

# The Communication and European Regional Economic Growth:

the Interactive Fixed Effects Approach

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# Table of contents

1. Introduction
2. Literature Review
3. Eurostat Data
4. EMPIRICAL STUDY
5. Conclusion

# Introduction

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# Background

## European Integration History

- European Coal and Steel Community (1951)
- The Treaties of Rome (1957)
- The Treaty on European Union (Maastricht Treaty, 1992)
- Treaty of Amsterdam (1997), Treaty of Nice (2001) and Treaty of Lisbon (2007)

Regional Factor **Mobility**: partial facts and reality

Factor Accumulation and Refugees Migration

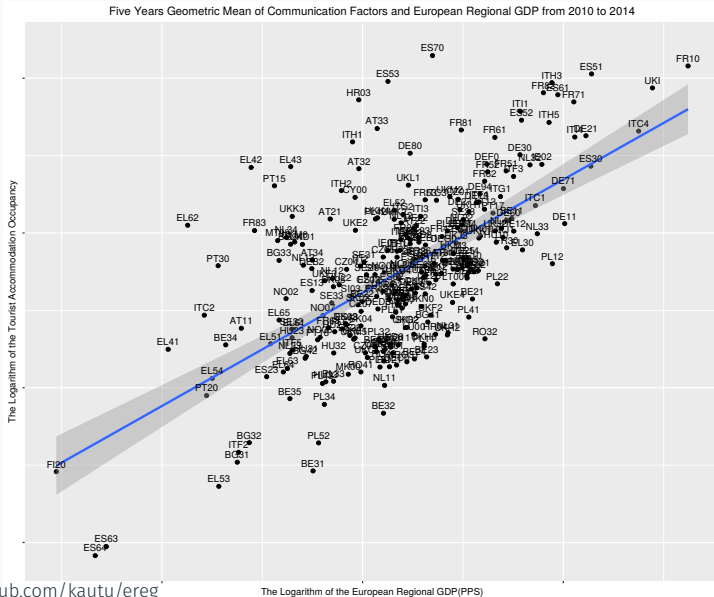
Business Facilitation and Survival Standards

**Imbalance**<sup>1</sup> everywhere between EU15 and EU28, continuous legislative proposals to consolidate and complement

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<sup>1</sup>Lucas (1990) Paradox and the allocation puzzle of Gourinchas and Jeanne (2013)

## Communication and European Regional GDP



# Literature Review

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# neoclassical growth model

## PHYSICAL CAPITAL, POPULATION, HUMAN CAPITAL AND TECHNOLOGY

- **Barro (1991)** education quality of the **initial human capital** and the **initial real per capita GDP** in the cross sectional growth approach for 98 countries from 1960 to 1985.
- **Barro and Sala-i-Martin (1992)** the poor regions grow faster than the rich ones in cross sectional **convergence** study across 48 contiguous states in United States from 1963 to 1986.
- **Barro (2012)** reexamined the iron law of **convergence** in the international panels including country fixed effects over 10 five-years intervals from 1960-65 to 2005-09.
- **Mankiw, Romer and Weil (1992)** the accumulation of **physical capital**, higher quality of **human capital** and higher **population** growth within the endogenous-growth model framework for 121 countries from 1960 to 1985.

# endogenous growth model

## PHYSICAL CAPITAL, POPULATION, HUMAN CAPITAL AND TECHNOLOGY

- **Romer (1986)** endogenous **technological change**, increasing marginal productivity of knowledge and decreasing marginal productivity of physical capital.
- **Romer (1990)** technological improvement, **knowledge translation** into market practices and non-rivalry and partial excludability of technology. **Romer (1987)** **specialization** and variety in production.
- **Aghion and Howitt (1992)** **industrial innovations** and product obsolescence through Schumpeters process of creative destruction, and **Howitt (1999)** **R&D subsidies**.
- **Akcigit, Celik and Greenwood (2016)** **patent market** searching frictions and patent reassignments in United States firm activities.



## GOVERNMENT TAXATION AND ECONOMIC POLICY ANALYSIS

- **Rebelo (1991)** the lower economic growth was translated from higher **income tax rates** and poorer property rights enforcement.

## TAXATION EFFECTS AND INTERNATIONAL MOBILITY OF TALENTED MIGRATION

- **Kleven, Landais and Saez (2010)** specifically segmenting on **European professional football market**, and
- **Akcigit, Baslandze and Stantcheva (2016)** particularly highlighting on **top superstar patent inventors**.

## CATEGORY GROWTH DETERMINANTS

- **Durlauf, Johnson and Temple (2005)** summarized 145 variable regressors of economic growth determinants, categorized into institutional measurement, demographic characteristics, macroeconomics fundamentals, geography endowments and cultural differences.
- **Rockey and Temple (2015)** recently revisited theoretical arguments and empirical analysis of Bayesian Model Averaging, while reviewing the practical methods implemented on identifying economic growth determinants from cross section approaches.<sup>2</sup>

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<sup>2</sup>Cuaresma et al (2016) proposing the use of Latent Class Analysis methods to analyze the covariate inclusion patterns across specifications resulting from Bayesian model averaging exercises in Sala-i-Martin, Doppelhofer and Miller (2004) dataset [4].

## PANEL DATA IMPROVEMENTS AND PRACTICAL IMPLEMENTATION

- **Durlauf, Johnson and Temple (2005)** inevitable limitations of the traditional classical panel data approaches.
- **Bai (2009)** identification, consistency and the limiting distribution of the interactive fixed effects estimator in panel data models with large  $N$  (the number of units) and large  $T$  (the number of time periods).
- **Kneip, Sickles and Song (2012)** proposed a semi-parametric method for arbitrary temporal heterogeneity in panel data models without any explicit restrictions on the temporal pattern of individual patterns, as combining smoothing spline techniques with principal component analysis.
- **Bada and Liebl (2014)** published the compiled R package *phtt* for panel data with general forms of unobservable heterogeneous effects in large dimensions of  $N$  and  $T$ .

Table 1: DETERMINING THE NUMBER OF FACTORS

Bai and Ng (2002)	Panel Criteria Bayes Information Criterion
Ahn and Horenstein (2013)	Eigenvalue Ratio Growth Ratio
Onatski (2010)	sample covariance Eigenvalues

**Moon and Weidner (2015)** the limiting distribution of the least squares estimator is independent of the number of factors, when it is assumed to be not underestimated in the interactive fixed effects.

\***Bai and Liao (2017)** “doubly weighted convergence” in estimating high-dimensional inverse covariance matrix , with cross-sectional correlations and heteroskedasticity. <sup>3</sup>

<sup>3</sup>Applying the proposed method to the **Wolfers (2006)** US divorce rate data, and provides tighter confidence intervals than existing methods, under more general unobserved heterogeneity. [1]

## GROUP EFFECTS ESTIMATORS

- **Bester and Hansen (2009)** assumed individual specific parameters common across groups at some level when **membership** grouped on multiple observable variables, but
- **Lin and Ng (2012)** created the pseudo threshold variables to partition the panel data into **clustering groups** when group membership is unknown.
- **Bonhomme and Manresa (2015)** recently exploited **K-Means** algorithm for time-varying grouped patterns of unobserved heterogeneity in linear panel data models.

# Eurostat Data

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STATISTICAL OFFICE OF THE EUROPEAN UNION (**EUROSTAT**).

- **268 regions** or 4020 total observations from 2000 to 2014,
- 28 Member States of the EU, and EFTA and candidate countries.

NOMENCLATURE DES **U**NITS **T**ERRITORIALES **S**STATISTIQUES CLASSIFICATION

- geographical nomenclature subdividing the economic territory of the European Union into regions at three different levels, covering **NUTS levels** 1, 2 and 3, respectively from larger to smaller areas, [14]
- **Population** of NUTS level 2 regions ranges from 800 thousand to 3 million. Administrative Structures in priority.
- **Regulation (EC) No 1059/2003** of the European Parliament and of the Council of 26 May 2003 on the establishment of a common classification of territorial units for statistics.
- **Eurostat Regional Yearbook (2016 edition)** doi: 10.2785/29084

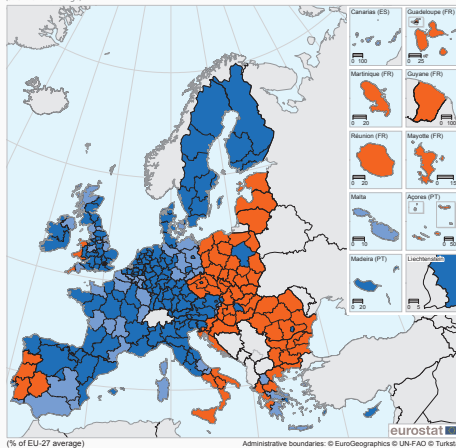
# GDP per inhabitant (in PPS), by NUTS 2 regions



1

Regional policies and Europe 2020

Map 1.1: Eligibility of regions for cohesion funds based on gross domestic product (GDP) per inhabitant (in PPS), by NUTS 2 regions, for the programming period 2014–20 (\*)  
(% of EU-27 average)



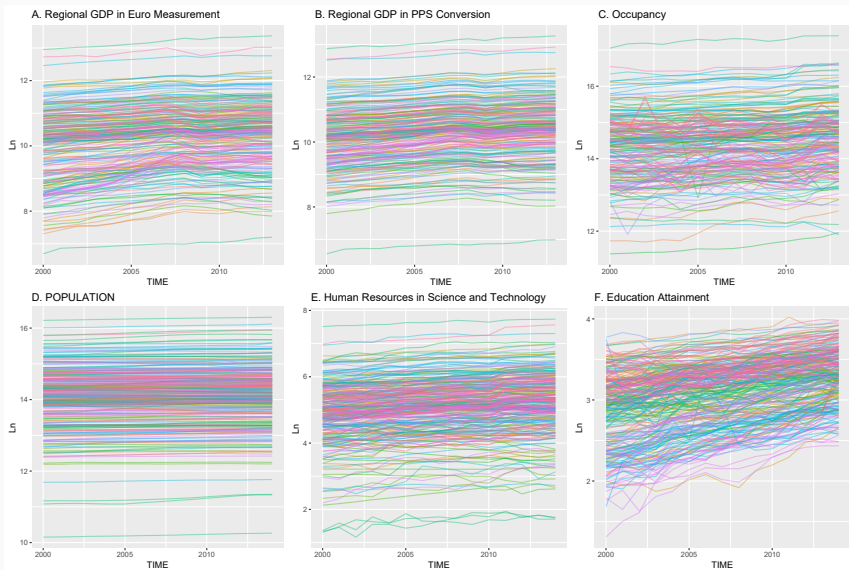
Less developed regions (GDP per inhabitant, < 75)

Transition regions (GDP per inhabitant, ≥ 75 – < 90)

More developed regions (GDP per inhabitant, ≥ 90)

Administrative boundaries: © EuroGeographics © UN-FAO © Turkstat  
Cartography: Eurostat — GISCO, 04/2016





**Figure 3:** Dependent Variables and Explanatory Variables

# EMPIRICAL STUDY

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# Model Specification

SOLOW (1956) - SWAN (1965) MODEL:

The constant returns to scale **Cobb-Douglas** production function. Y is *Output*, K is *Capital*, H is *Human Capital*, A is *Technology*, L is *Employment*.

$$Y_t = K_t^\alpha H_t^\beta (A_t L_t)^{1-\alpha-\beta} \quad (1)$$

ASSUMPTION:

The *Physical Capital* [10] has the free mobility across the regions, and the aggregate sum of Capital almost remains unchanged in EU, i.e., Investment is adequate and accessed smoothly without any searching frictions.

$$GDP_{it} = \underbrace{e^{Region_{it}}}_{\text{Unobservable}} \cdot \underbrace{Communication_{it}^\eta}_{\text{Structural Mobility Factor}} \cdot \underbrace{Population_{it}^\alpha HRST_{it}^\beta EDAT_{it}^\gamma}_{\text{Neoclassical Growth Determinants}} \quad (2)$$

$$Region_{it} = \underbrace{\lambda'_i \cdot f_t}_{\text{interactive}} + \underbrace{u_{it}}_{\text{idiosyncratic}} \quad (3)$$

# European Regional GDP Determinants

**Table 2: COMMUNICATION FACTORS OF EUROPEAN REGIONAL GDP DETERMINANTS**

	(1)	(2)	(3)	(4)	(5)	(6)
intercept	9.9800 (0.0959)***	10.0000 (0.0814)***	9.9800 (0.0875)***	10.0000 (0.0766)***	9.9800 (0.0875)***	10.0000 (0.0766)***
ln Arrival	0.1960 (0.0060)**	0.1640 (0.0051)**				
ln Occupancy			0.0206 (0.0059)***	0.0190 (0.0052)**		
ln Capacity					0.0206 (0.0059)***	0.0169 (0.0052)**
interactive dimensions	none 4	two-ways 3	none 4	two-ways 3	none 4	two-ways 3
observation	2842	2842	2842	2842	2842	2842
R <sup>2</sup>	0.9999	0.9999	0.9999	0.9999	0.9999	0.9999

Standard errors of coefficients are presented under the parentheses below.  
The significance level: \*\*\* <0.001, \*\* 0.001, \* 0.05.

# The Traditional GDP Determinants

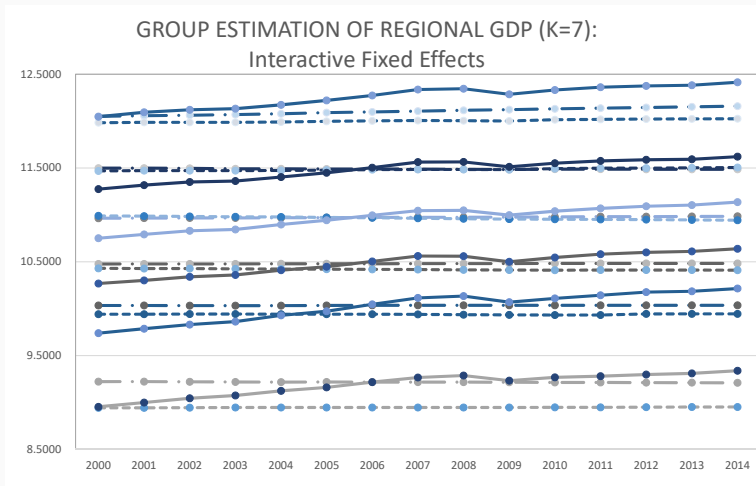
**Table 3:** ALTERNATIVE FACTORS OF EUROPEAN REGIONAL GDP DETERMINANTS

Measurement	(1) EURO	(2) EURO	(3) PPS	(4) PPS
intercept	11.9000 (2.6300)***	7.7800 (1.9700)***	20.6000 (1.9000)***	17.2000 (1.3900)***
ln Population	-0.1480 (0.1860)	0.1630 (0.1400)	-0.7570 (0.1350)***	-0.5040 (0.0984)***
ln HRST	0.0021 (0.0145)	-0.0181 (0.0113)	0.0276 (0.0106)**	0.0113 (0.0082)
ln EDAT	0.0044 (0.0154)	0.0349 (0.0118)**	-0.0329 (0.0112)**	-0.0148 (0.0085)
ln Occupancy	0.0178 (0.0068)**	0.0049 (0.0052)	0.0194 (0.0049)***	0.0126 (0.0038)***
interactive dimensions	individual 3	two-ways 4	individual 3	two-ways 4
observation	4020	4020	4020	4020

Table 4: Filtering K-Means Algorithm ( $K = 7$ ) - KSS (2012)

	(1)	(2)	(3)	(4)	(5)	(6)
PANEL A						
intercept	10.5000 (9.5400)	18.0000 (6.0100)**	26.7000 (6.2400)***	23.6000 (7.1300)***	19.0000 (2.8200)***	16.8000 (4.1700)***
ln Population	-0.1250 (0.6040)	-0.5470 (0.3940)	-1.1100 (0.4260)**	-0.9460 (0.4990).	-0.6750 (0.2010)***	-0.5880 (0.3170).
ln HRST	0.1380 (0.0884)	0.0253 (0.0495)	0.0346 (0.0257)	0.0061 (0.0201)	0.0401 (0.0240).	0.0222 (0.0194)
ln EDAT	-0.0016 (0.0999)	-0.1150 (0.0632).	-0.0304 (0.0305)	0.0228 (0.0203)	-0.0391 (0.0270)	-0.0509 (0.0194)**
ln Occupancy	0.1470 (0.0470)**	0.1180 (0.0347)***	0.0277 (0.0107)**	0.0190 (0.0097)*	0.0249 (0.0097)*	0.0042 (0.0100)
PANEL B						
intercept	9.5100 (0.7940)***	9.6100 (0.5600)***	24.9000 (6.3800)***	23.5000 (2.8400)***	18.9000 (4.3100)***	17.0000 (0.1480)***
ln Population			-0.9790 (0.4350)*	-0.9340 (0.4960).	-0.6620 (0.2030)**	-0.6030 (0.3280).
ln Occupancy	0.1430 (0.0462)**	0.1130 (0.0342)***	0.0264 (0.0106)*	0.0186 (0.0096).	0.0227 (0.0097)*	
observation	150	285	660	915	990	975

# Interactive Fixed Effects: Individual Effects and Time Heterogeneity



# Classification and Regression Tree

Durlauf and Johnson (1995) Multiple regimes in **Regression Tree** on the behavior of cross-country growth rates [7]

Han and Wei (2017) re-examing *Middle-Income Trap Hypothesis* with **Conditional Inference Regression Tree** [11], within R package *party*.<sup>4</sup>

- Online Appendix Table 2 **Random Forrest**

Kleinberg et al (2018) Bail Decisions on jail or release

- **Gradient Boosting Decision Trees**<sup>5</sup> in *Experimental Criminology*. [13]

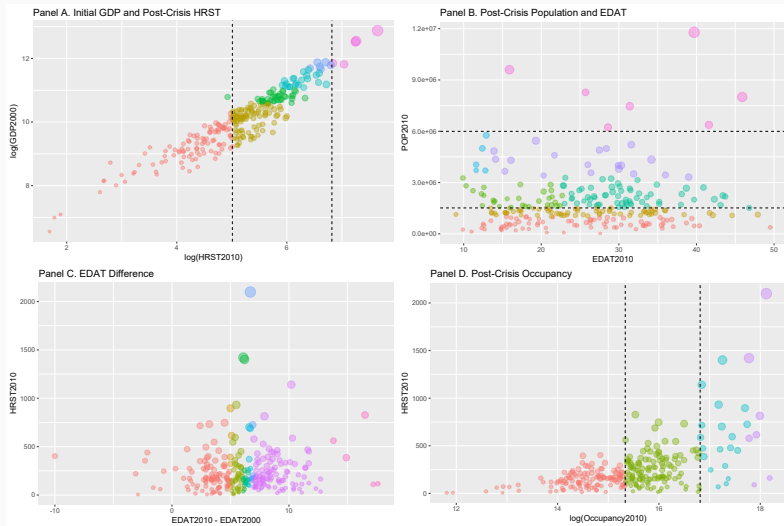
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<sup>4</sup>Framework Initialed by Hothorn et al (2006)

<sup>5</sup>Exploiting the Greedy Function Approxiamation of Friedman (2001) AoS



# Classification and Regression Tree (CART)



**Figure 5:** Regional GDP Partitioning Branches

## Conclusion

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# Empirical Results

## BI-DIRECTIONAL CAUSALITY <sup>6</sup>

- **Facilitation Effects** as Catalyst of Communication Power
  - **Business** Relationship (Exhibition, Trade Fair and Congress)
  - Science, Technology and **Academic** Research (Conferences, Seminars and Workshops)
  - Entertainment (Sports, Music and Events)
- Scale Effects as Constraint of Regional GDP
  - Splendid **Historical** Sites (Maintenance and Preservation)
  - Fascinating Tourist Attractions (**Infrastructure** and Engineering)
  - Marketing Campaigns Promotion (Hospitality and **Services**)

## Fading Driven Power of Traditional Determinants

- Population and Education in European Regions after millennium

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<sup>6</sup>De Vita, Trachanas and Luo (2018) revisited the bi-directional causality between debt and growth through LM unit root test, nonparametric Granger Causality test and SYS-GMM estimation. [6]

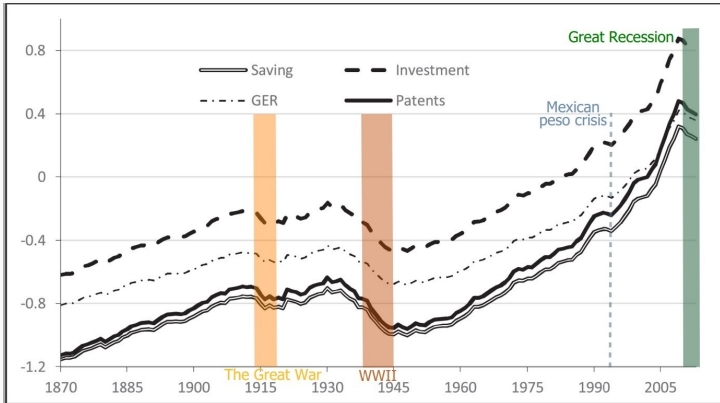
# Category Growth Determinants

Table 5: Sala-i-Martin, Doppelhofer and Miller (2004)

Macroeconomics	Institutional	Geography	Demographic	Cultural
Investment Price	Years Open 1950-94	Tropical Area	Primary Schooling	East Asian
GDP in 1960 (log)	Openness 1965-74	African Dummy	Popu Density Coastal	Confucian
Fraction GDP in Mining	Political Rights	Latin American	Malaria Prevalence	Muslim
Gov. Consumption Share	European Dummy	Spanish Colony	Life Expectancy	Buddhist
Real Exchange Rate Distortions	Outward Orientation	Population In Tropics	Population Density	Ethnolinguistic
Government Share of GDP	Civil Liberties	Air Distance to Big Cities	Higher Education	Foreign Language
Primary Exports 1970	Revolutions and Coups	Absolute Latitude	Fraction Hindus	Protestants
Public Investment Share	British Colony Dummy	Landlocked Country	Population under 15	Catholic
Nominal Government GDP Share	Defense Spending Share	Land Navigable Water	Fertility in 1960s	Colony
Hydrocarbon Deposits in 1993	Socialist Dummy	Land Area	Population Over 65	Religion
Terms of Trade Growth	English Speaking Population	Tropical Climate Zone	Population in 1960	Orthodox
Public Education Spending Share	Oil Producing Country		Population Growth	
Size of Economy	Timing of Independence		Interior Density	
Average Inflation 1960-90	Spent in War 1960-90			
Square of Inflation 1960-90	Capitalism			
Terms of Trade Ranking	War Participation 1960-90			

# Periodization in the Changing World

## BUSINESS CYCLES AND DEVELOPMENT PHASES [16]



**Figure 6:** Semi-elasticities of outcome variables with respect to inequality, 21 OECD Countries, 1870-2011. Madsen, Islam and Doucouliagos (2018) Figure 3.

## STRUCTURED SATURATION HYPOTHESIS [15]

Regions of EU developed countries in general aggregate equilibrium:

- Constant *Population*, even in slightly decreasing interval.
- Higher Quality of *Education*, no obvious abundant improvement.
- *Science and Technology* remains the same role in progression.
- *Physical Capital* is chasing the opportunity for higher revenues and lower expenses in obstacles, barriers and gravity.

More Factors will be accumulated through **Communication** within some regions than the others. Meanwhile, Regional GDP are sharply distributed into the imbalanced structured saturation.

## REGIONAL SCIENCE AND URBAN ECONOMICS

**Behrens, Duranton and Robert-Nicoud (2014)** more talented individuals **sorting** into large cities, large cities selecting more productive entrepreneurs and firms, or agglomeration economies.<sup>7</sup>

**de la Roca and Puga (2017)** **Learning** by Working in big cities. [5]

**Henderson et al (2018)** Section II. A. 2 Reviewed the **Persistence** of Geography Characteristics.<sup>8</sup> e.g. Medieval Trade and Urban Network.

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<sup>7</sup>The higher productivity of large cities [2]

<sup>8</sup>Decomposing the structural transformation of **urbanization and agglomeration** into the rising agricultural productivity and falling transport costs. [12]

## NETWORK SCIENCE

**Fagiolo (2017)** Reviewed topological properties and evolution of **international trade network (ITN)** [8]

**Fagiolo and Santoni (2015)** **global country centrality** in temporary **human-mobility network** enhances both per-capita income and labor productivity in 1995-2010. [9]

**Chakrabarti (2018)** **International Trade Network**, negative relationship between standard deviation of detrended (HP filtered) log per-capita GDP and log of intra-Europe Eigenvector **Centrality** in 1992-2012. [3]



Questions?

# Appendix: Group Estimation

**Table 6: Filtering K-Means Algorithm (K = 7) - Bai (2009)**

	(1)	(2)	(3)	(4)	(5)	(6)
intercept	2.4800 (0.0009)***	13.6000 (0.0007)***	8.7800 (0.0251)***	7.2000 (0.0206)***	7.6100 (0.0218)***	0.5250 (0.0363)***
ln Population	0.5510 (0.1710)**	-0.1710 (0.2540)	0.1260 (0.0755).	0.2260 (0.0690)**	0.1510 (0.0565)**	0.6480 (0.0568)***
ln HRST		-0.0530 (0.0337)	0.0242 (0.0196)	0.0012 (0.0136)	0.0009 (0.0165)	
ln EDAT	0.0885 (0.0396)*					-0.0108 (0.0130)
ln Occupancy	0.0406 (0.0246).	0.0482 (0.0209)*	0.0129 (0.0078).	0.0023 (0.0066)	0.0188 (0.0069)**	0.0045 (0.0079)
dimensions	3	4	4	4	4	4
R <sup>2</sup>	0.9989	0.9984	0.9960	0.9966	0.9959	0.9992
interactive	twoways	twoways	time	time	time	time
observation	150	285	660	915	990	975



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