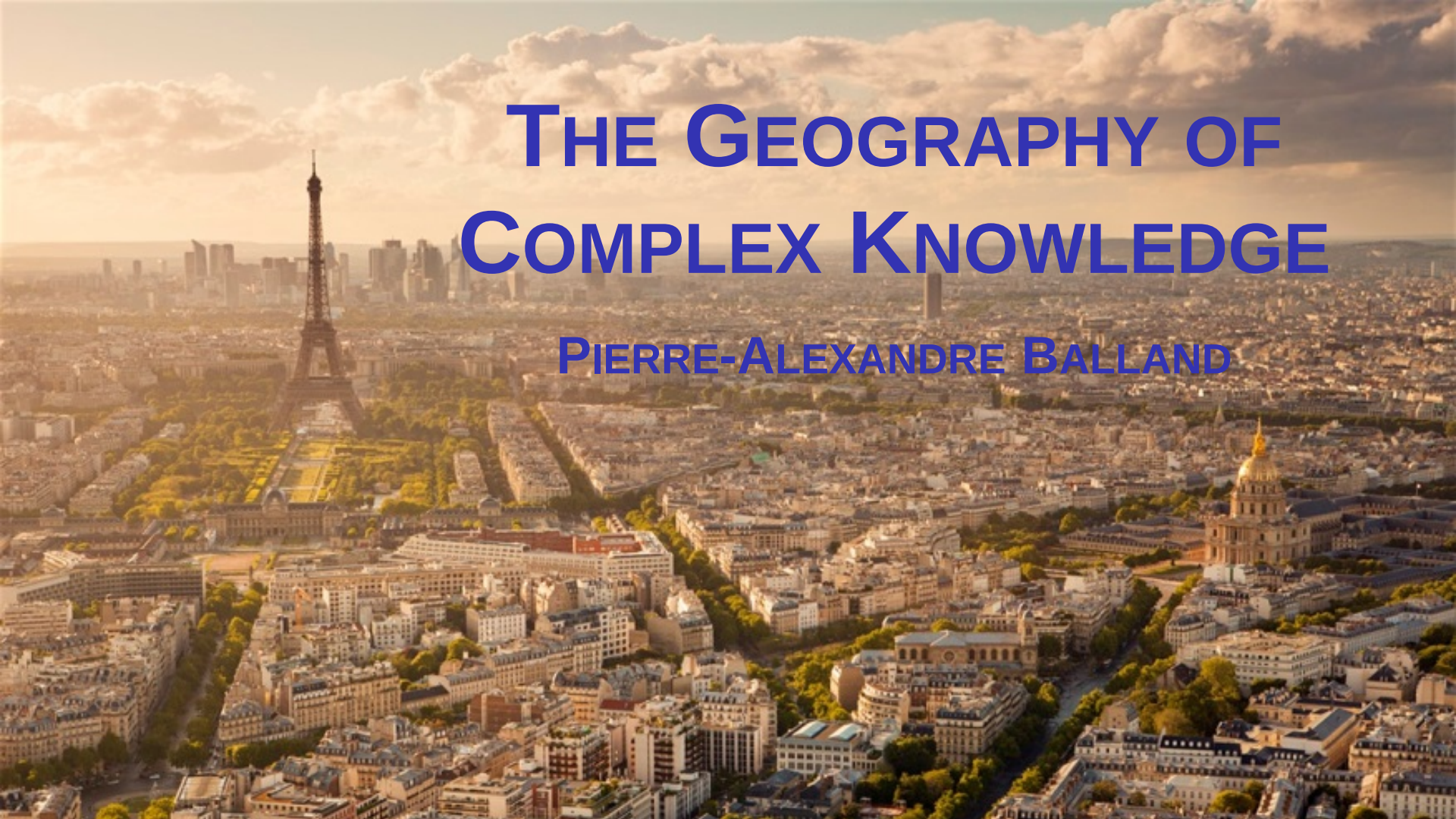


The Geography of Complex Knowledge

Pierre-Alexandre Balland

The great spatial divide


AXER LES 1%
TS GÉNÉRAUX CITOYENS
et se

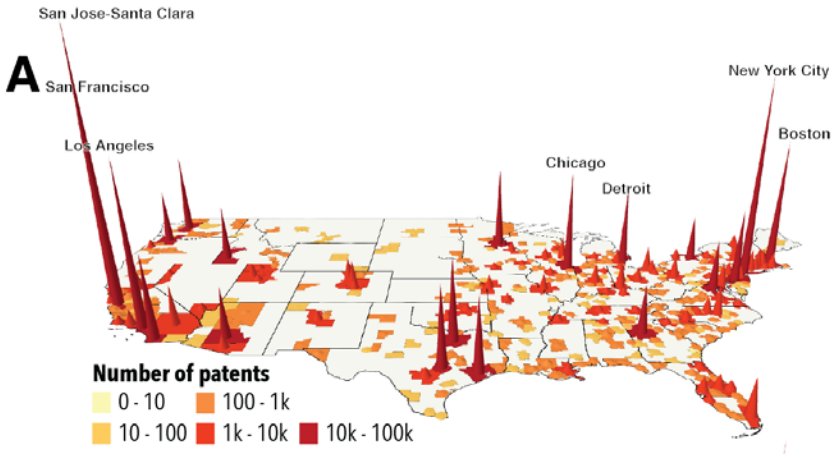
Winner Takes-All Economy

THE WORLD OF KNOWLEDGE **CONSUMPTION** IS GETTING **FLATTER**

Digital technologies, transports and globalization allows products to be widely distributed

Free online courses from Massachusetts Institute of Technology

WINNER TAKES-ALL ECONOMY



The World of Knowledge **Production** is Getting **Spikier**

Knowledge increasingly concentrates as it becomes more complex

Winner Takes-All Economy

THE WORLD OF KNOWLEDGE **CONSUMPTION** IS GETTING **FLATTER**

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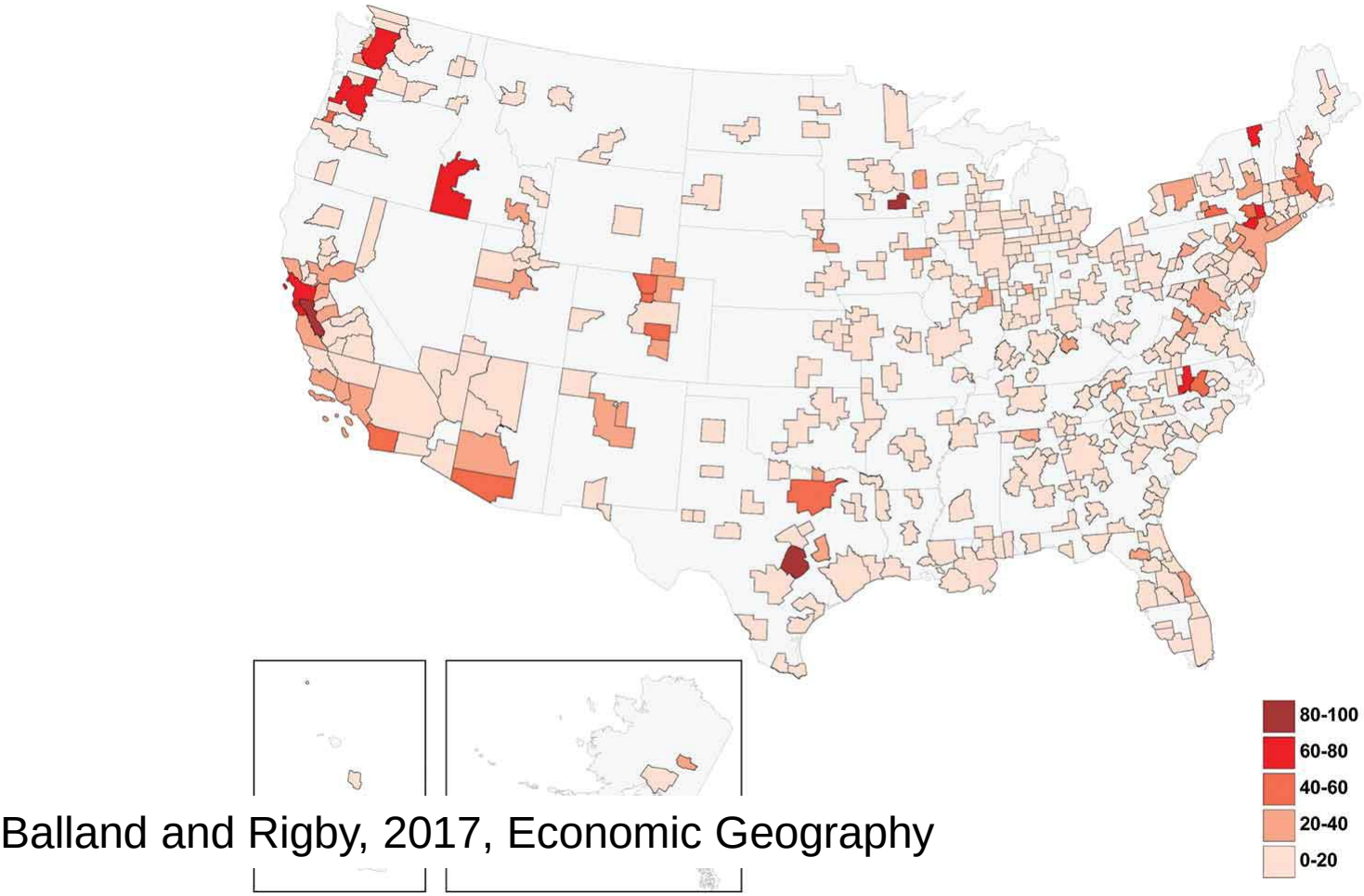
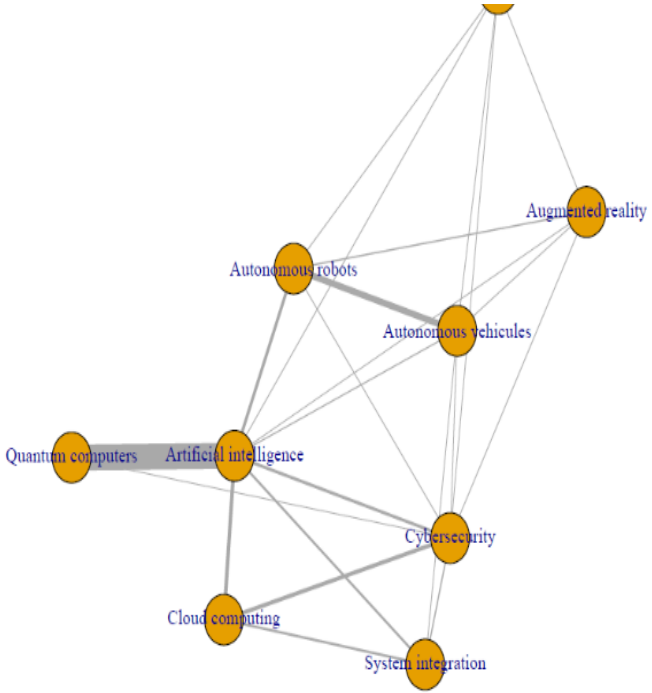
WINNER TAKES-ALL ECONOMY

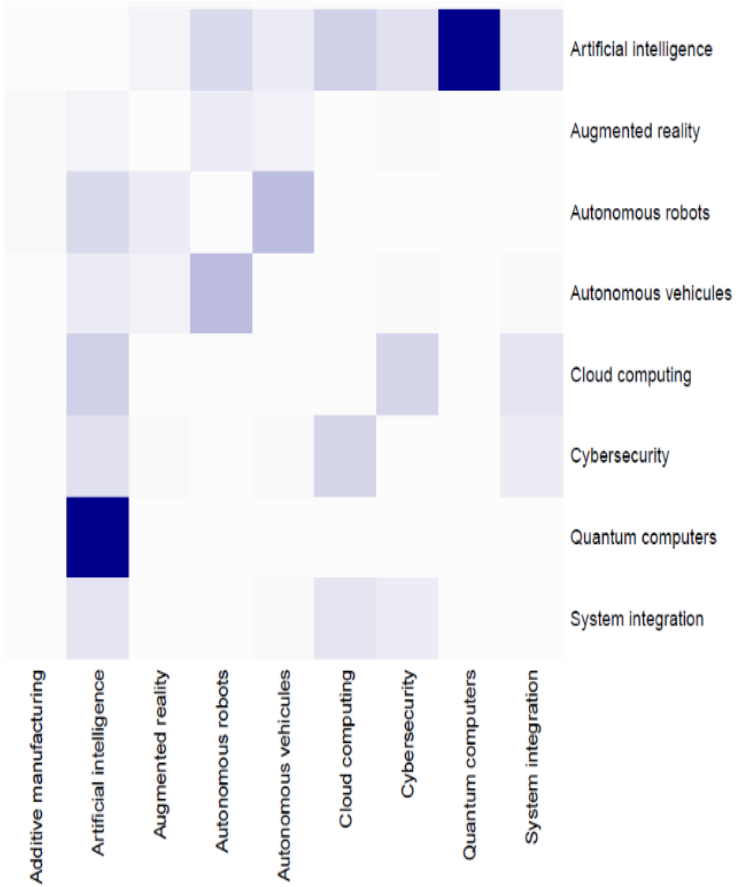
Knowledge complexity scores



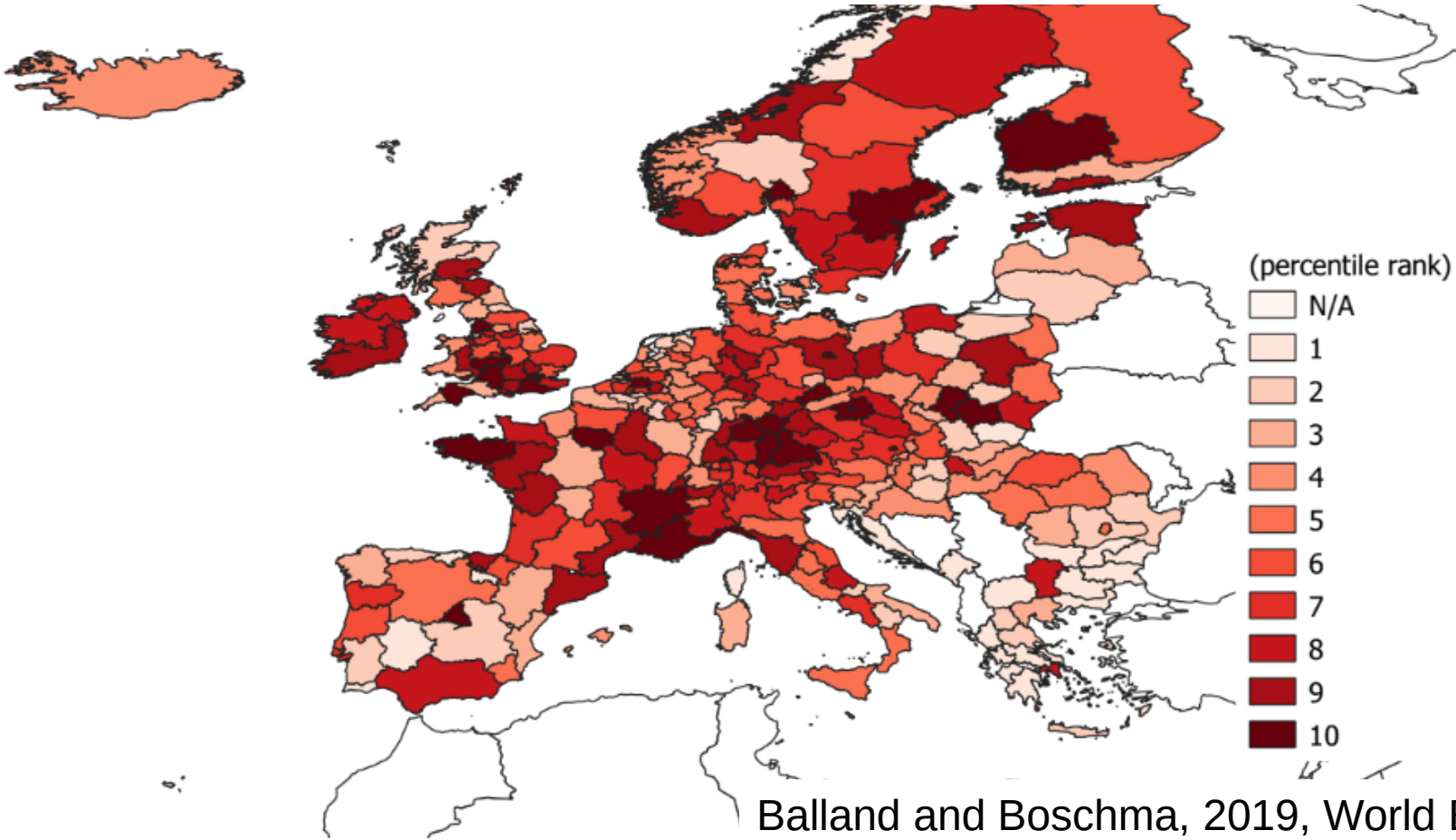
Balland and Rigby, 2017, Economic Geography

European Hubs of the industries of the future



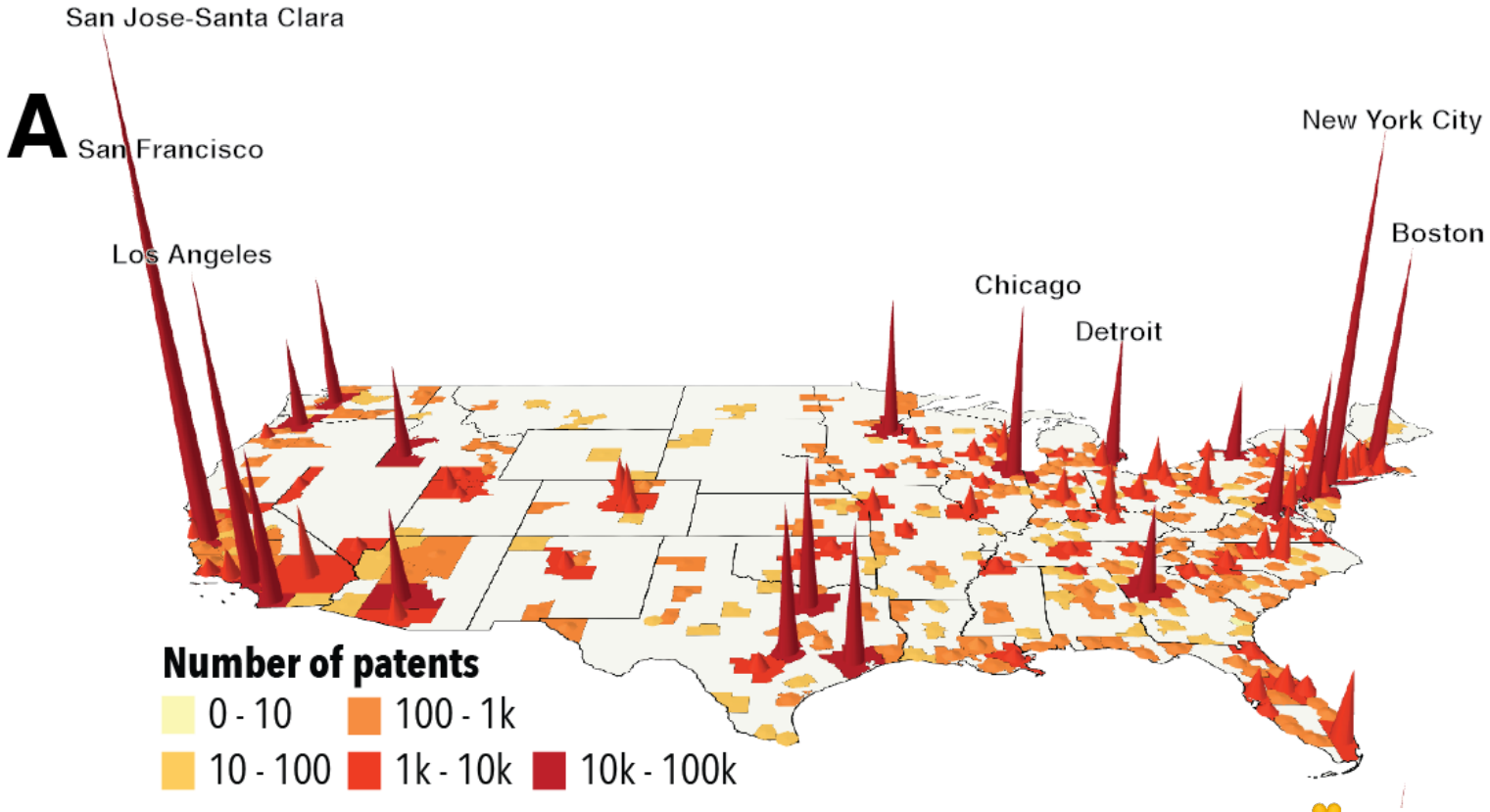


European Hubs of the industries of the future



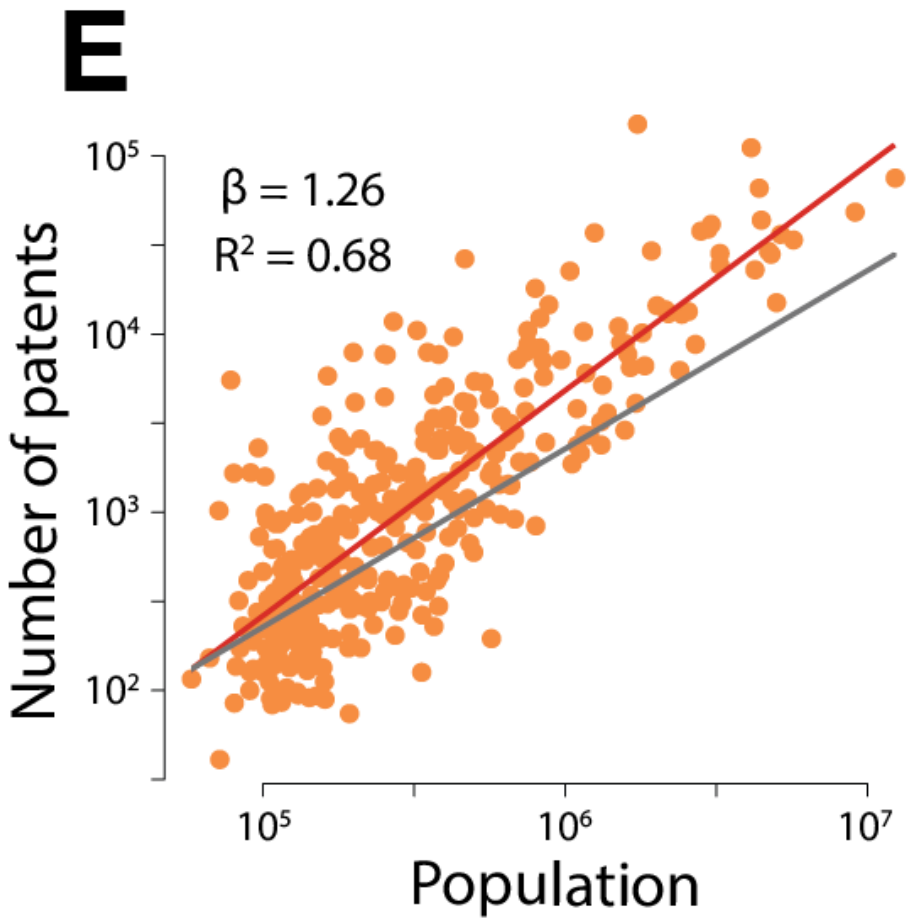
Balland and Boschma, 2019, World Bank Report

Unequal distribution of econ. activities

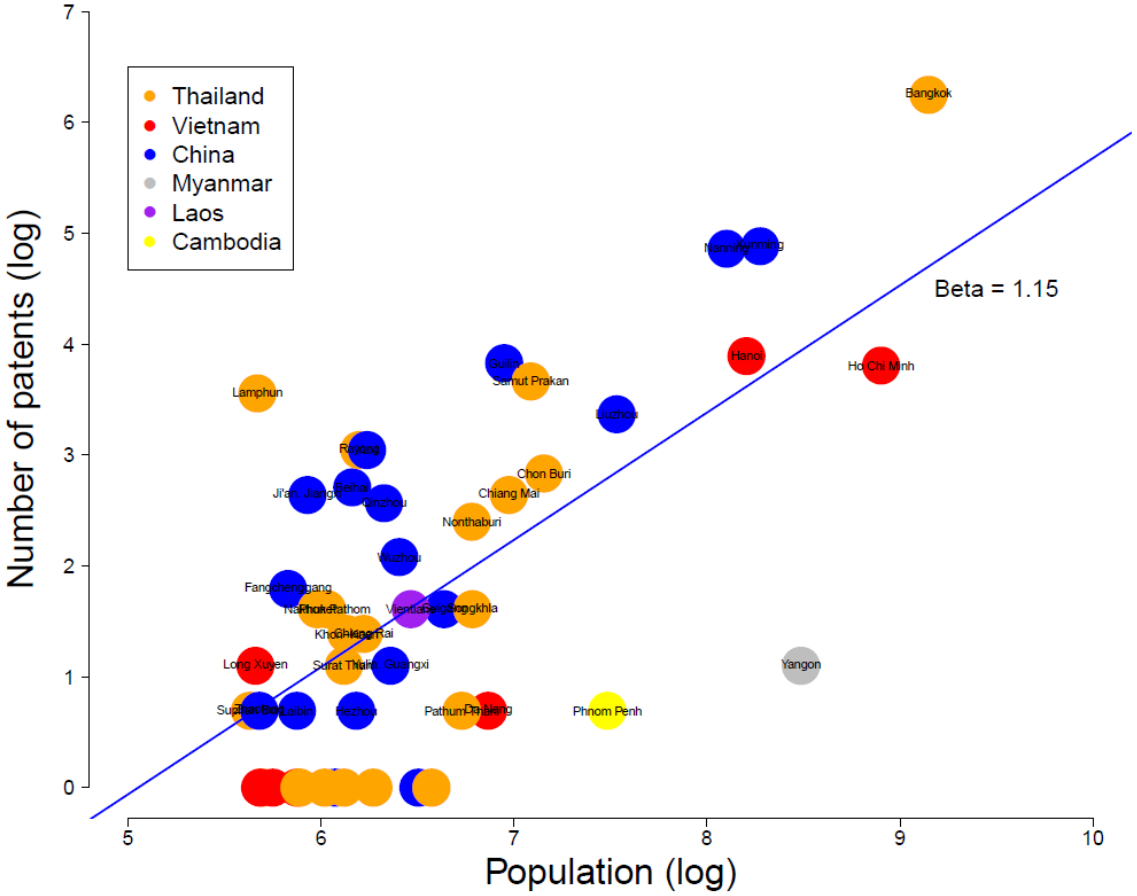


Balland, Jara-Figueroa, Petralia, Steijn& Rigby and Hidalgo, PGR 🤞

Superlinear scaling – patents in US cities

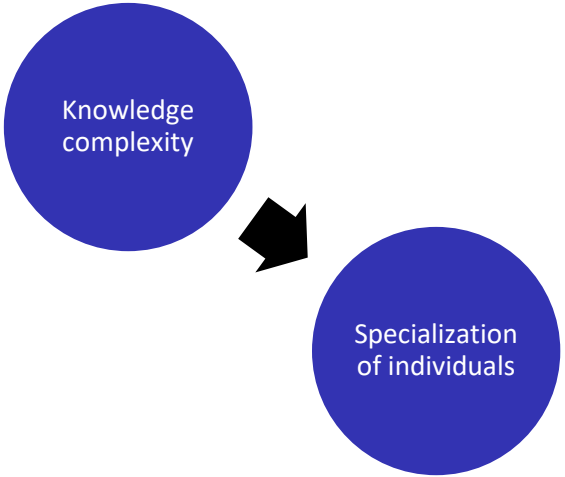


Superlinear scaling – patents in GMS cities

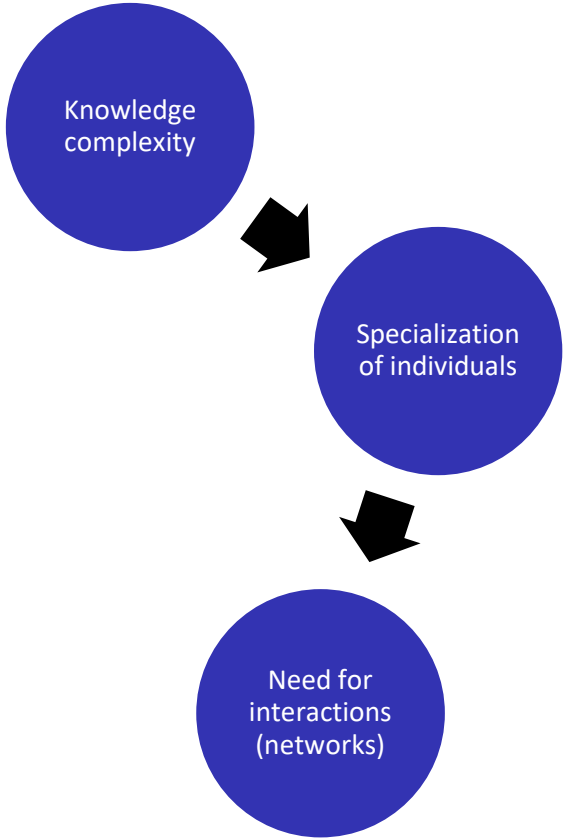


From Complexity to Spatial Inequality

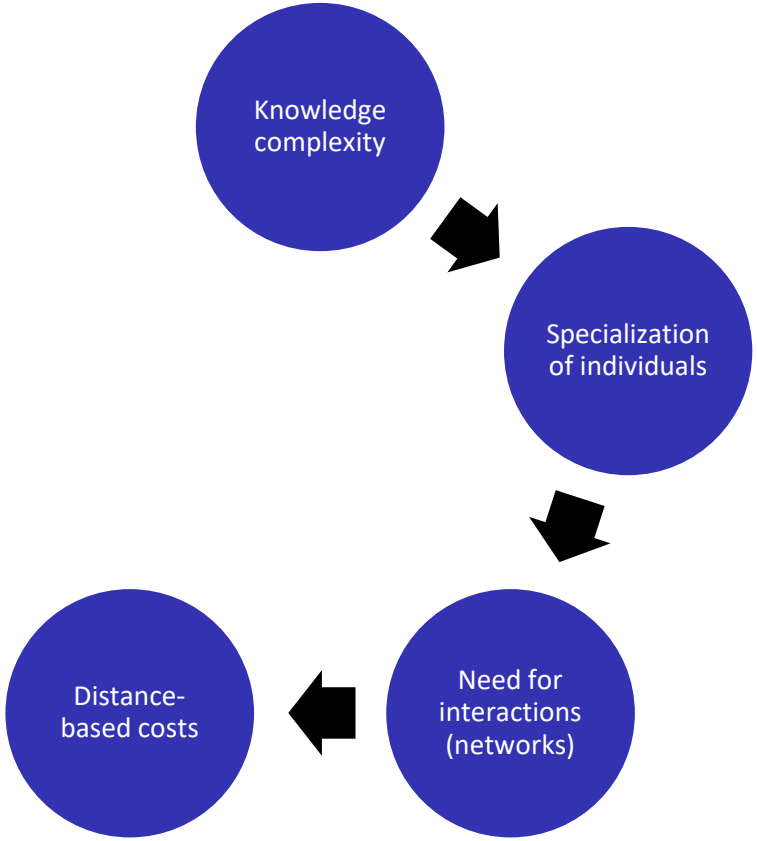
From Complexity to Spatial Inequality



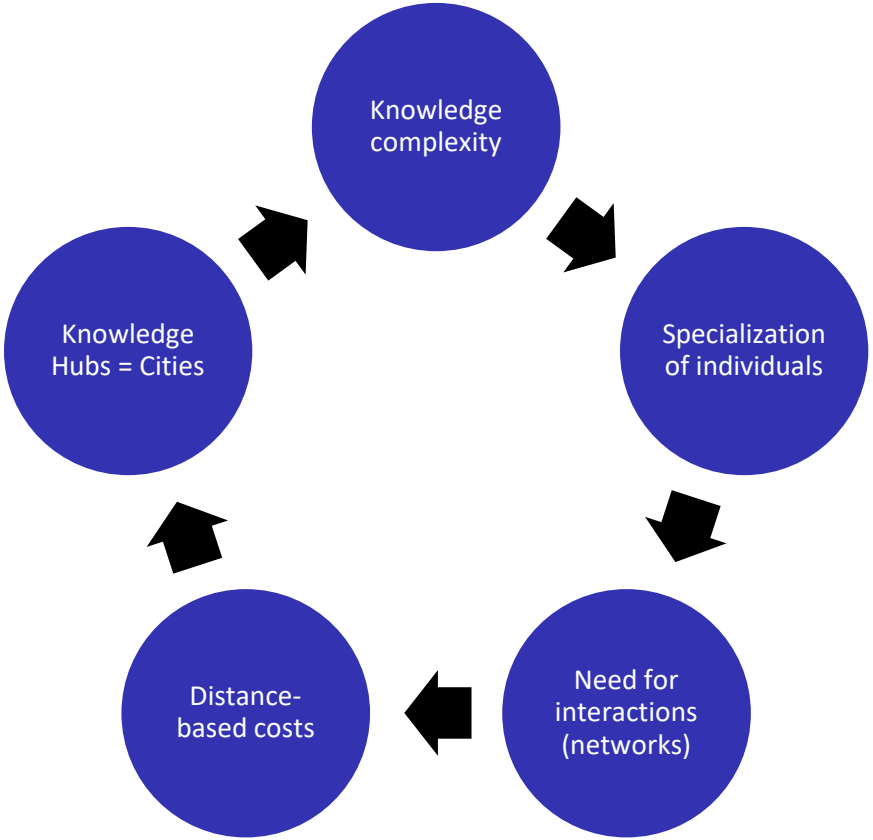
From Complexity to Spatial Inequality

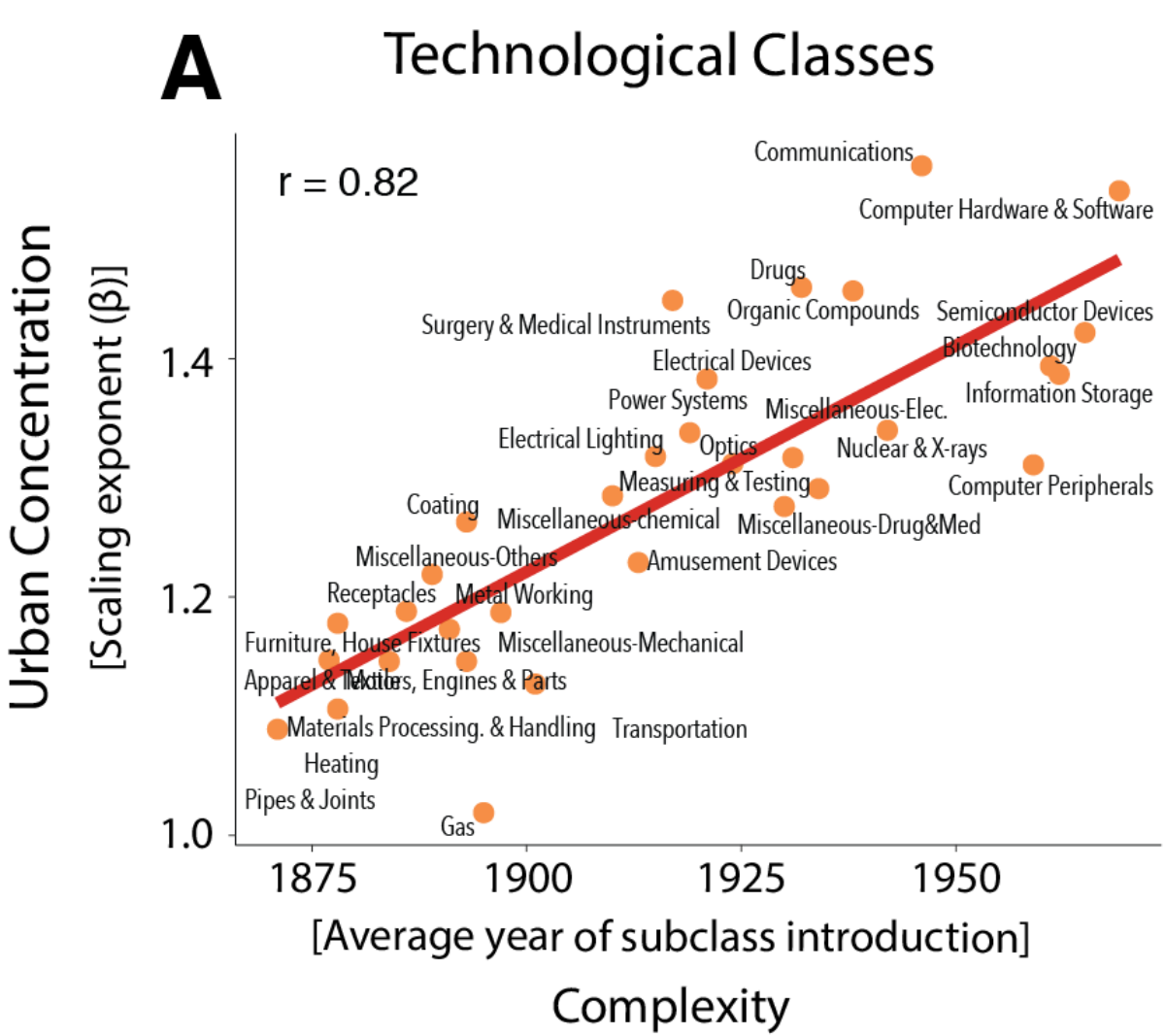


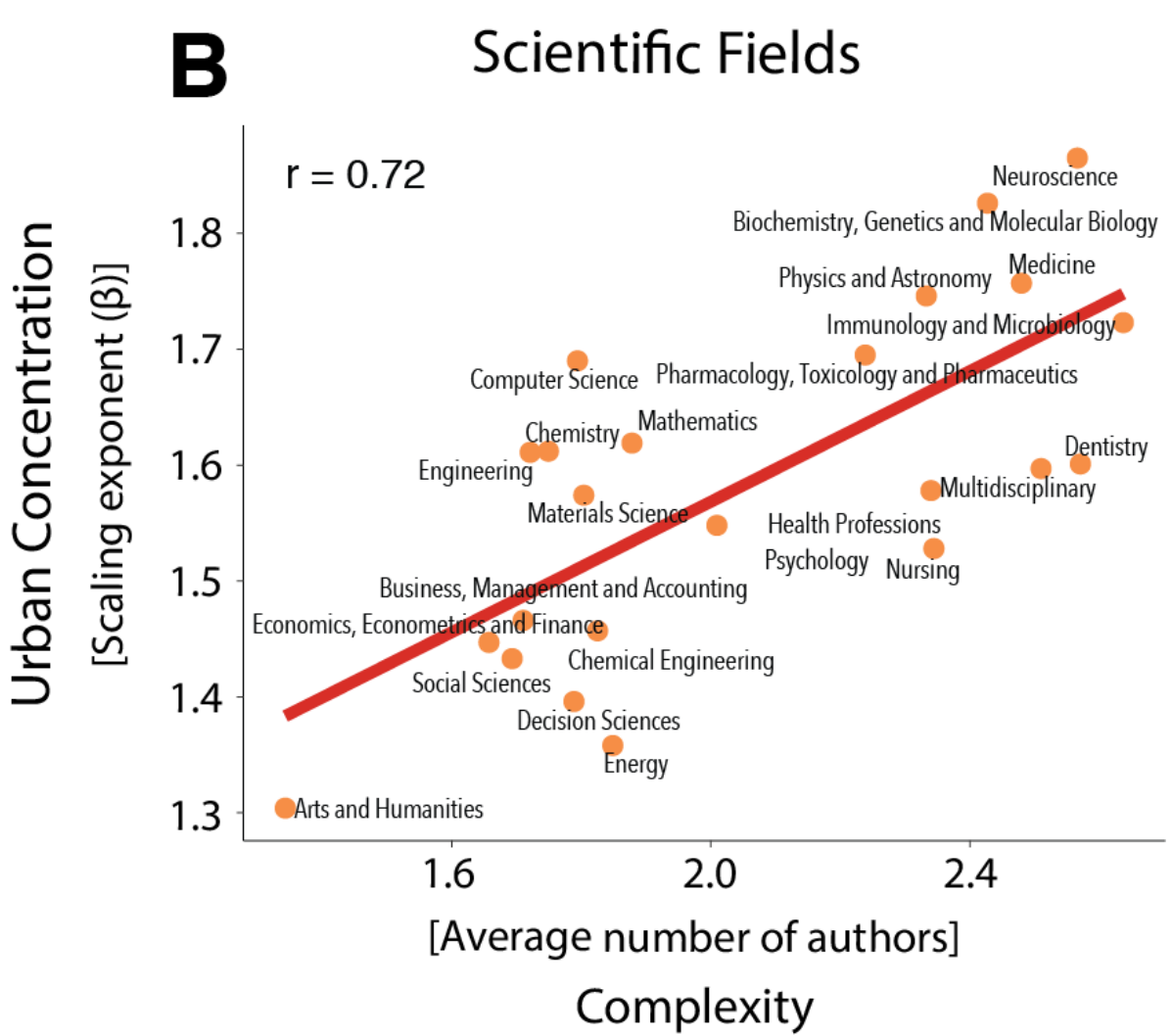
From Complexity to Spatial Inequality

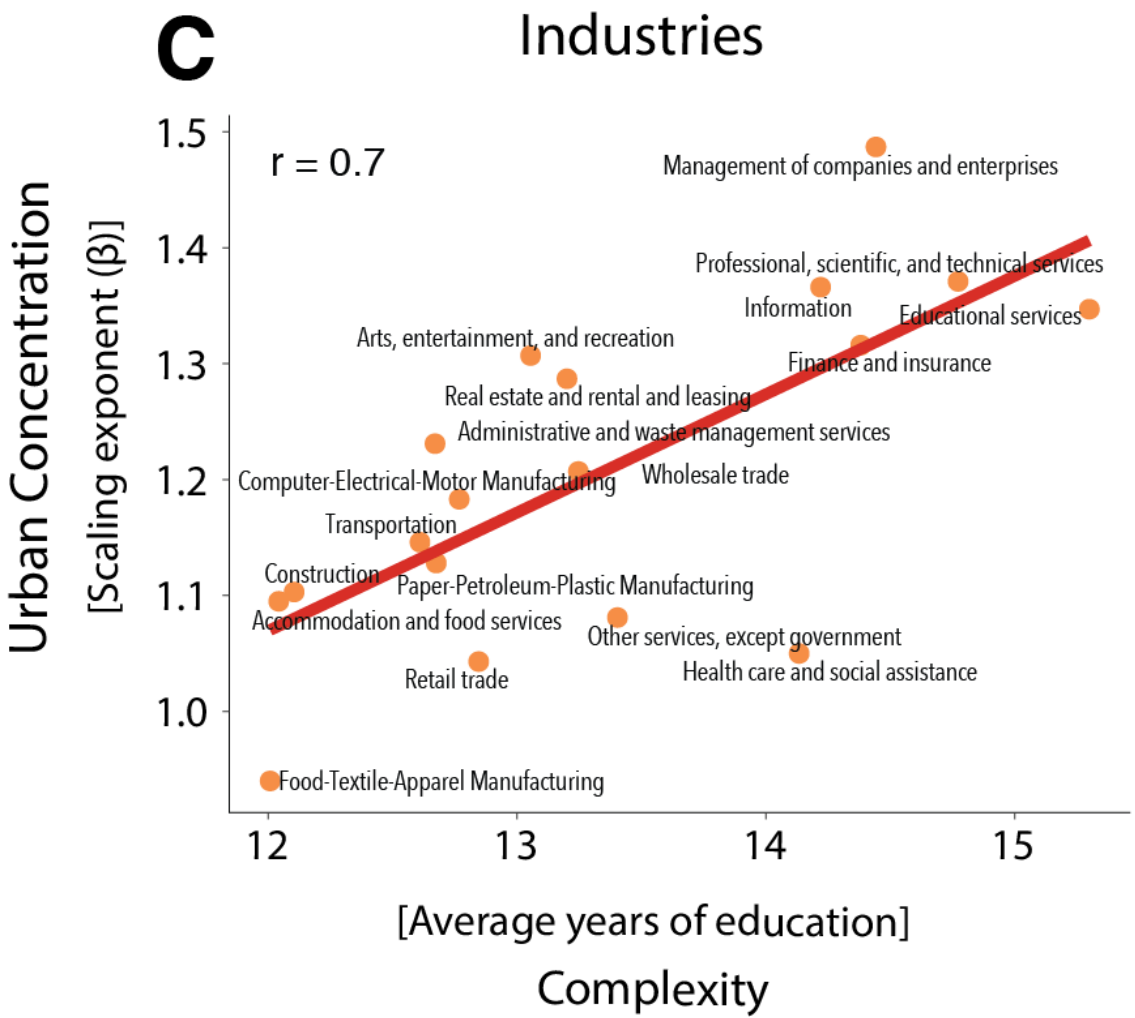


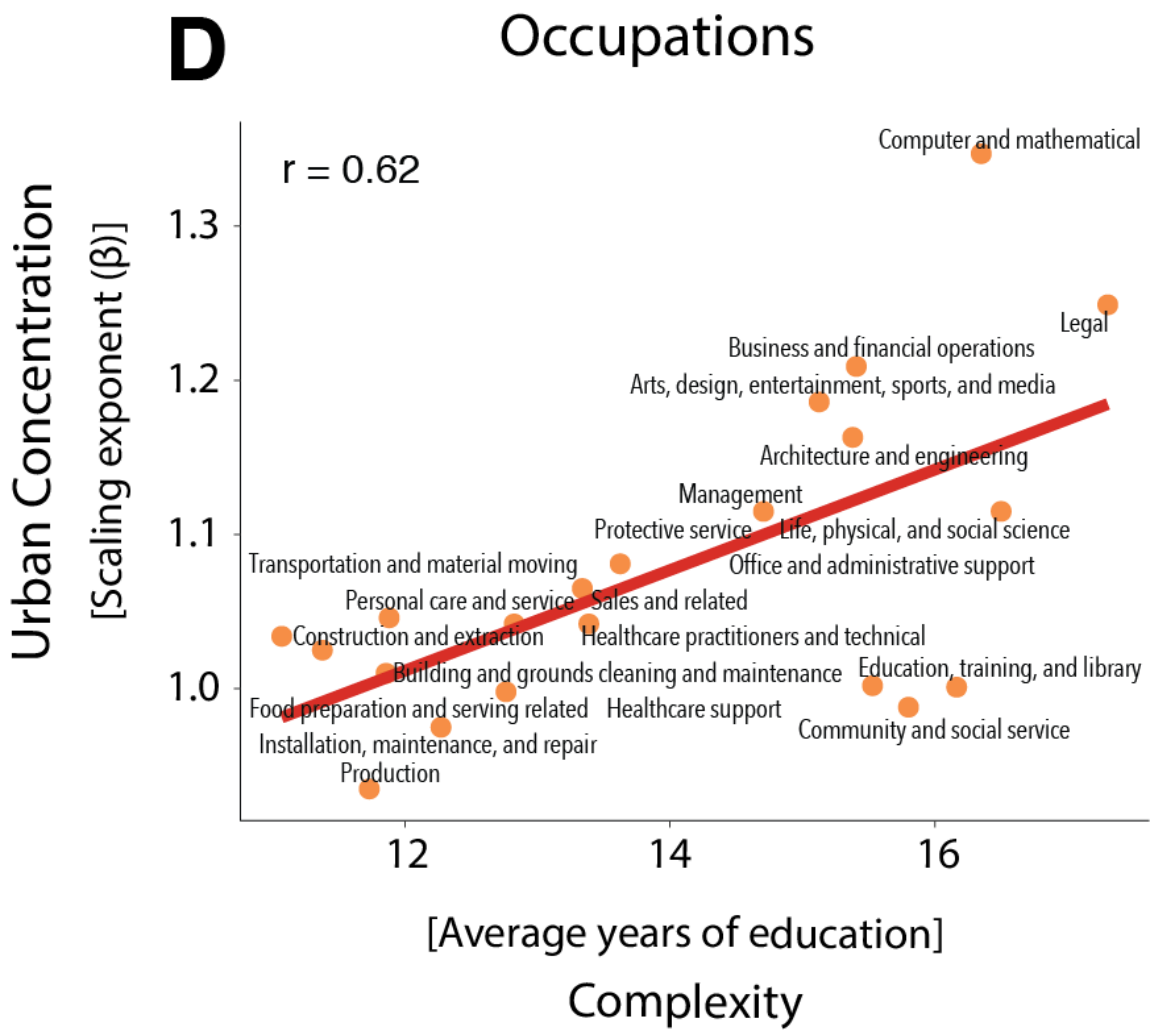
The geography of complex knowledge




A
Technological Classes
r = 0.82
Communications
Computer Hardware & Software
Drugs
Organic Compounds
Semiconductor Devices
Surgery & Medical Instruments
Biotechnology
Electrical Devices
Information Storage
Power Systems
Miscellaneous-Elec.
Electrical Lighting
Optics
Nuclear & X-rays
Measuring & Testing
Computer Peripherals
Coating
Miscellaneous-chemical
Miscellaneous-Drug&Med
Miscellaneous-Others
Amusement Devices
Receptacles
Metal Working
Furniture, House Fixtures
Miscellaneous-Mechanical
Apparel & Textiles
Engines & Parts
Materials Processing. & Handling
Transportation
Heating
Pipes & Joints
Gas
1.0
1.2
1.4
1875
1900
1925
1950
Urban Concentration
[Scaling exponent (β)]
[Average year of subclass introduction]
Complexity


B
Scientific Fields
r = 0.72
Urban Concentration
[Scaling exponent (β)]
1.8
1.7
1.6
1.5
1.4
1.3
1.6
2.0
2.4
[Average number of authors]
Complexity
Neuroscience
Biochemistry, Genetics and Molecular Biology
Physics and Astronomy
Medicine
Immunology and Microbiology
Pharmacology, Toxicology and Pharmaceutics
Computer Science
Mathematics
Chemistry
Engineering
Dentistry
Multidisciplinary
Materials Science
Health Professions
Psychology
Nursing
Business, Management and Accounting
Economics, Econometrics and Finance
Chemical Engineering
Social Sciences
Decision Sciences
Energy
Arts and Humanities


C
Industries
r = 0.7
Urban Concentration
[Scaling exponent (β)]
1.5
1.4
1.3
1.2
1.1
1.0
Management of companies and enterprises
Professional, scientific, and technical services
Information
Educational services
Arts, entertainment, and recreation
Finance and insurance
Real estate and rental and leasing
Administrative and waste management services
Computer-Electrical-Motor Manufacturing
Wholesale trade
Transportation
Construction
Paper-Petroleum-Plastic Manufacturing
Accommodation and food services
Other services, except government
Retail trade
Health care and social assistance
Food-Textile-Apparel Manufacturing
12
13
14
15
[Average years of education]
Complexity


D
Occupations
r = 0.62
Urban Concentration
[Scaling exponent (β)]
1.3
1.2
1.1
1.0
12
14
16
[Average years of education]
Complexity
Computer and mathematical
Legal
Business and financial operations
Arts, design, entertainment, sports, and media
Architecture and engineering
Management
Protective service
Life, physical, and social science
Transportation and material moving
Office and administrative support
Personal care and service
Sales and related
Construction and extraction
Healthcare practitioners and technical
Building and grounds cleaning and maintenance
Education, training, and library
Food preparation and serving related
Healthcare support
Community and social service
Installation, maintenance, and repair
Production

The Historical Gap

There is virtually no historical and systematic analysis on the geography of innovation and technological change prior to 1975.

Biotechnology

1790 **1975** **2010**

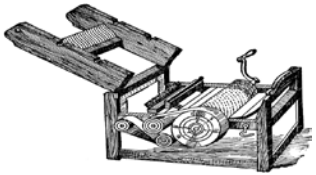
1st U.S. Patent

Information & Communication

The Historical Gap

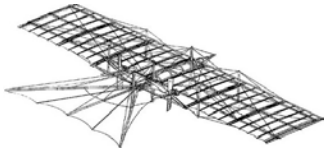
There is virtually no historical and systematic analysis on the geography of innovation and technological change prior to 1975.

Cotton Gin



Telephone

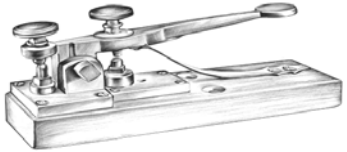
Airplane



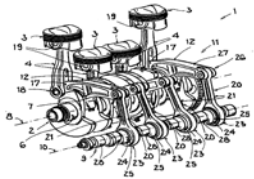
Biotechnology

1790 1820 1850 1880 1910 1940 1975 2010

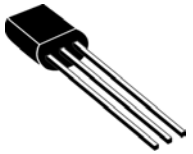
1st U.S. Patent



Telegraph



Internal combustion engine

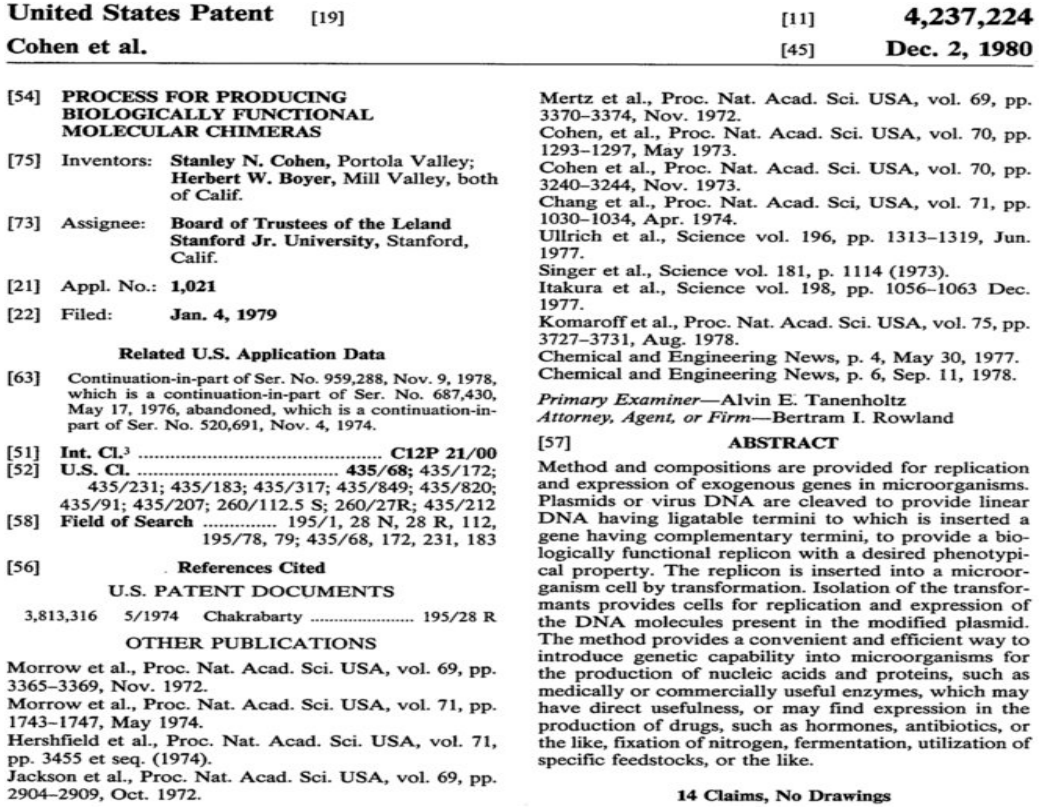


Semiconductor

Information & Communication

Historical Patent Dataset (HistPat)

www.nature.com/articles/sdata201674 (Petralia, Balland, Rigby; 2016)



United States Patent [19]
Cohen et al.

[11] **4,237,224**
[45] **Dec. 2, 1980**

[54] **PROCESS FOR PRODUCING BIOLOGICALLY FUNCTIONAL MOLECULAR CHIMERAS**

[75] Inventors: **Stanley N. Cohen**, Portola Valley; **Herbert W. Boyer**, Mill Valley, both of Calif.

[73] Assignee: **Board of Trustees of the Leland Stanford Jr. University**, Stanford, Calif.

[21] Appl. No.: **1,021**

[22] Filed: **Jan. 4, 1979**

Related U.S. Application Data

[63] Continuation-in-part of Ser. No. 959,288, Nov. 9, 1978, which is a continuation-in-part of Ser. No. 687,430, May 17, 1976, abandoned, which is a continuation-in-part of Ser. No. 520,691, Nov. 4, 1974.

[51] **Int. Cl.**[3] **C12P 21/00**
[52] **U.S. Cl.** ..... **435/68**; 435/172; 435/231; 435/183; 435/317; 435/849; 435/820; 435/91; 435/207; 260/112.5 S; 260/27R; 435/212
[58] **Field of Search** ..... 195/1, 28 N, 28 R, 112, 195/78, 79; 435/68, 172, 231, 183

[56] **References Cited**

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3,813,316 5/1974 Chakrabarty ..... 195/28 R

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Hershfield et al., Proc. Nat. Acad. Sci. USA, vol. 71, pp. 3455 et seq. (1974).
Jackson et al., Proc. Nat. Acad. Sci. USA, vol. 69, pp. 2904–2909, Oct. 1972.
Mertz et al., Proc. Nat. Acad. Sci. USA, vol. 69, pp. 3370–3374, Nov. 1972.
Cohen, et al., Proc. Nat. Acad. Sci. USA, vol. 70, pp. 1293–1297, May 1973.
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Singer et al., Science vol. 181, p. 1114 (1973).
Itakura et al., Science vol. 198, pp. 1056–1063 Dec. 1977.
Komaroff et al., Proc. Nat. Acad. Sci. USA, vol. 75, pp. 3727–3731, Aug. 1978.
Chemical and Engineering News, p. 4, May 30, 1977.
Chemical and Engineering News, p. 6, Sep. 11, 1978.

Primary Examiner—Alvin E. Tanenholtz
Attorney, Agent, or Firm—Bertram I. Rowland

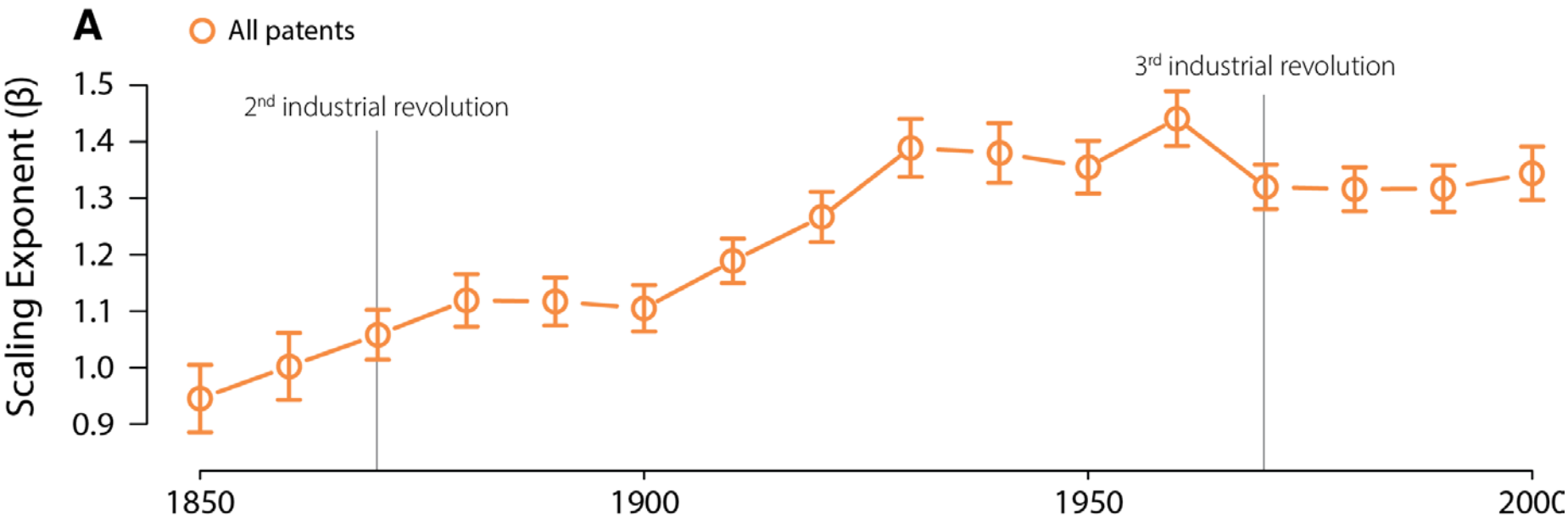
[57] **ABSTRACT**

Method and compositions are provided for replication and expression of exogenous genes in microorganisms. Plasmids or virus DNA are cleaved to provide linear DNA having ligatable termini to which is inserted a gene having complementary termini, to provide a biologically functional replicon with a desired phenotypical property. The replicon is inserted into a microorganism cell by transformation. Isolation of the transformants provides cells for replication and expression of the DNA molecules present in the modified plasmid. The method provides a convenient and efficient way to introduce genetic capability into microorganisms for the production of nucleic acids and proteins, such as medically or commercially useful enzymes, which may have direct usefulness, or may find expression in the production of drugs, such as hormones, antibiotics, or the like, fixation of nitrogen, fermentation, utilization of specific feedstocks, or the like.

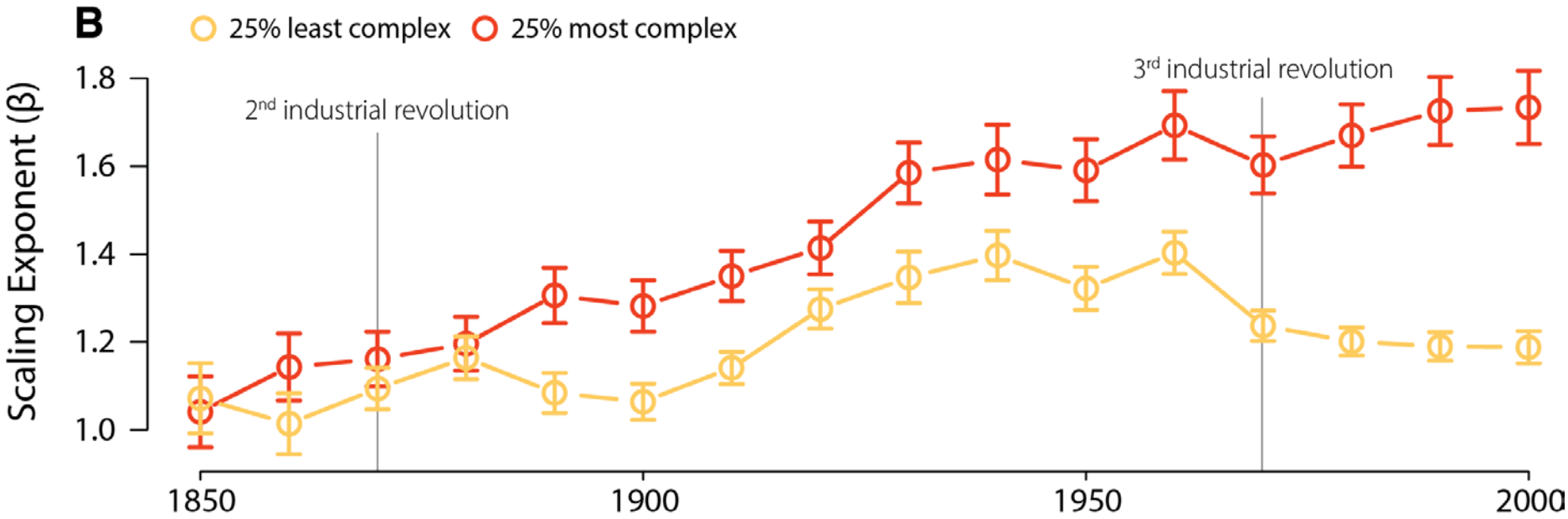
14 Claims, No Drawings

- ~ 7,000,000 US patents
- 1790 to 2016
- Geography of patents (county level – 4,000)
- And their tech classes (436 classes; 150,000 sub-classes)
- ...

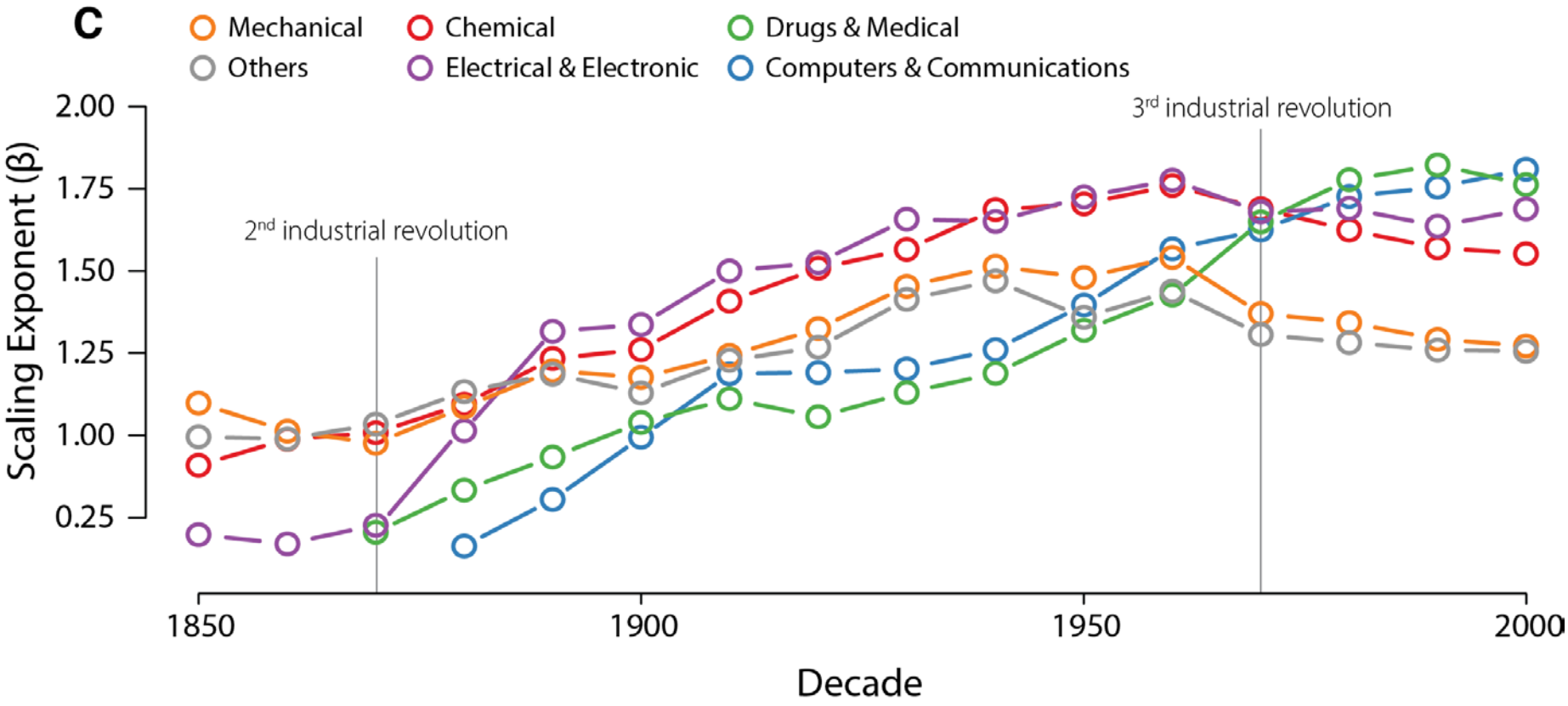
Complexity and scaling (1850-2000)



Complexity and scaling (1850-2000)



Complexity and scaling (1850-2000)



Take-Away Messages

- Knowledge complexity drives spatial inequality

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- The urban advantage (scaling) has continuously increased over the past 200+ years – the world is getting spikier

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- Knowledge complexity drives spatial inequality
- The urban advantage (scaling) has continuously increased over the past 200+ years – the world is getting spikier
- Scaling reflects knowledge complexity (most complex technologies & industries scale the most)
- Is it just the beginning of the great spatial divide we start to observe?
- How to make sure that policy like the smart specialization strategy won't increase this great spatial divide?