The role that geography plays in regional economic growth:

Income convergence of Chinese provinces and the effect of free trade

agreements on the development of triborders areas

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Tri-border Areas and the Location of Economic Activity in Open Economies

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On average, do border and non-border regions have the same level of economic activity?

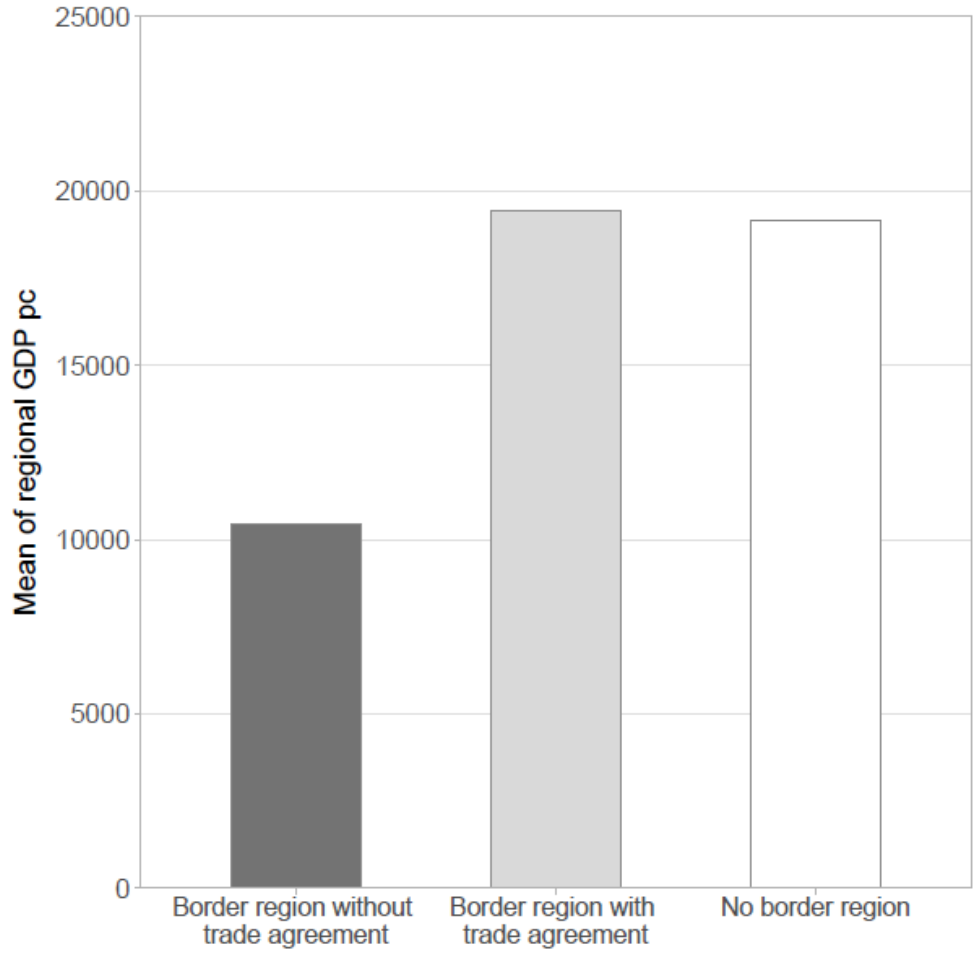


Figure 2: Average regional GDP per capita in our sample.

Research question ->

What is the causal effect of regional trade agreements among neighboring countries on the economic activity of areas near the international border?

Related literature

Trade and the location of economic activity

Krugman, P. (1991), Brülhart, M. (2011), Hirte, G., Lessmann, C., & Seidel, A. (2020), World Bank. (2008), Combes, P. P., Mayer, T., & Thisse, J. F. (2008)

"... the tendency for trade liberalisation to favour re-location towards border regions emerges as an almost ubiquitous result" Brülhart, M. (2011, p. 67)

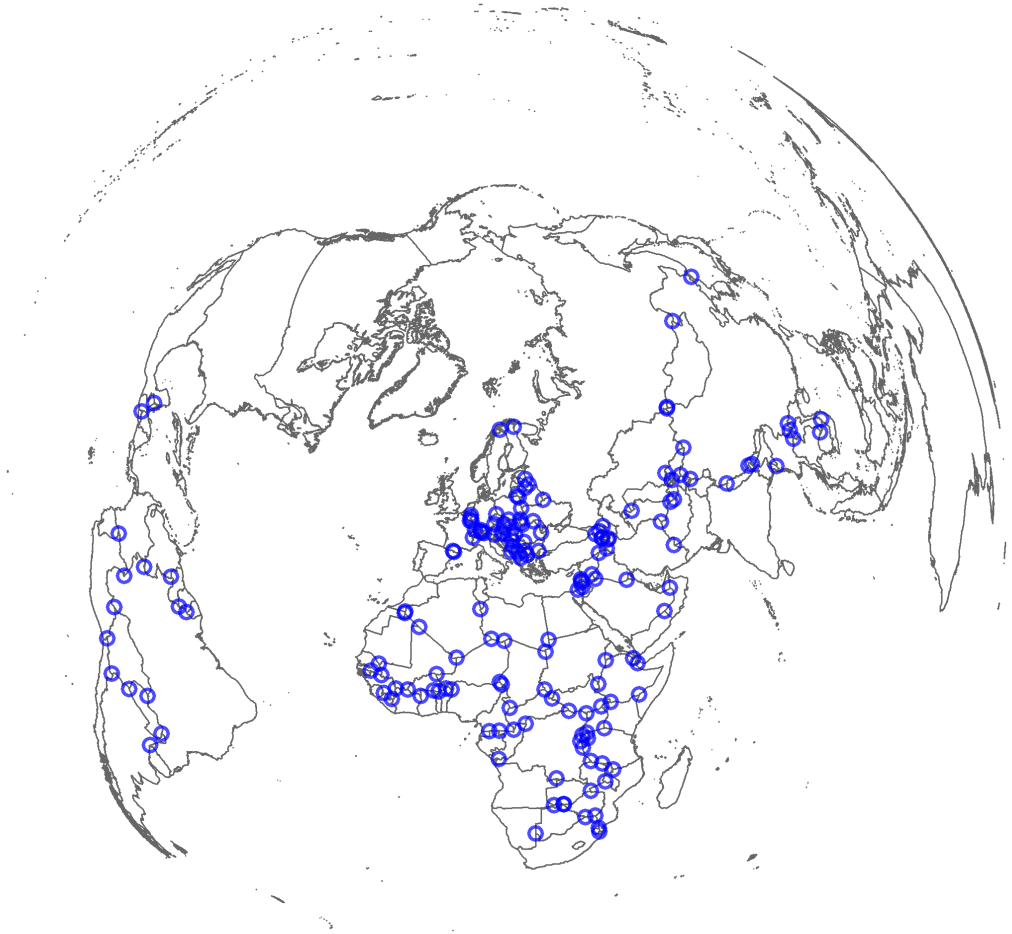
Trade openness and international borders:

McCallum, J. (1995),Eberhard-Ruiz, A., & Moradi, A. (2019), Brülhart, M., Cadot, O., & Himbert, A. (2019), Adam, H. L., Larch, M., & Stadelmann, D. (2021)

Nighttime lights as a proxy for economic activity:

Chen, X., & Nordhaus, W. D. (2011), Henderson, J. V., Storeygard, A., & Weil, D. N. (2012), Nordhaus, W., & Chen, X. (2015), Lessmann, C., & Seidel, A. (2017)

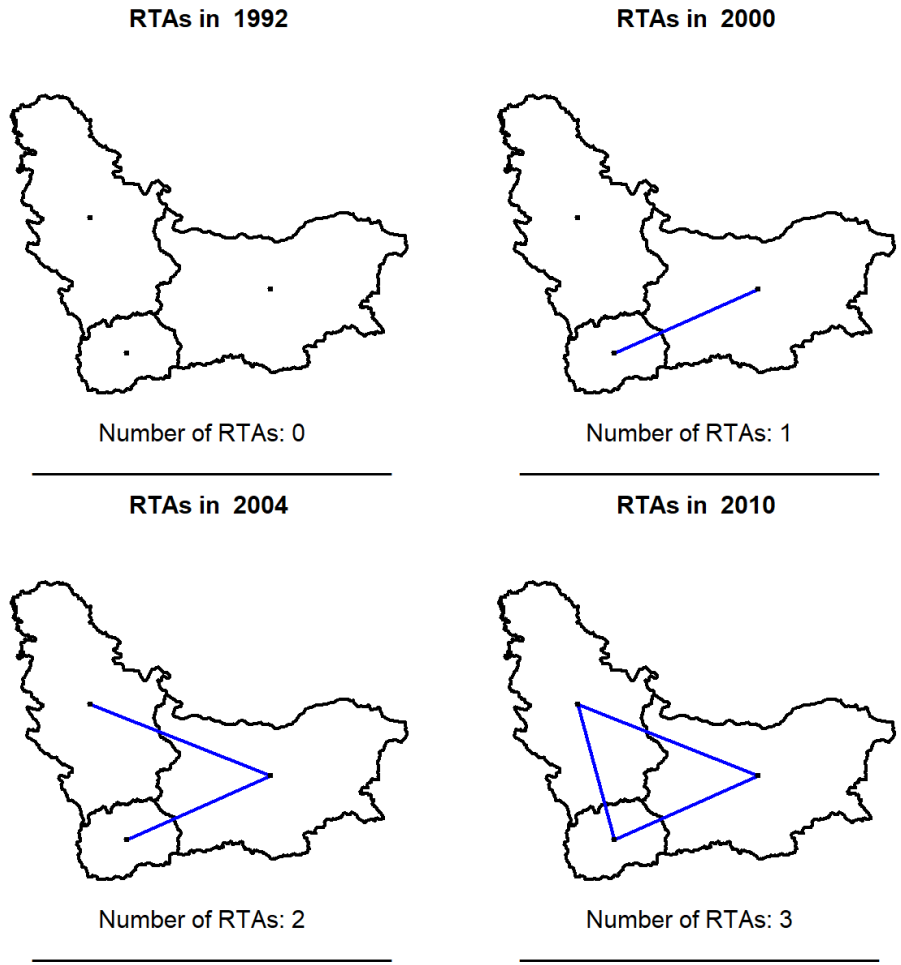
What are tripoints? How many tripoints are there in the world?



tri-border areas (also called tripoints, trijunctions, triple points)

Identification Strategy ->

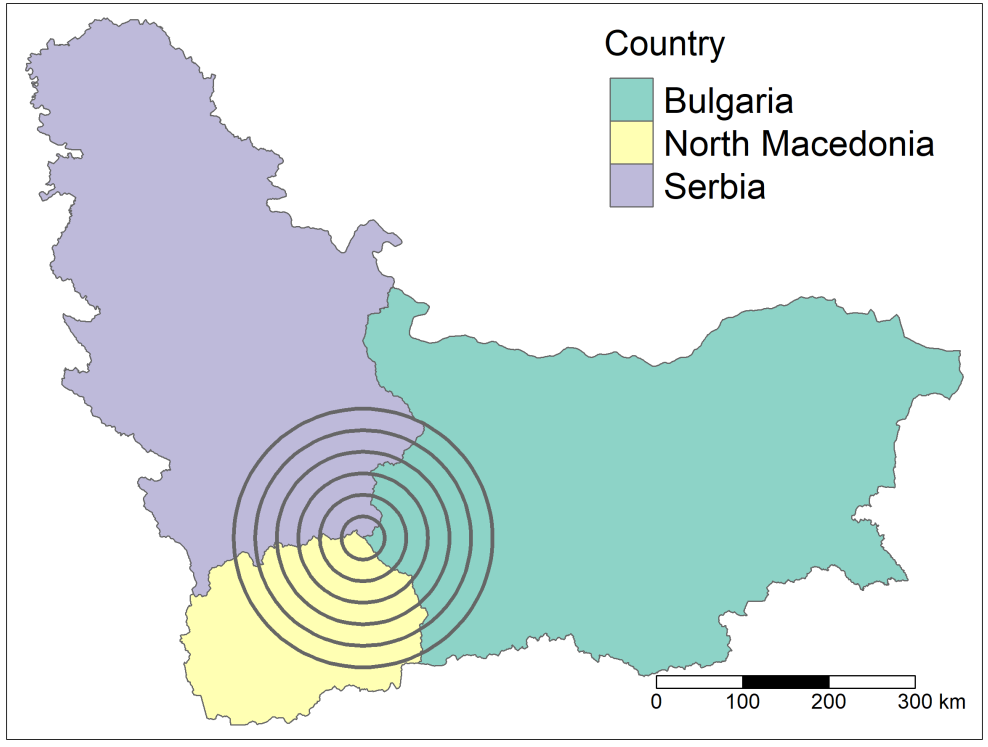
Quasi random treatment: start of the ***first*** regional trade agreement in the triplet.



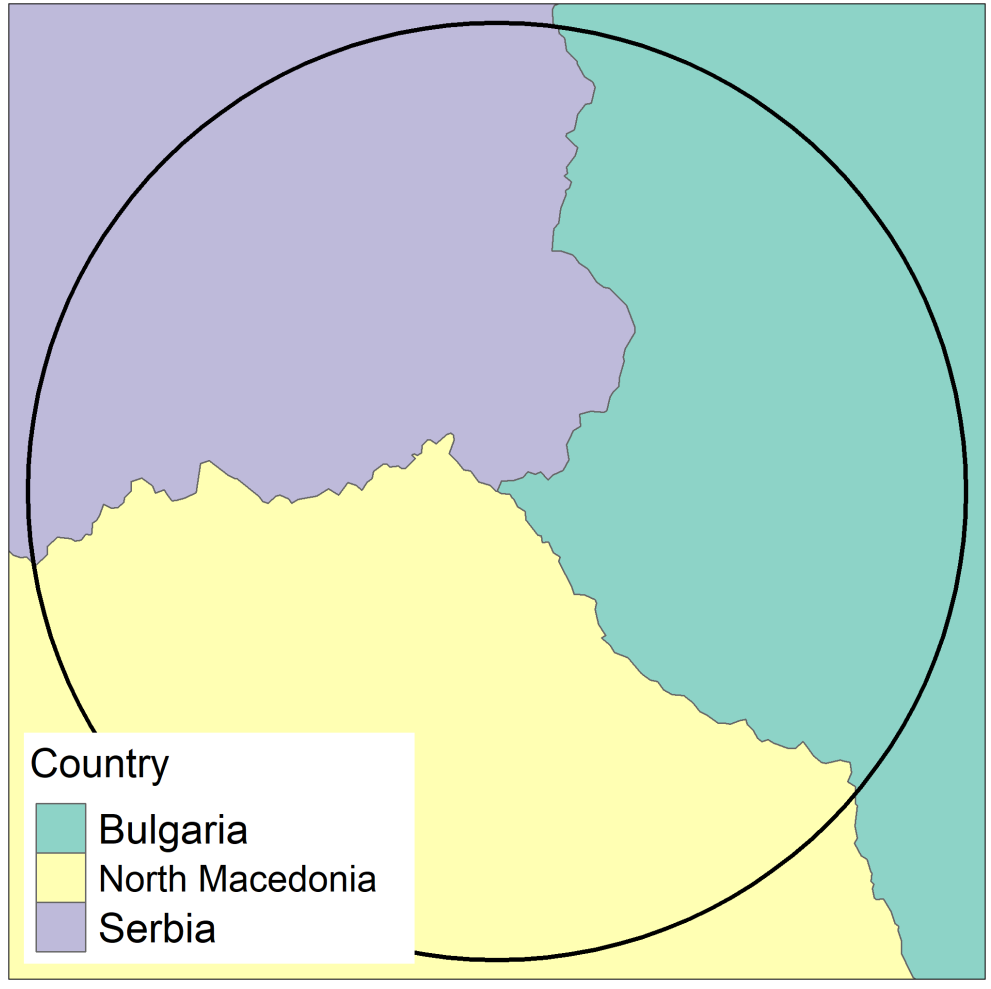
Data on RTAs taken from Mario Larch's Regional Trade Agreements Database Egger, P., & Larch, M. (2008)

Where is economic activity measured?

Triplet of countries and several buffer area

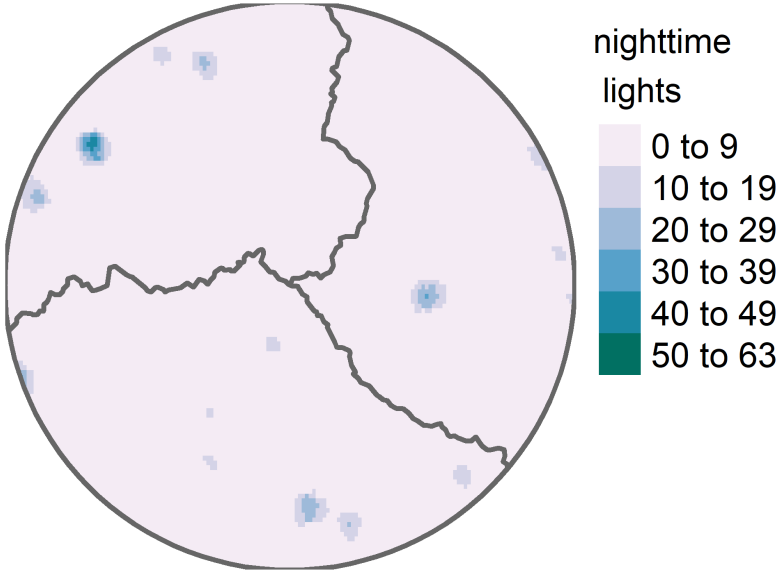


closer view - radius of 75 kilometers

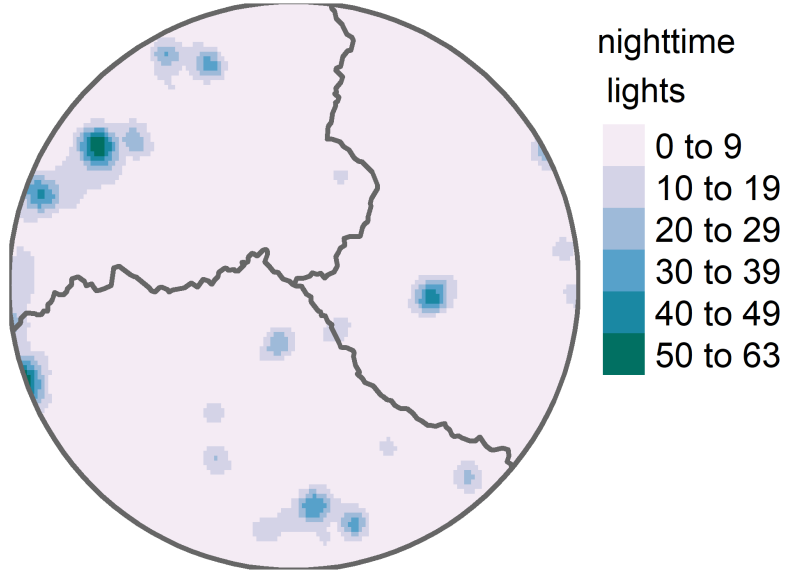


How is economic activity measured?

1992

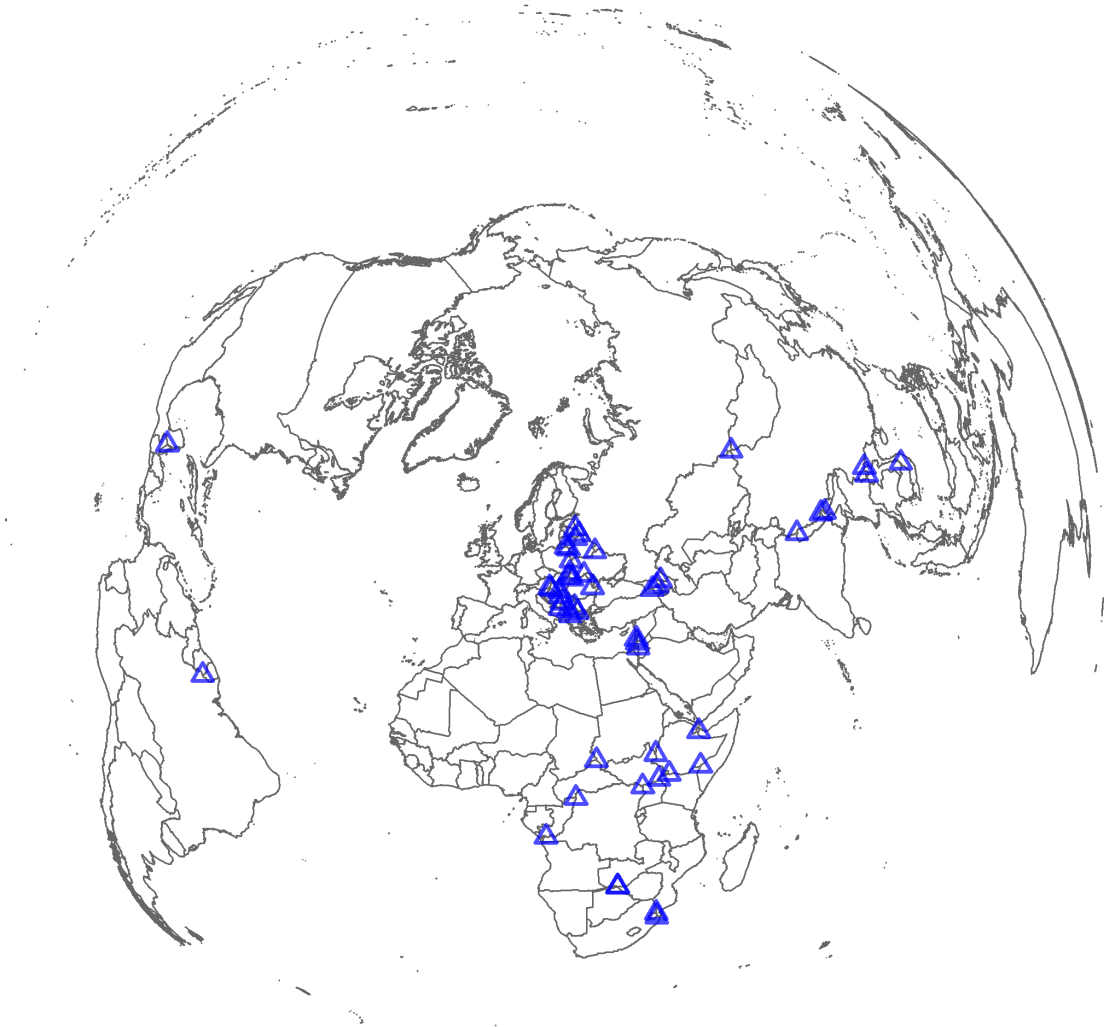


2005



Raster of nighttime lights for one buffer area. Data taken from Li, X., Zhou, Y., Zhao, M., & Zhao, X. (2020)

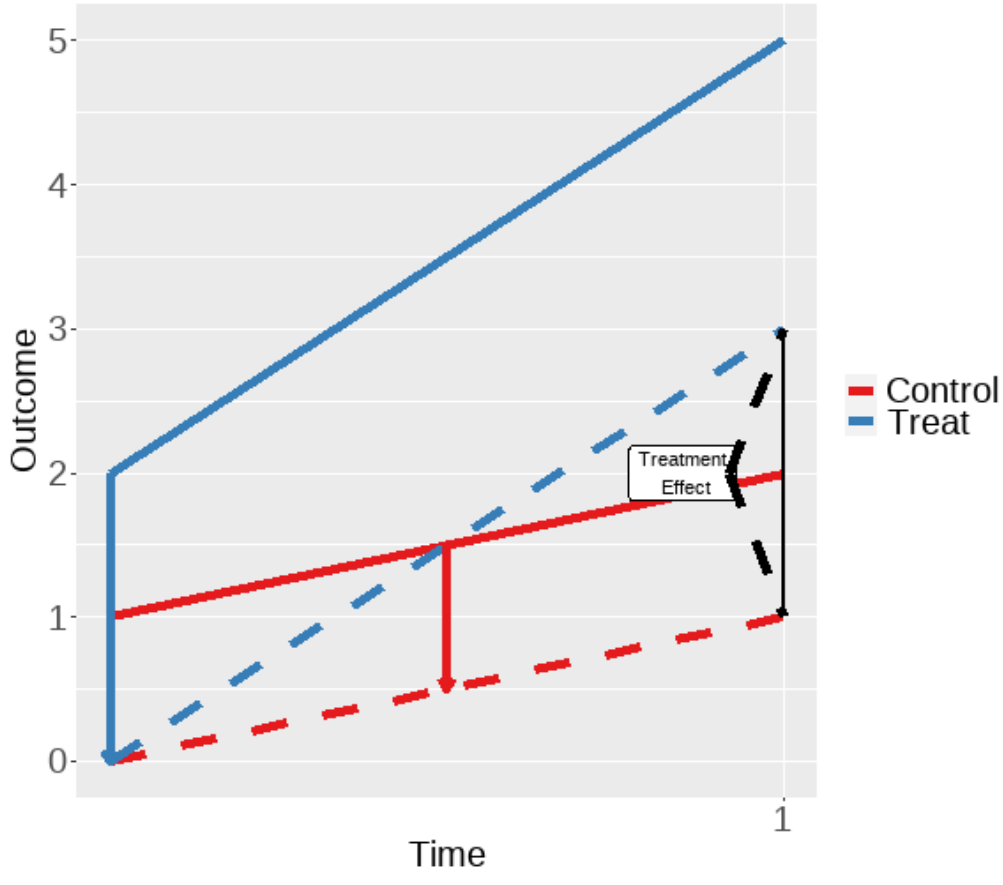
Final dataset of tripoints and RTAs



Empirical Startegy: Difference-in-Differences

$$ln\, LIGHTS_{ijt} = \alpha_0 + \alpha_1 RTA_{ijt} + FE + \varepsilon_{ijt}$$

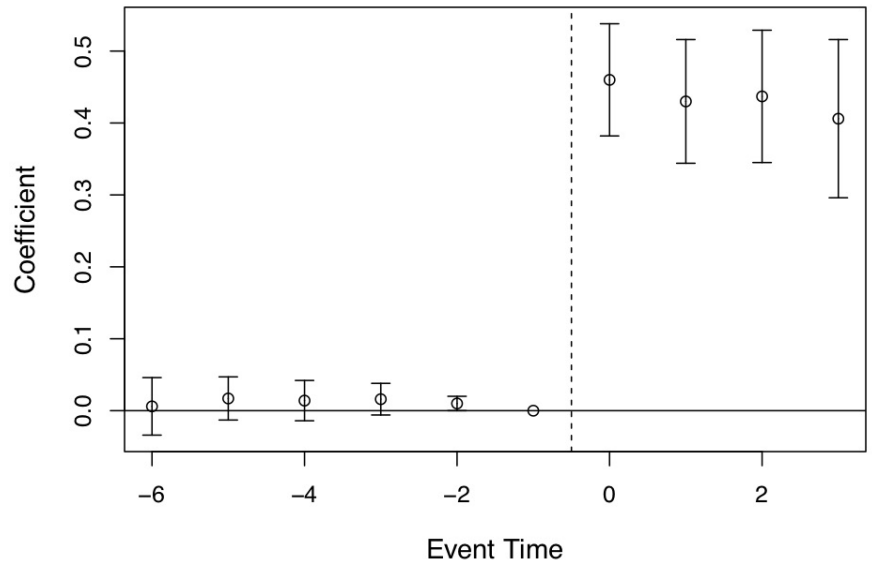
Where $LIGHTS_{ijt}$ is the sum of lights in the area of the country i, in triplet j at time t, RTA_{ijt} is a dummy variable which takes the value of 1 if region i in triplet j is part of a country which had a trade agreement (with other neighboring country in the triplet) in time t, FE are country-triplet and year fixed effects, and ε_{ijt} is an idiosyncratic error term.



Event-study Design

$$ln\, LIGHTS_{ijt} = \alpha_0 + \sum_{\tau=-q}^{-1} \gamma_\tau D_{ijt}^{\tau} + \sum_{\tau=1}^{m} \delta_\tau D_{ijt}^{\tau} + FE + \varepsilon_{ijt}$$

Where $LIGHTS_{ijt}$ is the sum of lights in the area of the country i, in triplet j at time t. Treatment occurs at time o and we include q leads or anticipatory effects and m lags or post-treatment effects. FE are country-triplet and year fixed effects, and ε_{ijt} is an idiosyncratic error term



Example of a event study plot, image taken from Cunningham, S. (2021).

Results : Regression Estimates

50 KM

Table 1. buffer areas, radius = 50kms

	Dependent variable is log(lights)					
	(1)	(2)	(3)	(4)	(5)	(6)
treatment	0.102	0.102	0.048	0.048	0.189	0.189***
	(0.146)	(0.105)	(0.153)	(0.113)	(0.127)	(0.055)
No. triplets	46	46	41	41	27	27
No. countries	64	64	59	59	36	36
Observations	2,361	2,361	2,022	2,022	1,192	1,192
R^2	0.902	0.902	0.878	0.878	0.920	0.920
Adjusted R^2	0.894	0.894	0.869	0.869	0.912	0.912
Residual Std. Error	1.260	1.260	1.280	1.280	0.471	0.471
Note:					*p<0.1; **p<0.05; ***p<0.01	

25 KM

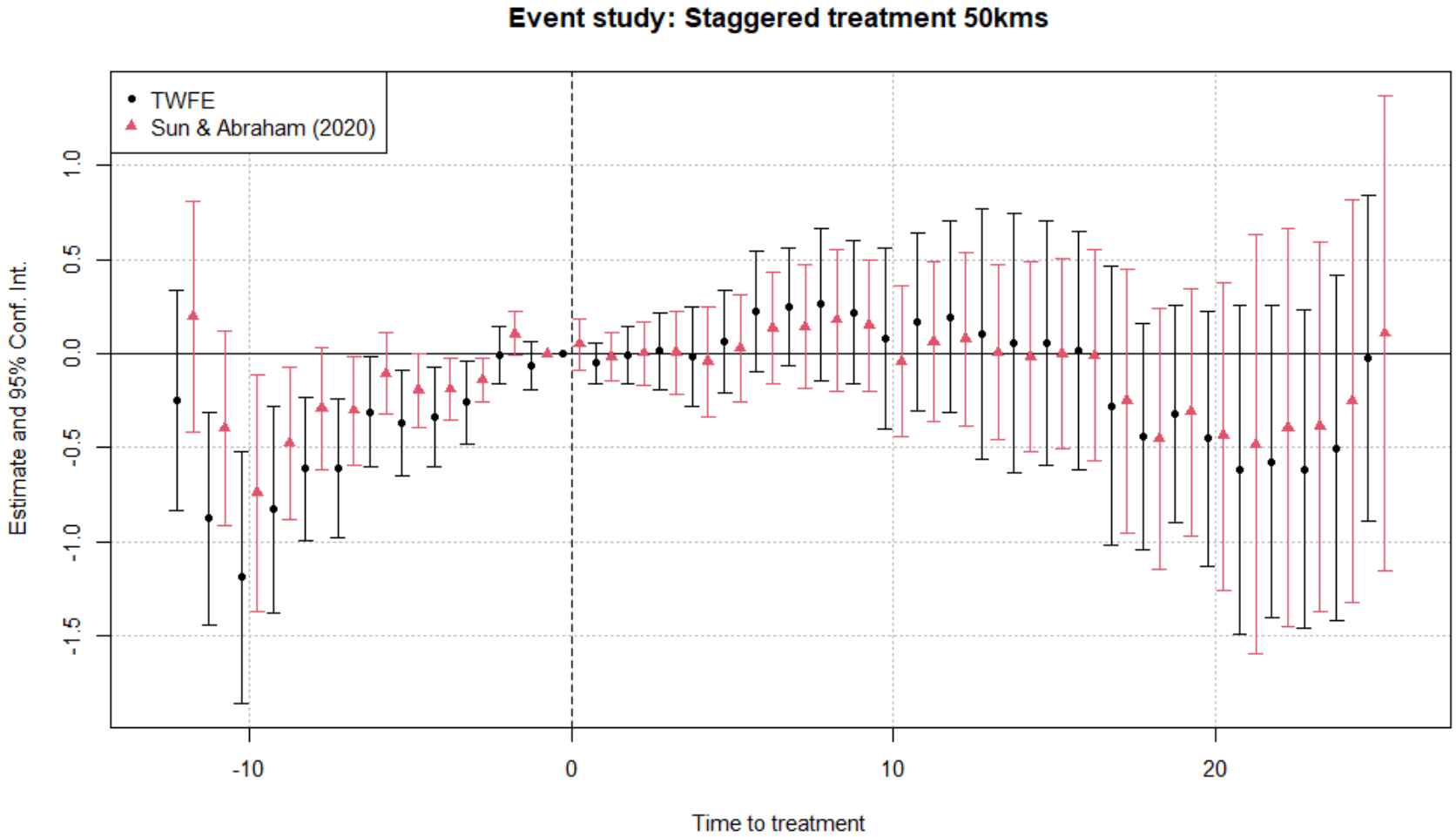
Appendix Table A1. buffer areas, radius = 25kms

	Dependent variable is log(lights)					
	(1)	(2)	(3)	(4)	(5)	(6)
treatment	0.050	0.050	0.026	0.026	0.254**	0.254***
	(0.170)	(0.118)	(0.185)	(0.138)	(0.100)	(0.071)
No. triplets	46	46	39	39	17	17
No. countries	64	64	57	57	32	32
Observations	2,361	2,361	1,929	1,929	661	661
R^2	0.848	0.848	0.816	0.816	0.928	0.928
Adjusted R^2	0.836	0.836	0.802	0.802	0.919	0.919
Residual Std. Error	1.420	1.420	1.510	1.510	0.443	0.443
Note:					*p<0.1; **p<0.05; ***p<0.01	

Columns with odd numbers: clustered errors

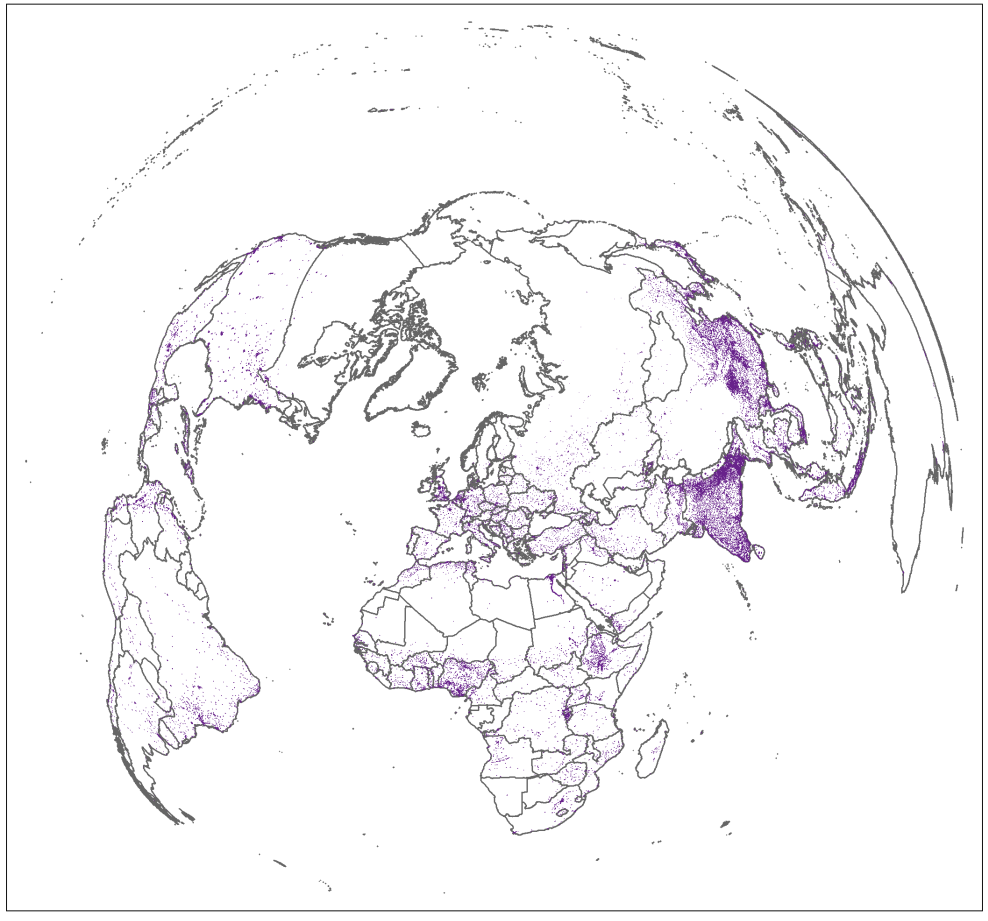
Columns with even numbers: standard errors

However...

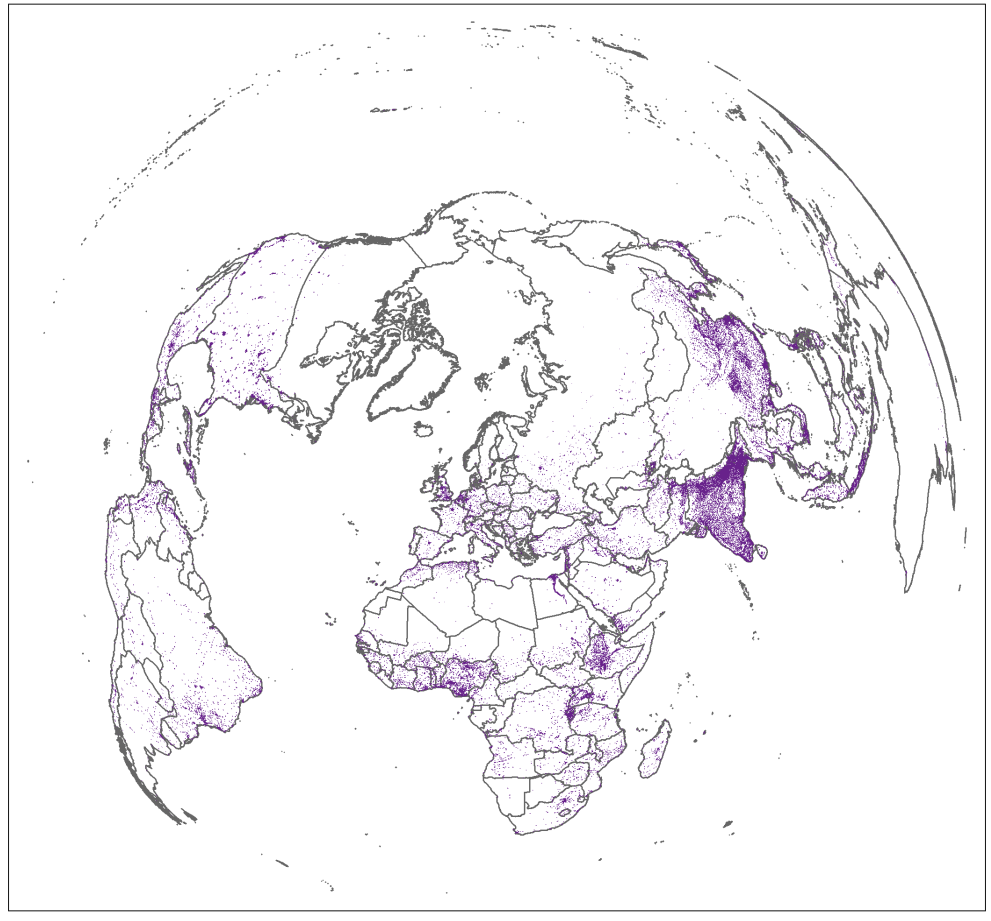

Event study: Staggered treatment 50kms
TWFE
Sun & Abraham (2020)
Estimate and 95% Conf. Int.
1.0
0.5
0.0
-0.5
-1.0
-1.5
-10
0
10
20
Time to treatment

Cities

1990



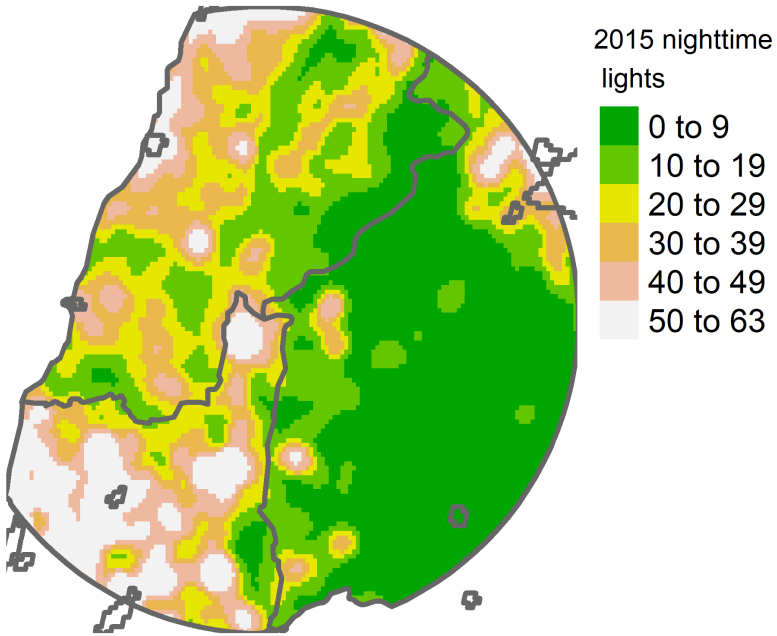
2015



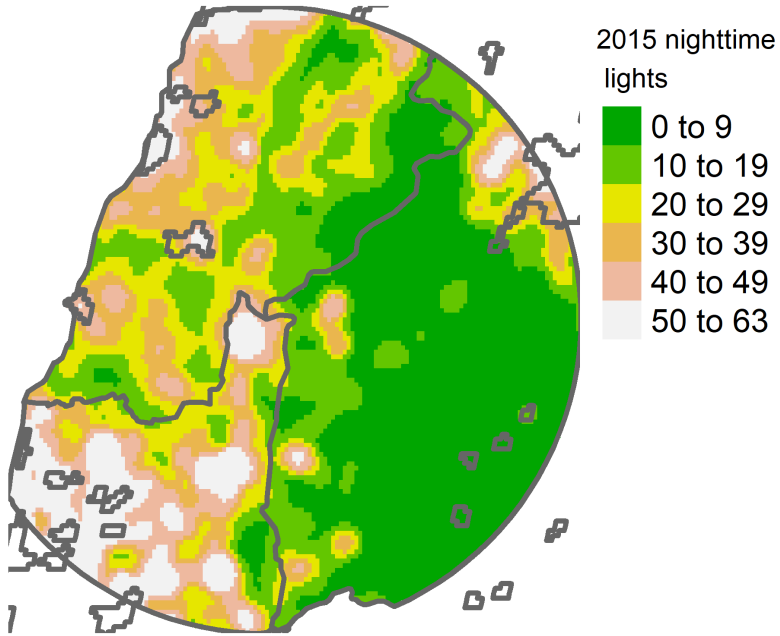
Data for the poygons of cities taken from Bluhm, et al. (2021). Number of cities in 1990 and 2015 is 24652 and 30675.

A triplet of countries, cities and buffer areas

City polygons in 1990



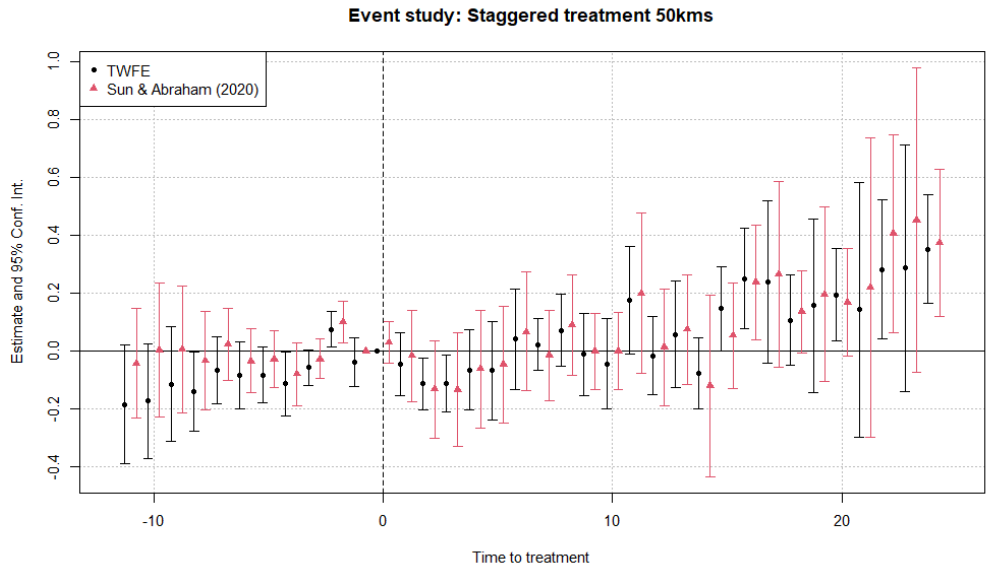
City polygons in 2015



Cities in 1990

Table 2. 50kms city size in year 1990

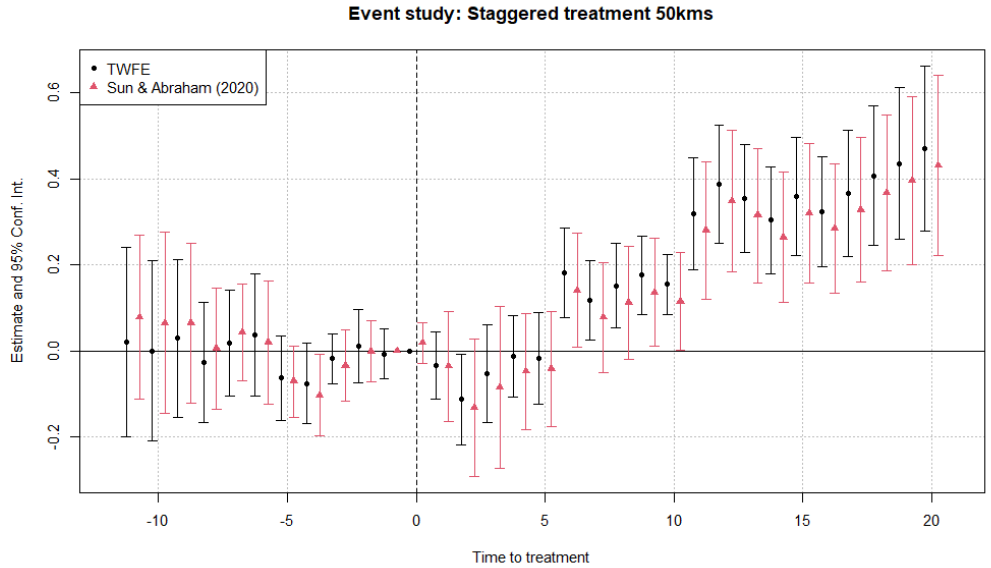
	Dependent variable is log(lights)					
	(1)	(2)	(3)	(4)	(5)	(6)
treatment	−0.073	−0.073	−0.077	−0.077	0.004	0.004
	(0.115)	(0.112)	(0.117)	(0.113)	(0.048)	(0.031)
No. triplets	9	9	8	8	7	7
No. countries	16	16	14	14	11	11
Observations	546	546	470	470	398	398
R^2	0.962	0.962	0.941	0.941	0.984	0.984
Adjusted R^2	0.956	0.956	0.932	0.932	0.982	0.982
Residual Std. Error	0.576	0.576	0.554	0.554	0.141	0.141
Note:						*p<0.1; **p<0.05; ***p<0.01



Cities in 2015

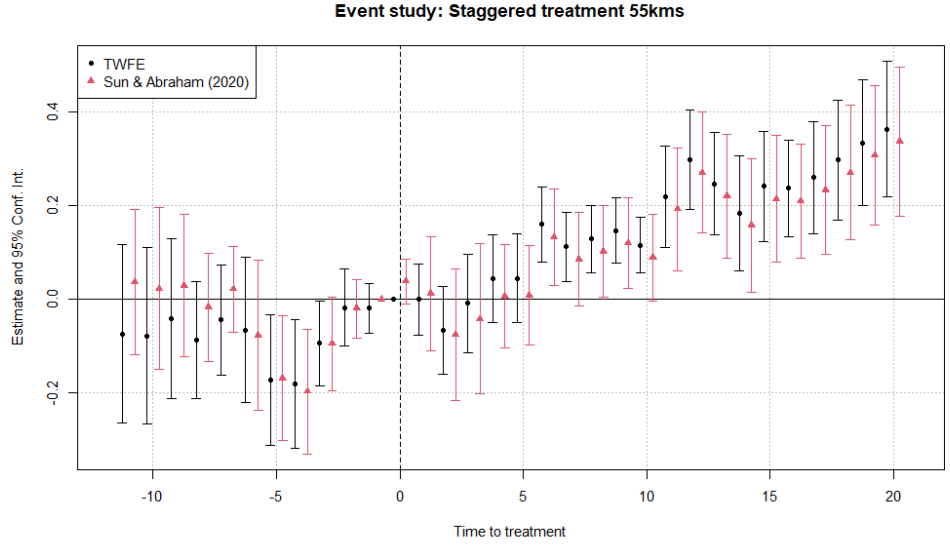
Table 3. 50kms city size in year 2015

	Dependent variable is log(lights)					
	(1)	(2)	(3)	(4)	(5)	(6)
treatment	0.132	0.132	−0.059	−0.059	0.082	0.082***
	(0.186)	(0.090)	(0.089)	(0.087)	(0.066)	(0.027)
No. triplets	9	9	7	7	6	6
No. countries	16	16	12	12	9	9
Observations	1,057	1,057	829	829	541	541
R^2	0.969	0.969	0.975	0.975	0.991	0.991
Adjusted R^2	0.967	0.967	0.972	0.972	0.989	0.989
Residual Std. Error	0.631	0.631	0.558	0.558	0.141	0.141
Note:						*p<0.1; **p<0.05; ***p<0.01



Appendix Table A7. 55kms city size in year 2015

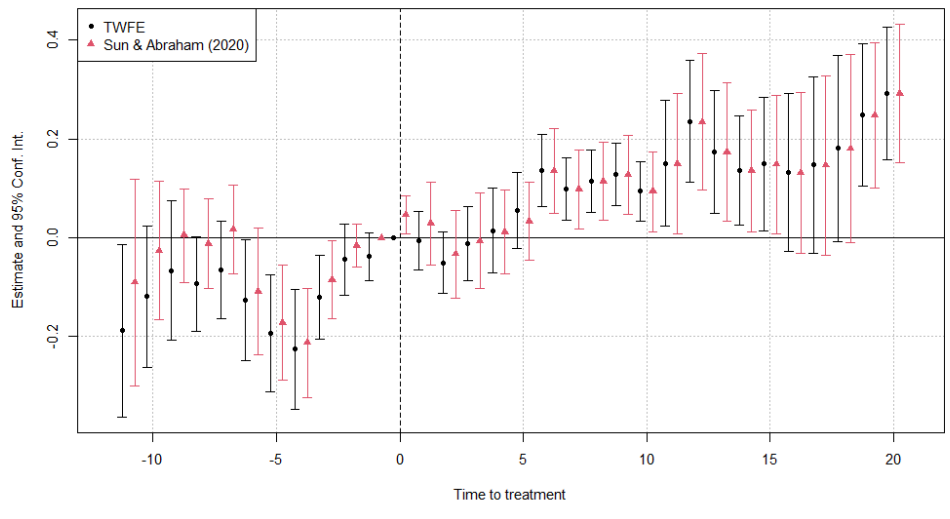
	Dependent variable is log(lights)					
	(1)	(2)	(3)	(4)	(5)	(6)
treatment	0.131	0.131*	−0.003	−0.003	0.155**	0.155***
	(0.153)	(0.075)	(0.085)	(0.072)	(0.060)	(0.027)
No. triplets	10	10	8	8	7	7
No. countries	17	17	13	13	10	10
Observations	1,273	1,273	1,045	1,045	757	757
R^2	0.972	0.972	0.975	0.975	0.984	0.984
Adjusted R^2	0.969	0.969	0.973	0.973	0.982	0.982
Residual Std. Error	0.586	0.586	0.513	0.513	0.156	0.156
Note:						*p<0.1; **p<0.05; ***p<0.01



Appendix Table A8. 60kms city size in year 2015

	Dependent variable is log(lights)					
	(1)	(2)	(3)	(4)	(5)	(6)
treatment	0.129	0.129**	0.034	0.034	0.176***	0.176***
	(0.120)	(0.063)	(0.061)	(0.061)	(0.045)	(0.025)
No. triplets	12	12	10	10	8	8
No. countries	20	20	16	16	12	12
Observations	1,634	1,634	1,374	1,374	1,027	1,027
R^2	0.971	0.971	0.971	0.971	0.976	0.976
Adjusted R^2	0.968	0.968	0.969	0.969	0.974	0.974
Residual Std. Error	0.560	0.560	0.503	0.503	0.175	0.175
Note:						*p<0.1; **p<0.05; ***p<0.01

Event study: Staggered treatment 60kms



location of tripoints

Original sample

Restricted sample

Conclusions:

- There is not a significant effect of RTAs on economic activity for buffer areas.
- There is not a significant effect of RTAs on economic activity for 1990 cities within buffer areas.
- The effect of RTAs on economic activity can be measured for 2015 cities.
- RTAs appear to be driving the agglomeration of output in cities/population growth of cities.

Further research:

- Heterogeneous effects of RTAs for different geographical regions.
- The effects of different types of trade agreements on the light intensities at border regions.
- Robustness checks, another DID estimators **Goodman-Bacon, A. (2021)**, **Callaway, B., & Sant'Anna, P. H. (2021)**

When regions grow Solo(w): Neoclassical convergence and spatial filtering across Chinese provinces

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Carlos Mendez, Nagoya University, Japan

Linda Glawe, University of Hagen, Germany

Motivation:

- The estimates from the augmented Solow growth model are biased since neighbor effects are not taken into account.
- There is limited research on the effect geographical links and convergence accounting across Chinese provinces.

Research Questions:

- **To what extent the role of space affects the convergence of Chinese regions?**
- **What are the contribution of capital inputs and productivity on the convergence of provincial income per capita?**

Methods:

- Classical convergence framework (Barro and Sala-i-Martin, 1992)
- Convergence growth accounting (Wong, 2007; Feyrer, 2007)
- Spatial autocorrelation - Moran's I (Moran, 1948)
- Getis Filter (Getis, 1995, 2010)

Outline

1. **Introduction and Data**
    - A newly constructed data-set
2. **Methods**
    - **Spatial autocorrelation** Standard Moran's I
    - **Spatial Filtering Perspective** Getis Spatial Filter
    - **Convergence regression and accounting**
3. **Related Literature**
4. **Results**
    - Spatial filtering
    - Spatial and non-spatial convergence accounting
5. **Concluding Remarks**

(1) Data

A balanced dataset for 31 provinces over the 1990-2017 period.

GDP per capita. Real GDP in constant 2010 prices is calculated using GDP and CPI data from the National Bureau of Statistics of China (NBS, 2021).

Human capital. The CHLR human capital index (cf. Fraumeni et al., 2019).

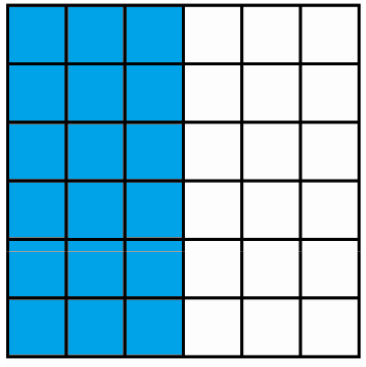
Capital output ratio. the current provincial physical capital stock divided by the current provincial GDP.

(2) Spatial Autocorrelation :

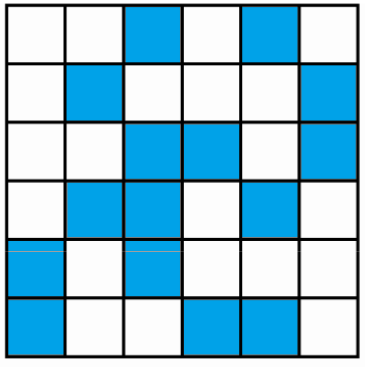
Moran's I

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

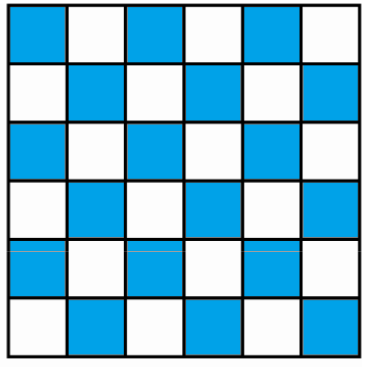
It captures the relationship of a variable in one location with the spatially weighted average of values at neighboring locations.



Positive spatial autocorrelation



No spatial autocorrelation



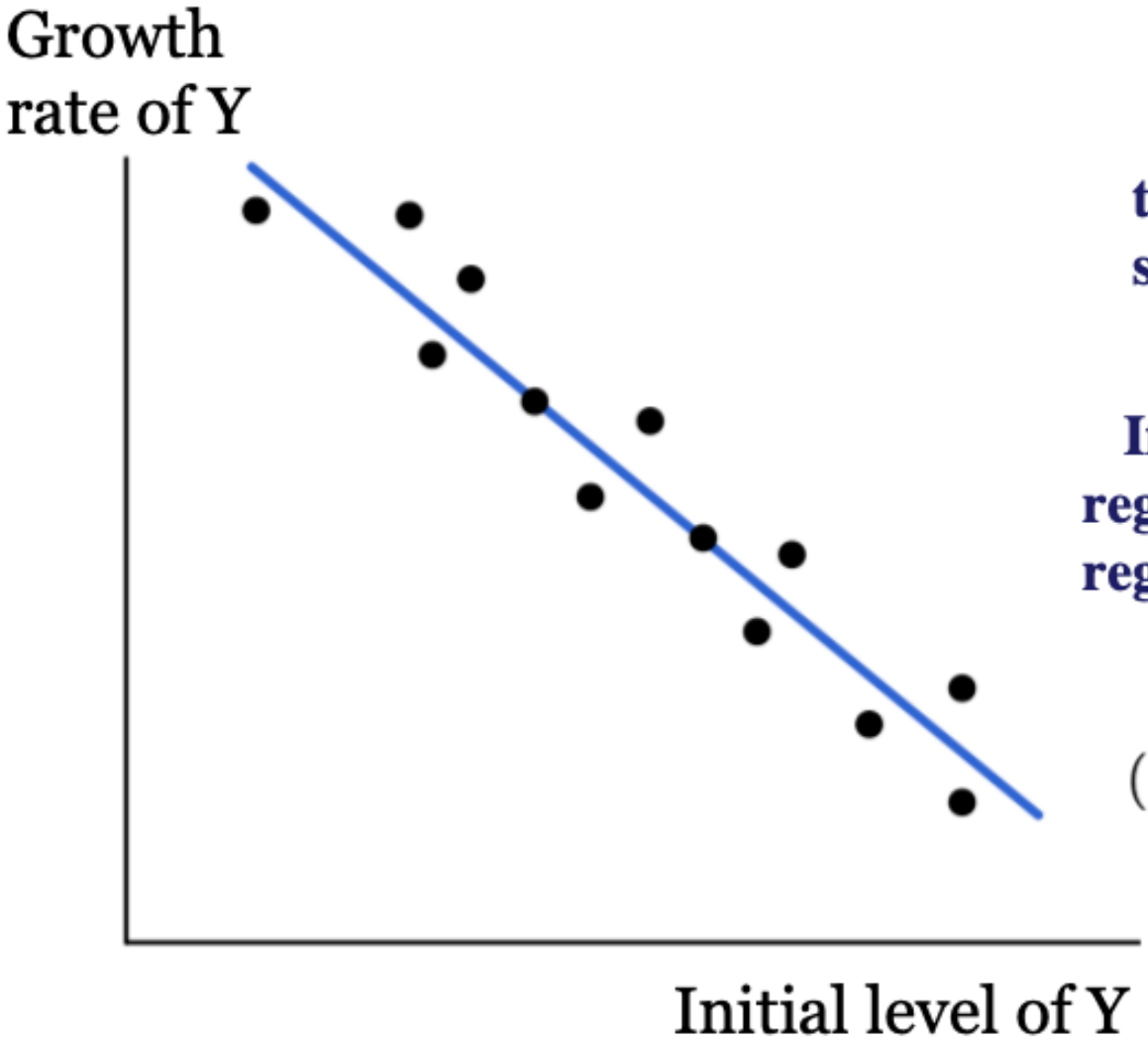
Negative spatial autocorrelation

(2) Spatial Filtering Perspective

$$x_i^* = \frac{xi(W_i)}{(n-1)G_i(d_m)}$$

The spatial filtering of the data can help us to avoid misguided interpretation.

(2) Beta convergence



The inverse relationship between the initial level of a variable and its subsequent growth rate.

If such inverse relationship exists, poor regions tend to grow faster than the rich regions.

$$(1/T) \cdot log\frac{y_{iT}}{y_{i0}} = \alpha - \frac{[1 - e^{-\beta T}]}{T} \cdot log(y_{i0})$$

(2) Growth accounting

Growth accounting decomposition based on Solow (1956):

$$Y = \left(\frac{K}{Y}\right)^{\frac{\alpha}{1-\alpha}} AhL.$$

$$\ln\left(\frac{Y}{L}\right) = \frac{\alpha}{1-\alpha}\ln\left(\frac{K}{Y}\right) + \ln(h) + \ln(A)$$

Taking derivatives with respect to time yields a growth accounting decomposition:

$$g\left(\frac{Y}{L}\right) = \frac{\alpha}{1-\alpha}g\left(\frac{K}{Y}\right) + g(h) + g(A),$$

We can write this equation as:

$$g(y) = g(k) + g(h) + g(A),$$

(2) Convergence accounting

The standard unconditional beta convergence regression is:

$$g(y) = c + \beta \ln(y_{t0}) + \epsilon$$

From the last equation in the previous slide it can be shown that:

$$\beta = \beta_k + \beta_h + \beta_A$$

where the β_i coefficients are obtained from the following regressions

$$g(k) = c_k + \beta_k \ln(y_{t0}) + \epsilon$$

$$g(h) = c_h + \beta_h \ln(y_{t0}) + \epsilon$$

$$g(A) = c_A + \beta_A \ln(y_{t0}) + \epsilon$$

(2) Spatial Convergence accounting

In the context of our production function, let us define the log of the net spatial residual as:

$$\ln\left(\frac{Y}{L}\right) = \frac{\alpha}{1-\alpha}\ln\left(\widetilde{\frac{K}{Y}}\right) + \ln(\tilde{h}) + \ln(\widetilde{A}) + \ln(NSR)$$

which implies:

$$g(y) = g(\tilde{k}) + g(\tilde{h}) + g(\widetilde{A}) + g(NSR) \Longrightarrow \beta = \beta_{\tilde{k}} + \beta_{\tilde{h}} + \beta_{\tilde{A}} + \beta_{NSR}$$

where the β_i coefficients are obtained from the following regressions

$$g(\tilde{k}) = c_{\tilde{k}} + \beta_{\tilde{k}}\ln(y_{t0}) + \epsilon$$

$$g(\tilde{h}) = c_{h} + \beta_{\tilde{h}}\ln(y_{t0}) + \epsilon$$

$$g(\tilde{A}) = c_{\tilde{A}} + \beta_{\tilde{A}}\ln(y_{t0}) + \epsilon$$

$$g(NSR) = c_{NSR} + \beta_{NSR}\ln(y_{t0}) + \epsilon$$

(2) Related literature

Convergence of Chinese provinces

- **Chen and Fleisher (1996)** there are no signs of unconditional convergence for the sample period 1952-1992. Nevertheless, for the most recent period of 1978-1993 they find weak evidence of unconditional convergence.
- **Raiser (1998)** The author uses data for 29 provinces for the period 1978-1992. He reports that overall provincial income levels have converged. Nevertheless, a major slow-down in the convergence speed was reported in the second half of the 1980s.
- **Weeks and Yao (2003)** . The authors use the system-GMM estimator and report a very slow convergence speed (0.41%) during the pre- reform period 1953–1977 and a much faster speed (2.23%) during the reform period 1978–1997.

Convergence and spatial filtering

- Europe (Fischer and Stumpner, 2010), Brazil (Cravo and Resende, 2013)
- Indonesia (Santos-Marquez et al., 2022), Spain (Maza and Villaverde, 2009)
- **China** by **Villaverde and Maza (2012)**, Chinese provincial GDP per capita in 1992-2007. they use a different convergence framework known as distribution dynamics.

(3) Results: Spatial filtering

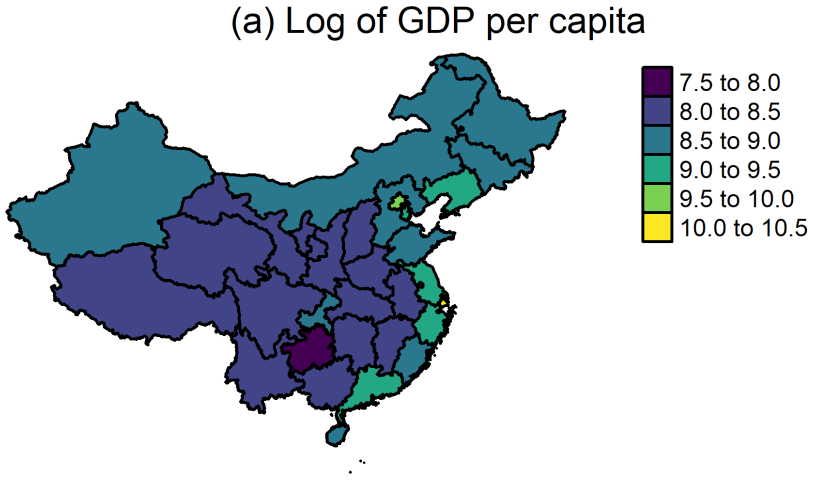
Spatial autocorrelation for A, K/Y , h and Y /L is continuously significant from 1998 to 2010

Table 1: Moran's I statistic for original and filtered variables in 1998 and 2010

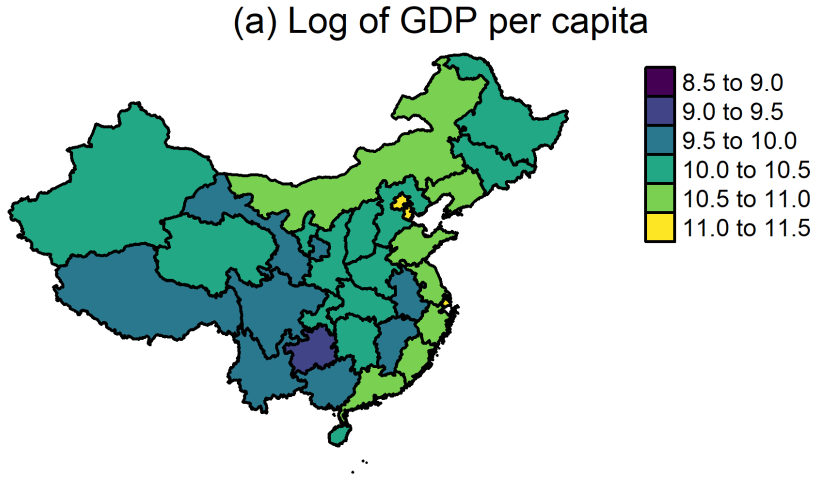
variable	distance band	k = 4	k = 5	k = 6
tr_y_1998	0.09*	0.22***	0.19***	0.17***
tr_y_2010	0.19***	0.35***	0.31***	0.28***
tr_y_tilde_1998	-0.11	-0.04	-0.03	-0.06
tr_y_tilde_2010	-0.07	0.04	0.02	0
tr_K_Y_1998	0.31***	0.31***	0.26***	0.24***
tr_K_Y_2010	0.48***	0.41***	0.36***	0.36***
tr_K_Y_tilde_1998	-0.04	-0.02	-0.07	-0.09
tr_K_Y_tilde_2010	-0.11	-0.05	-0.1	-0.06
tr_h_1998	0.05*	0.11*	0.1*	0.09**
tr_h_2010	0.06*	0.11*	0.09*	0.07*
tr_h_tilde_1998	-0.08	-0.09	-0.07	-0.07
tr_h_tilde_2010	-0.09	-0.09	-0.09	-0.09
tr_A_1998	0.12**	0.1*	0.1*	0.06*
tr_A_2010	0.11**	0.08*	0.12*	0.11**
tr_A_tilde_1998	-0.19	-0.13	-0.12	-0.15
tr_A_tilde_2010	-0.19	-0.12	-0.09	-0.1
tr_K_Y_1998	0.31***	0.31***	0.26***	0.24***
tr_K_Y_2010	0.46***	0.41***	0.36***	0.35***
tr_K_Y_tilde_1998	-0.03	-0.03	-0.07	-0.09
tr_K_Y_tilde_2010	-0.12	-0.06	-0.11	-0.07

(3) Results: Spatial filtering

(a) 1998



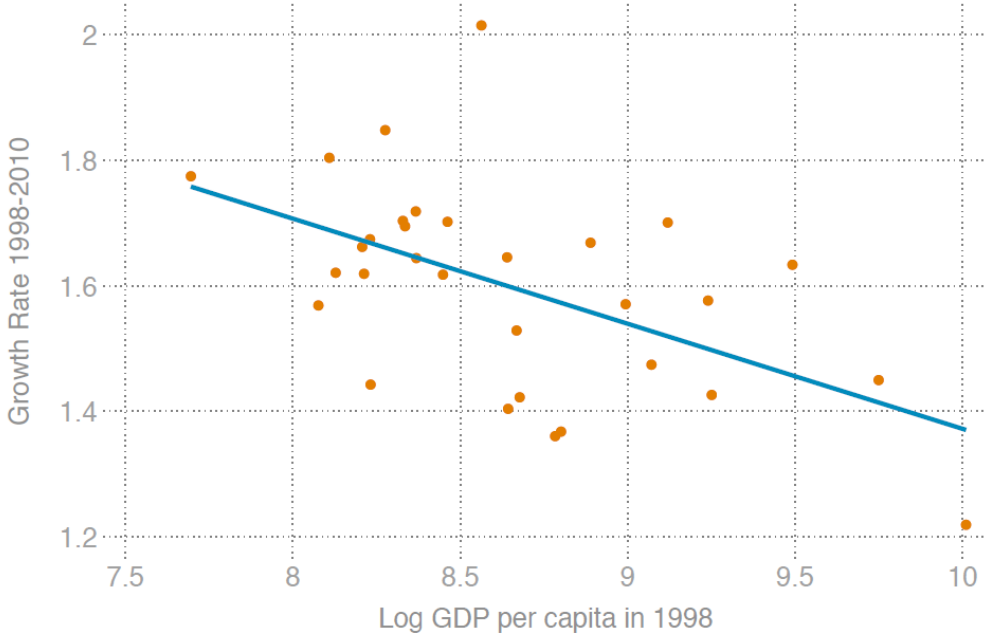
(b) 2010



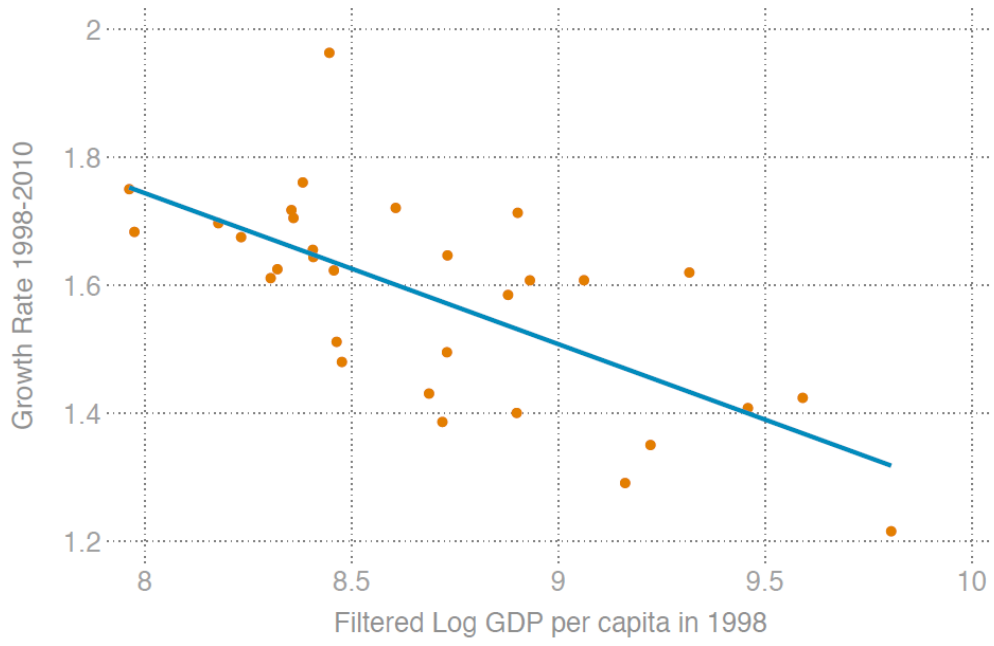
(3) Results: beta convergence

There is overall unconditional convergence in provincial GDP per capita

Original data



Filtered data



(3) Results: spatial and non-spatial convergence accounting

Table 2: Beta convergence accounting 1998-2010

	Model 1	Model 2
Aggregate efficiency	70.75	69.52
Capital inputs	29.25	26.92
Physical capital	12.95	14.04
Human capital	16.30	12.88
Spatial dependence		3.55

Notes: The numbers indicate the relative contribution of efficiency, capital, and spatial dependence to the convergence coefficient presented in Figure 3.

(6) Concluding Remarks

- **Convergence of TFP explains most of the convergence of regional income.**
- **The convergence of capital inputs account for about 30% of income covergence.**
- **Spatial effects are reducing the regional income disparities.**

Implications

- To spatially filter regional income and other variables is important in order to avoid misleading interpretations.
- Geography matters! breaking spatial barriers and continuing to enhance inter-regional connectivity and cooperation must be on top of the policy agenda.

(6) Next steps

- Review a more extensive list of papers that analyse regional convergence in China.

- Select the appropriate α in the growth equation.

- Document and improve the Getis filter function. We would like to have as one of the outputs of this paper a function that can be part of a package for spatial analysis in R.

- Compare the results of this project with the results reported in previous papers.

Thank you very much for your attention

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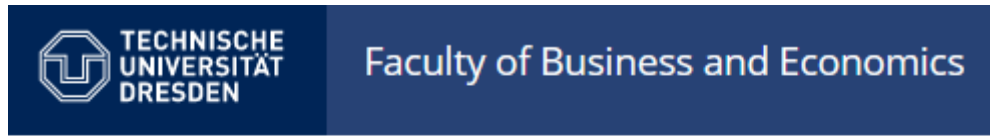

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