Regional Convergence, Spatial Scale, and Spatial Dependence:

Evidence from Homicides and Personal Injuries in Colombia 2010-2018

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[Slides and paper available at: https://felipe-santos.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.
- Scarce academic literature on inequality (convergence approach) 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)

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: stagnation 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**
    - 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 municipality and departament level.
- Population census and estimates for states and municipalitites.
- Raw rates computed

$$Hrate = homicides/population$$

- Survival rates (non- murder rates) computed

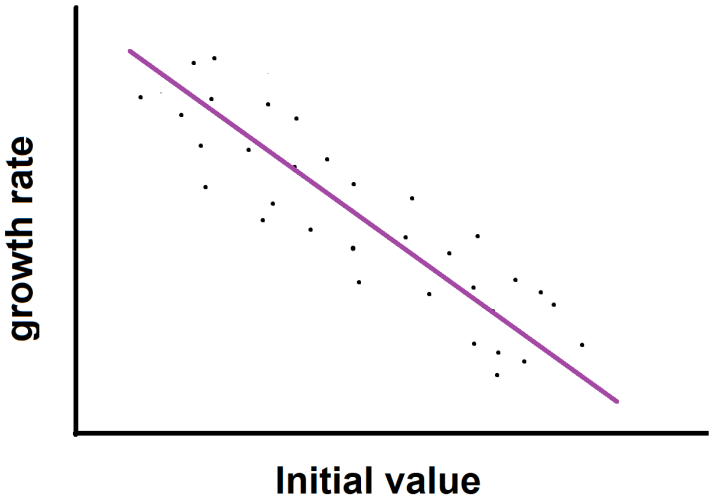
$$NMR = 10000 - raw\ rate * 10000$$

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

(2) Global convergence:

Using the classical convergence framework

Beta convergence (the catch-up effect)

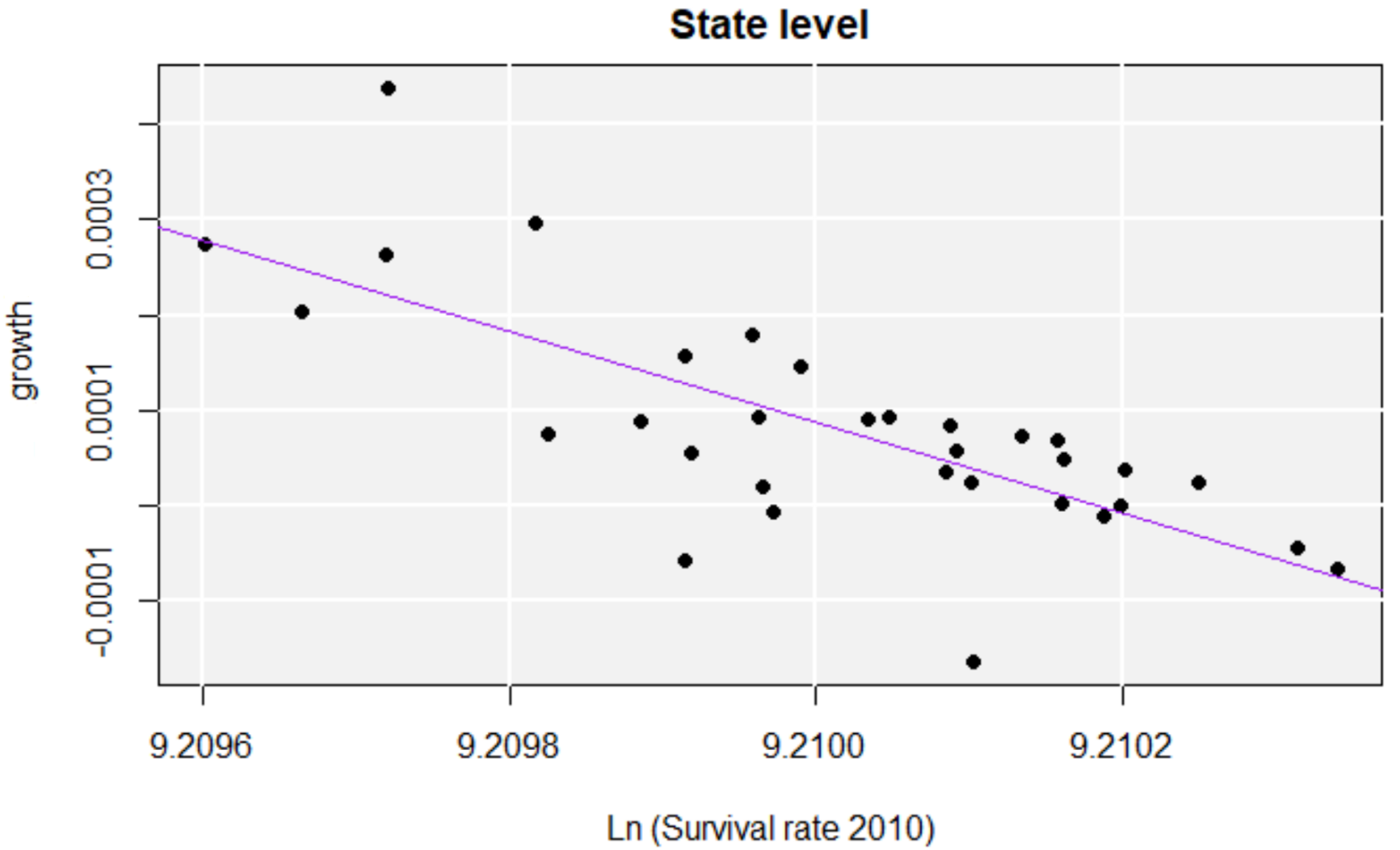


Sigma convergence (the dispersion of the data decreaseses over time)

States- Sigma and Beta convergence (NMR)

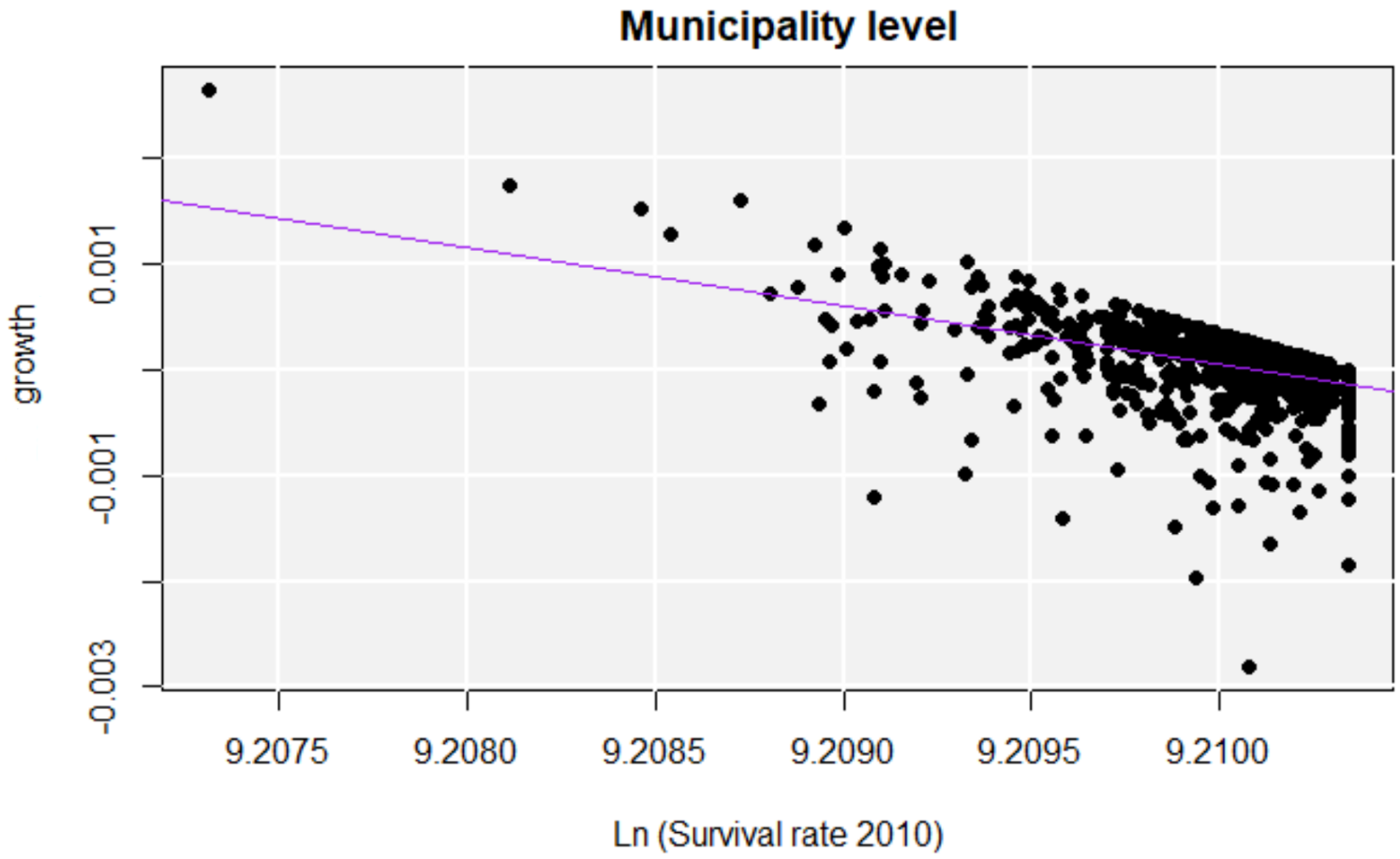
$$\sigma(Standard\ \ deviation)\ \sigma_{2010} = 1.84 \quad \sigma_{2018} = 1.26$$

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



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

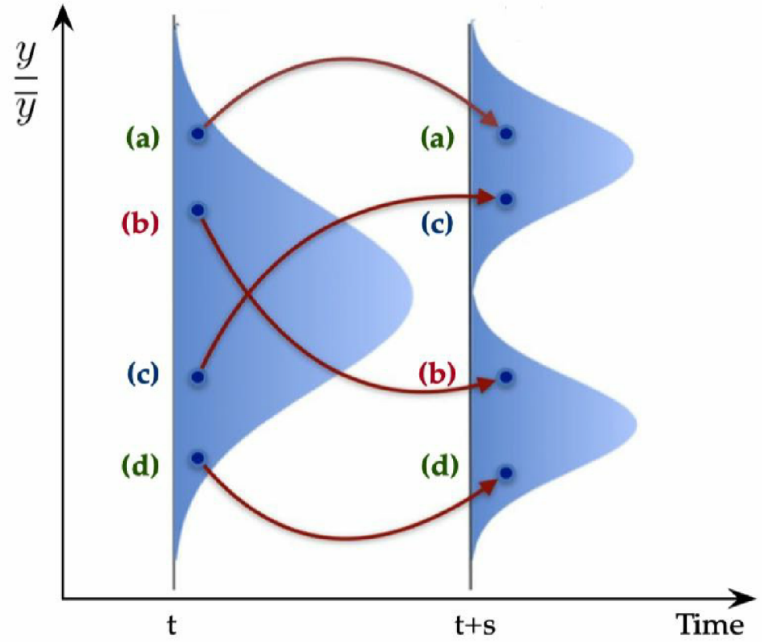
Crime Rate	Beta Coefficient	Half-Life (in years)	σ_{2010}	σ_{2018}
NMR (state)	-0.08	8.6	1.9	1.3
NMR (municipality)	-0.10	6.9	3.1	3.3
NPIR (state)	-0.13	5.3	9.3	8.2
NPIR (municipality)	-0.06	10.2	9.5	15.0

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

(3) State and Municipality disaggregation:

The distribution dynamics framework

$$\underbrace{f_{t+s}(z)}_{\text{Future Distribution}} = \int \underbrace{f_{t+s|Z_t=x}(z)}_{\text{Transitional Operator}} \underbrace{f_t(x)}_{\text{Initial Distribution}} dx$$



Source: Adapted from Quah (1993).

(3) Local convergence clusters

NMR State level: 4+? convergence clusters

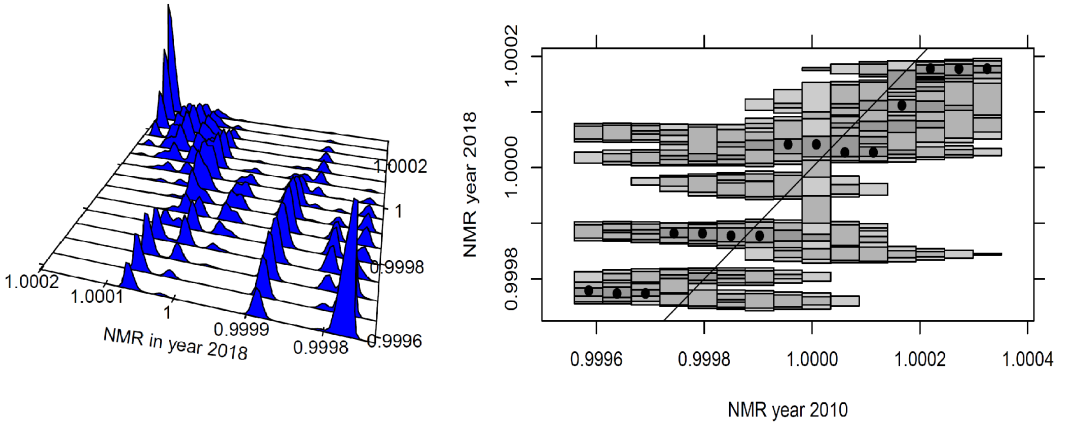
NMR Municipal level: 2+? convergence clusters

NPIR State level : 2 convergence clubs

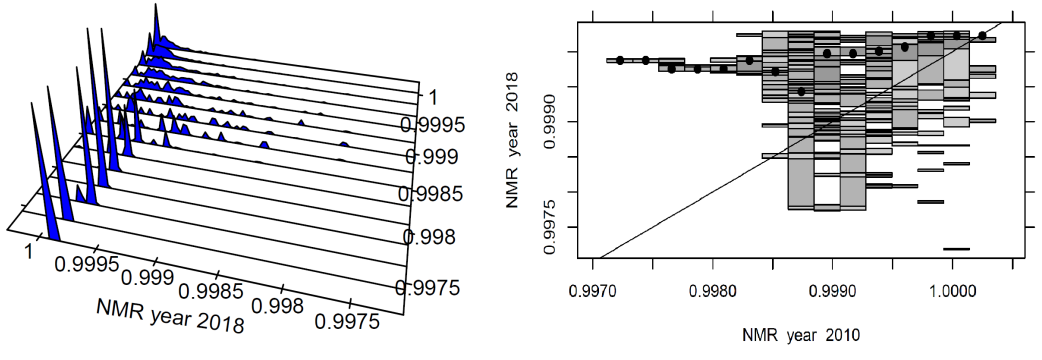
NPIR Municipal level : stagnation and 2 convergence clubs

NMR at both levels

State level: 4+? convergence clusters



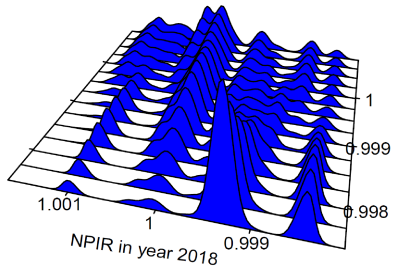
Municipality level: 2+? convergence clusters

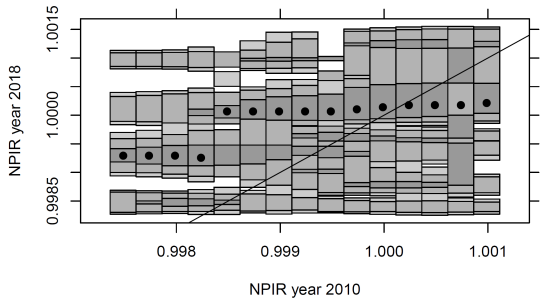


Interesting results; there are fewer clusters but sigma convergence is not present.

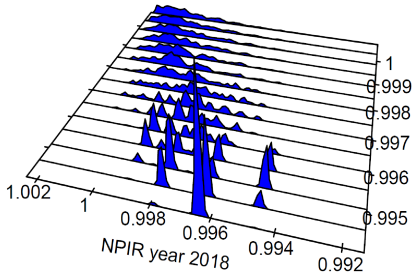
NPIR at both levels

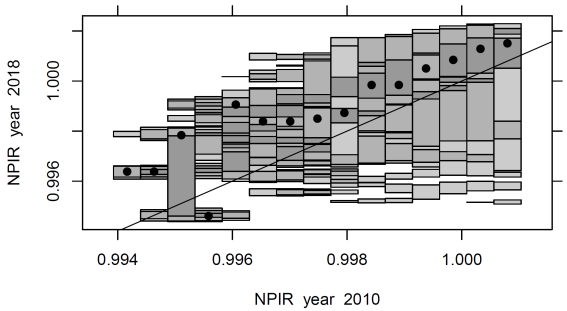
State level: 2 convergence clusters





Municipality level: 2 convergence clusters and stagnation

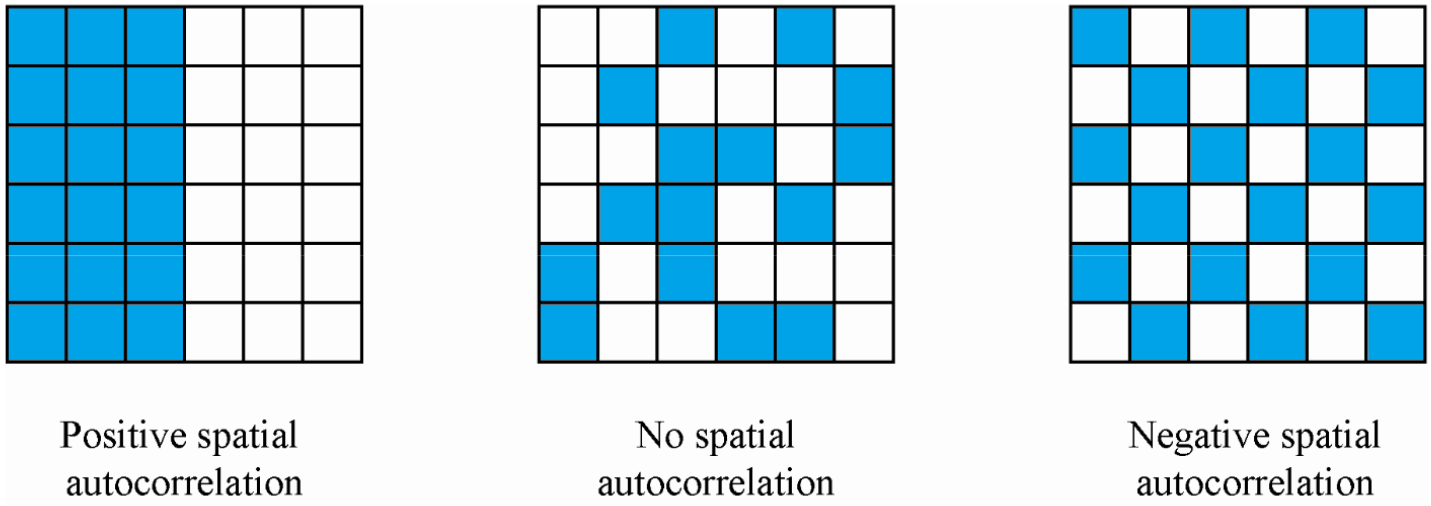




Interesting results; the same number of cluster but stagnation patterns are stronger at the municipal level

(4) Spatial Autocorrelation (Theory)

High Intuition Concept



Positive spatial autocorrelation

No spatial autocorrelation

Negative spatial autocorrelation

Source: adapted from Radill (2011)

More Formal (less intuitive)

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

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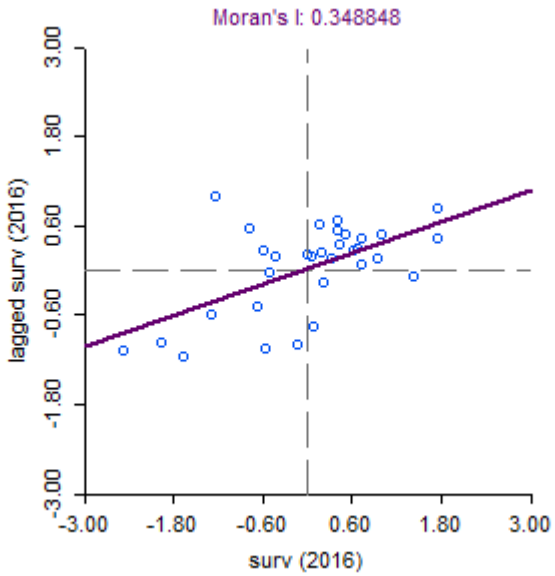
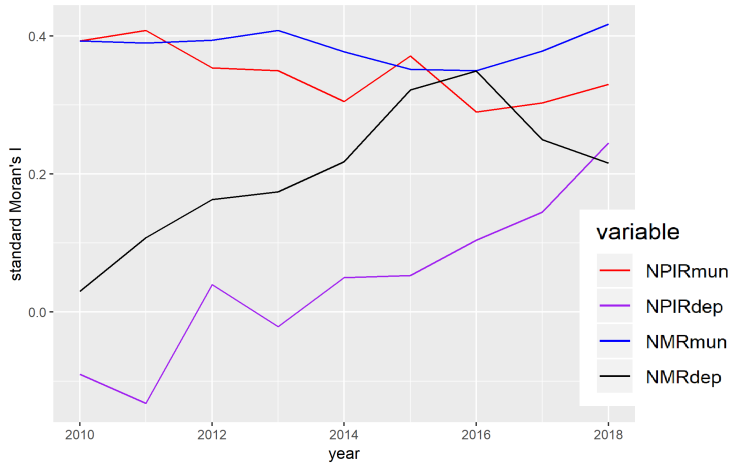


Differential Moran Scatter Plot ($y_{i,t} - y_{i,t-1}$)

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)

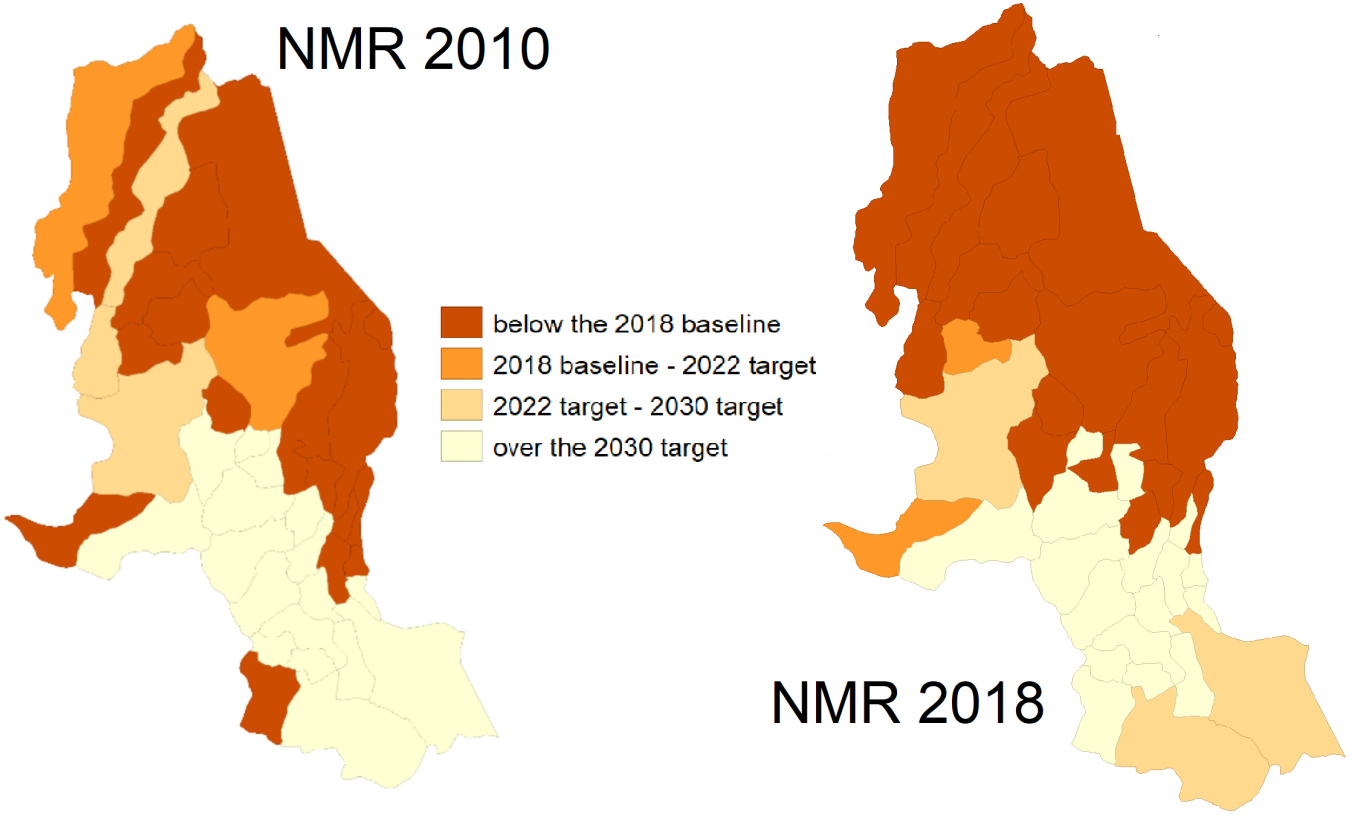
(4) Spatial autocorrelation (Results)

- **State level**: Moran's I statistic is significant, differntial 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.
- Ultimately, this type of analysis could serve a as tool for combating organized crime in specific locations (Ingram and Marchesini da Costa , 2017).
- Ultimately, this type of analysis could serve a as tool for combating organized crime in specific locations

	(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).

(5) Concluding Remarks

Uplifting results "on average" :

- Differences in overall raw rates at the state level **have decreased**. On average less homicides but more personal injuries.
- **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** for NMR are not conlusive and similar to the ones reported by Royuela et al 2015.

Policy, Space and CCTs

(5) Concluding Remarks

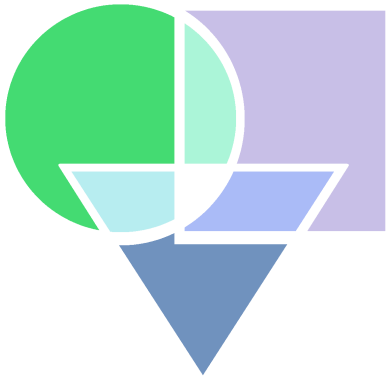
Implications and further research

- Strong spatial autocorrelation suggest the posibility of applying spatial filter 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

If you are interested in our research please check our QuaRCS lab website
https://quarcs-lab.rbind.io/



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