Regional Convergence, Spatial Scale, and Spatial Dependence:

Evidence from Homicides and Personal Injuries in Colombia 2010-2018

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[Slides available at: https://quarcs-lab.rbind.io/]

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. **Among the most unequal countries in the world in terms of the income gini coefficient**.
- **Scarce academic literature on inequality (convergence approach) and crime at the municipality level**.

Research Objective:

- Study convergence/divergence of homicide rates (**NMR**) and personal injury rates (**NPIR**) across municipalities and departments in Colombia 2010-2018
- Analyze spatial autocorrelation and its robustness at different disaggregation levels

Methods:

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

Main Results:

1. **Sigma Convergence** and **Beta Convergence** for both homicide and personal injury rates at the state level. However just **Beta Convergence** for both crimes at the municipal level.
2. Regional disaggretation matters: **Local convergence clusters**
3. **Clustering dynamics** different clubs for both crimes and levels
4. **Spatial Autocorrelation** robust only at the municipality level

Main Contributions

1. Study of **classical and distribution convergence** for two crimes and **contrasting results for two levels**: 32 States and 1120 municipalities.
2. Spatial autocorrelation is **robust for the higher level**.
3. Uniform progress of States and municipalitites (NMR). **first robust findings of convergence of NMR** in the literature.

Outline of this presentation

1. **Data description** Non crime 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**
    - The Colombian National Development Plan 2018-22
    - CCTs 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 municipal and departmental levels.
- Population census and estimates for states and municipalitites.
- Raw rates are computed:

$$raw\ rates = crimes/population$$

- Non-crime rates are computed:

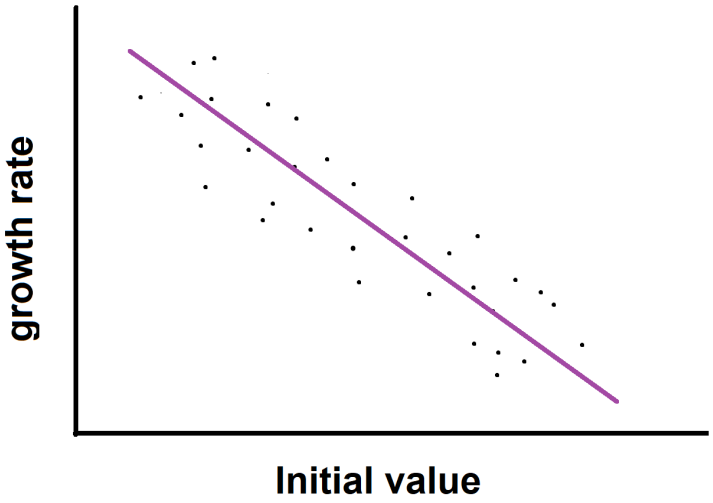
$$NCR = 10000 - raw\ rate * 10000$$

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

(2) Global convergence:

Using the classical convergence framework

Beta convergence (the catch-up effect)

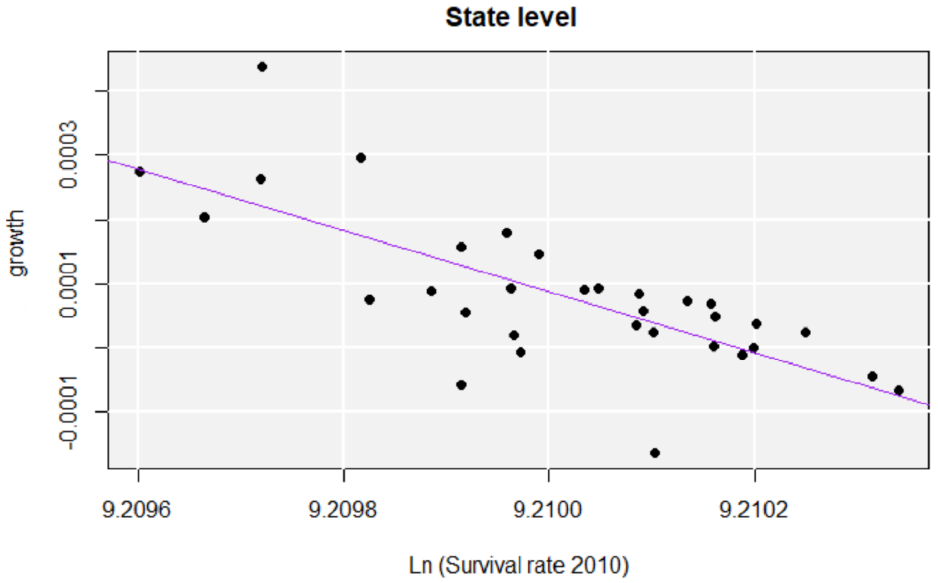


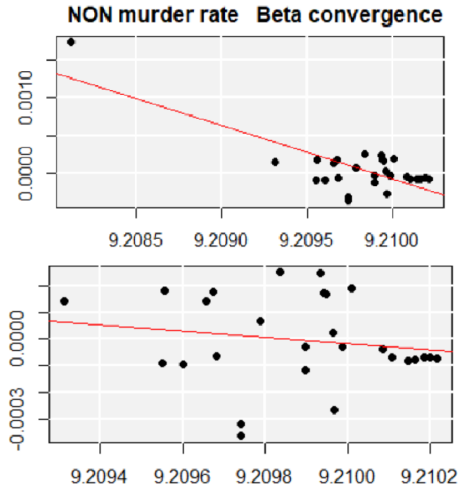
Sigma convergence (the dispersion of the data decreaseses over time)

States- Sigma and Beta convergence (NMR)

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

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



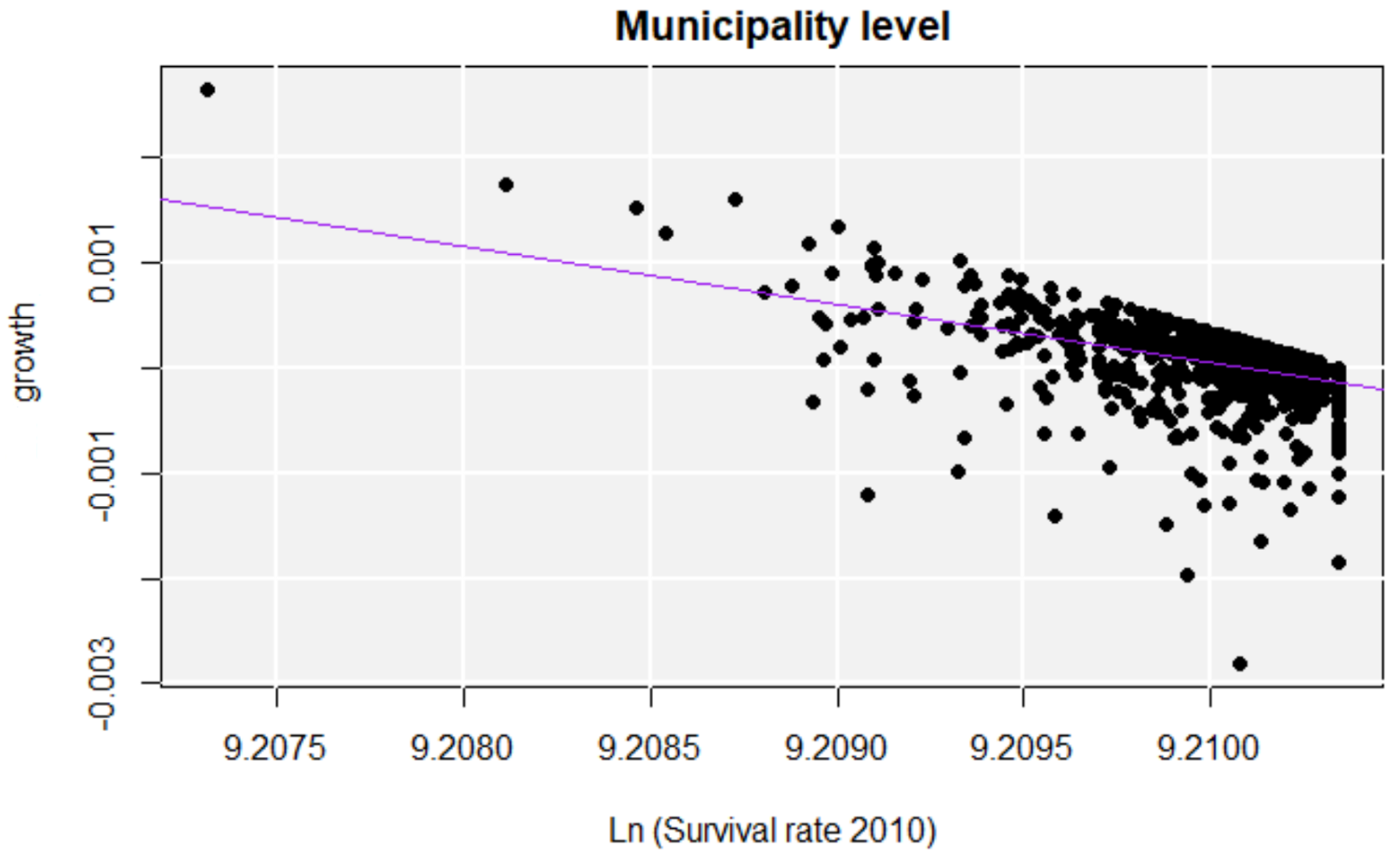


Data for 1990-2005

Royuela and García, 2015

Municipalities - ONLY Beta convergence (NMR)

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



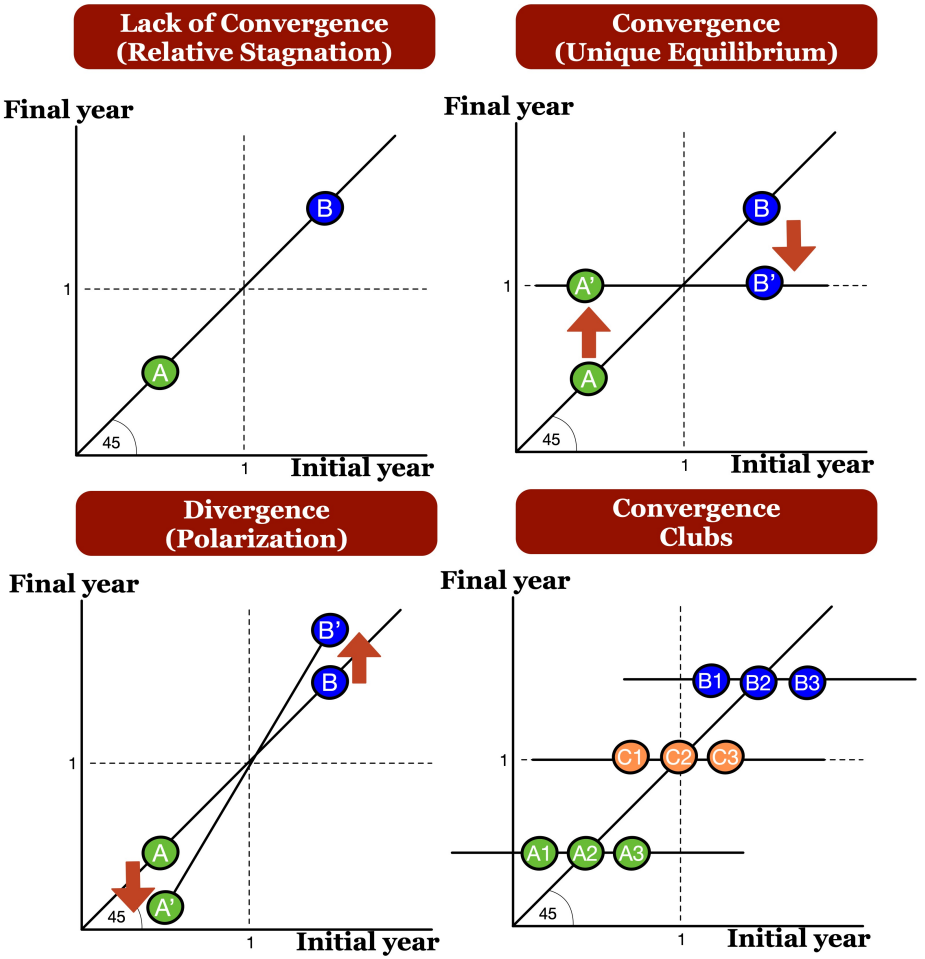
Beta and sigma convergence summary

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: The distribution dynamics framework



(3) Local convergence clusters

NMR State level: 4+? convergence clusters

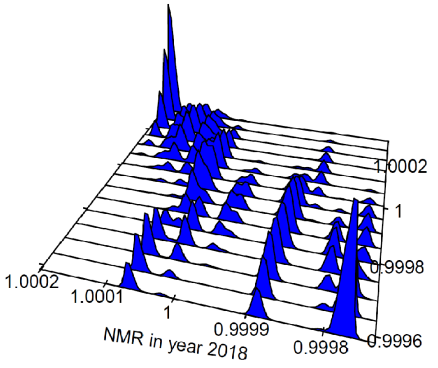
NMR Municipal level: 2+? convergence clusters

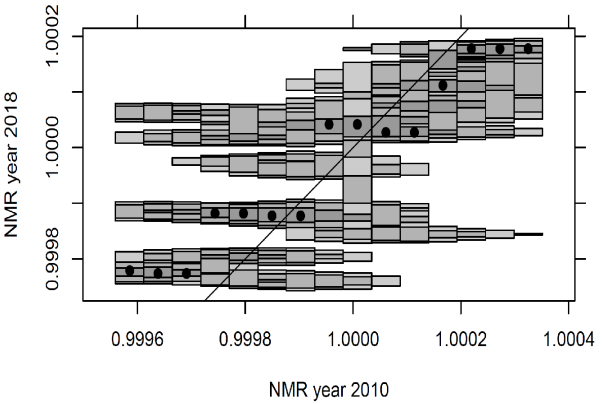
NPIR State level : 2 convergence clubs

NPIR Municipal level : "stagnation" and 2 convergence clubs

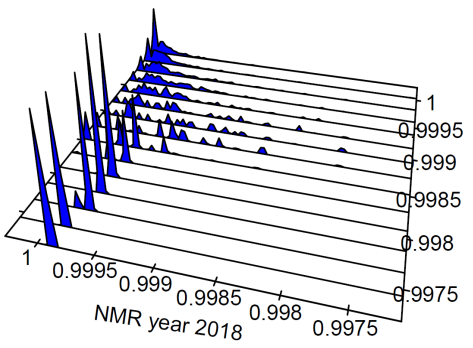
NMR at both levels

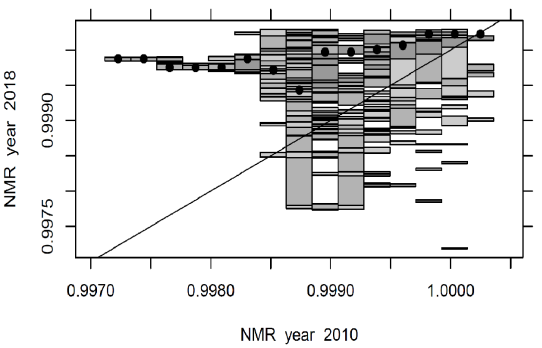
State level: 4+? convergence clusters (previous studies found 2-3)





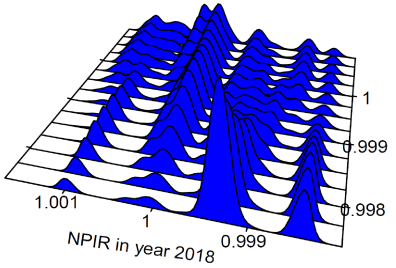
Municipality level: 2+? convergence clusters

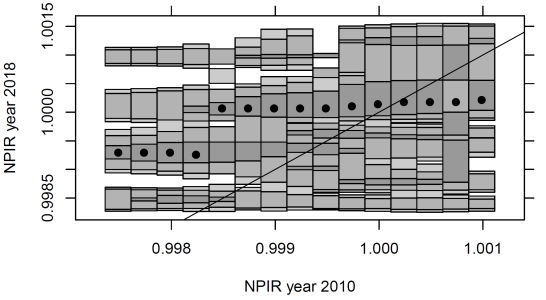




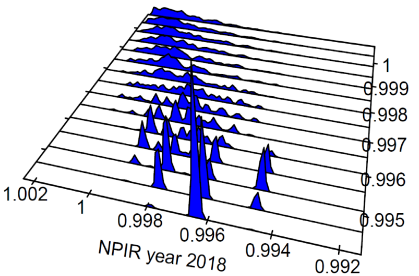
NPIR at both levels

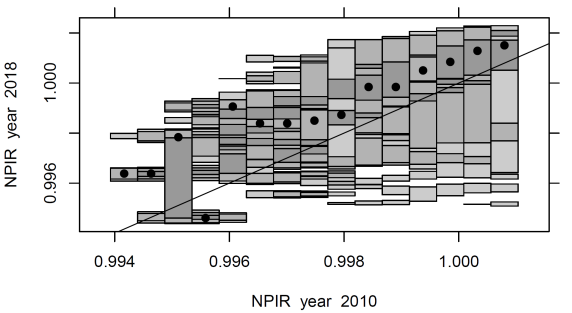
State level: 2 convergence clusters





Municipality level: 2 convergence clusters and "stagnation"

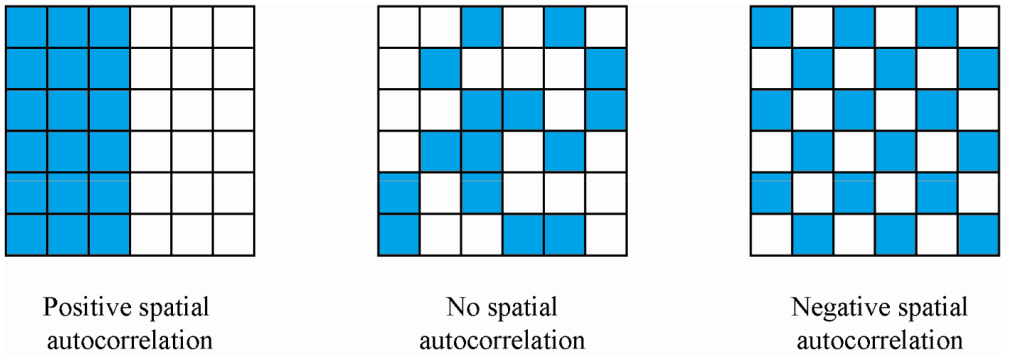




Interesting results; the same number of clusters but stagnation patterns are stronger at the municipal level

(4) Spatial Autocorrelation (Theory)

High Intuition Concept



Source: adapted from Radill (2011)

More Formal (less intuitive)

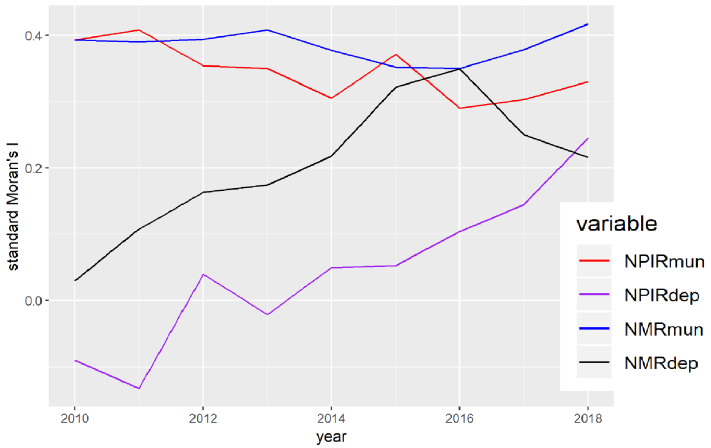
$$I = \frac{\sum_i \sum_j w_{ij} z_i . z_j}{\sum_i z_i^2} = \frac{\sum_i (z_i \times \sum_j w_{ij} z_j)}{\sum_i z_i^2}.$$

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

If 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. $y_{i,t} = y*_{i,t} + \mu_i$. Differencing the variable to control for the locational fixed effects $y_{i,t} - y_{i,t-1}$.

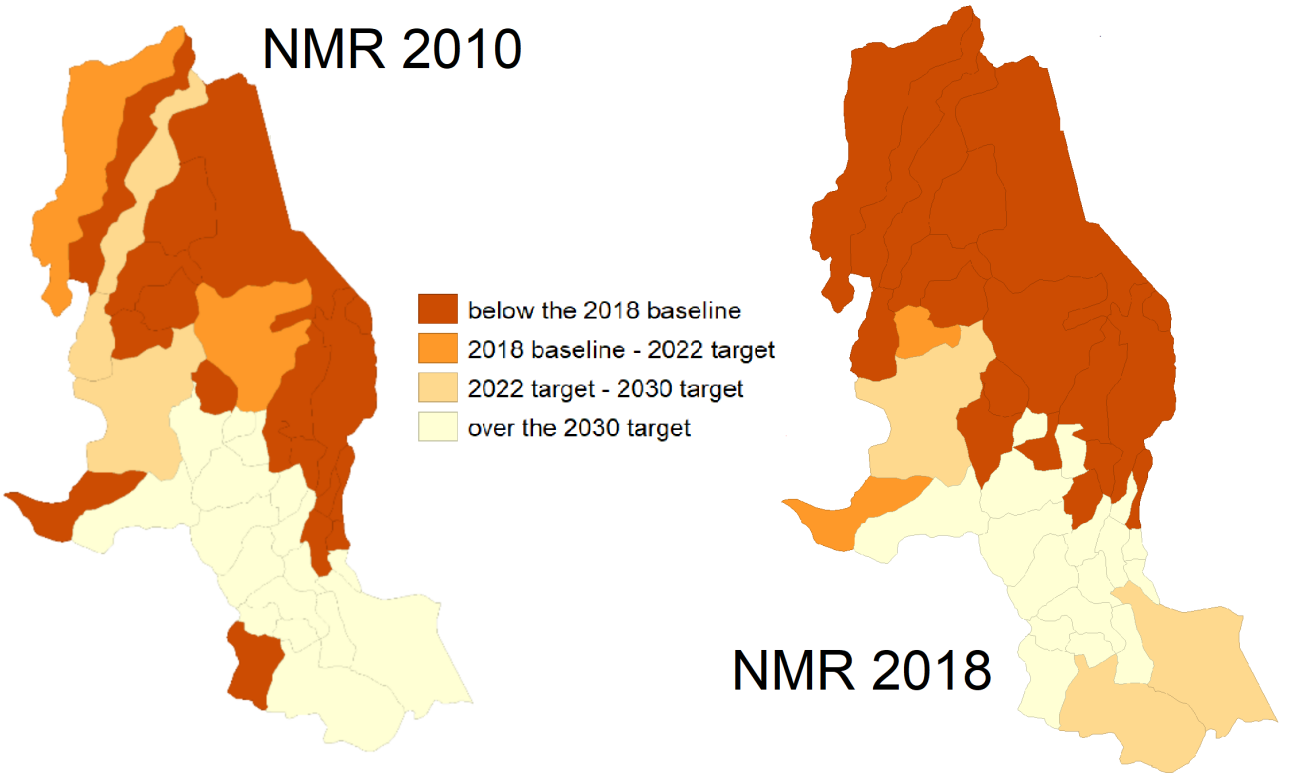
(4) Spatial autocorrelation (Results)

- **State level**: Moran's I statistic is significant, differential Moran's I is not significant (**not robust**)
- **Municipal level**: Standard and Differential Moran's I significant (**robust**)



(5) Policy discussion

- vertical and horizontal policy coordination, spillovers and borders.
- 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



(5) 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.
- A research jump **from micro to macro** both in scale and time.
- Ultimately, this type of analysis could serve a as tool **for combating organized crime** in specific locations (Ingram and Marchesini da Costa , 2017).

	(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

(5) Concluding Remarks

Uplifting results "on average" :

- Differences in overall raw rates at the state level **have decreased**. On average less homicides (**inclusive improvement at the state level**) but "more" personal injuries (More research is needed, less dispersion).
- **fast beta convergence** at the municipality level.
- **Robust signs of convergence** of homicide and personal injury rates at the state level. The first in the convergence literature about crime in Colombia.

Beyond classical convergence :

- Regional differences matter in **both disaggreagation levels**. there are **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**

Policy, Space and CCTs

(5) Concluding Remarks

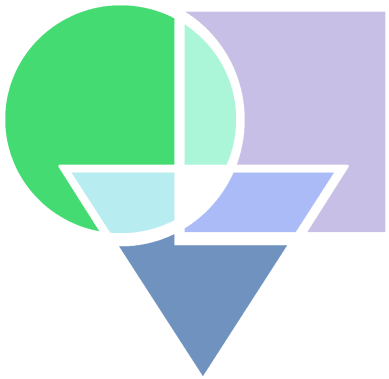
Implications and further research

- Strong spatial autocorrelation suggest the posibility of applying spatial filters in order to remove the spatial component of crime variables.
- Convergence clusters help us to find regions with similar outcomes, coordination among them can be promoted.
- Has crime followed a trajectory or are there more spill over patterns? are there local clusters? LISA analysis.
- At the state or department level (including more variables) a probit model may help us to find the determinants for a conditional "jump" to the upper clusters.

Thank you very much for your attention

You can find this presentation on my website https://felipe-santos.rbind.io and on our lab's website https://quarcs-lab.rbind.io/

If you are interested in our research, the tools we use and the data we handle; please check our QuaRCS lab website.



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