to place of activity in the city



Three dimensions of time



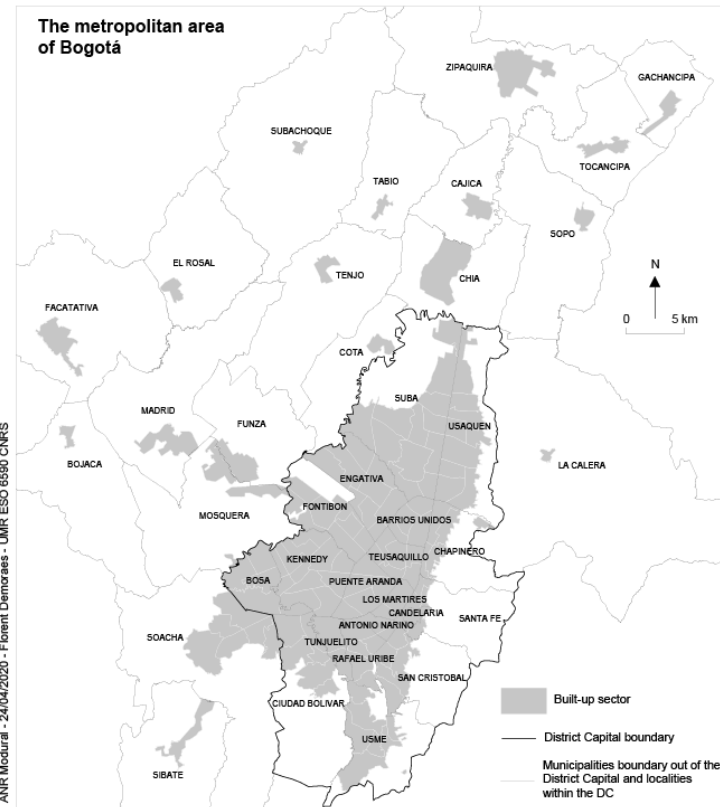


Study Area

Bogotá, a city undergoing transformation



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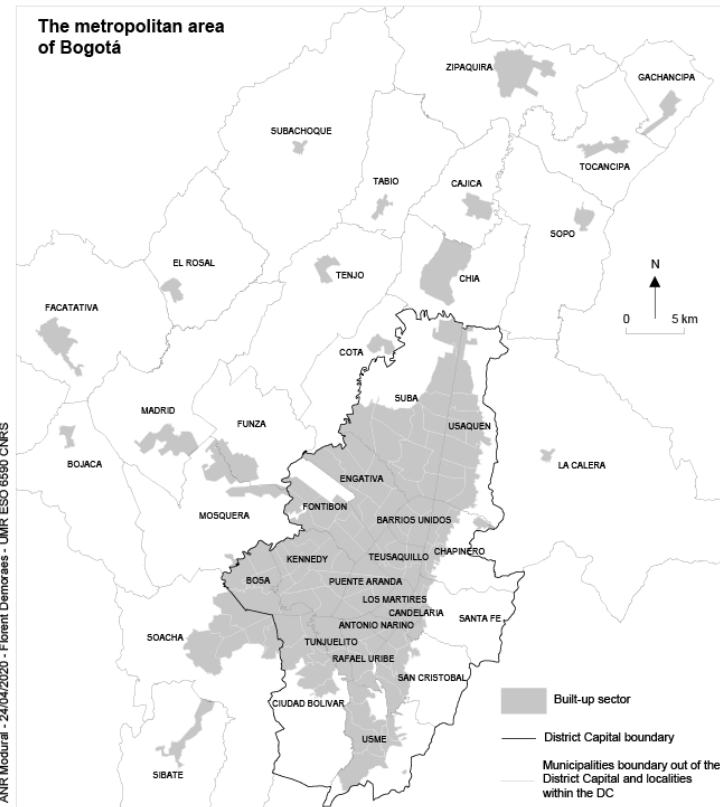
Study Area

Bogotá, a city undergoing transformation

4.9 millions inhabitants in 1993



© V. Gauésset





Study Area

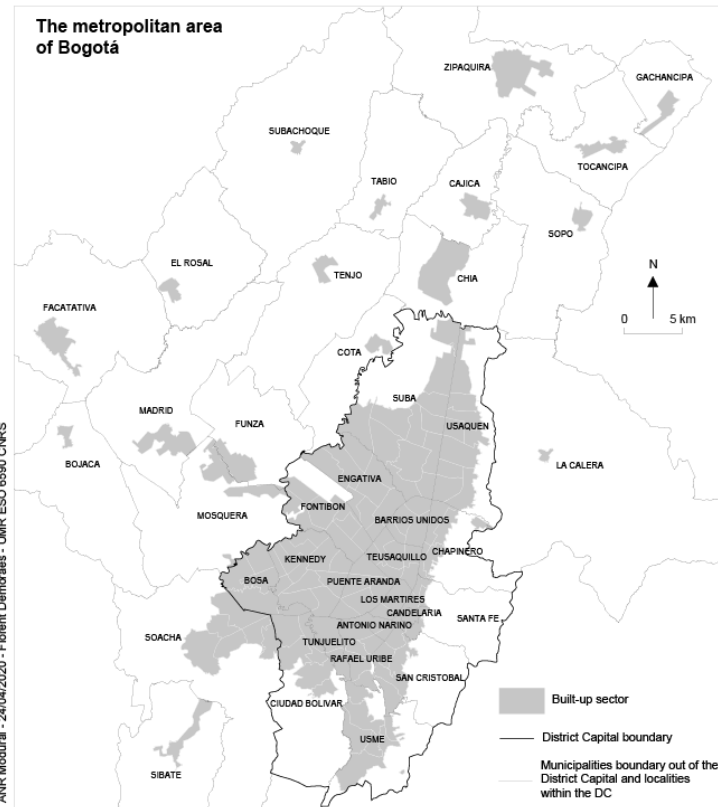
Bogotá, a city undergoing transformation

4.9 millions inhabitants in 1993

6.7 millions inhabitants in 2005



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Study Area

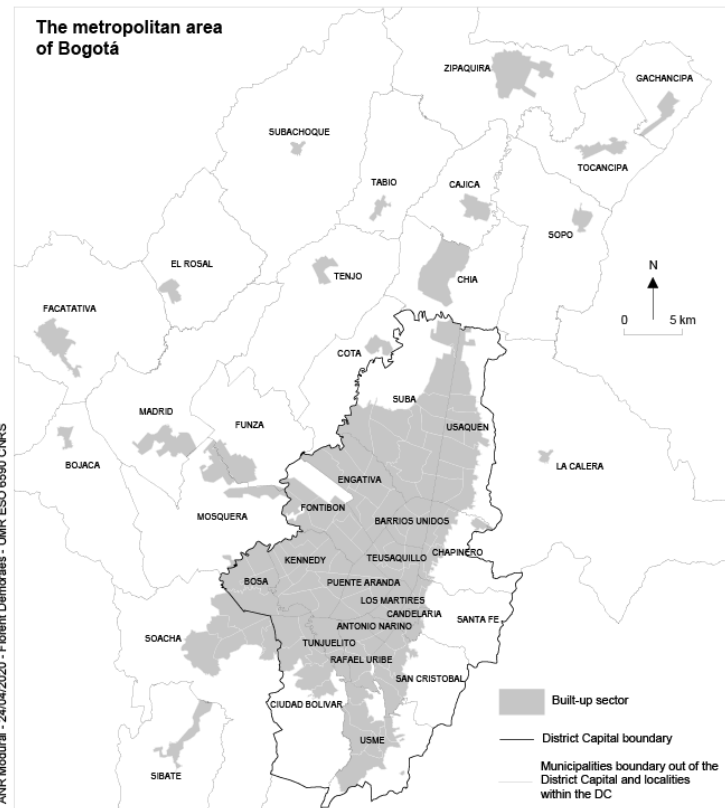
Bogotá, a city undergoing transformation

4.9 millions inhabitants in 1993

6.7 millions inhabitants in 2005



+36,7 %





Study Area

Bogotá, a city undergoing transformation

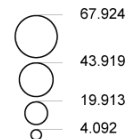
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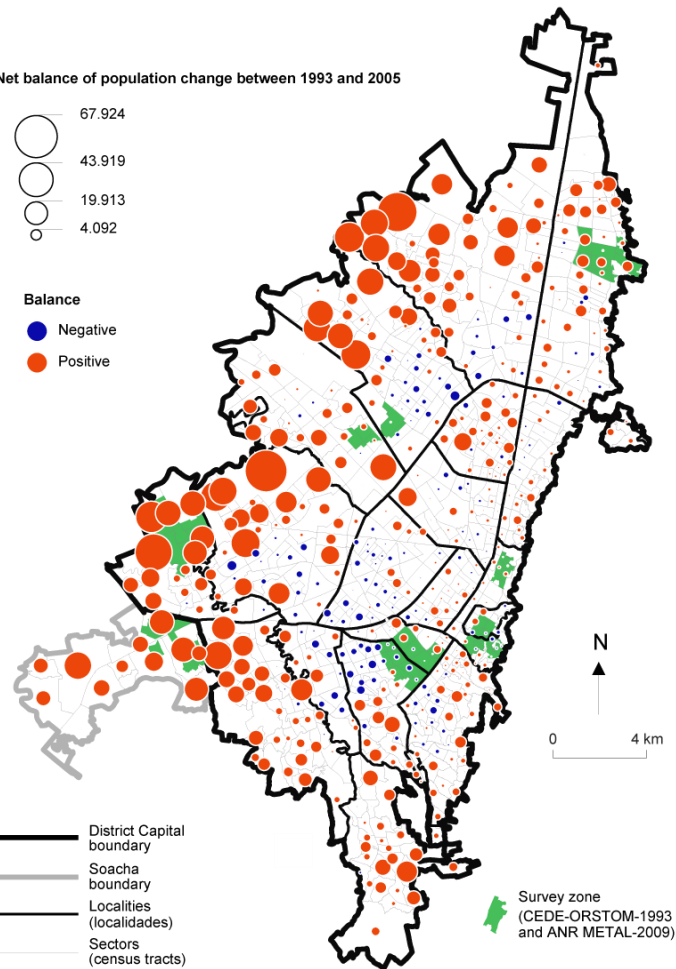


+36,7 %

Net balance of population change between 1993 and 2005



Balance
● Negative
● Positive



— District Capital boundary
— Soacha boundary
— Localities (localidades)
— Sectors (census tracts)

Survey zone (CEDE-ORSTOM-1993 and ANR METAL-2009)



Study Area

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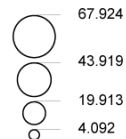
6.7 millions inhabitants in 2005



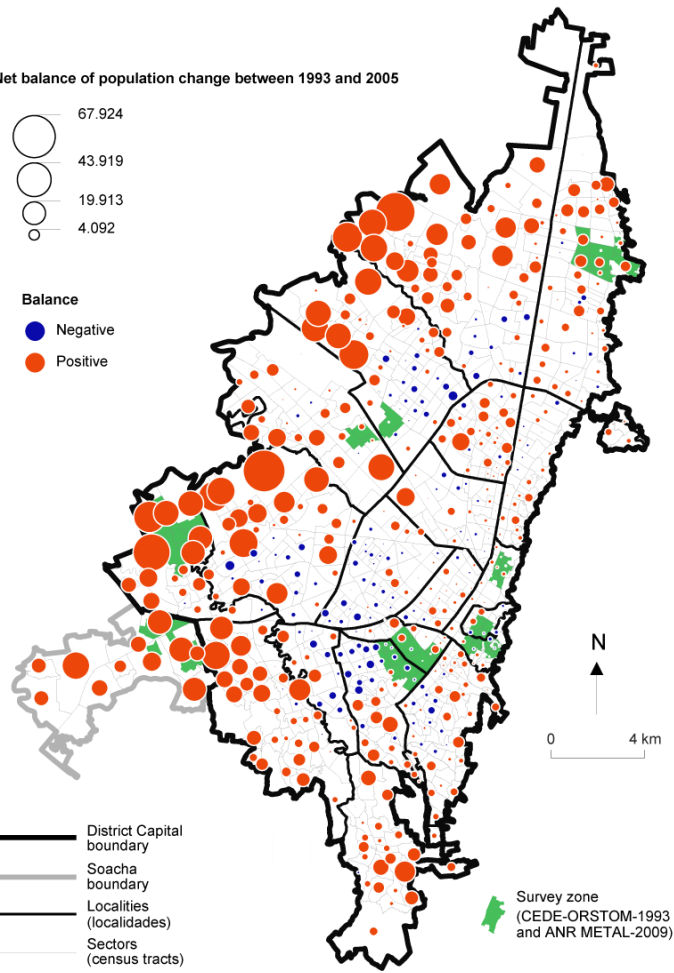
Poorer classes in the southern and north-western outskirts



Net balance of population change between 1993 and 2005



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Study Area

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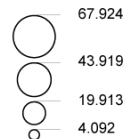
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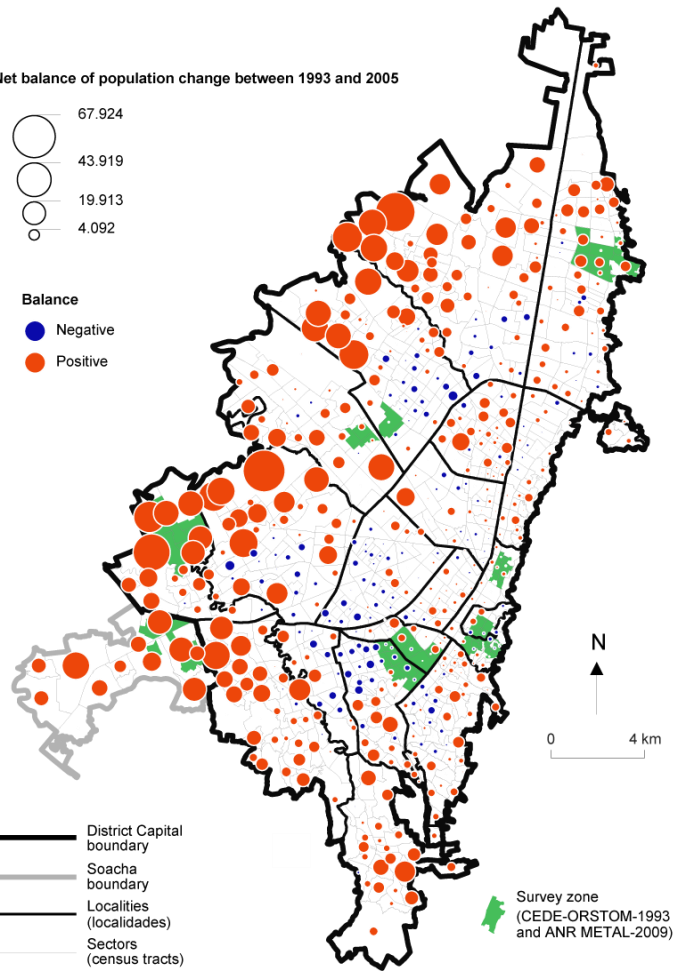
Wealthier classes in the north-east of the DC



Net balance of population change between 1993 and 2005



Balance



- District Capital boundary
- Soacha boundary
- Localities (localidades)
- Sectors (census tracts)

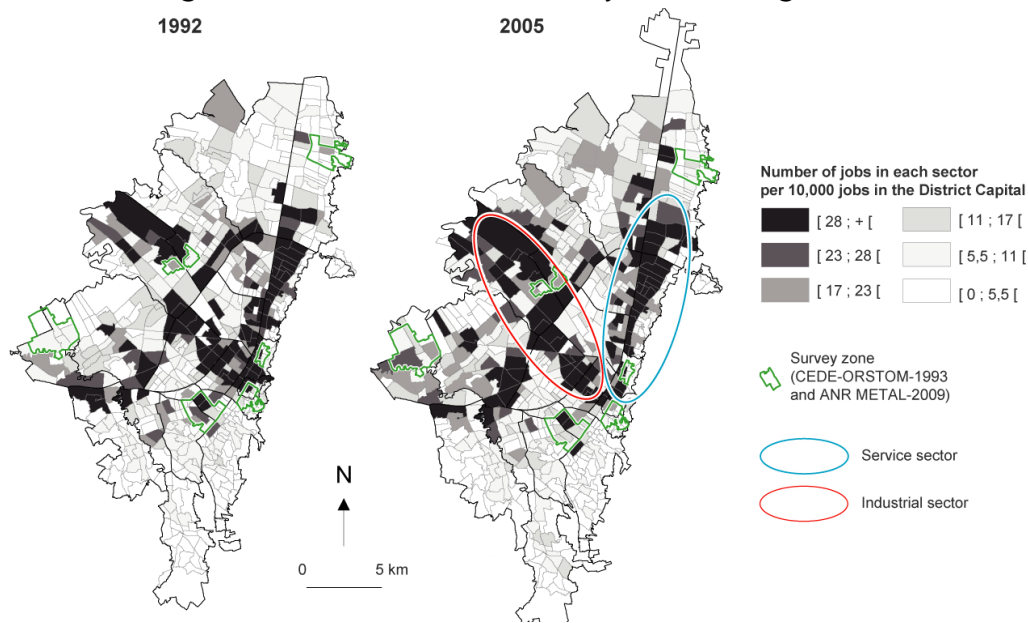
Survey zone (CEDE-ORSTOM-1993 and ANR METAL-2009)



Study Area

Bogotá, a city undergoing transformation

Changes to the distribution of jobs in Bogotá DC





Study Area

Bogotá, a city undergoing transformation

- ▶ Public primary and secondary schools are uniformly distributed in space



Study Area

Bogotá, a city undergoing transformation

- ▶ Public primary and secondary schools are uniformly distributed in space
- ▶ Universities are mainly concentrated in the city center and on the northern outskirts of Bogotá



Study Area

Bogotá, a city undergoing transformation

- ▶ Public primary and secondary schools are uniformly distributed in space
- ▶ Universities are mainly concentrated in the city center and on the northern outskirts of Bogotá
- ▶ Recent growth in household car ownership rates (from 30% to 41%) + commissioning of a BRT system in 2001 → the Transmilenio





Material

2 surveys in the wake of the GRAB initiative (Ined)

CEDE-ORSTOM (1993)

F. Dureau ; C. E. Flórez

922 households

3.973 individuals

ANR-METAL (2009)

F. Dureau

881 households

3.256 individuals



Material

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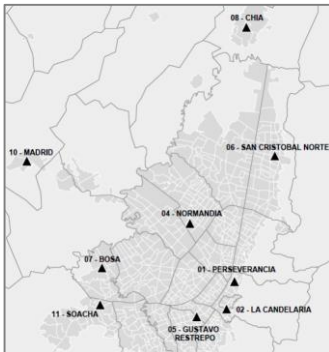
ANR-METAL (2009)

F. Dureau

881 households

3.256 individuals

→ **Nine survey zones** common to the two dates



→ Not a longitudinal survey

→ Only **one component** of surveys: **commutes** from home to place of activity

→ Only **one destination** per day per individual (sector level)



Study population

- ▶ Selection of households with 2 categories of individuals at different stages in the life course



Adults



with a paid activity, including at home



Children

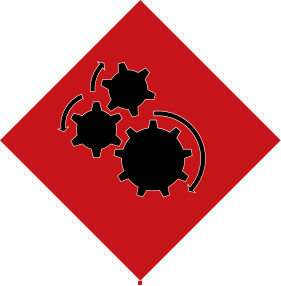


Primary and secondary school

Survey zone (Id)	Number of households		Number of individuals		Number of schoolchildren		Number of working adults	
	1993	2009	1993	2009	1993	2009	1993	2009
Bosa (07)	50	57	165	190	86	90	79	100
Chía (08)	29	27	101	81	44	32	57	49
Gustavo Restrepo (05)	51	52	185	156	89	65	96	91
La Candelaria (02)	53	47	181	146	98	69	83	77
Madrid (10)	49	47	182	162	96	88	86	74
Normandía (04)	46	26	158	70	61	19	97	51
Perseverancia (01)	44	19	144	58	73	26	71	32
San Cristobal (06)	66	35	233	108	126	50	107	58
Soacha (11)	46	50	155	165	75	69	80	96
Overall total	434	360	1504	1136	748	508	756	628

47% of the overall households

44% of households



Analytical framework: Space-Time of Action (STA)

- ▶ Inspired from Action Space (Von Dürckheim, 1932)
→ set of places that an individual or group of individuals visit
- ▶ Space-Time of Action: all the destinations visited by individuals for work or study, together with the time they take to reach them (Demoraes et al., 2018)



Method and terminology

- ▶ Three parameters: location of place of residence, location of place of activity, travel time → spatiotemporal reference system
- ▶ 1 - Calculation of the Euclidean distance for each origin-destination pair in 1993 and in 2009, and average speed of travel for each pair
- ▶ 2 - Calculation of overall average speed of travel for all the origin-destination pairs
- ▶ 3 - Calculation of a “distance-time”, corresponding to the distance an individual would have travelled in the length of time recorded for their actual journey, had they been travelling at the overall average speed
- ▶ 4 - Calculation of the location of “place-times of activity” (PTAs) by applying trigonometric principles



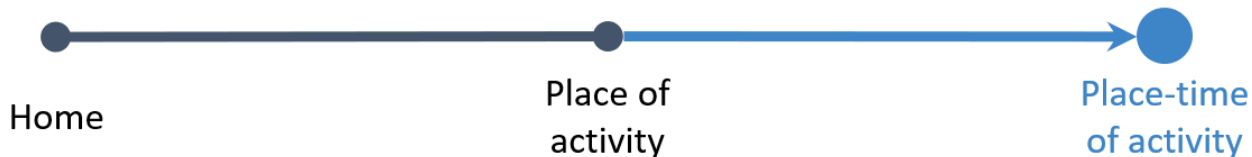
Method

2 cases

- ▶ PTA is shifted nearer to home when the individual reaches the place more quickly, i.e. at greater speed than overall average speed



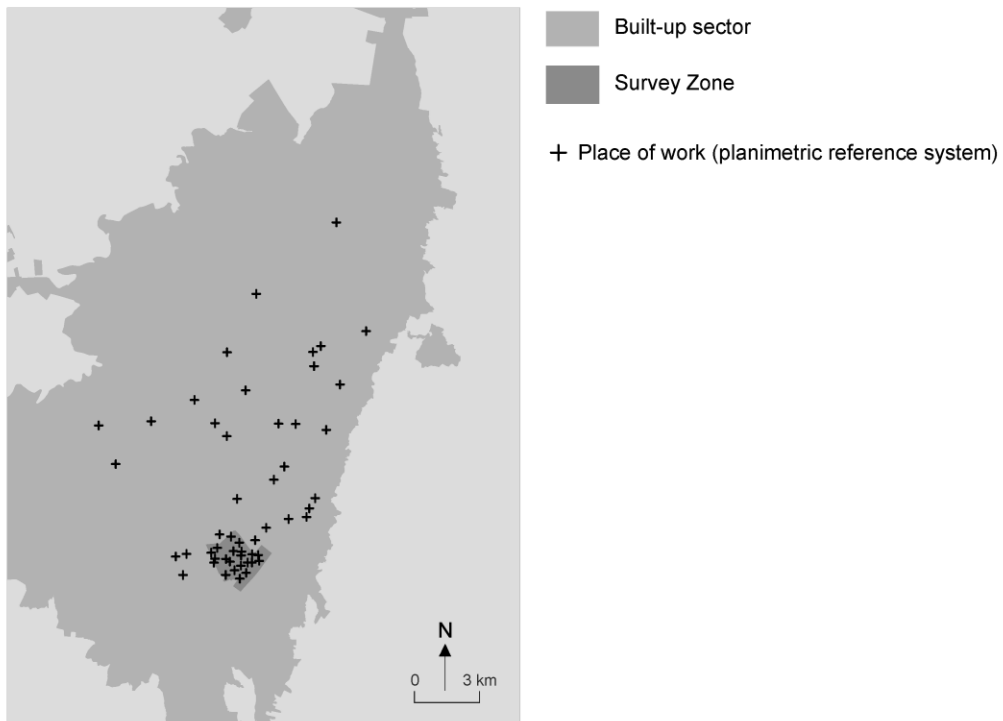
- ▶ PTA is shifted further from home when the individual reaches the place less quickly, i.e. at less than overall average speed





Method

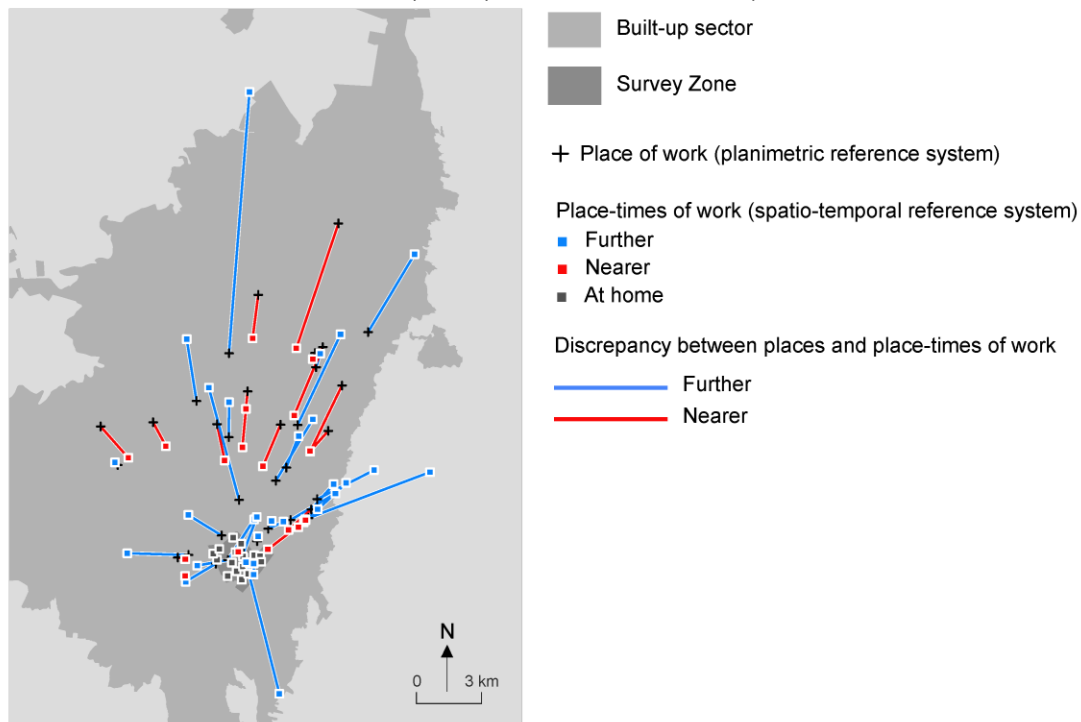
05 - Gustavo Restrepo (Adults in 1993)





Method

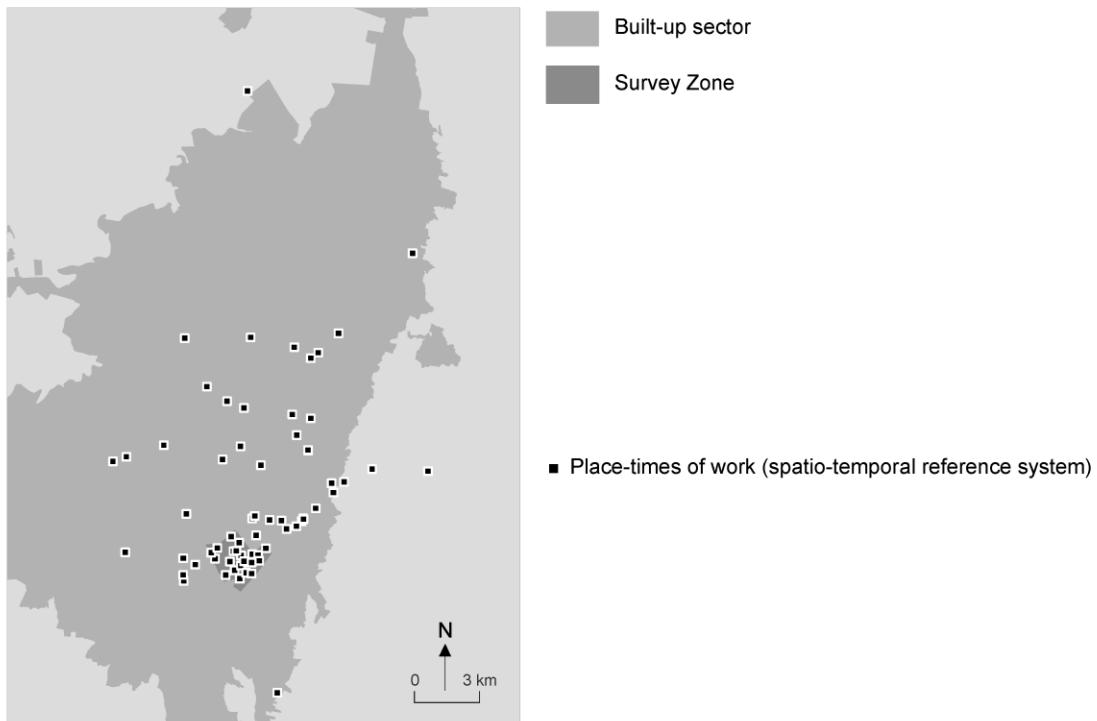
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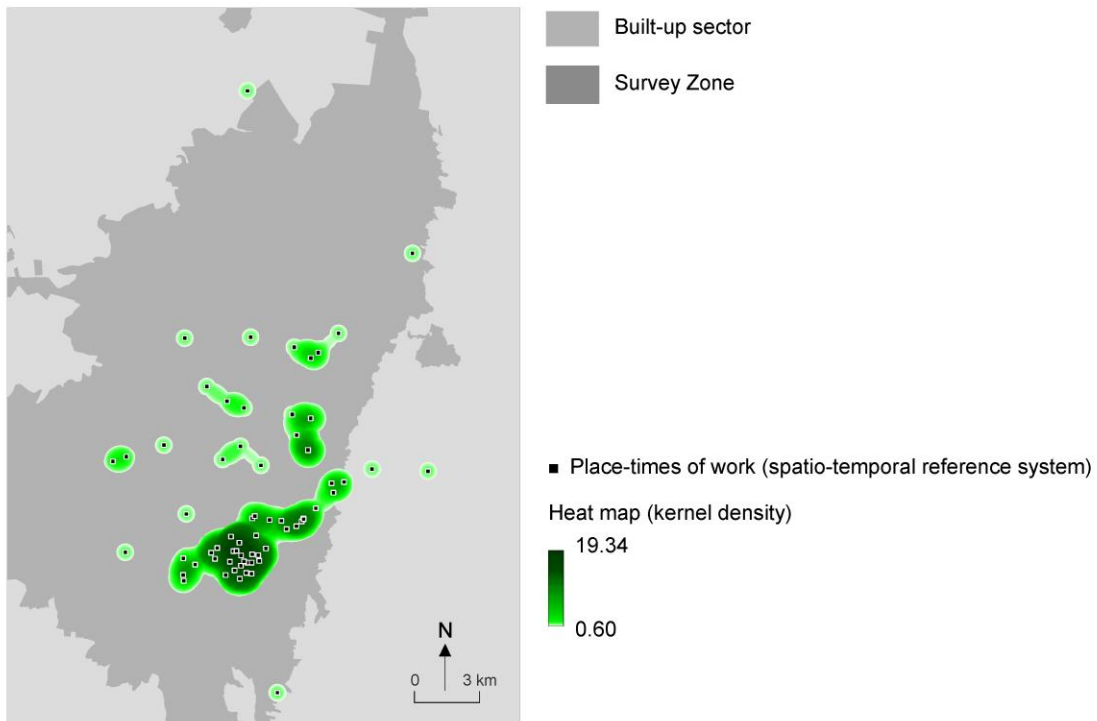
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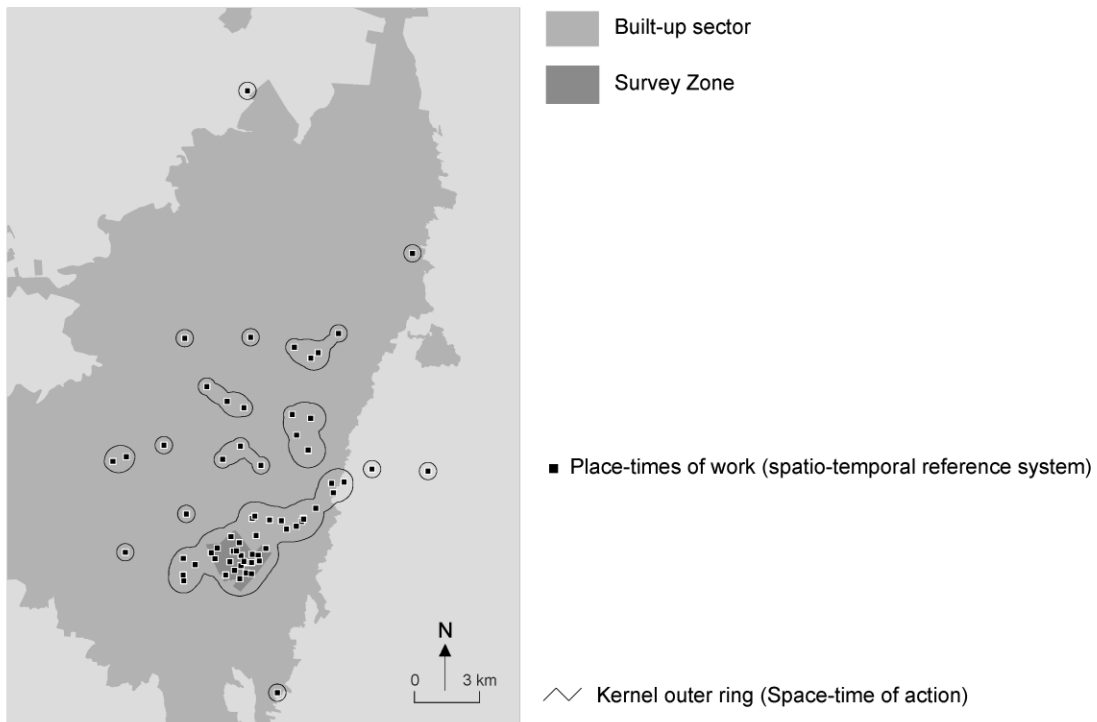
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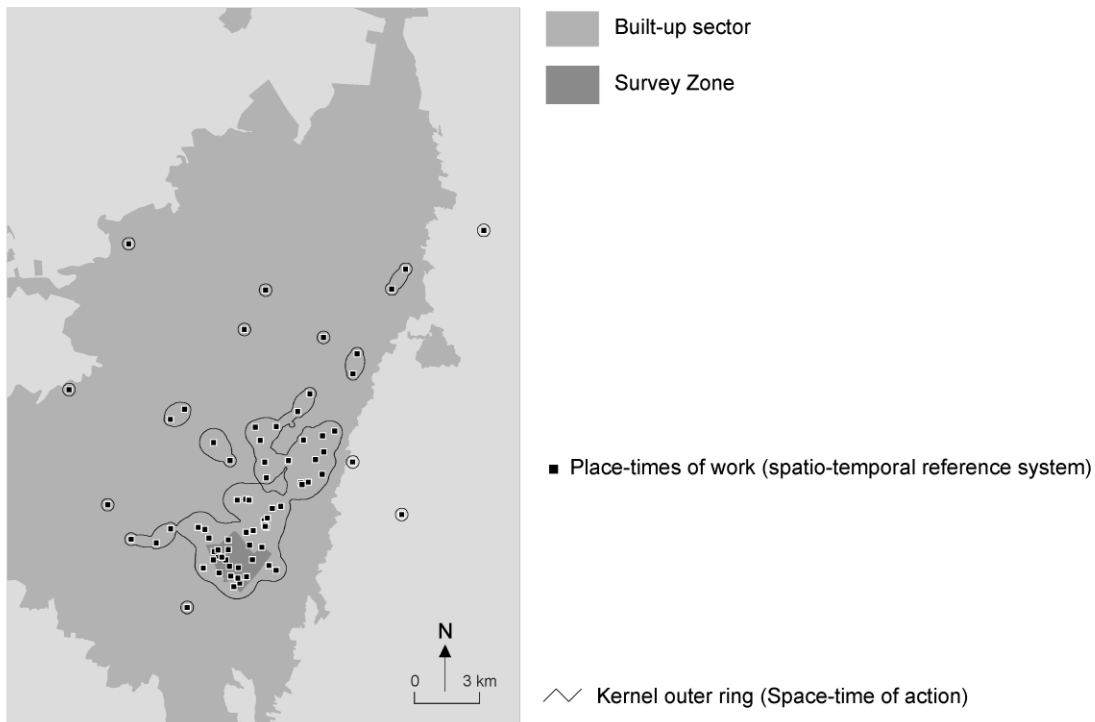
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Method

05 - Gustavo Restrepo (Adults in 2009)

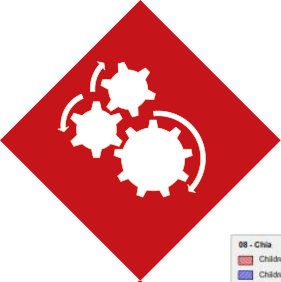




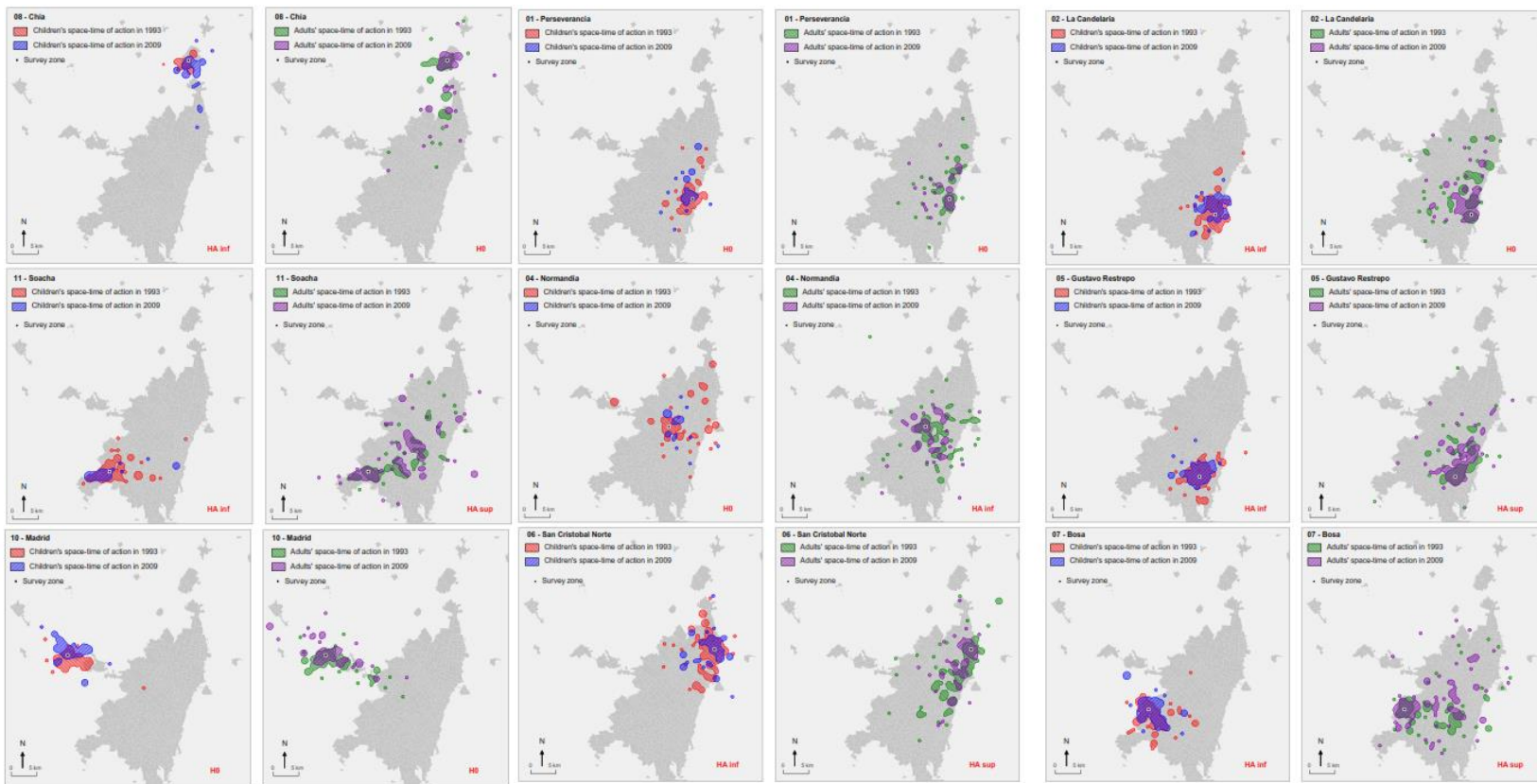
Method

05 – Gustavo Restrepo (Adults in 1993 and 2009)





Method





Method

- ▶ How to really detect changes to household members' access to place of activity?
- ▶ Space-Times of Action can be modeled as **two-dimensional objects**
- ▶ Selection of a **bivariate colocation test** used in **spatial epidemiology** (Souris and Bichaud 2011)
- ▶ **Are the points in one spatial pattern close overall to points in a second spatial pattern ?**
- ▶ Application of this test to compare the Space-Times of Action of pairwise categories for each survey zone



Method

Principles of the bivariate colocation test

P1 → the place-times of activity of the individuals from group 1 (ex: schoolchildren living in Zone 1 in 1993)

P2 → the place-times of activity of the individuals from group 2 (ex: schoolchildren living in the same zone in 2009)

1 - Calculation of the Euclidian distance between each place-time of activity from group 1 and its closest place-time of activity from group 2

2 - Calculation of the mean of these distances → the **index**

2 hypotheses

H0: the observed index cannot be differentiated from the indices obtained by a random spatial distribution

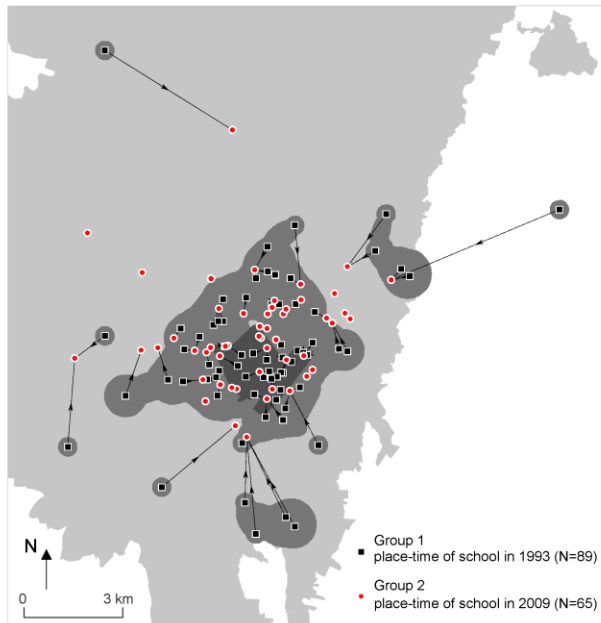
HA: the probability of obtaining the observed index by chance is lower than a determined α value (5%)

The statistical distribution of the index under the H0 hypothesis is estimated using a Monte Carlo simulation



Method

Observed situation
(05 - Gustavo Restrepo)



- Group 1
place-time of school in 1993 (N=89)
- Group 2
place-time of school in 2009 (N=65)

Index = 768 m.

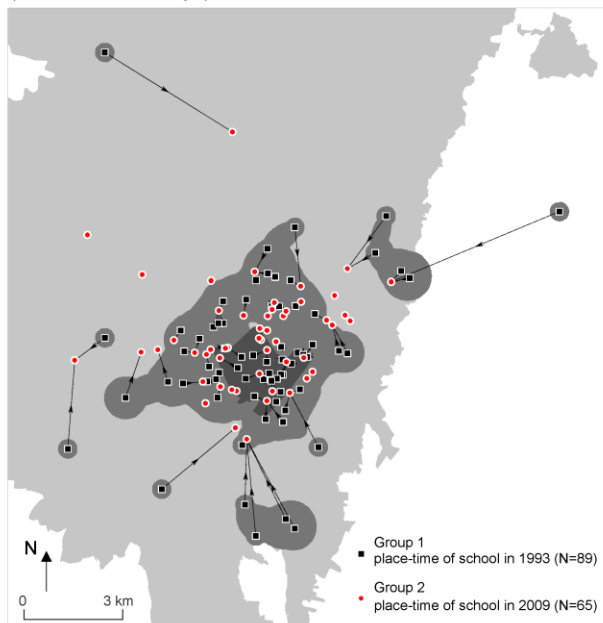
■ Survey Zone ■ Children's Space-Time of Action in 1993

→ Link between each place-time of destination from group 1 (schoolchildren in 1993) to its closest neighbor from group 2 (schoolchildren in 2009)



Method

Observed situation
(05 - Gustavo Restrepo)

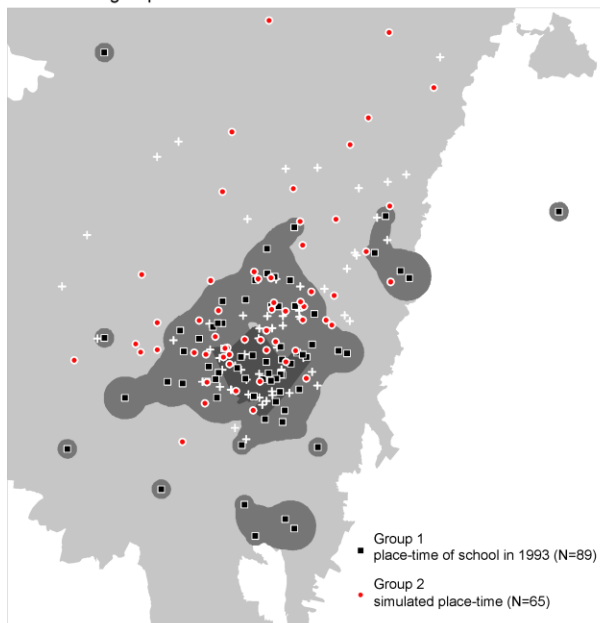


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Survey Zone Children's Space-Time of Action in 1993

Link between each place-time of destination from group 1 (schoolchildren in 1993) to its closest neighbor from group 2 (schoolchildren in 2009)

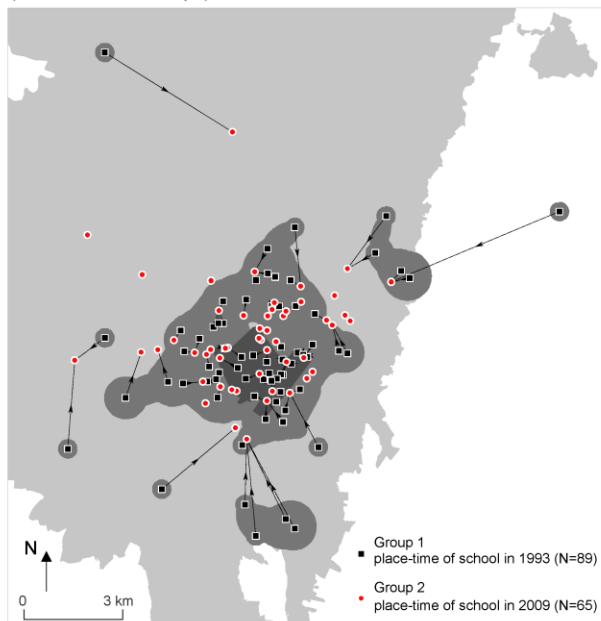
First simulation
Points from group 2 are randomly distributed among S1
Points from group 1 do not move





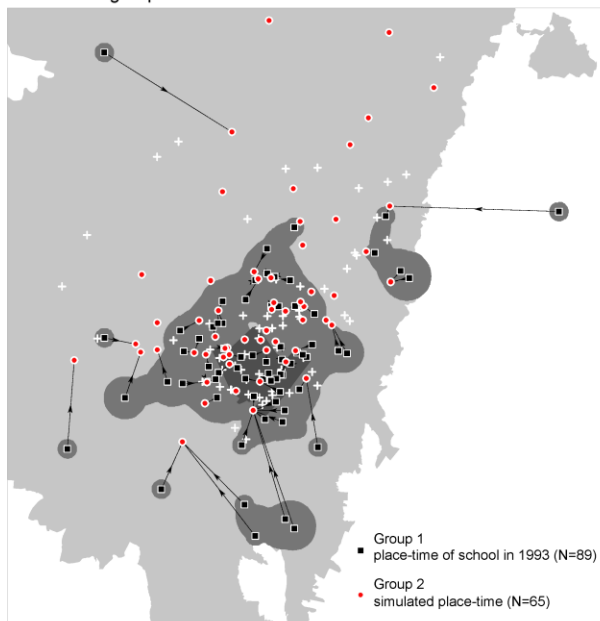
Method

Observed situation
(05 - Gustavo Restrepo)



Index = 768 m.

First simulation
Points from group 2 are randomly distributed among S1
Points from group 1 do not move



Index = 797 m.

Survey Zone Children's Space-Time of Action in 1993

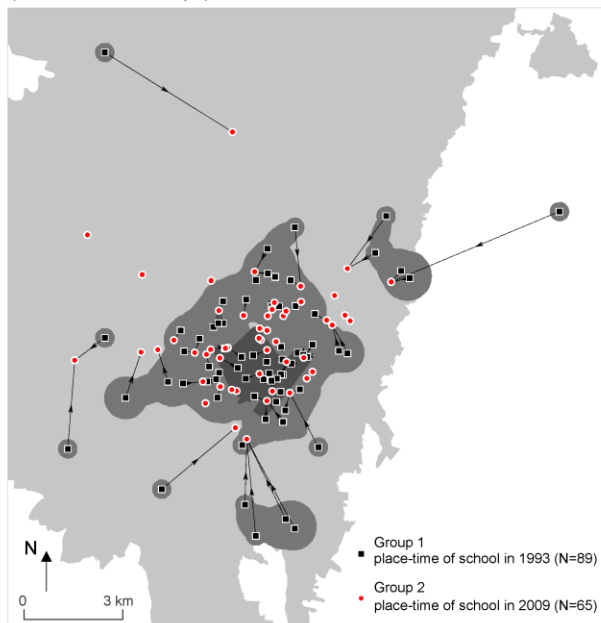
Link between each place-time of destination from group 1 (schoolchildren in 1993) to its closest neighbor from group 2 (schoolchildren in 2009)

S1: all possible place-times of destination from individuals living in the survey zone in 2009 (N = 149)



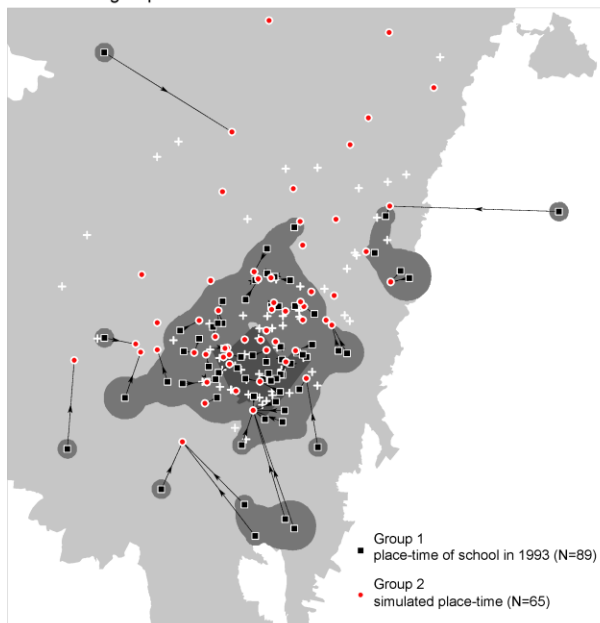
Method

Observed situation
(05 - Gustavo Restrepo)



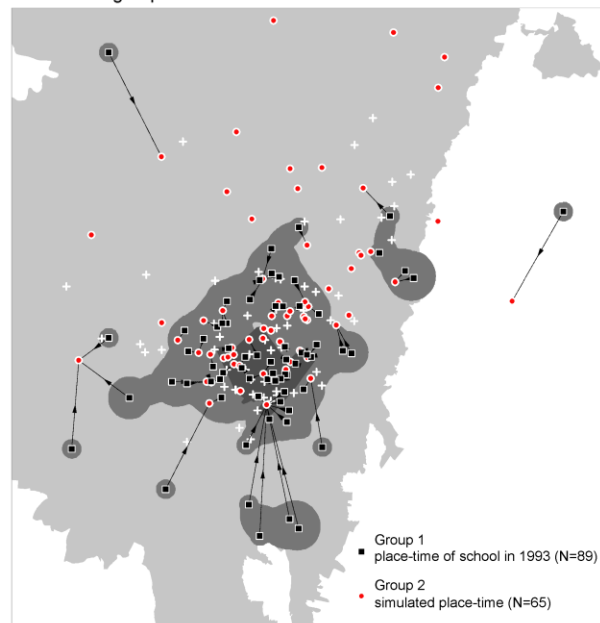
Index = 768 m.

First simulation
Points from group 2 are randomly distributed among S1
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Index = 797 m.

Second simulation
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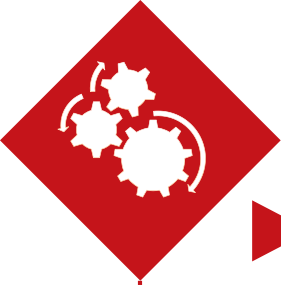
Index = 808 m.

Survey Zone Children's Space-Time of Action in 1993

Link between each place-time of destination from group 1 (schoolchildren in 1993) to its closest neighbor from group 2 (schoolchildren in 2009)

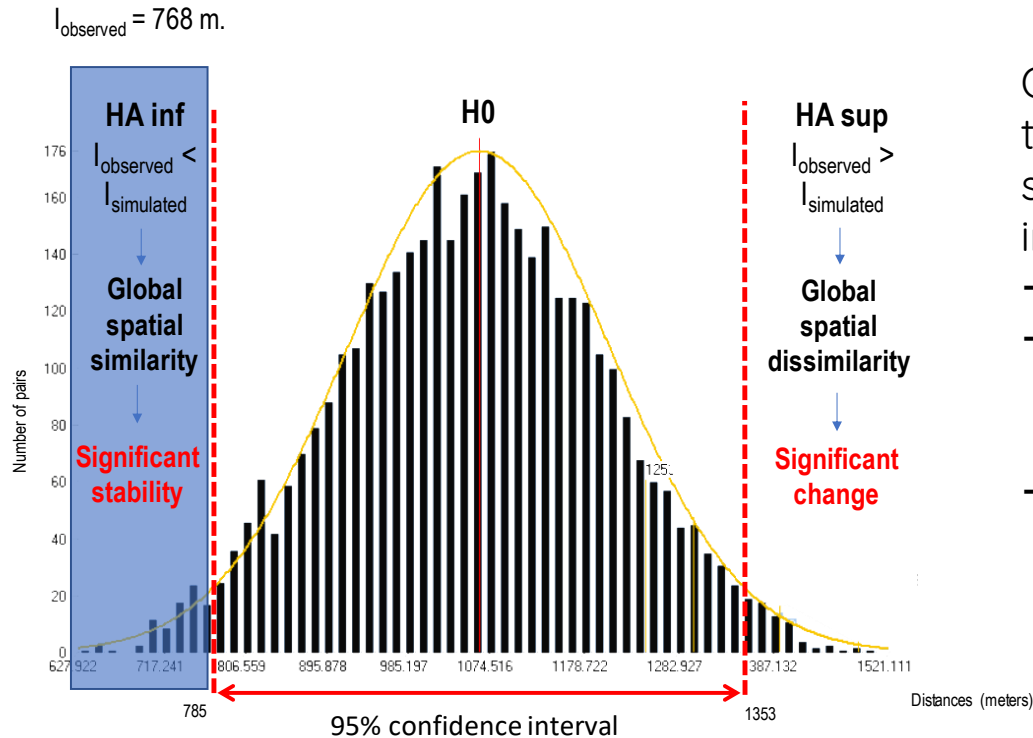
S1: all possible place-times of destination from individuals living in the survey zone in 2009 (N = 149)

→ 4000 times



Method

▶ Result of the bivariate colocation test for schoolchildren in Gustavo Restrepo



Observed index (768 m.) out of the confidence interval and smaller than the simulated indices

- HA
- Global spatial similarity between place-times of school in 1993 and 2009
- Significant stability in children's access to place of education



Results

Gustavo Restrepo (05), San Cristobal (06),
Bosa (07), Soacha (11)

	Schoolchildren 1993	Adults 1993
Schoolchildren 2009	HA inf	-
Adults 2009	-	HA sup

Candelaria (02), Chía (08)

	Schoolchildren 1993	Adults 1993
Schoolchildren 2009	HA inf	-
Adults 2009	-	H0

Normandía (04)

	Schoolchildren 1993	Adults 1993
Schoolchildren 2009	H0	-
Adults 2009	-	HA inf

Perseverancia (01), Madrid (10)

	Schoolchildren 1993	Adults 1993
Schoolchildren 2009	H0	-
Adults 2009	-	H0



Results

Gustavo Restrepo (05), San Cristobal (06),
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	Schoolchildren 1993	Adults 1993
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?



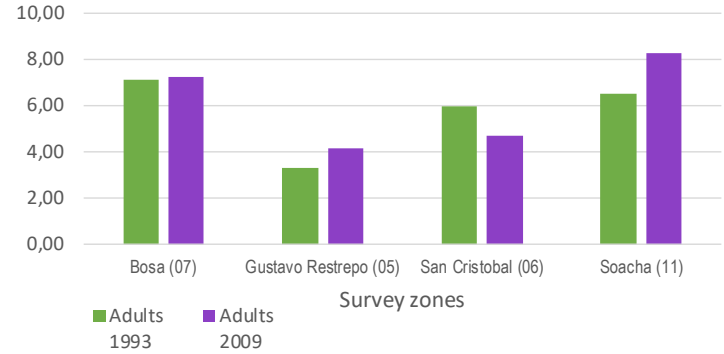
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Gustavo Restrepo (05), San Cristobal (06),
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km Mean of distance-times between home and place-time of activity in 1993 and in 2009





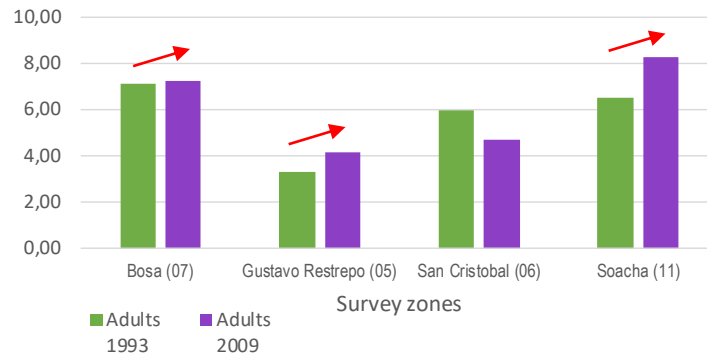
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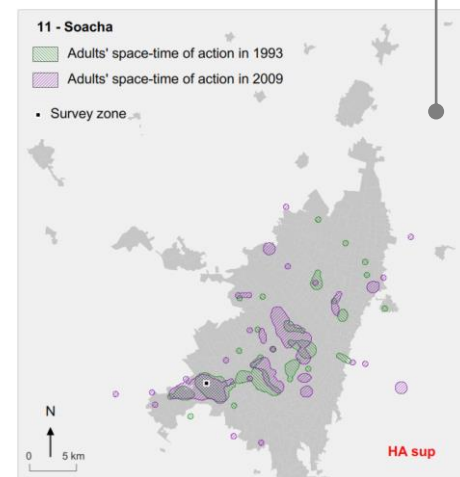
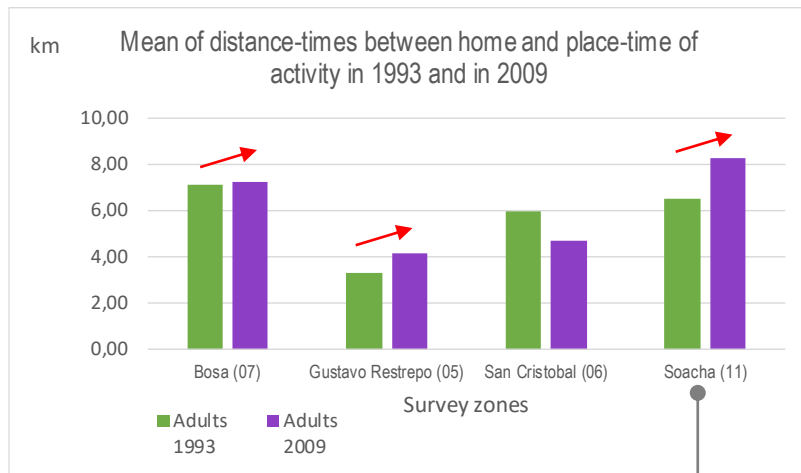




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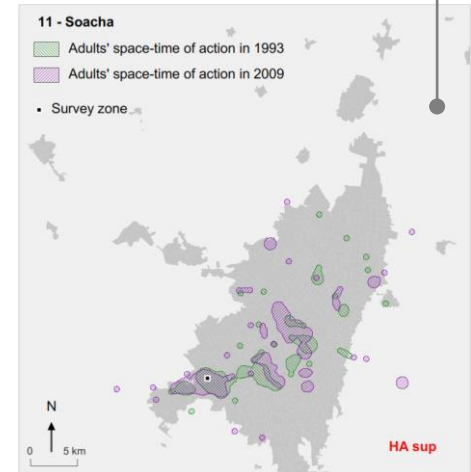
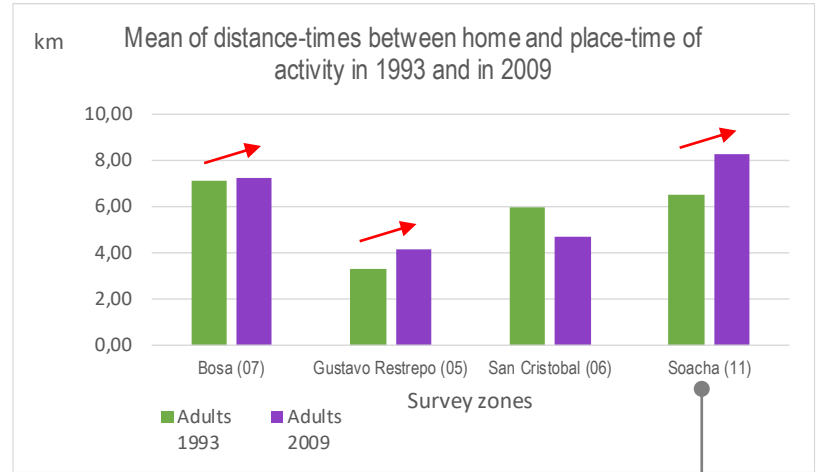
Results

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	Schoolchildren 1993	Adults 1993
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Decrease in work at home + increase in the use of public transport (from 58.8% to 64.8%) + increase in travel time (from 58 to 64 minutes) in public transport





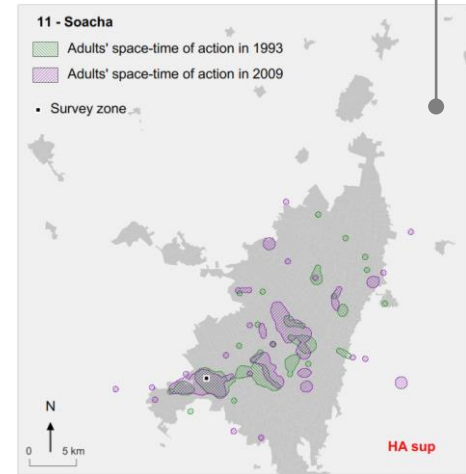
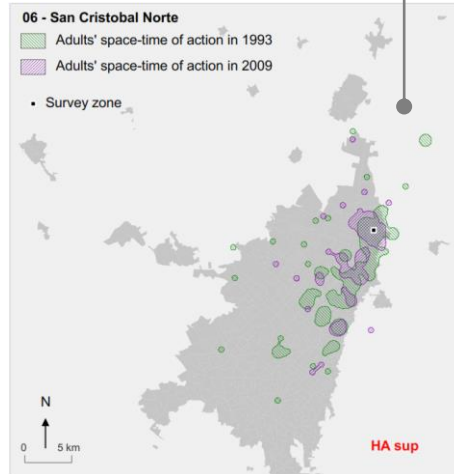
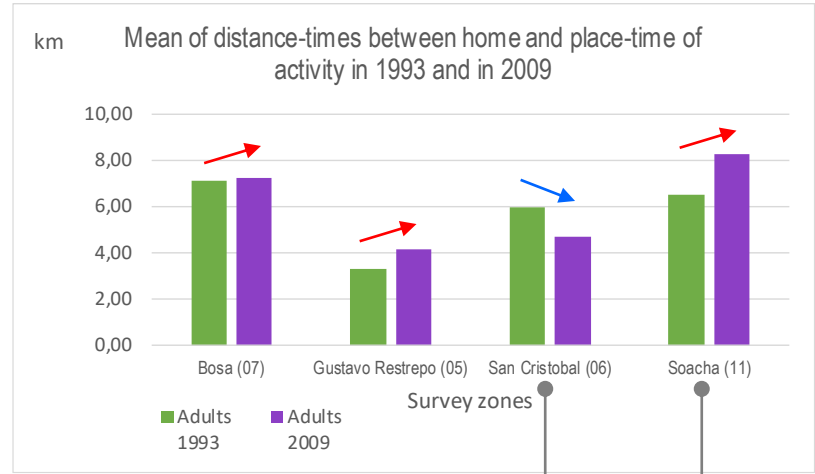
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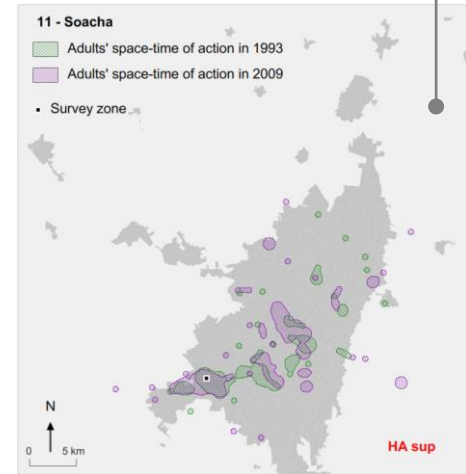
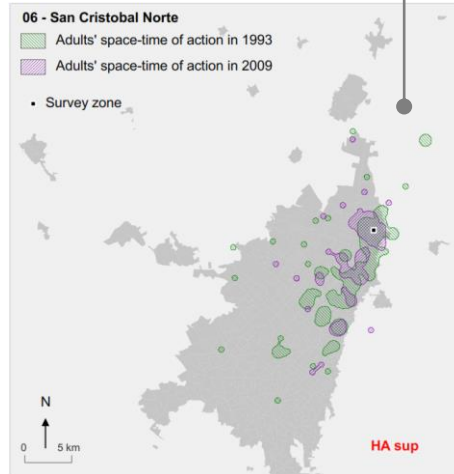
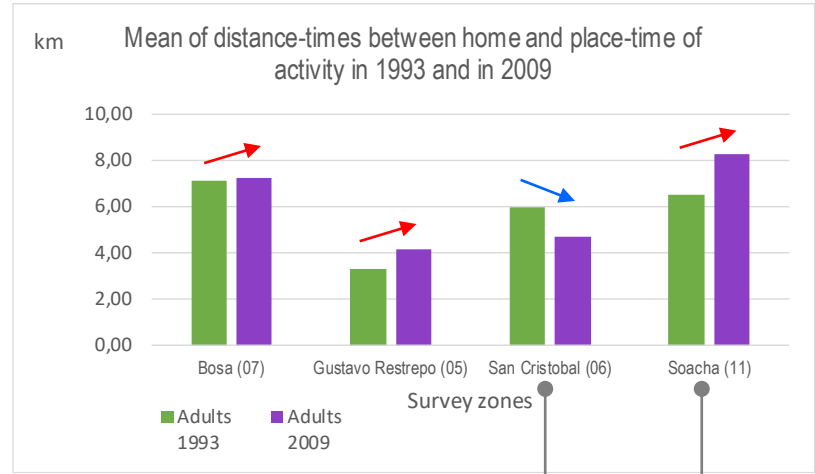




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Decrease in work at home + increase in the use of public transport (from 58.8% to 64.8%) + increase in travel time (from 58 to 64 minutes) in public transport

Increase in the use of public transport (from 45.8% to 61.4%) + decrease in travel time (from 52 to 38 minutes) in public transport



Conclusion

- ▶ Space-Times of Actions → a measure of accessibility to place of activity aggregated by group
- ▶ STAs for the two dates show changes in how two co-residing categories of individuals (working adults and schoolchildren) relate to urban environment
- ▶ STAs bring out groups whose situation improves or deteriorates over time in comparison to other groups
- ▶ The bivariate colocation test indicates an overall stability in children's access to school place and a more contrasting situation for adults. Distance-times mostly reveal a worsening
- ▶ But STAs do not enable to directly apprehend arrangements and trade-offs within families → need of qualitative analysis (in-depth interviews)
- ▶ Calculating STAs is simple with just three input variables (origin, destination, and travel time). Delineating STAs using the outer ring of the heat maps is also quite easy
- ▶ STAs may be applied to numerous surveys for which individual-level data is available and to GPS traces



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