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

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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 Question:

- **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).

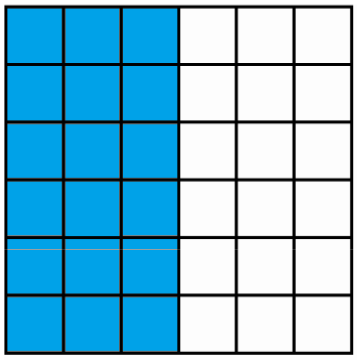
Capital output ratio. the current provincial physical capital stock divided by the current provincial GDP.

(2) Spatial Autocorrelation :

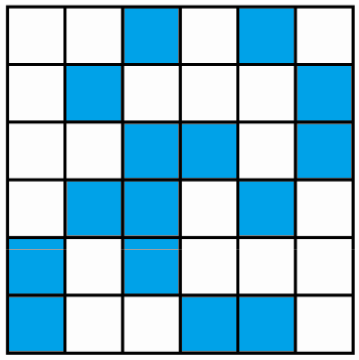
Moran's I

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

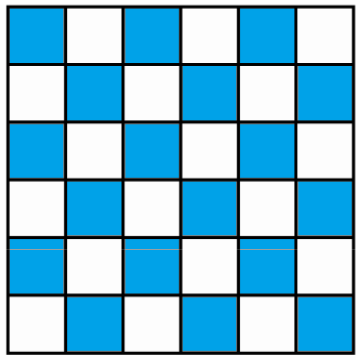
It captures the relationship of a variable in one location with the spatially weighted average of values at neighboring locations.



Positive spatial autocorrelation



No spatial autocorrelation



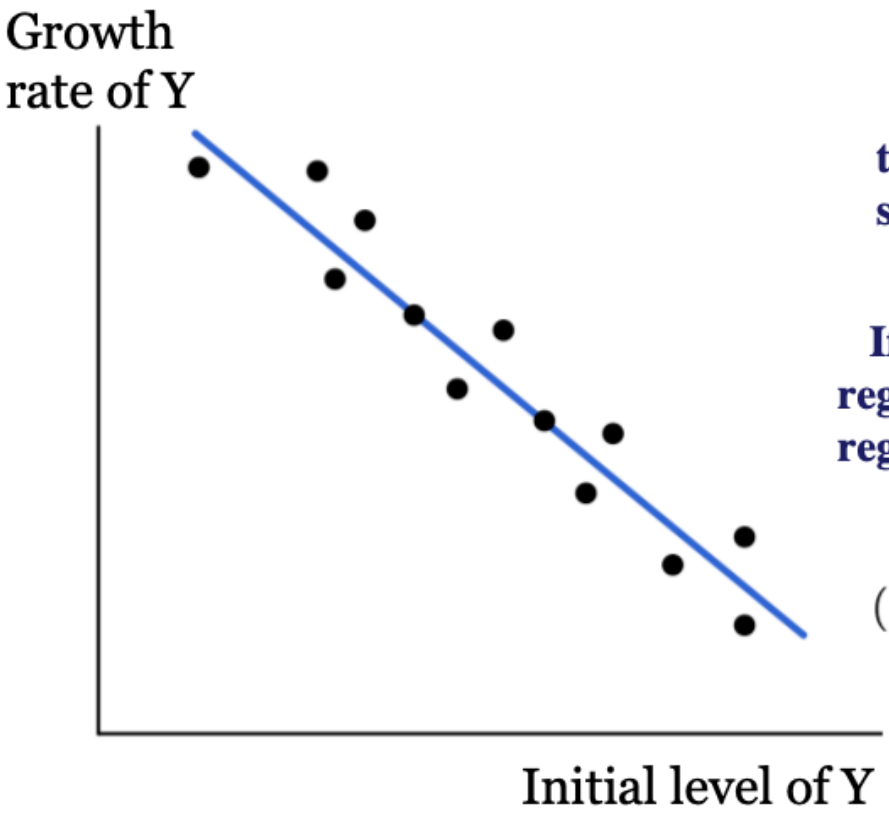
Negative spatial autocorrelation

(2) Spatial Filtering Perspective

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

A 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

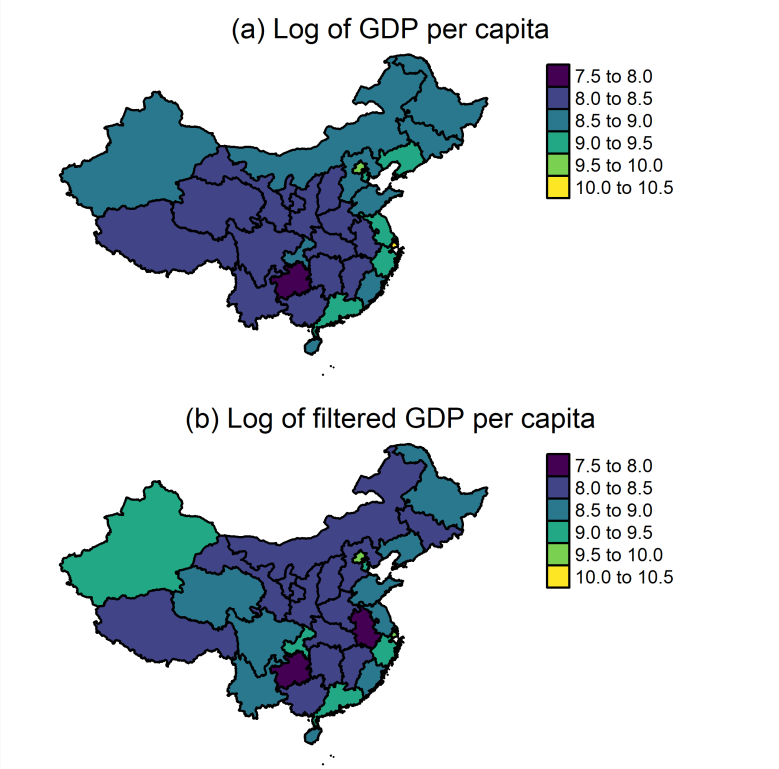
Spatial autocorrelation for A, K/Y , h and Y /L is continuously significant from 1998 to 2010

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

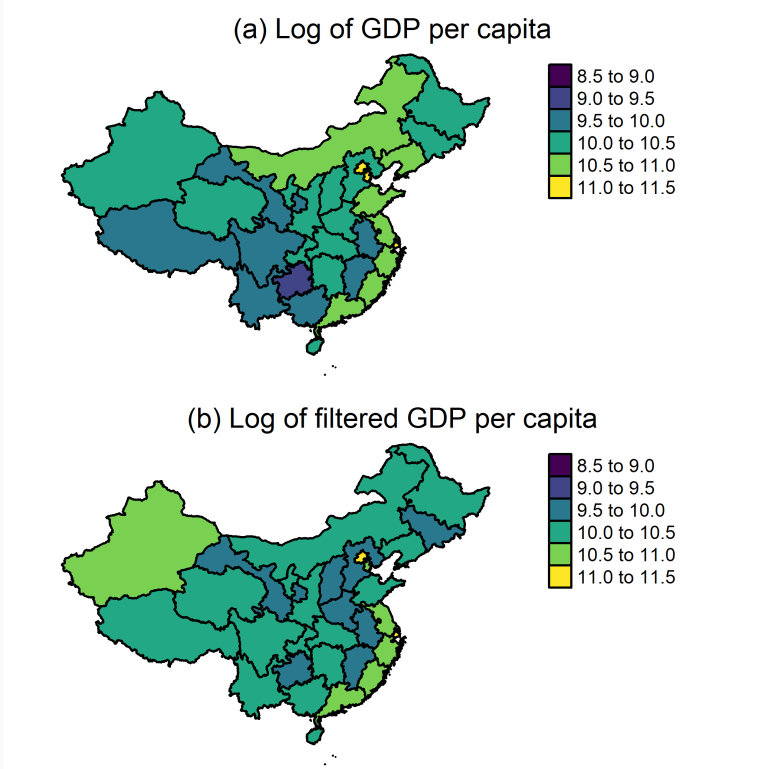
variable	distance band	k = 4	k = 5	k = 6
tr_y_1998	0.09*	0.22***	0.19***	0.17***
tr_y_2010	0.19***	0.35***	0.31***	0.28***
tr_y_tilde_1998	-0.11	-0.04	-0.03	-0.06
tr_y_tilde_2010	-0.07	0.04	0.02	0
tr_K_Y_1998	0.31***	0.31***	0.26***	0.24***
tr_K_Y_2010	0.48***	0.41***	0.36***	0.36***
tr_K_Y_tilde_1998	-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



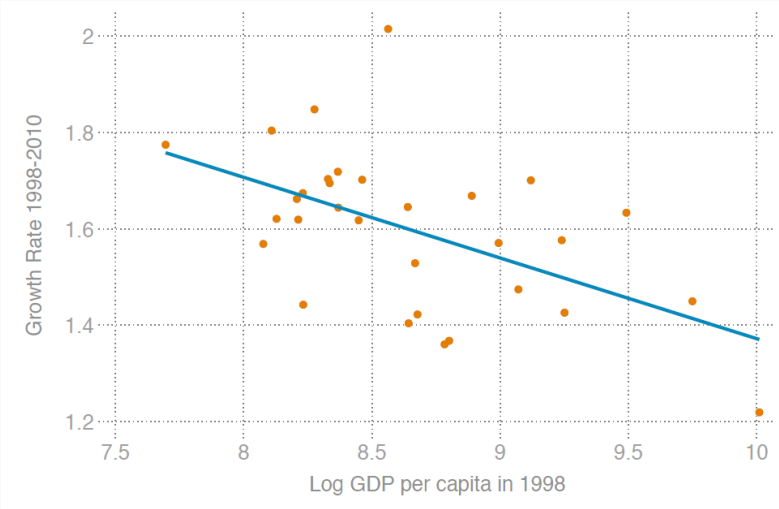
(b) 2010



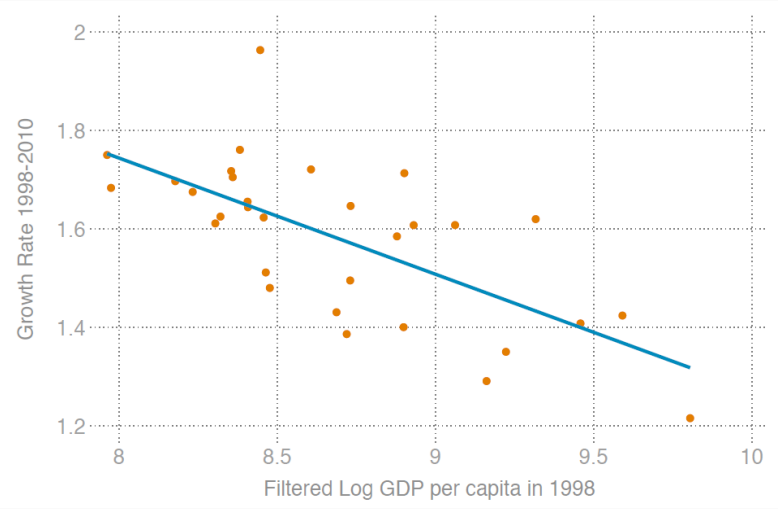
(3) Results: beta convergence

There is overall unconditional convergence in provincial GDP per capita

Original data



Filtered data



(3) Results: spatial and non-spatial

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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