Regional Convergence, Spatial Scale, and Spatial Dependence:

Evidence from Homicides and Personal Injuries in Colombia 2010-2018

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Motivation:

- Beyond GDP, social variables and their convergence are relevant for development studies (Royuela et al 2015)
- Persistent income differences, differences in health indicators and in "general" regional inequality in Colombia.
- Scarce academic literature on inequality (convergence approach) at the municipality level.

Research Objective:

- Study convergence/divergence of homicide rates and personal injury across municipalities and departments in Colombia 2010-2018
- Analyze spatial autocorrelation and its robustness at different disaggregate levels

-Discuss policy implications of findings

Methods:

- Classical convergence framework (Barro and Sala-i-Martin 1992)
- Distributional convergence framework (Quah 1996; Hyndman et. al 1996)
- Spatial autocorrelation (Moran's I)

Main Results:

1. **Sigma Convergence** for both rates at the state level, **Beta Convergence** for both levels and rates.

2. Regional disaggretation matters: **Local convergence clusters**

3. **Clustering dynamics**

    - NMR State level: 4+? convergence clusters
    - NMR Municipal level: 2+? convergence clusters -NPIR State level: 2 convergence clubs -NPIR Municipal level: divergence and 2 convergence clubs

4. **Spatial Autocorrelation** robust only at the municipality level

Outline of this presentation

1. **Data description** Survival rates (not homicide rates)
2. **Global convergence:** Using classical summary measures
    - Beta convergence
    - Sigma convergence
3. **Regional disaggregation:**
    - Distribution dynamics framework
    - Distributional convergence
4. **Global spatial autocorrelation:**
    - Disaggreagation effects
5. **Policy discussion**
    - Colombian National Development Plan
    - RCT and spatial autocorrelation
6. **Concluding Remarks**

Data:

- Total number of homicides and personal injuries in Colombia per year from 2010 until 2018 (data taken from the National police).
- Data is agreggated at the municipality and departament level.
- Population census and estimates for states and municipalitites.
- Raw rates computed

$$Hrate = homicides/population$$

- Survival rates (non- murder rates) computed

$$NMR = 10000 - raw\ rate * 10000$$

- **Survival rates** are chosen because positively defined variables are a **standard** in the convergence literature.

(2) Global convergence:

Using classical summary measures

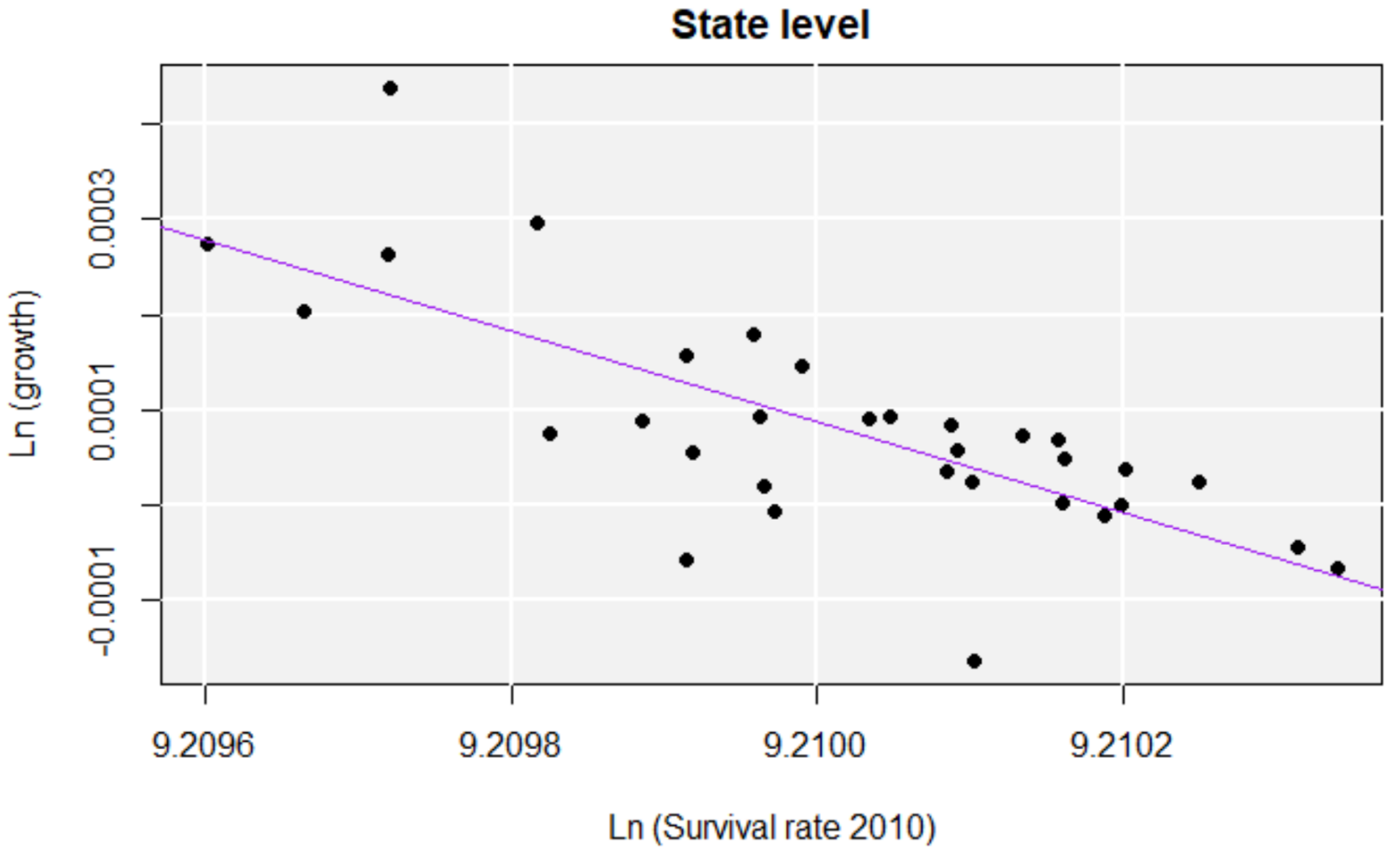
Beta convergence

Sigma convergence

States- Sigma and Beta convergence

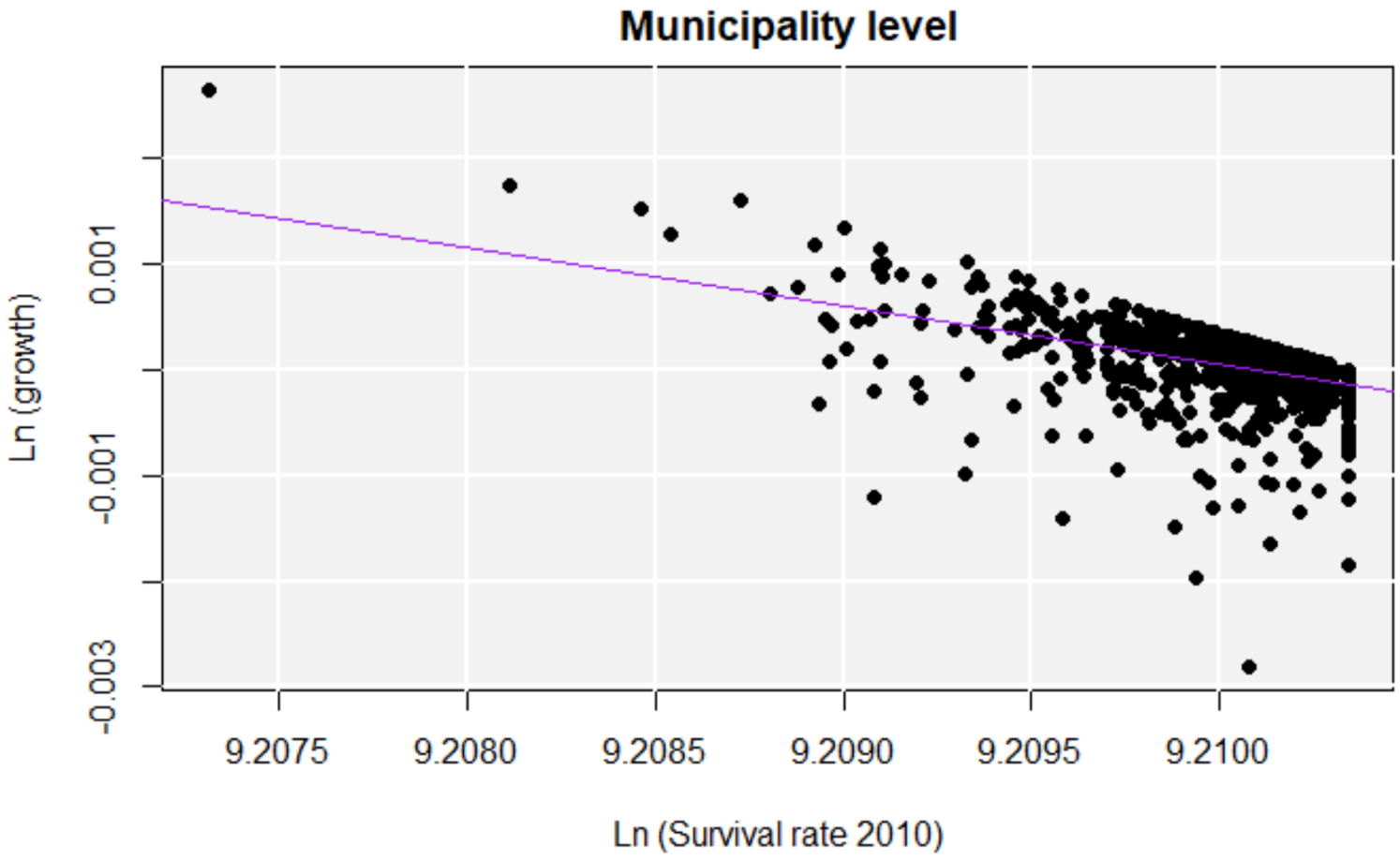
$$\sigma(Standard\ \ deviation)\ \sigma_{2010} = 1.84 \quad \sigma_{2018} = 1.26$$

$$log\frac{Y_t}{Y_0} = \alpha + \beta * logY_0 + \epsilon \quad \beta = -0.476^{***} \quad halflife = 8.59\ years$$



Municipalities - Beta convergence (only)

$$log\frac{Y_t}{Y_0} = \alpha + \beta * logY_0 + \epsilon \quad \beta = -0.551^{***} \quad halflife = 6.92\ years$$



Beta and sigma convergence summary

Table 1. Classical convergence framework summary

Crime Rate	Beta Coefficient	Half-Life (in years)	σ_{2010}	σ_{2018}
NMR (state)	-0.08	8.6	1.9	1.3
NMR (municipality)	-0.10	6.9	3.1	3.3
NPIR (state)	-0.13	5.3	9.3	8.2
NPIR (municipality)	-0.06	10.2	9.5	15.0

Note: all beta coefficients are highly significant p-value < 0.001

(3) State and Municipality disaggregation:

Distribution dynamics framework

Distributional convergence class: middle

Regional heterogeneity matters

Dynamics of the **entire regional distribution**

conditional density estimation

The distribution dynamics framework

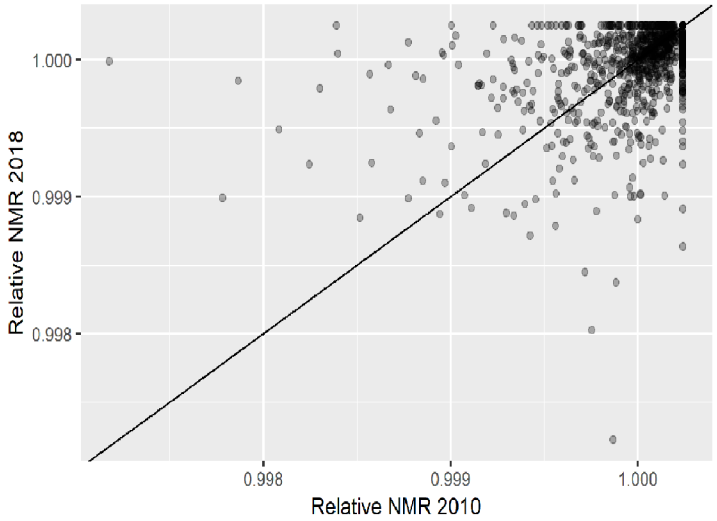
(4) Local convergence clusters

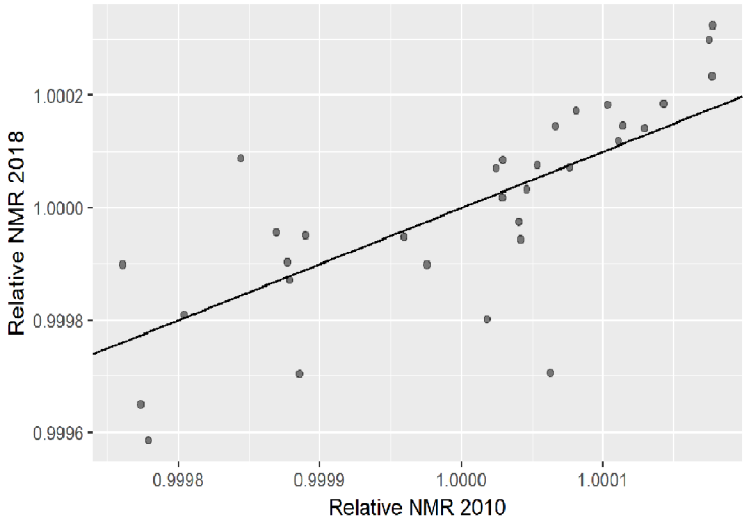
State level: 4+? convergence clusters

Municipality level: 2+? convergence clusters

Where are the clusters?

Municipality level - - - - - - - - - - - - - - Department Level

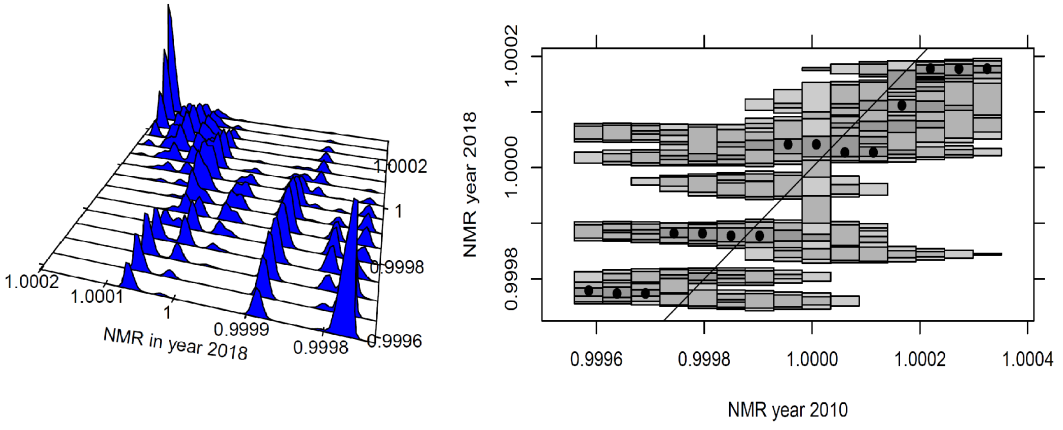




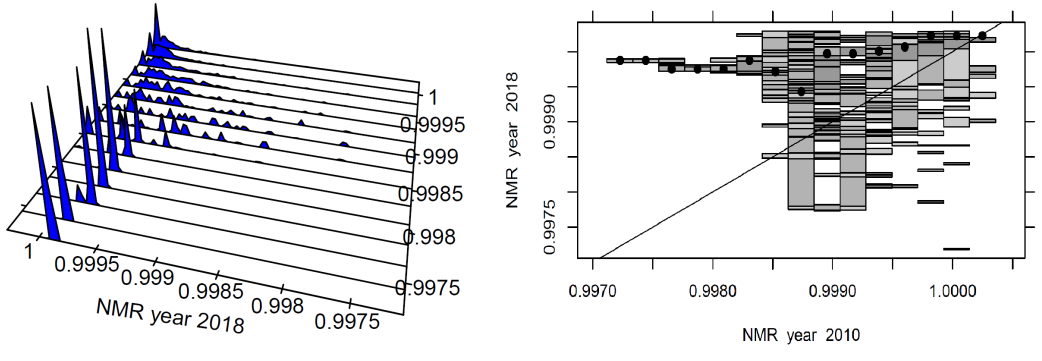
Those lines are not regression trends!

NMR at both levels

State level: 4+? convergence clusters



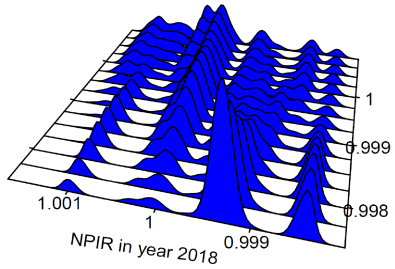
Municipality level: 2+? convergence clusters

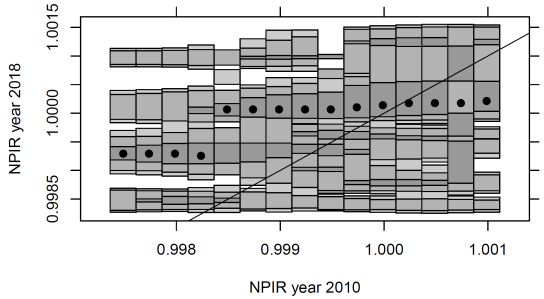


Interesting results; there are fewer clusters but sigma convergence is not present.

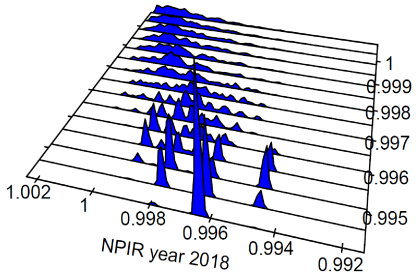
NPIR at both levels

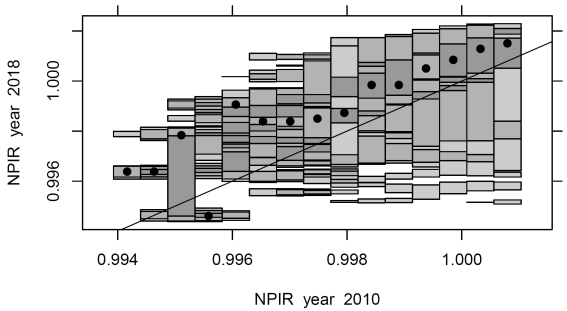
State level: 2 convergence clusters





Municipality level: 2 convergence clusters and divergence

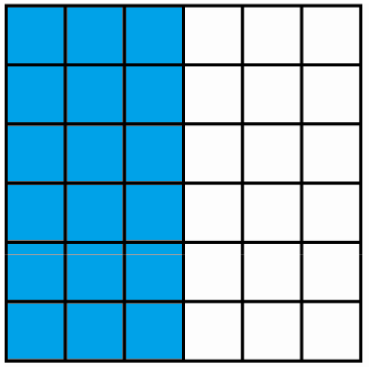




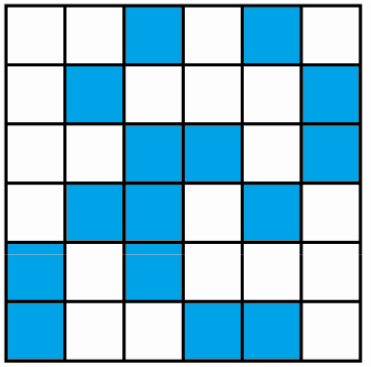
Interesting results; there are fewer clusters but sigma convergence is not present.

(4) Spatial Autocorrelation (moran I definition)

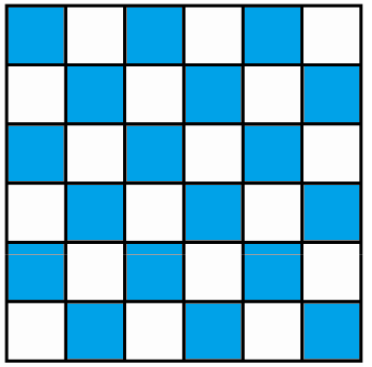
High Intuition Concept



Positive spatial autocorrelation



No spatial autocorrelation



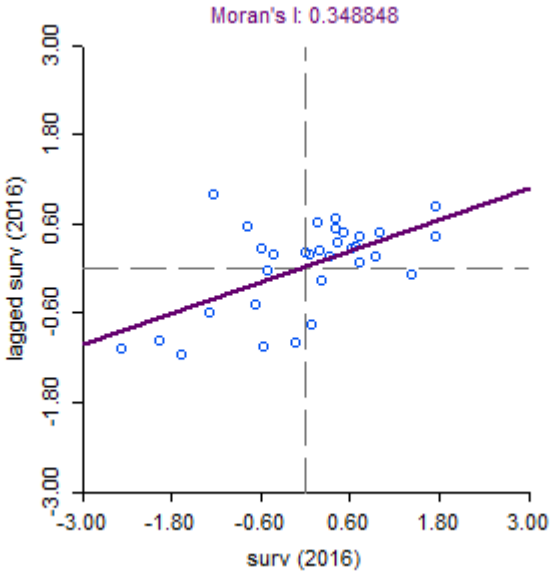
Negative spatial autocorrelation

Source: adapted from Radill (2011)

More Formal (less intuitive)

$$I = \frac{\sum_i \sum_j w_{ij} z_i . z_j}{\sum_i z_i^2} = \frac{\sum_i (z_i \times \sum_j w_{ij} z_j)}{\sum_i z_i^2}.$$

In the linear regression **y=α+βx** , the estimate for **β** is $\sum_i (x_i \times y_i) / \sum_i x_i^2$.In the Moran scatter plot shown below, **y** is the spatial lag variable $\sum_j w_{ij} z_j$



Differential Moran Scatter Plot ($y_{i,t} - y_{i,t-1}$)

Differencing the variable to control for the locational fixed effects: We computate the Moran's I for the variable $y_{i,t} - y_{i,t-1}$. If we consider there is a fixed effect μ_i related to location i, it is possible to present the value at each location for time t as the sum of some intrinsic value and the fixed effect. $y_{i,t} = y *_{i,t} + \mu_i$ (Geoda documentation 2019)

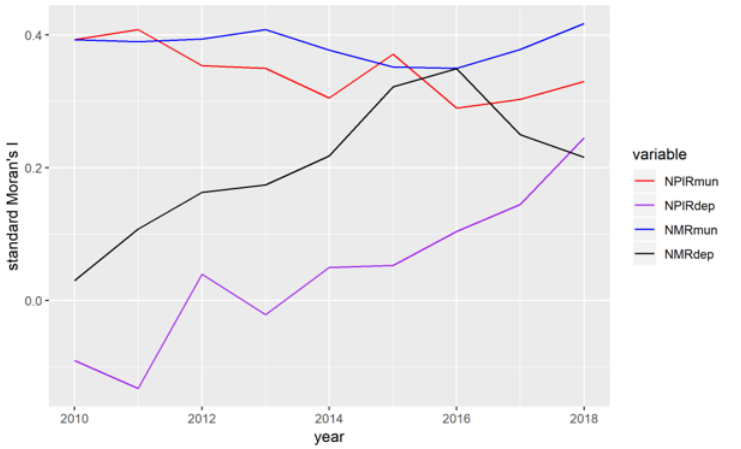
(4) Spatial autocorrelation

1. **State level**: Moran's I statistic significant, differntial Moran's I is not significant (**not robust**)

2. **Municipality level**: Differential Moran's I significant (**robust**)

Figure 6: Moran's I for crime rates at both spatial levels

(a) Moran's I for crime rates



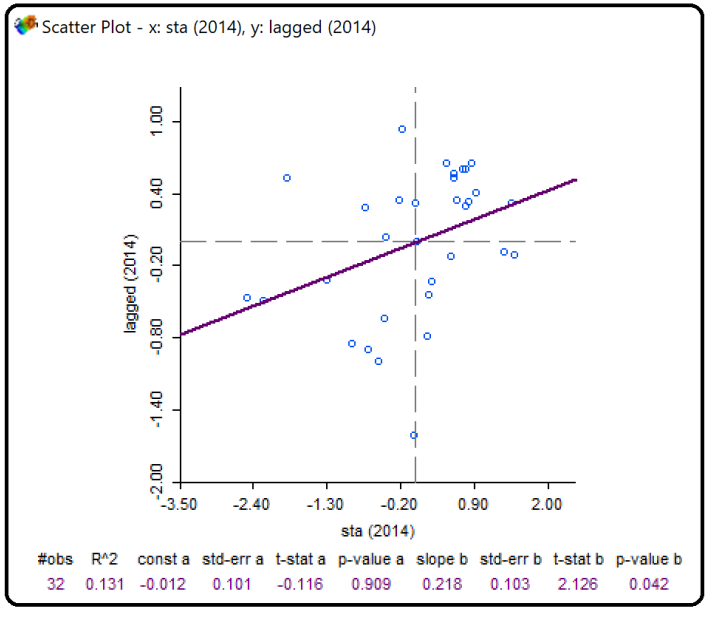
(b) Differential Moran's I for crime rates

(4) Spatial autocorrelation

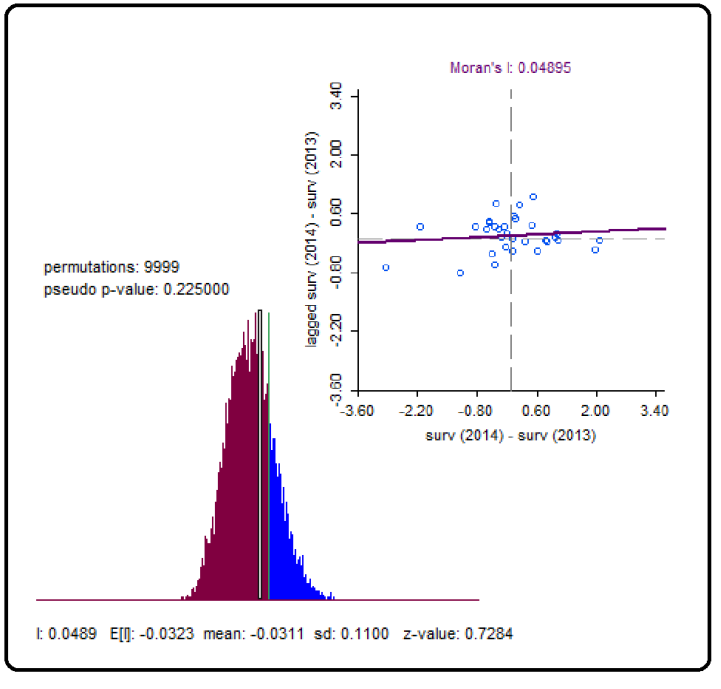
State level (not robust)

- Univatiate Moran's I is significant from 2012.
- But, **The differential moran statistic is not significant**. It is then considered that the significance of Spatial Autocorrelation is **not robust**.
- See plots for 2014 and 2014-2013, similar for other years (standarized variables)

Univariate Moran



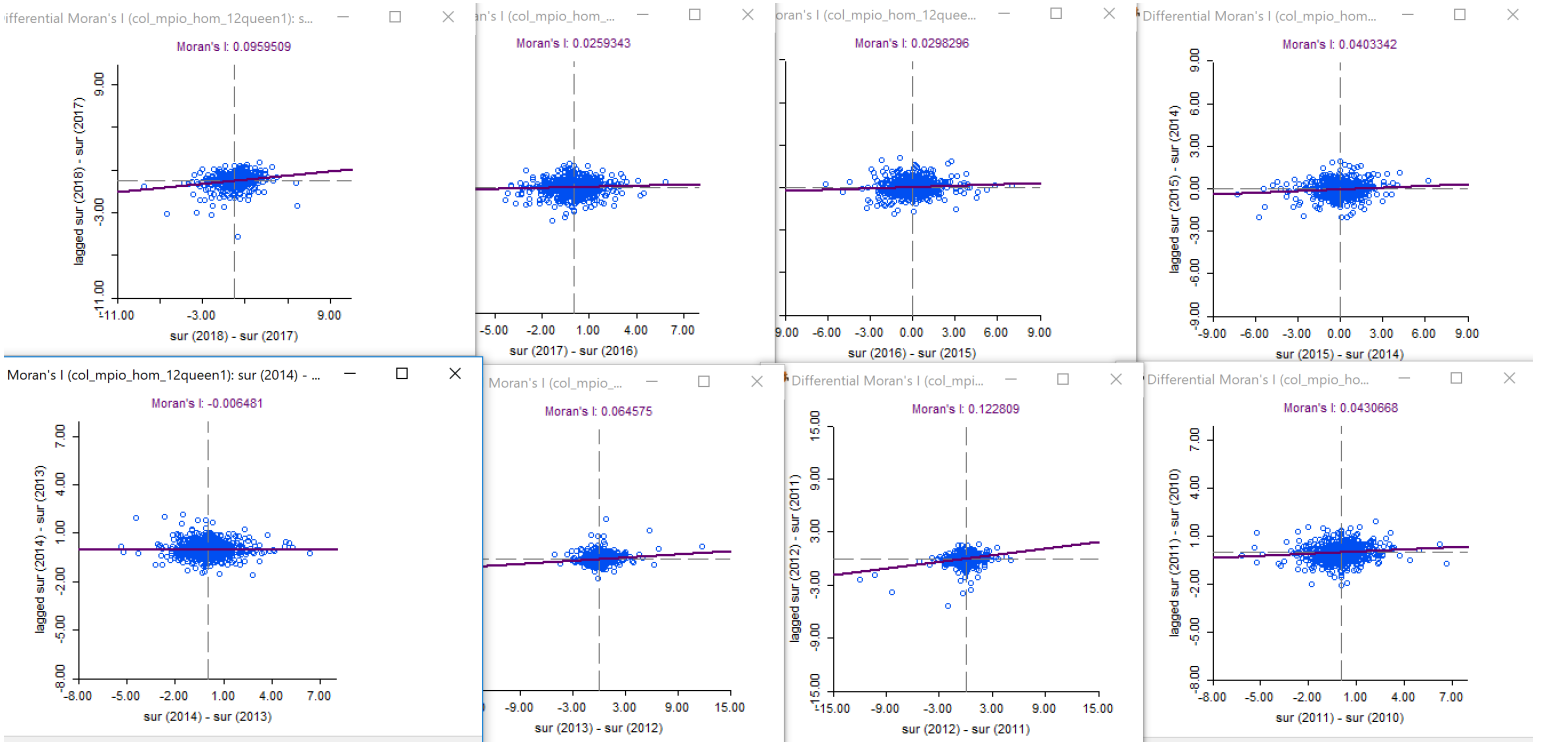
Differential Moran



(4) Spatial autocorrelation

Municipality level (Robust)

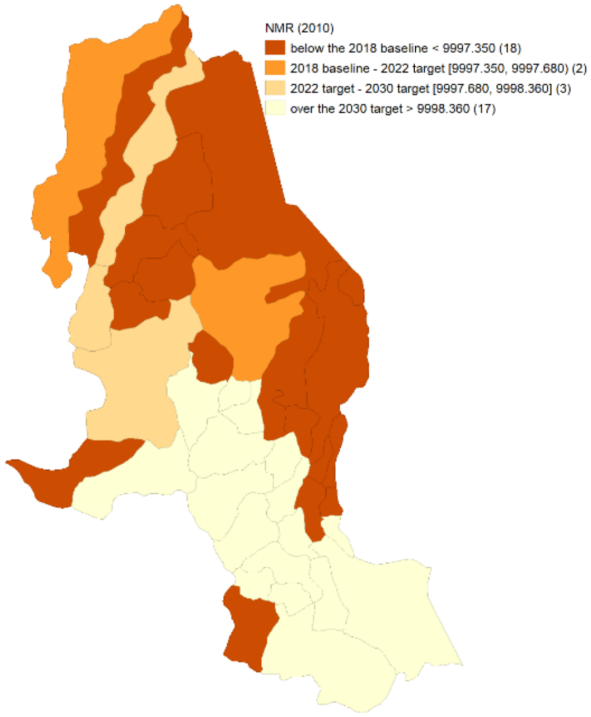
- The univariate Moran's I is not significant in 2010 and 2011. however, it is significant from 2012 to 2018; reaching a maximum value in 2016.
- Differential Moran's I ($sur_{2018} - sur_{2010}$) is **significant** $Moran's\ I = 0.22^{***}$
- Subsequent Differential Moran's I $sur_t - sur_{t-1}$ **statistically significant at the municipality level**. Except 2014-2013 (not statistically significant) see graphs

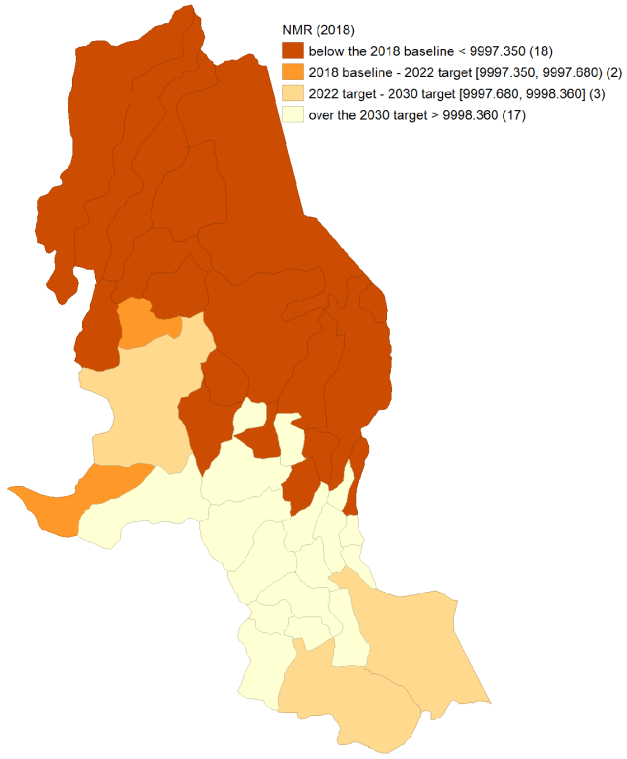


(4) Policy discussion

vertical and horizontal policy coordiantion:

It could be more appropriate for the formulation of national development plans to have convergence targets at the state level as well as the municipal level





(4) Policy discussion

The need for a spatial perspective in current cash transfer programs:

- Spatial regressions could be used to test determinant hypothesis
- Moreover, such research could contribute to the literature by suggesting a case for spatially focused CCTs.
- Ultimately, this type of analysis could serve a as tool for combating organized crime in specific locations

Cuadro 2: Efecto promedio de las transferencias de FA sobre el crimen

	(1)	(2)	(3)	(4)	(1)	(2)	(3)	(4)
Panel A: Efecto sobre la tasa de homicidios y el robo a casas								
	Tasa de homicidios				Robo a casas			
Proporción FA con pago	0,248	0,231	0,185	0,230	1,199	1,569	2,549	2,171
	(0,440)	(0,426)	(0,375)	(0,363)	(2,896)	(2,495)	(2,084)	(2,132)
R^2	0,00	0,00	0,00	0,01	0,00	0,00	0,00	0,00
Observaciones	30.155	30.155	15.480	9.610	30.155	30.155	15.480	12.545
Panel B: Efecto sobre el robo a personas y a vehículos								
	Robo personas				Robo vehículos			
Proporción FA con pago	-6,649**	-6,711**	-6,263**	-7,547**	-0,512*	-0,527**	-0,265	0,052
	(3,117)	(2,980)	(2,714)	(3,251)	(0,262)	(0,204)	(0,196)	(0,327)
R^2	0,01	0,01	0,01	0,01	0,00	0,00	0,00	0,01
Observaciones	30.155	30.155	15.480	12.545	30.155	30.155	15.480	9.610
Ancho de banda	8 días	8 días	3 días	I&K	8 días	8 días	3 días	I&K
Forma funcional	Sin incluir	Cuártica	Cuadrática	Lineal	Sin incluir	Cuártica	Cuadrática	Lineal

Camacho, A., & Mejía, D. (2013). Las externalidades de los programas de transferencias condicionadas sobre el crimen: El caso de Familias en Acción en Bogotá (No. IDB-WP-406). IDB Working Paper Series

(5) Concluding Remarks

Uplifting results "on average" :

- Differences in overall raw rates at the state level **have decreased** and the means at both levels have increased (survival rate)
- **Global convergence on average at the state level**, while fast beta convergence at the municipality level.

Beyond classical convergence :

- Regional differences matter in **both disaggreagation levels**.
- **Multiple local convergence clubs**; with more clubs at the state level.

The Role of Space

- Subsequent Differential Moran's I are robust and significant at the **municipality level only**
- Results at the **state level** are not conlusive and similar to the ones reported by Royuela et al 2015.

(5) Concluding Remarks

Implications and further research

- Strong spatial autocorrelation suggest the posibility of applying the Getis filtering in order to filter the spatial component of homicide variables.
- Convergence clusters help us to find regions with similar outcomes, coordination among them can be promoted.
- Has crime followed a trajectory? can a speed and direction of contagious patterns be found?
- At the state or department level (including more variables) can a probit model help us to find the determinants for a conditional "jump" to the upper clusters.

Thank you very much for your attention

If you are interested in our research, you can check my webisite where you can find this presentation https://felipe-santos.rbind.io please check Prof. Carlos Mendez website https://carlos-mendez.rbind.io

And our QuaRCS lab website https://quarcs-lab.rbind.io/

Stay tuned for my Master's thesis

Will the SGDs be Achieved in Colombia? A Study of National Convergence and Regional differences.

Gender inequality, Income, Eduacation, Crime... Classical convergence, Distributional Dynamics, Spatial Filtering, Spatial econometrics, long-run Filtering...