Moving Citizens and Deterring Criminals: Innovation in Public Transport Facilities

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Outline

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Motivation

- Urban policies are tools to deal with cities challenges: labor force efficiency, transportation, and crime.
- Determinants of crime in big cities might include: payoffs of crime, probability of apprehension, and citizens' characteristics [Glaeser and Sacerdote, 1999]. We focus on **infrastructure**.
- This study examines the effects of urban infrastructure on crime and its mechanisms. Could be relevant for cities that implement these systems and those with high crime criminality:
  - Some examples: La Paz, Rio de Janeiro. Mexico city.

Medellín & Metrocable

- Medellín (Colombia) has a complex relationship between public policy and public security.
- Labeled one of the most violent cities in the world 20 years ago, it has had a remarkable reduction in crime rates: 98.2 homicides per 100,000 inhabitants in 2000 to 26.95 in 2014.
- **Metrocable**: cable cart public transportation system introduced in 2004 to reach geographically challenging areas.
- The number of homicides around the two initial metro lines decreased after the implementation of the Metrocable.

Outline

The role of public transportation stations

- Loukaitou-Sideris et al. [2001, 2002] finds no direct positive effect of all Los Angeles' metro stations on crime. It depends on the station's characteristics.
- La Vigne [1996, p.191] argues about Washington D.C.'s metro: "Metro's success suggests that it is indeed possible to manipulate environments to reduce criminal opportunities. "

The role of public transportation stations

- Levine and Wachs [1986], Brantingham and Brantingham [1993], Loukaitou-Sideris [1999]: stations act as **crime attractors** or **generators**.

- Ehrlich [1973], La Vigne [1996], Foster et al. [2010]: on the contrary, stations **reduce crime** acting as **safe zones** for citizens and increasing policing.

A previous Metrocable study

- Cerda et al. [2012] examine the effect of Metrocable on crime using pre and post-implementation surveys.
- The homicide rate decreased 66% more in treated neighborhoods.
- **Pros:** captures the feeling of victimization, uses diverse crime outcomes.
- **Cons:** lack of information at low geographical level, specific control group, perception variables, no spatial specification.

Outline

Hypotheses

- Metrocable led to a greater homicide reduction for treated neighborhoods.
- Stations act as security zones.
- **Economic mechanism:** Metrocable has an inclusive effect, improving residents' social opportunities (Lochner [1999], Scorzafave and Soares [2009], Menezes et al. [2013]). This mechanism is supported by the 'Spatial mismatch hypothesis' [Kain, 1992]
- **Police mechanism:** stations have police presence and security cameras, which deter criminal activity (Becker [1968], Ehrlich [1973]).
- There's a spillover effect on neighbors, which could impact broader areas.

Assumptions

- Treatment (Metrocable) was assigned according to geographical characteristics.
- Neighbors of treated units experienced similar crime reduction patterns as the geographical units which were treated.
- Spatial side effects can be identified for the last assumption.

Spatial Diff-in-Diff

- We use a spatial difference-in-difference approach (similar to Delgado and Florax [2015] and Chagas et al. [2016]).
- Crime outcomes:
  - $y_i(1)$ if region i is affected by Metrocable.
  - $y_i(0)$ if region i is not affected.
- A starting model would be:

$$y_{it} = X_{it}\beta + u_{it} \tag{1}$$

Spatial Diff-in-Diff

- Due to the relevance of the spatial relationship, the correct specification would be:

$$Y_{it} = W\rho Y_{it} + X_{it}\beta + U_{it} \tag{2}$$

Where W is a spatial weight matrix.

Spatial Diff-in-Diff

- The traditional Diff-in-Diff equation has the form:

$$Y_{it} = X_{it}\beta + \alpha_0 D_{it} + \alpha_1 t_{it} + \alpha D_{it} * t_{it} + U_{it} \tag{3}$$

Where:

- t_{it} is a time dummy (0 for pre-treatment and 1 post-treatment).
- α measures the impact of the treatment.
- D is a binary vector which identifies treated units.

Spatial Diff-in-Diff

- Including spatial effects, the model is re-specified as:

$$\begin{aligned} Y_{it} = & W\rho Y_{it} + X_{it}\beta + \alpha_0 D_{it} + \alpha_1 t_{it} + \alpha D_{it} * t_{it} + \\ & \alpha_2 WD_{it} + \delta WD_{it} * t_{it} + U_{it} \end{aligned} \tag{4}$$

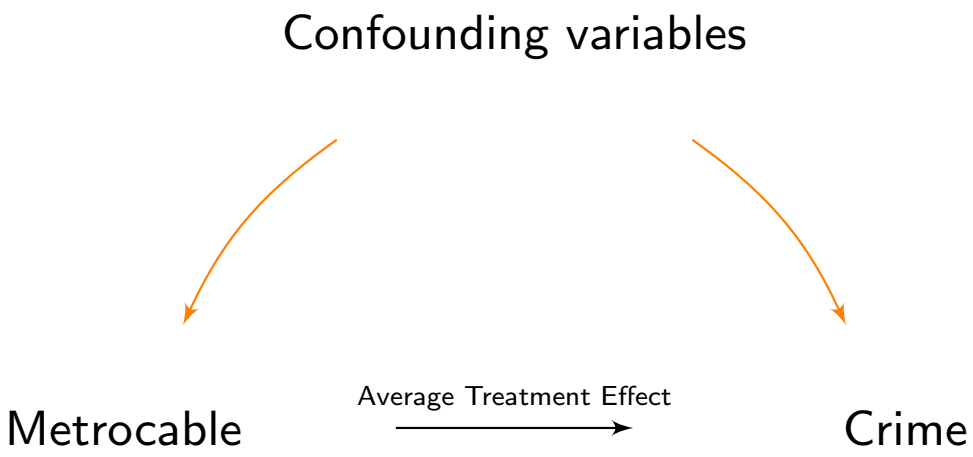
- α_2 captures differences between units spatially correlated with treatment and the control group.

- δ identifies the spatial effect of treatment.

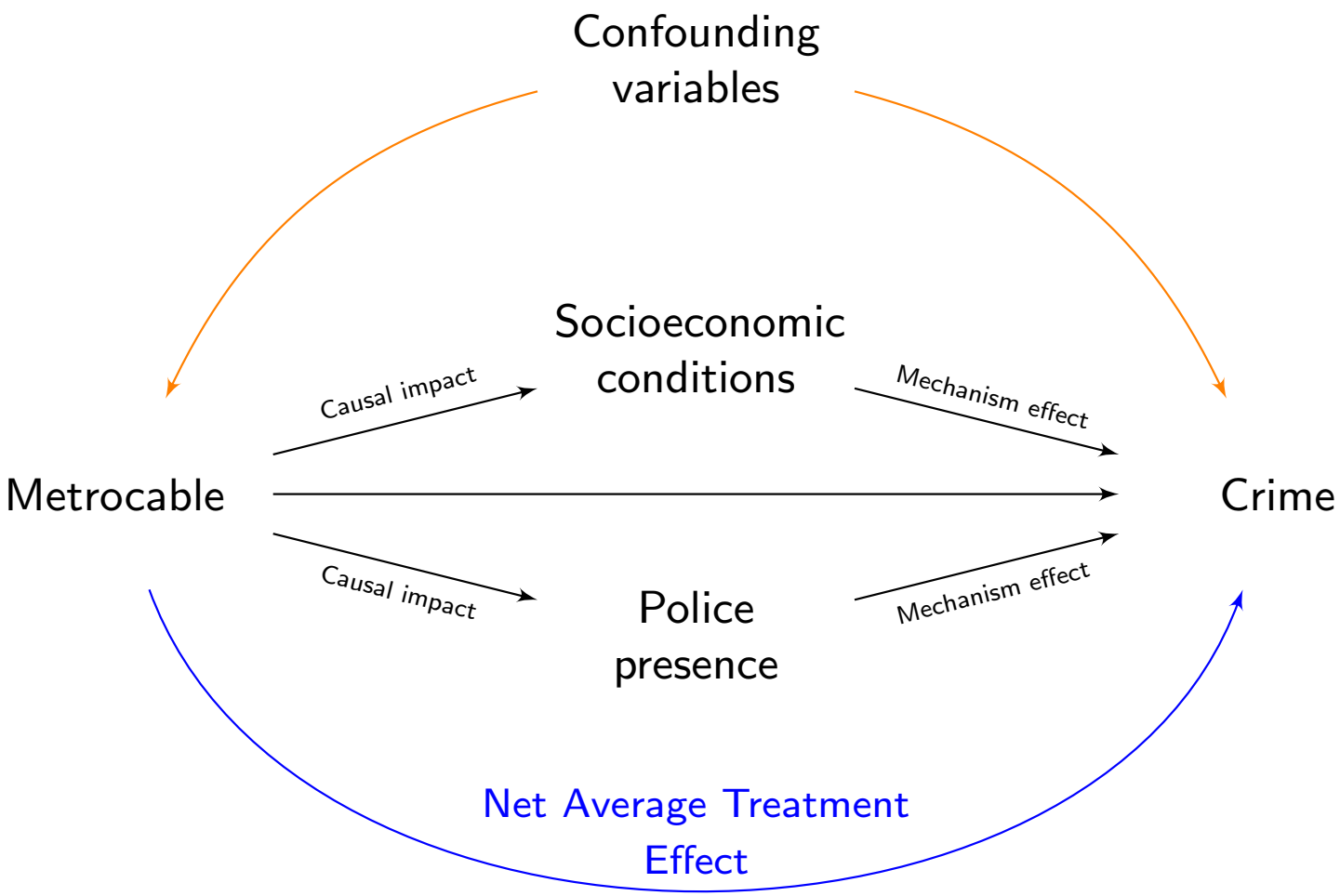
- We evaluate the **average treatment effect**:

$$ATE = E\left[Y\left(1\right) - Y\left(0\right)|X, D, t, WD\right] \tag{5}$$

Mechanisms


Confounding variables
Metrocable
Average Treatment Effect
Crime

Mechanisms


Confounding variables
Socioeconomic conditions
Causal impact
Mechanism effect
Metrocable
Crime
Causal impact
Police presence
Mechanism effect
Net Average Treatment Effect

Mechanisms

How we do it?

- Estimate the effect of the treatment on the mechanism
- Estimate the effect of the mechanism on the outcome
- Obtain the marginal effects of the mechanisms on the outcome (for treated units)
- Plug the obtained effect of the treatment on the mechamis using the marginal effects.

Outline

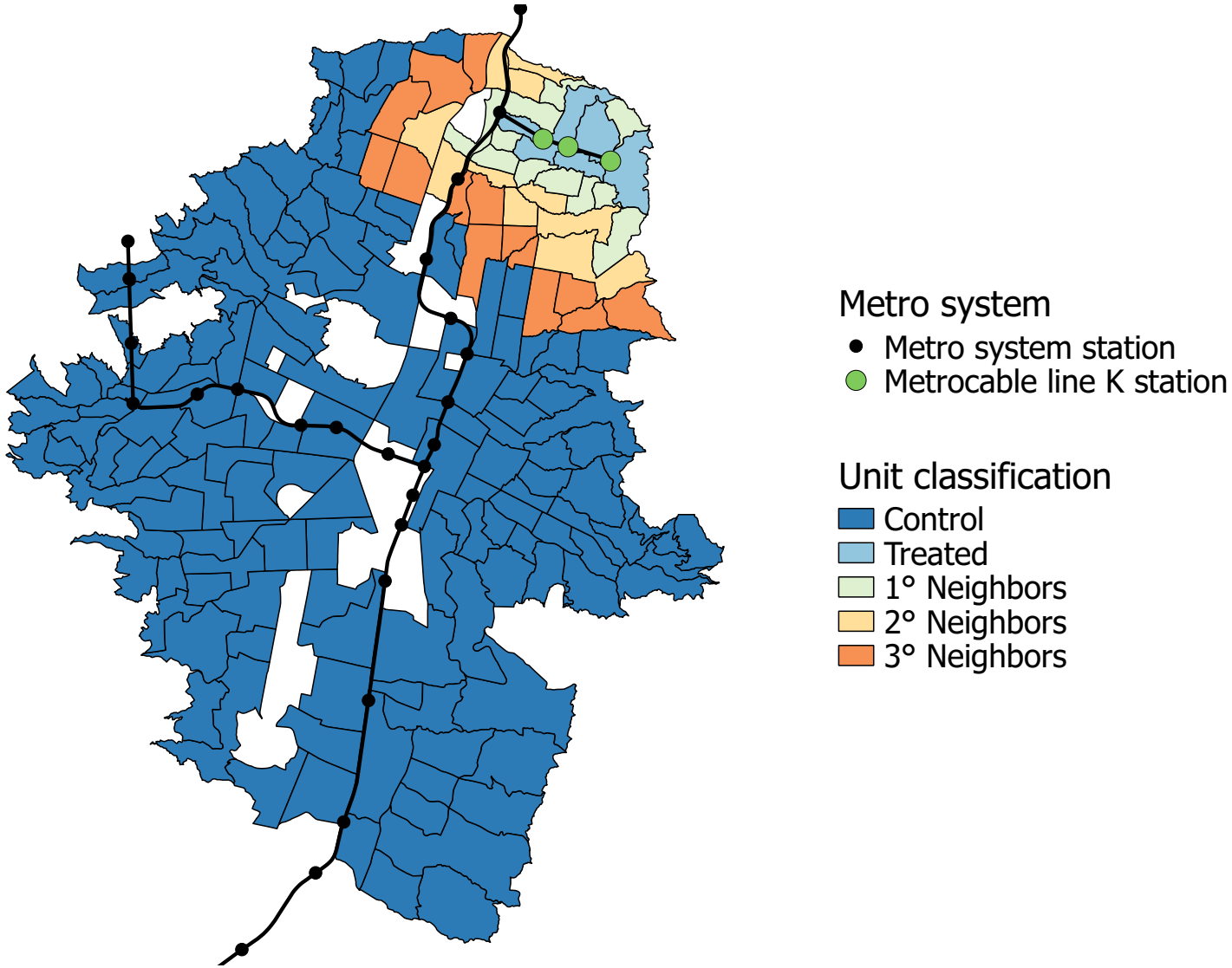
Data sources

- We use georeferenced homicide data as our output.
- We compiled georeferenced data for arrests, burglary
- Complementary covariates are taken from the Quality of Life survey (2004, 2005, 2006, 2012).
- Geographical units of analysis come from the *max-p regions* model from Duque et al. [2012].
- The *max-p regions* model designs regions keeping a number of observations and a high degree of homogeneity, reaching significance at low geographical levels.

Summary statistics

Variable	N	Mean	Std. Dev.	Min	P50	Max
2004						
ln(Homicides+1)	176	1.60	0.77	0.00	1.61	3.78
ln(Labor Income)	176	13.14	0.51	12.40	12.99	14.97
ln(Captures)	176	3.19	0.97	0.00	3.18	6.95
% Employees with Social Security	176	70.16	13.52	19.86	70.94	98.01
ln(Population)	176	9.13	0.66	6.39	9.21	10.50
% Married population	176	25.04	7.21	5.23	24.56	45.77
% Secondary Incomplete	176	20.12	5.30	7.69	21.16	35.05
% Young 15-19 do not assist to school	176	71.76	16.61	9.18	72.33	100.00
Average number of children	176	2.00	0.37	0.99	1.99	3.21
2006						
ln(Homicides+1)	176	1.27	0.82	0.00	1.39	3.53
ln(Labor Income)	176	11.94	0.58	9.98	11.87	13.70
ln(Captures)	176	2.41	1.15	0.00	2.49	7.04
% Employees with Social Security	176	59.92	14.12	24.33	58.92	98.86
ln(Population)	176	9.14	0.62	7.13	9.08	10.60
% Married population	176	25.21	6.67	7.74	24.61	42.66
% Secondary Incomplete	176	14.85	3.84	5.07	15.20	22.83
% Young 15-19 do not assist to school	176	74.29	13.91	31.82	73.90	100.00
Average number of children	176	1.94	0.32	1.03	1.96	2.62
2012						
ln(Homicides+1)	176	1.55	0.85	0.00	1.61	3.69
ln(Labor Income)	176	12.88	0.64	11.96	12.69	14.74
ln(Captures)	176	2.85	1.02	0.00	2.83	6.52
% Employees with Social Security	176	42.59	15.49	6.19	44.39	81.24
ln(Population)	176	9.14	0.52	7.59	9.09	10.40
% Married population	176	25.09	8.79	6.72	24.21	49.86
% Secondary Incomplete	176	14.57	5.23	2.49	15.01	29.26
% Young 15-19 do not assist to school	176	75.05	16.44	21.77	75.41	100.00
Average number of children	176	1.67	0.36	0.75	1.67	2.69

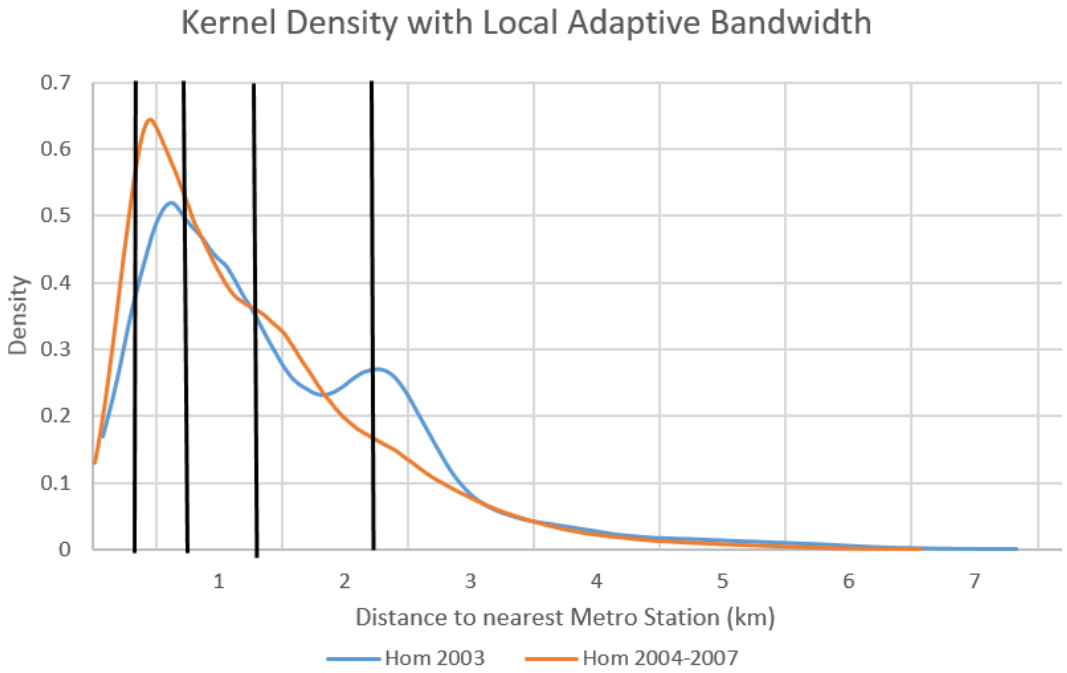
Max-p regions and treatment levels



Sample size and distance to treatment

	Mean distance to nearest Metorcable Line K station (Km)		Number of geographical units in group	
Group	Neighborhoods	Maxp 30	Neighborhoods	Maxp 30
1st Neighbors	0.69	0.77	11	11
2nd Neighbors	1.15	1.33	13	10
3rd Neighbors	1.84	2.18	9	14
Others	6.65	6.82	186	135
Total	5.65	5.54	226	176

Homicide distribution



- Black lines mark the mean distance of treated, 1st, 2nd, and 3rd neighbor units.
- Homicides concentrate around 1st neighbors.
- The distribution of homicide distances to metro stations has not drastically changed over time.

Homicide distribution

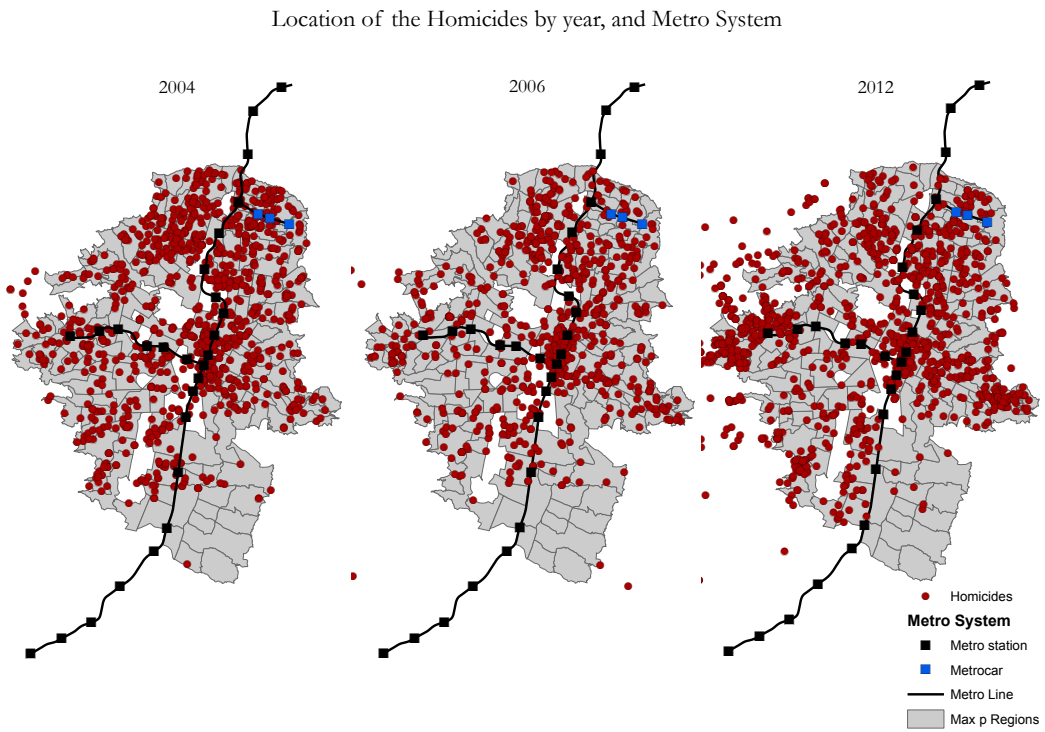
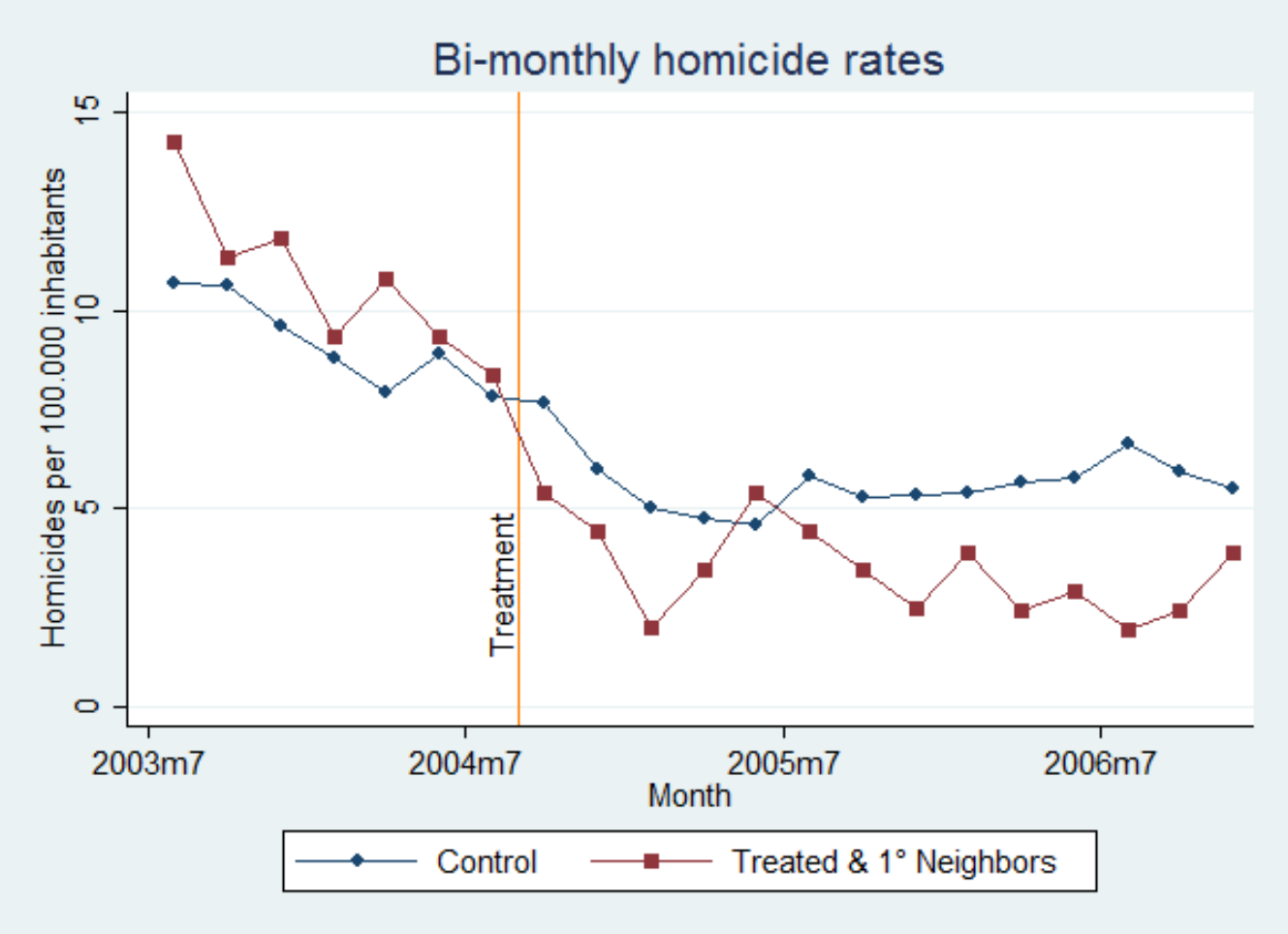


Figure 1: Location of Homicides and the Metro System

Reduction in the number of homicides, change in their pattern.

Pre and post-treatment behavior of homicides



Outline

Main results

Dependent: ln(Homicides+1)	Treated + 1st Neighbors	Treated + 2nd Neighbors	Treated + 3nd Neighbors
Difference in Difference			
		Short Impact (2004-2006)	
Total Impact	-0.53**	-0.18	-0.10
	(0.21)	(0.20)	(0.18)
	-41.19%	-16.48%	-9.44%
		Medium Impact (2004-2012)	
Total Impact	-0.71***	-0.59***	-0.62***
	(0.23)	(0.20)	(0.18)
	-50.97%	-44.35%	-45.97%
Spatial Difference in Difference			
		Short Impact (2004-2006)	
Total Impact	−0.54**	−0.23	−0.13
	(0.25)	(0.21)	(0.18)
	−41.77%	−20.19%	−11.97%
		Medium Impact (2004-2012)	
Total Impact	−0.68***	−0.56***	−0.60***
	(0.25)	(0.21)	(0.18)
	−49.38%	−42.80%	−45.25%
Number of treated units	17	27	41
Number of control units	159	149	135

Robustness test: neighborhoods as geo-units

Dependent: ln(Homicides+1)	Treated + 1st Neighbors	Treated + 2nd Neighbors	Treated + 3nd Neighbors
Difference in Difference			
		Short Impact (2004-2006)	
Total Impact	−0.50**	−0.13	−0.04
	(0.20)	(0.17)	(0.16)
	−39.38%	−12.47%	−4.00%
		Medium Impact (2004-2012)	
Total Impact	−0.68***	−0.60***	−0.56***
	(0.22)	(0.18)	(0.17)
	−49.12%	−45.39%	−42.96%
Spatial Difference in Difference			
		Short Impact (2004-2006)	
Total Impact	−0.51**	−0.16	−0.06
	(0.23)	(0.18)	(0.17)
	−39.98%	−15.15%	−5.80%
		Medium Impact (2004-2012)	
Total Impact	−0.62***	−0.56***	−0.54***
	(0.24)	(0.19)	(0.18)
	−46.12%	−43.13%	−41.43%
Number of treated units	18	31	40
Number of control units	208	195	186

Robustness test: genetic matching

- Proposed by Diamond and Sekhon [2013], restricts the control set to improve pre-treatment homogeneity.
- Weights for covariates are determined using a genetic search algorithm.
- We perform 1-to-1 matching based on pre-treatment social controls, homicides, and geographical characteristics: elevation and slope.

Robustness test: genetic matching

Diffs-in-Diffs estimators			
Max-p regions as analytical units			
	1st Neighbors	**2nd Neighbors**	**3rd Neighbors**
Short impact (2004-2006)	−0.53	−0.53**	−0.41*
	(0.32)	(0.24)	(0.21)
	−41.21%	−41.28%	−33.61%
Medium impact (2004-2012)	−1.01***	−0.82***	−0.84***
	(0.30)	(0.24)	(0.20)
	−63.50%	−55.82%	−56.83%
Neighborhoods regions as analytical units			
	1st Neighbors	**2nd Neighbors**	**3rd Neighbors**
Short impact (2004-2006)	−0.25	−0.28	−0.18
	(0.26)	(0.23)	(0.23)
	−22.00%	−24.72%	−16.07%
Medium impact (2004-2012)	−0.55*	−0.83***	−0.69***
	(0.31)	(0.26)	(0.22)
	−42.55%	−56.39%	−49.75%

Sequential estimations: criminal displacement?

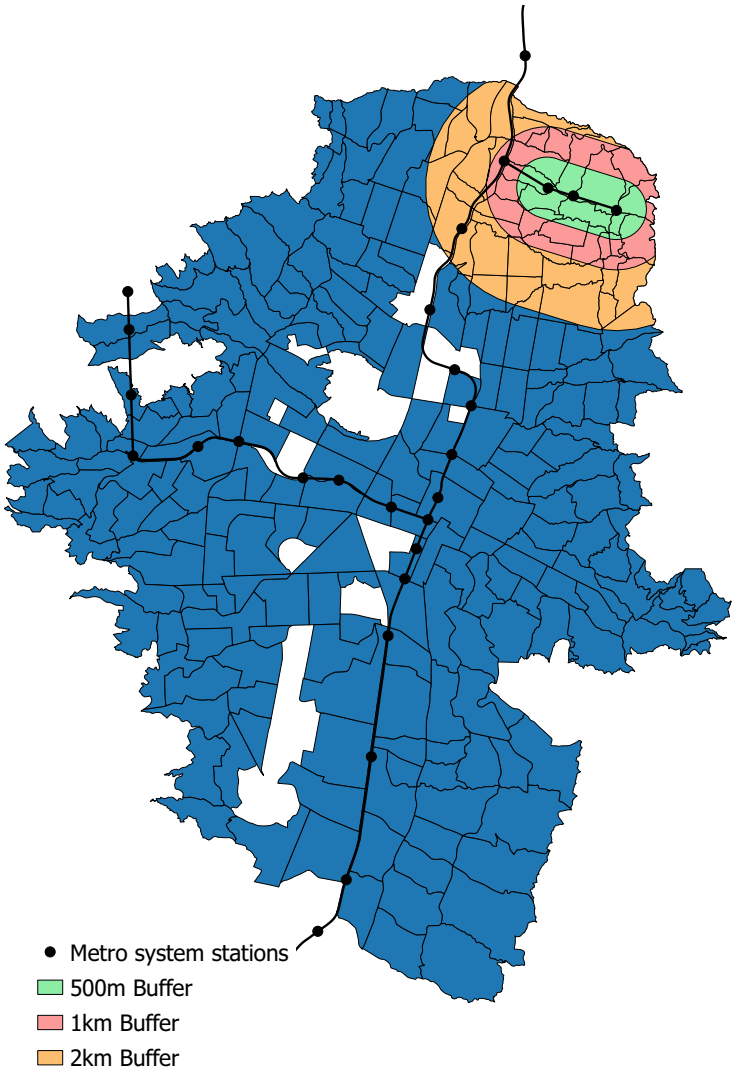
Spatial Diffs-in-Diffs using Max-p regions

Dependent: ln(Homicides+1)			
	Short impact (2004-2006)		
	1st Neighbors	2nd Neighbors	3rd Neighbors
Treated + 1st Neighbors	−0.59**		
	(0.30)		
Treated + 2nd Neighbors	−0.57*	0.30	
	(0.30)	(0.32)	
Treated + 3rd Neighbors	−0.56*	0.34	0.03
	(0.31)	(0.33)	(0.28)
	Medium impact (2004-2012)		
	1st Neighbors	2nd Neighbors	3rd Neighbors
Treated + 1st Neighbors	−0.71**		
	(0.31)		
Treated + 2nd Neighbors	−0.73**	−0.32	
	(0.31)	(0.33)	
Treated + 3rd Neighbors	−0.79**	−0.38	−0.53*
	(0.32)	(0.33)	(0.28)

Mechanisms, spatial Diffs-in-Diffs regressions

Dependent: ln(Homicides+1)	Treated + 1st Neighbors	Treated + 2nd Neighbors	Treated + 3nd Neighbors
	Short Impact (2004-2006)		
Total Impact	−0.54**	−0.23	−0.13
	(0.25)	(0.21)	(0.18)
	−41.77%	−20.19%	−11.97%
Net of Economic mechanism	−0.48*	−0.17	−0.09
	(0.25)	(0.21)	(0.18)
	−37.92%	−15.90%	−8.65%
Net of Police mechanism	−0.42*	−0.17	−0.07
	(0.22)	(0.19)	(0.16)
	−34.44%	−15.63%	−6.64%
Net of Both mechanisms	−0.31	−0.08	−0.00
	(0.23)	(0.19)	(0.16)
	−26.88%	−7.63%	−0.07%
	Medium Impact (2004-2012)		
Total Impact	−0.68***	−0.56***	−0.60***
	(0.25)	(0.21)	(0.18)
	−49.38%	−42.80%	−45.25%
Net of Economic mechanism	−0.66***	−0.56***	−0.60***
	(0.25)	(0.21)	(0.18)
	−48.35%	−42.72%	−45.37%
Net of Police mechanism	−0.60***	−0.47**	−0.46***
	(0.22)	(0.18)	(0.16)
	−45.07%	−37.23%	−36.90%
Net of Both mechanism	−0.55**	−0.45**	−0.45***
	(0.23)	(0.18)	(0.16)
	−42.37%	−36.27%	−36.15%

Robustness test: buffer estimations



- Neighborhoods as base analytical unit.
- Units are considered treated if at least 10% of their area lies in the buffer.

Robustness test: buffer estimations

Dependent: ln(Homicides+1)	500m	1km	2km
Short Impact (2004-2006)			
Total Impact	−0.29	−0.31*	−0.02
	(0.21)	(0.18)	(0.15)
	−24.83%	−26.58%	−2.41%
Net of Economic mechanism	−0.27	−0.28	−0.03
	(−0.20)	(0.17)	(0.15)
	−23.72%	−24.11%	−2.60%
Net of Police mechanism	−0.32*	−0.30*	−0.03
	(0.19)	(−0.16)	(0.14)
	−27.54%	−25.85%	−2.60%
Net of Both mechanisms	−0.21	−0.18	0.05
	(−0.20)	(−0.17)	(0.15)
	−19.26%	−16.15%	4.85%
Medium Impact (2004-2012)			
Total Impact	−0.42*	−0.67***	−0.55***
	(0.24)	(0.20)	(0.17)
	−34.48%	−48.76%	−42.54%
Net of Economic mechanism	−0.38	−0.66***	−0.57***
	(0.23)	(0.19)	(0.17)
	−31.72%	−48.08%	−43.48%
Net of Police mechanism	−0.42*	−0.57***	−0.47***
	(0.22)	(0.18)	(0.16)
	−34.34%	−43.72%	−37.49%
Net of Both mechanisms	−0.35	−0.53***	−0.45***
	(−0.22)	(0.18)	(0.16)
	−29.71%	−41.31%	−36.29%

Outline

Preliminary conclusions I

- The point estimates suggest that the implementation of the cable cart did not have an effect in the treated units alone, but had a large and statistically significant effect when considering the treated and neighbor units (up to third degree, depending on the time frame).
- We find small and not statistical significant results for the immediate short run (1, 2 years) estimates while we find strong and large effects over time.
- Our results seem not to rely on the choice of Max-p analytical units, as similar temporal and geographical effects arise when using neighborhoods as observations.
- Metrocables' effect could be greater, as using a homogeneous (limited) sample raises our estimates around 10%.
- Migration must not distort our estimates, as treated areas have under-average rates of migrant population (6% - 10%).
- We find no evidence of criminal displacement.

Preliminary conclusions II

- Our estimates suggest the greatest impact on homicide rates is found in a frame between 500m and 1km from the nearest Metrocable station. This is where neighbor units are mainly located.
- When considering the spatial interactions, the Metrocable has reduced long-run homicide rates in first neighbors by 50% while, when considering the second neighbors this effect is reduced to 40%.
- In the short run about 12% of the total effect can be attributed to the economic mechanism, effect that tends to be reduced in the medium run.
- We find that near 17% of the effect in the short run can be explained by the police mechanism (deterrent), however this mechanism reduces to about 8% in the medium run.
- Finally, we find that a combination of these two mechanisms explains about 34% of the effect in the short run and near 14% in the medium run.

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