Achieving Peace and the SDGs in Colombia:

Municipal Convergence, Crime, and the Role of Conditional Cash Transfers

Felipe Santos-Marquez

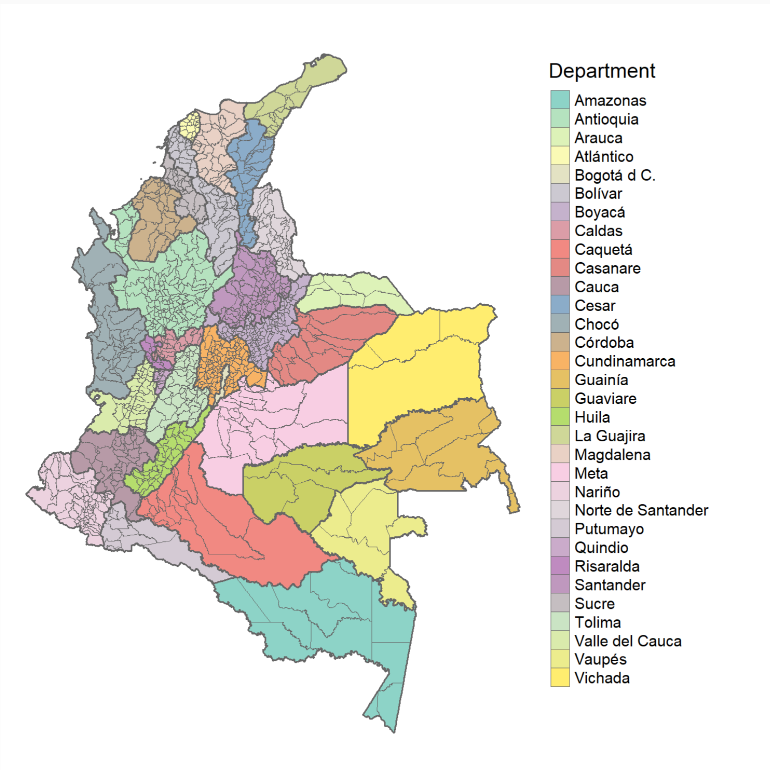
GSID, Nagoya University, JAPAN

Prepared for the TUD (Prof. Lessmann) meeting on November 13th 2020

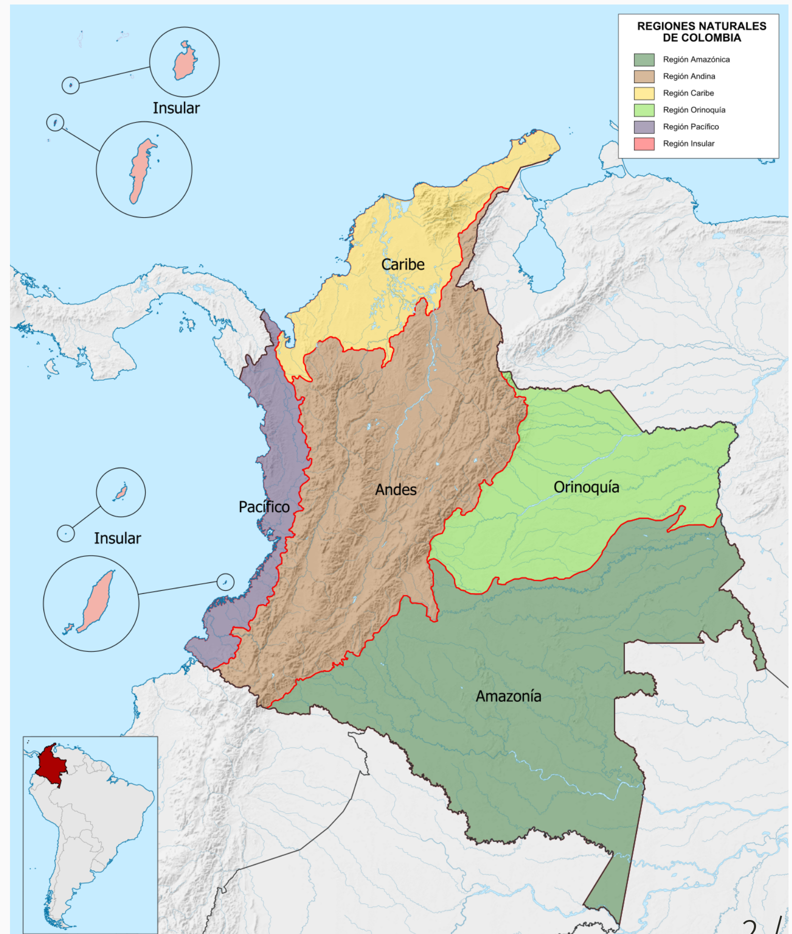
slides available at: https://masters-felipe-santos.netlify.app/

Colombian administrative levels

States and Municipalities

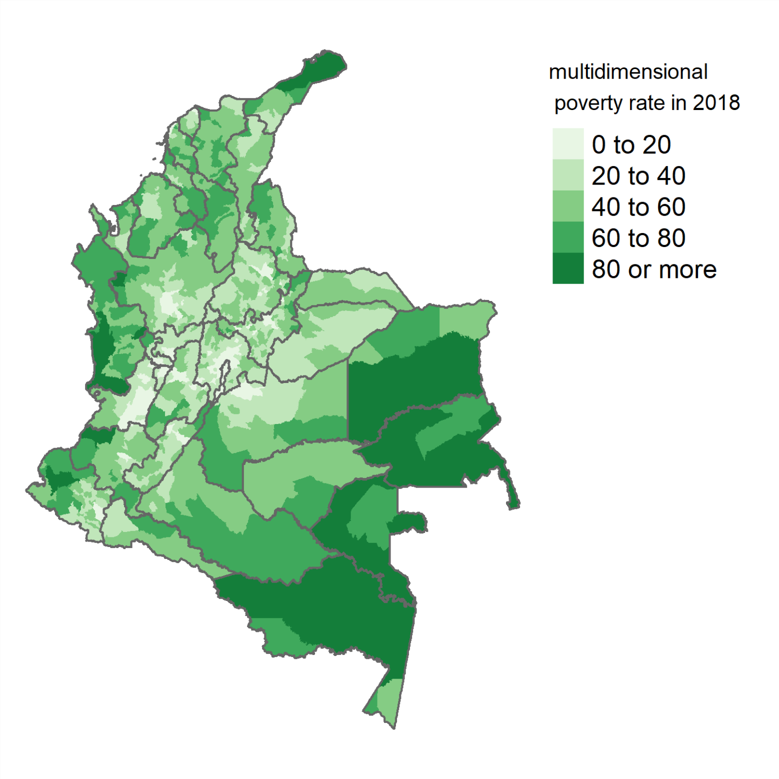


Natural Regions

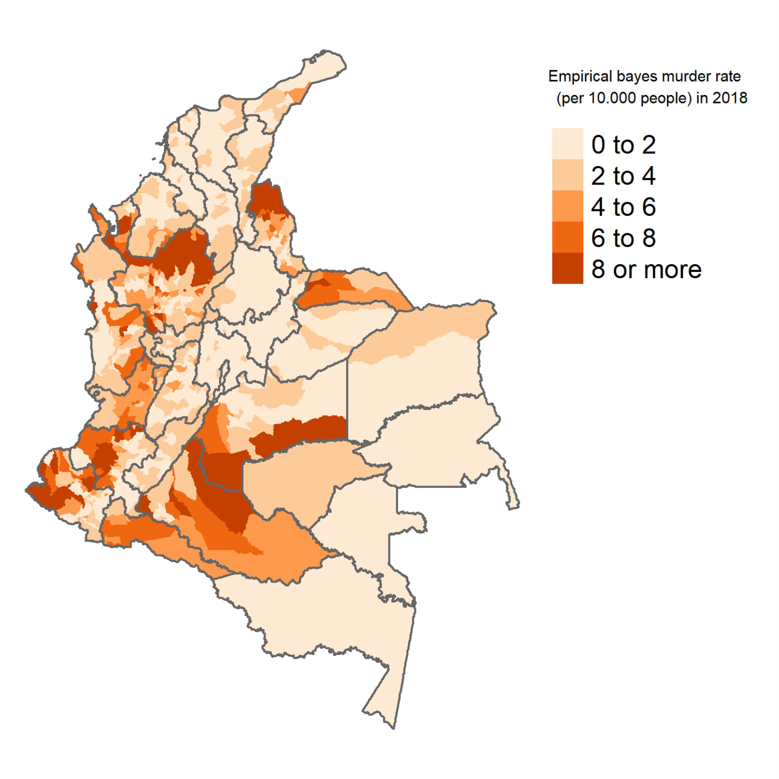


Large regional disparities in Colombia

Well-being

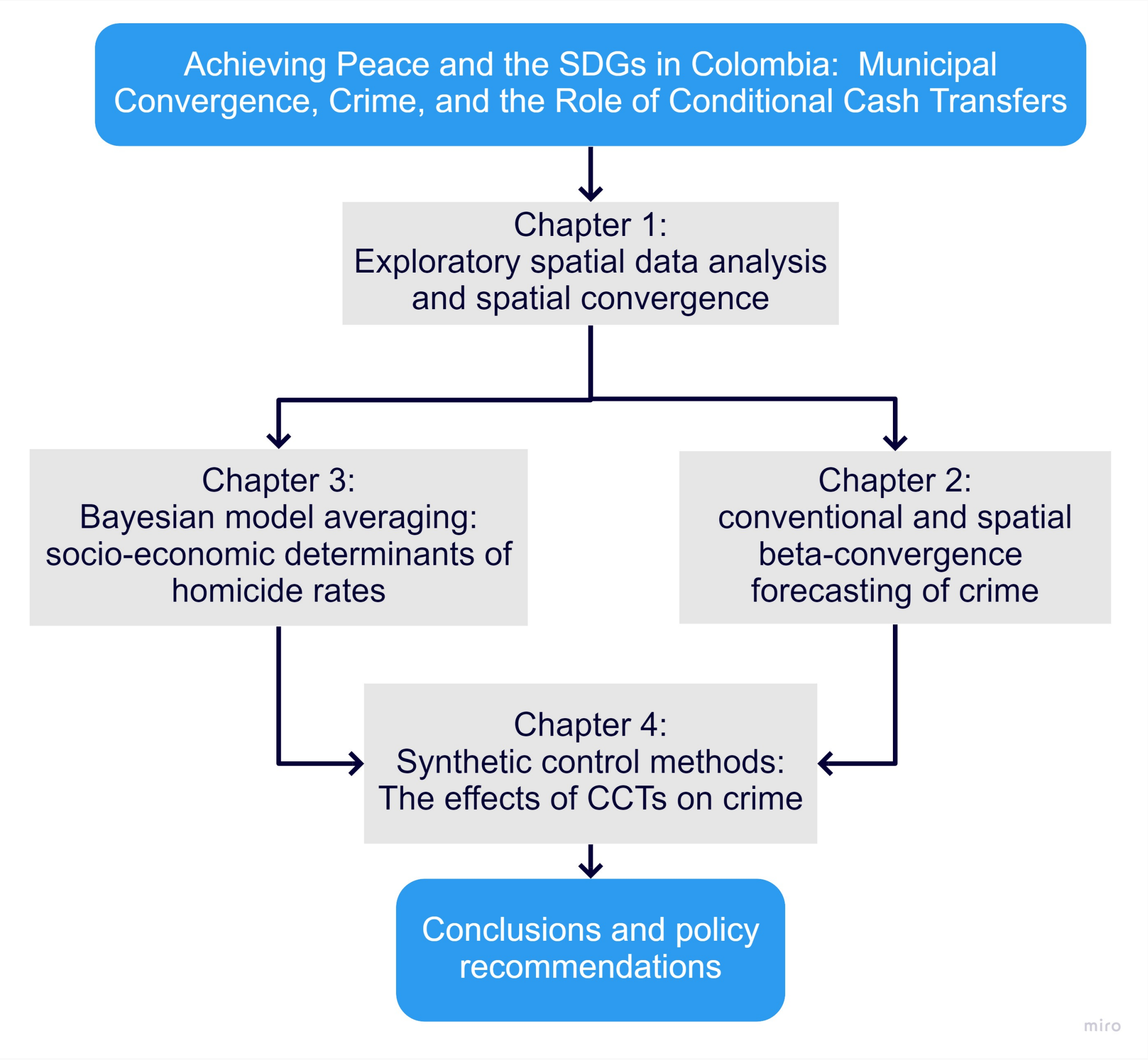


Crime



(In Germany is about 0.1 per 10.000 people,
In Japan is about 0.02 per 10.000 people)

Structure of the Dissertation



Chapter 1: Exploration and convergence

Methods: Classical beta convergence

$$(1/T) \cdot \log \frac{y_{iT}}{y_{i0}} = \alpha - \left[1 - e^{-\beta T}\right] \cdot \log(y_{i0}) + w_{i,0T}$$

The spatial lag model:

$$\log \frac{y_{iT}}{y_{i0}} = \alpha + \beta \cdot \log(y_{i0}) + \rho W \cdot \log \frac{y_{iT}}{y_{i0}} + \epsilon_t$$

The Spatial error model:

$$\log \frac{y_{iT}}{y_{i0}} = \alpha + \beta \cdot \log(y_{i0}) + \lambda W \epsilon_t + u_t$$

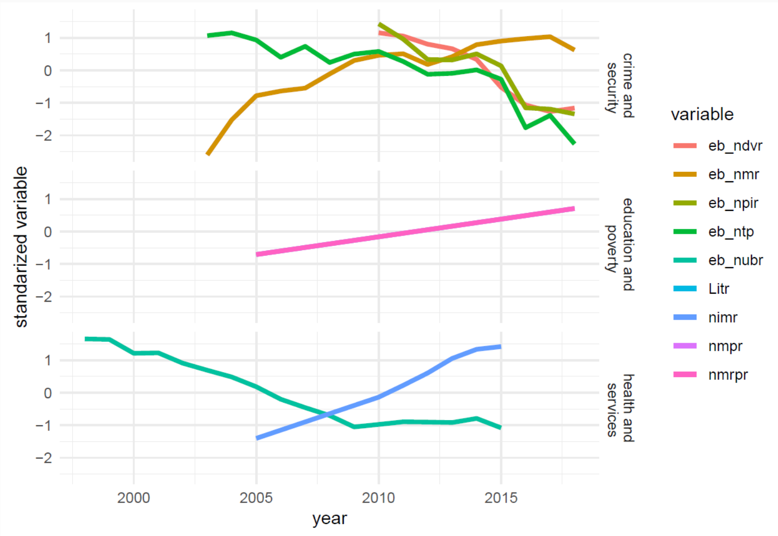
Global Spatial Autocorrelation: Global Moran's I

$$I_t = \frac{N}{\sum_{i=1}^{n} \sum_{j=1}^{n} w_{ij}} \left[\frac{\sum_{i=1}^{n} \sum_{j=1}^{n} w_{ij} \left(X_i - \bar{X}\right)\left(X_j - \bar{X}\right)}{\sum_{i=1}^{n} \left(X_i - \bar{X}\right)^2} \right]$$

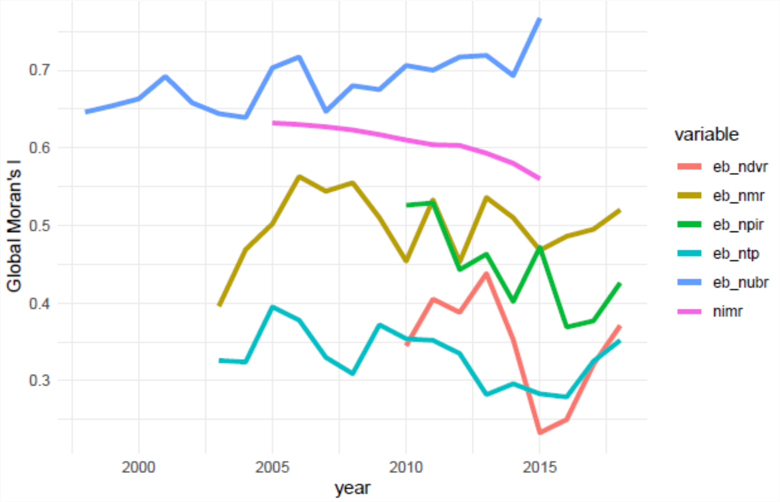
Chapter 1: Data and Results

Variable	Measurement	2018 baseline	2022 target	SDG	Other SDGs
Infant mortality	per 1000	16,5(2016)	14.0	3	1,2 and 4
Underweight birth	per 1000	9.1	8.0	3	1
Literacy	%	5.2	4.2	4	8
Domestic violence	per 100.000	157.5	132.0	16	-
Personal injuries	per 100.000	246.2	233.4	16	-
Theft to people	per 100.000	594.7	485.5	16	11
Homicide	per 100.000	25.8	23.2	16	11
Multi. poverty	%	17	11.9	1	3,4,6,7,8,9,10
Rural multi. poverty	%	36.6	33.0	1	3,4,6,7,8,9,10

Global trend



Spatial autocorrelation trend



Regression results

	Dependent variable:								
	eb_ntpr			eb_nmr			eb_ndvr		
	no spatial effects	spatial error	spatial lag	no spatial effects	spatial error	spatial lag	no spatial effects	spatial error	spatial lag
α	-5.20^{***}	-4.18^{***}	-3.74^{***}	8.74^{***}	9.08^{***}	8.03^{***}	4.11^{***}	5.72^{***}	4.07^{***}
	(0.67)	(0.69)	(0.61)	(0.13)	(0.11)	(0.15)	(0.39)	(0.40)	(0.37)
Y_{T0}	0.57^{***}	0.45^{***}	0.41^{***}	-0.95^{***}	-0.99^{***}	-0.87^{***}	-0.45^{***}	-0.62^{***}	-0.44^{***}
	(0.07)	(0.07)	(0.07)	(0.01)	(0.01)	(0.02)	(0.04)	(0.04)	(0.04)
speed of convergence	-0.03	-0.025	-0.023	0.199	0.283	0.137	0.074	0.121	0.073
half life	-23.21	-27.8	-30.49	3.49	2.45	5.07	9.39	5.72	9.49
λ		0.492^{***}			0.766^{***}			0.516^{***}	
ρ			0.482^{***}			0.218^{***}			0.43^{***}
Adjusted R^2	0.05	0.194	0.195	0.809	0.888	0.826	0.09	0.231	0.188
Akaike Inf. Crit.	-11892.7	-12074.2	-12075.2	-14794.3	-15387.5	-14895.3	-12643.8	-12828.8	-12769.2
LM test SEM	274.83^{***}			807.67^{***}			251.12^{***}		
LM test SAR	281.81^{***}			112.69^{***}			170.95^{***}		
Robust LM test SEM	0.33			705.64^{***}			138.46^{***}		
Robust LM test SAR	7.31^{***}			10.66^{***}			58.29^{***}		
Observations	1,120	1,120	1,120	1,120	1,120	1,120	1,120	1,120	1,120

Note: *p<0.1; **p<0.05; ***p<0.01

Chapter 2: Convergence and Forecasting

Exponential smoothing methods

$$\hat{y}_{T+1|T} = \alpha y_T + \alpha(1-\alpha) y_{T-1} + \alpha(1-\alpha)^2 y_{T-2} + \cdots$$

ARIMA models

$$y'_t = c + \phi_1 y'_{t-1} + \cdots + \phi_p y'_{t-p} + \theta_1 \varepsilon_{t-1} + \cdots \theta_q \varepsilon_{t-q} + \varepsilon_t$$

Space time Autoregressive models (STAR)

$$y_{it} = \sum_{k=1}^{p} \sum_{l=0}^{\lambda_k} \phi_{kl} \sum_{j=1}^{N} w_{ij}^{(l)} y_{jt-k} + a_{it}$$

Proposed models: Beta convergence -> Forecasting

$$\log\left(\hat{y}_{i(t+4)|t}\right) = \hat{\alpha}_{t+4|t} + \hat{\beta}_{t+4|t} \cdot \log(y_{it}) + w_{i,t}$$

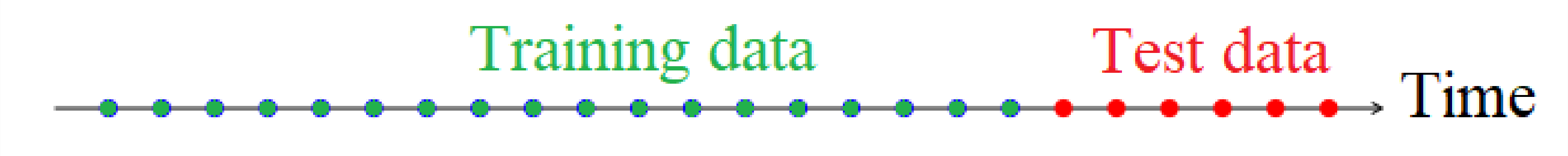
$$\log\left(\hat{y}_{i(t+4)|t}\right) = \hat{\alpha}_{t+4|t} + \hat{\beta}_{t+4|t} \cdot \log(y_{it}) + \hat{\theta}_{t+4|t} W \cdot \log(y_{it}) + \epsilon_{i,t}$$

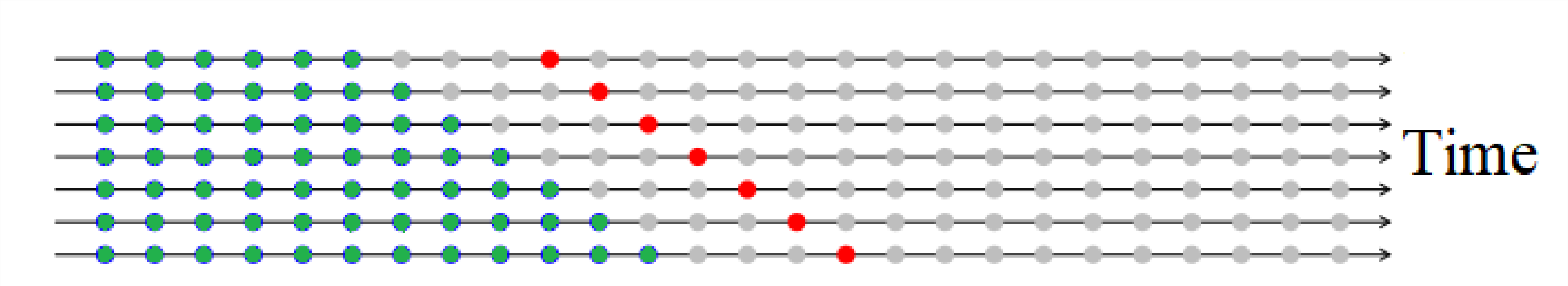
Cross validating forecasting models

How can the best forecasting model be chosen?

$$\text{Mean absolute error: } \text{MAE} = \text{mean}(|e_t|)$$
$$\text{Root mean squared error: RMSE } = \sqrt{\text{mean}\left(e_t^2\right)}$$

Cross-validation of forecasts





Results (Beta and spatial Beta)

Table 1 Forecast accuracy cross validation

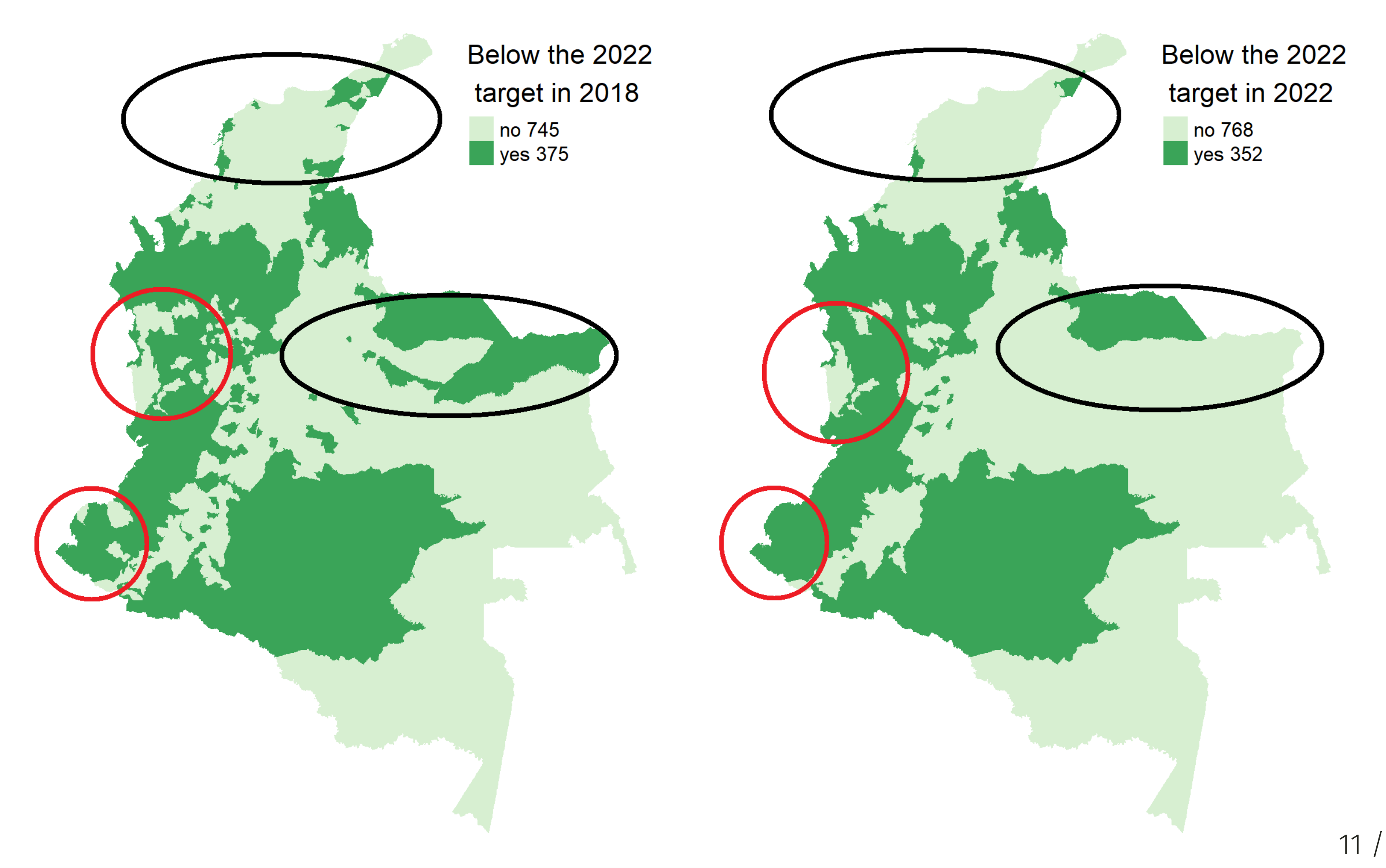
method	2011	2012	2013	2014	2015	2016	2017	2018
ETS (MAE)	2.83	2.31	1.49	1.46	1.43	1.38	1.37	1.42
ETS (RMSE)	5.74	4.66	2.40	2.36	2.33	2.44	2.14	2.66
ARIMA (MAE)	2.34	1.94	1.54	1.57	1.60	1.51	1.53	1.50
ARIMA (RMSE)	3.68	3.43	2.45	2.49	2.66	2.56	3.09	2.79
BETA (MAE)	1.83	2.36	2.21	1.84	1.51	1.19	1.02	1.31
BETA (RMSE)	2.29	3.42	2.66	2.32	2.14	2.18	1.72	2.80
Spatial B (MAE)	1.63	2.53	1.94	1.56	1.31	1.15	1.03	1.23
Spatial B (RMSE)	2.14	3.50	2.39	2.05	1.97	1.97	1.67	2.65
STAR (MAE)	2.49	2.46	2.19	2.23	2.37	2.32	2.37	2.59
STAR (RMSE)	2.80	3.31	2.55	2.53	2.76	2.71	2.79	3.54

Table 2 Forecasts yearly cross validation

method	MAE	RMSE
ETS	1.71	3.34
ARIMA	1.69	2.93
Beta	1.66	2.49
Beta Spatial	1.55	2.35
STAR	2.38	2.89

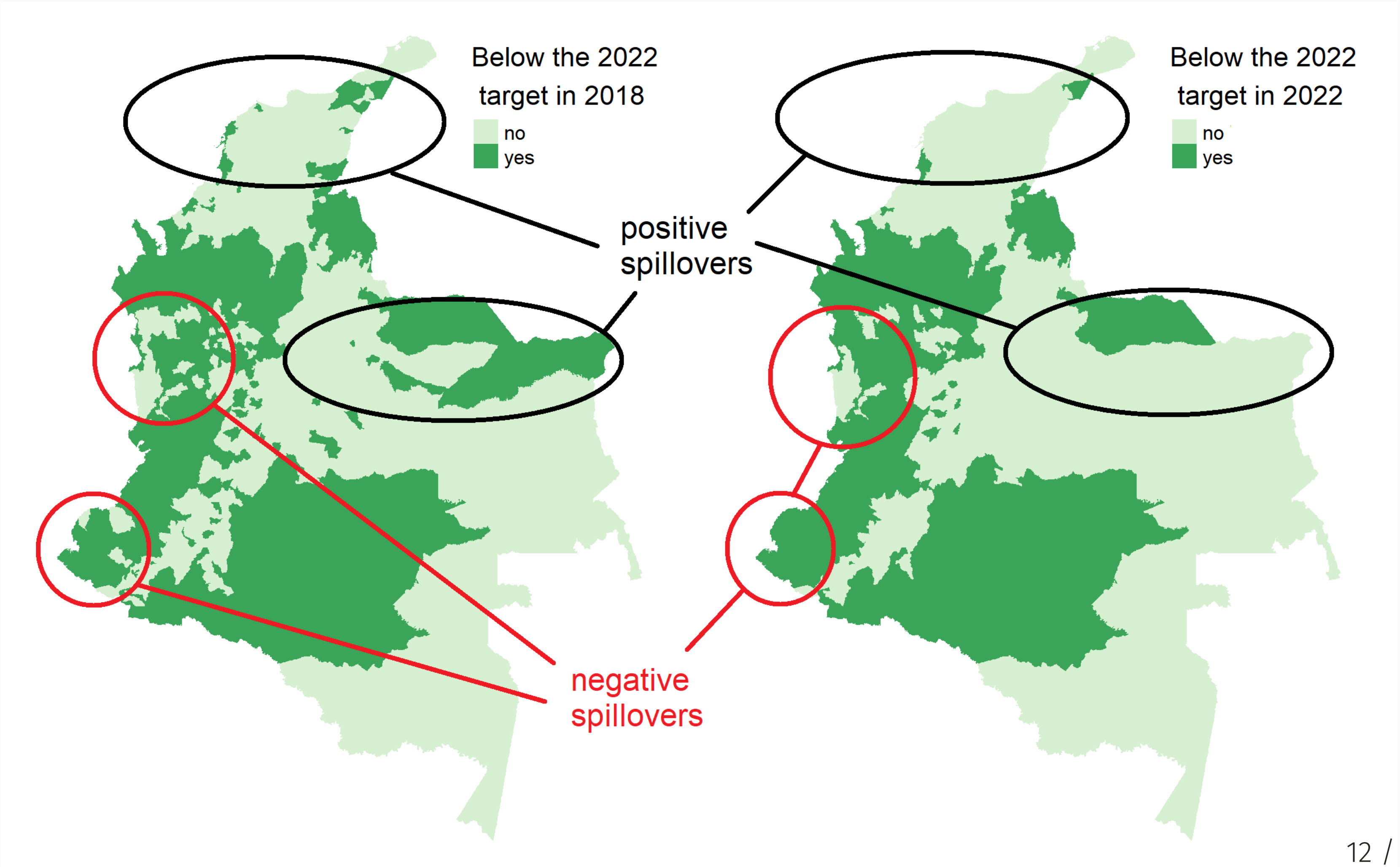
Spatial distribution of forecasted crime

municipalities in dark green are lagging behind



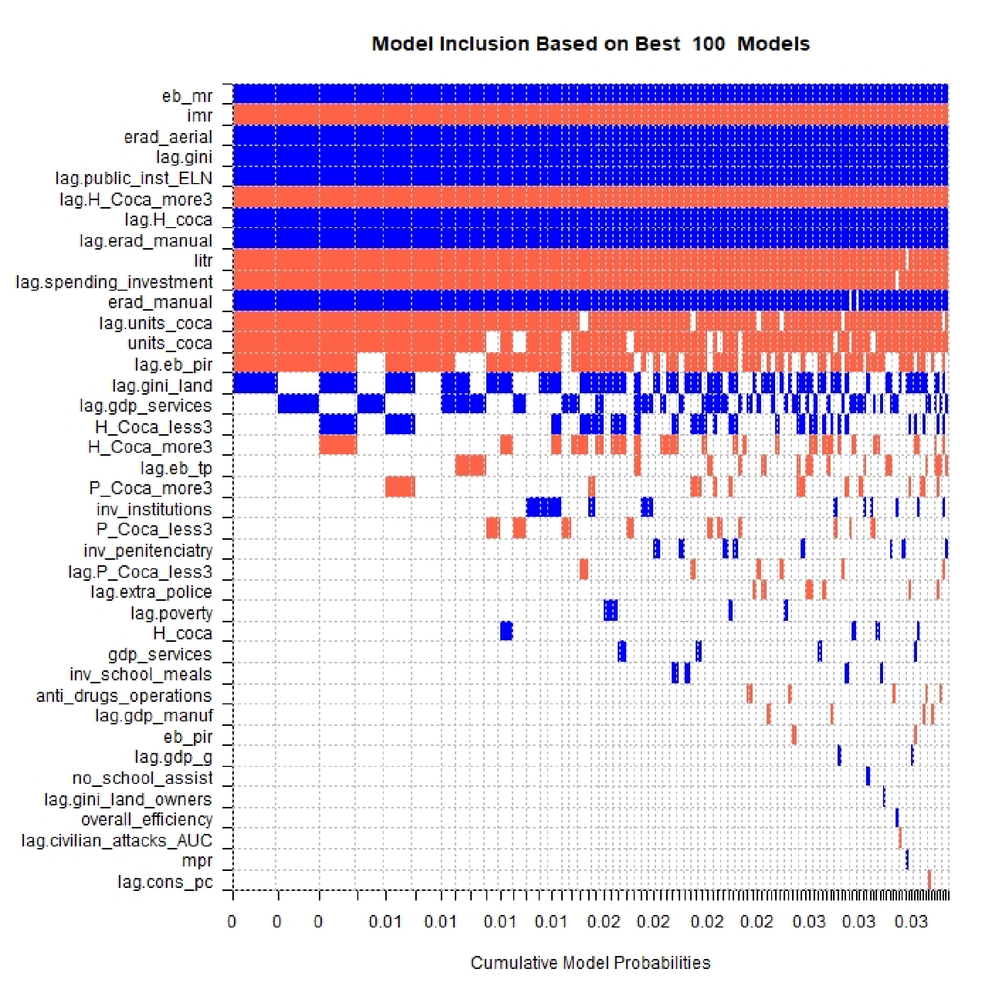
Spatial distribution of forecasted crime

municipalities in dark green are lagging behind



Chapter 3: BMA - crime determinants

212 variables (original and spatially lagged). **The significant determinants of homicides are** :



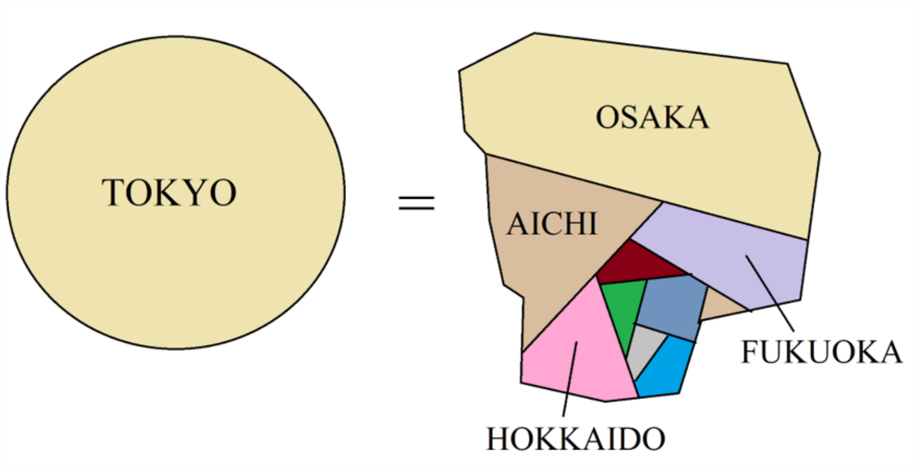
Significant determinants of homicides:

After running 2 million regressions...

description	variable	PIP all variables	Post mean all
murder rate	eb_mr	1.000	0.356 (0.031)
infant mortality rate	imr	1.000	-0.058 (0.011)
Coca H aerial eradication	erad_aerial	1.000	0.001 (0)
Lag. Coca crops with more than 3 H	lag.H_Coca_more3	1.000	-0.041 (0.006)
Lag. Coca hectares	lag.H_coca	1.000	0.023 (0.003)
Lag Attacks against public institutions by rebels	lag.public_inst_ELN	1.000	36.062 (7.46)
Lag. H manual eradication	lag.erad_manual	1.000	0.004 (0.001)
Lag. Income Gini	lag.gini	1.000	0.25 (0.041)
H manual eradication	erad_manual	0.990	0.002 (0.001)
Lag. Spending on investment local government	lag.spending_investment	0.986	-0.095 (0.025)
Literacy rate	litr	0.984	-0.051 (0.013)
Number of land units with coca crops	units_coca	0.961	-0.004 (0.003)
Lag. Number of land units with coca crops	lag.units_coca	0.943	-0.015 (0.004)
Lag. Personal injury rates	lag.eb_pir	0.681	-0.034 (0.025)
Lag. Land Gini	lag.gini_land	0.564	0.022 (0.021)

Synthetic control methods: visual intuition

In terms of GDP per capita



$$TOKYO = 0.4 * OSAKA + 0.2 * AICHI + 0.1 * FUKUOKA + \ldots$$

In terms of crime

The weights are found so that the synthetic municipality has a similar crime trend compared to the treatment region (2003-2011) and similar determinants from the BMA chapter.

Results: Pacific region

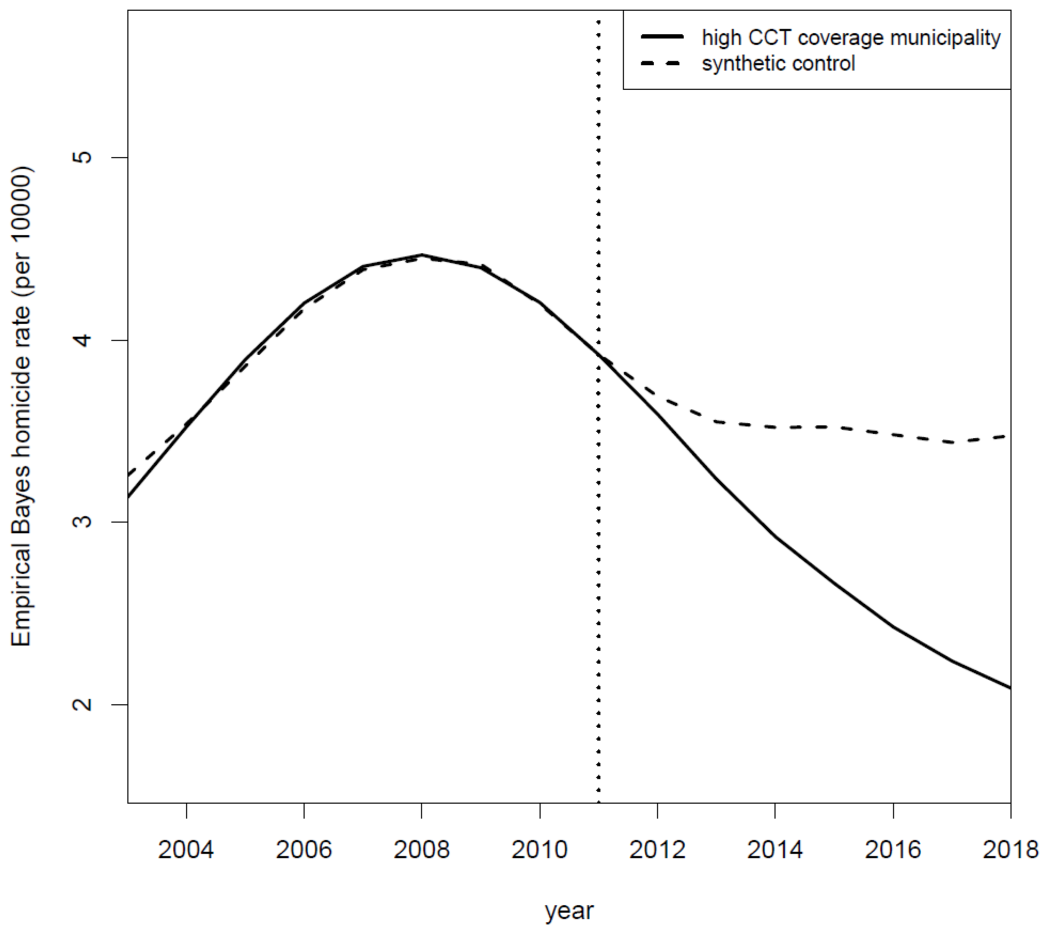
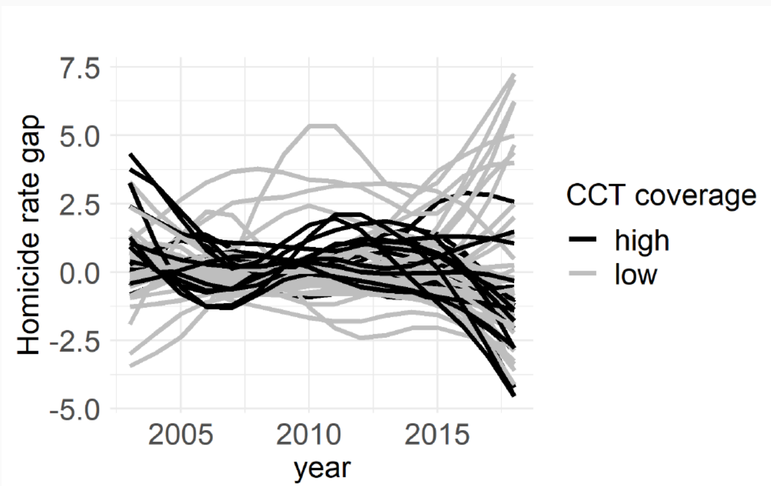


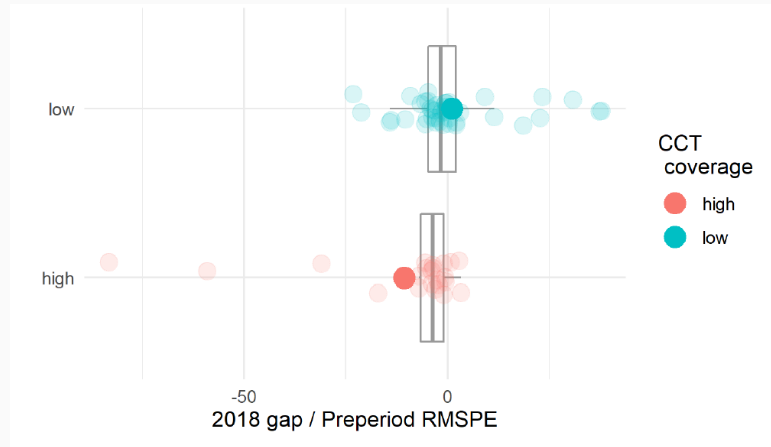
Figure 5.3: Trends in homicide rates: treated municipality (Popayan, Cauca) vs. synthetic control unit.

The effect on crime of CCTS

Crime gaps for treatment municipalities and low CCT coverage placebos

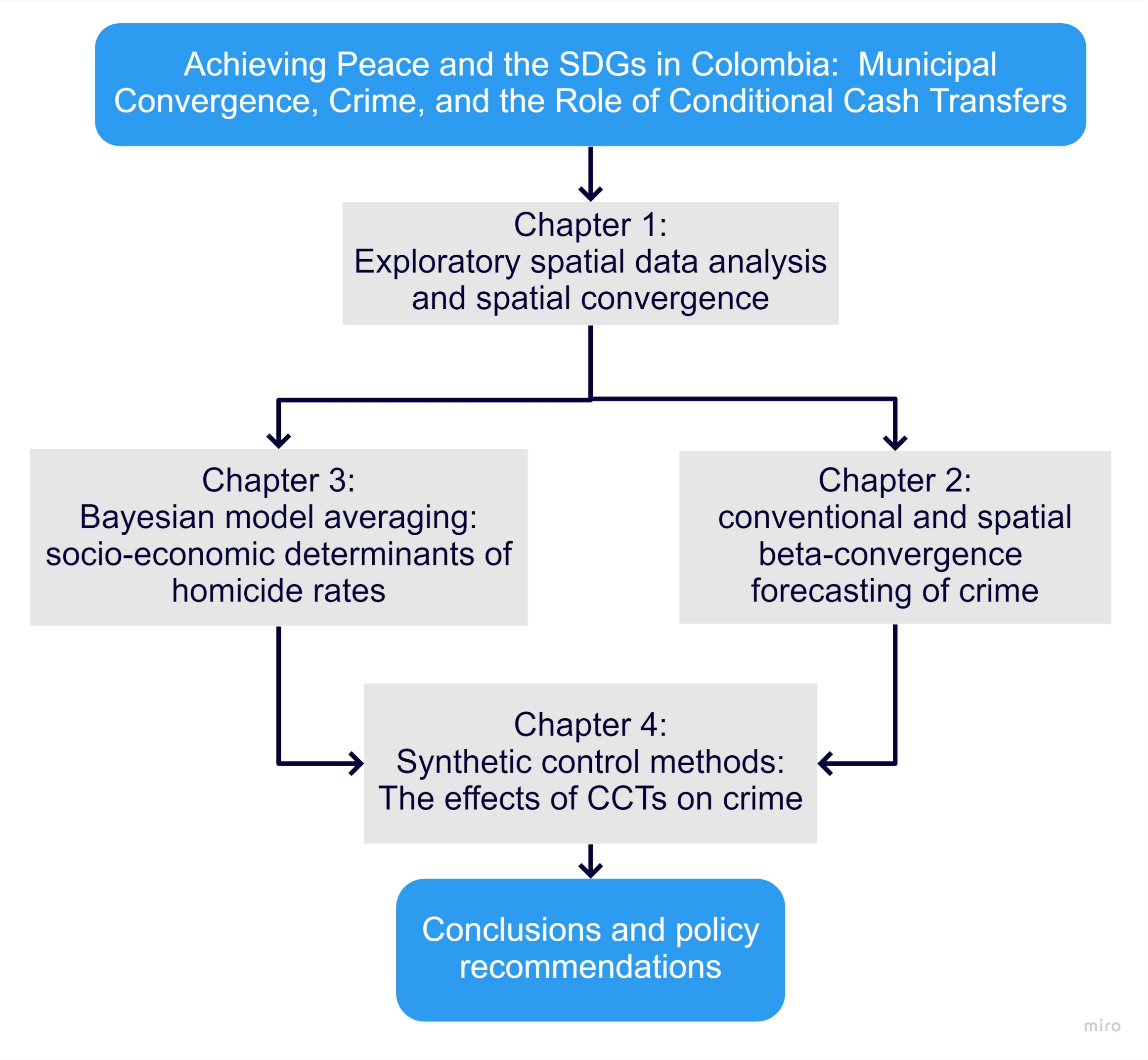


Overall effects = the gap in 2018 / Root mean sqaured predicted error



A t-test shows that the mean effect is statistically lower for the treatment group.

In just 15 minutes:



Thanks!

Thank you very much for your attention

Quantitative Regional and Computational Science Lab

https://quarcs-lab.org/