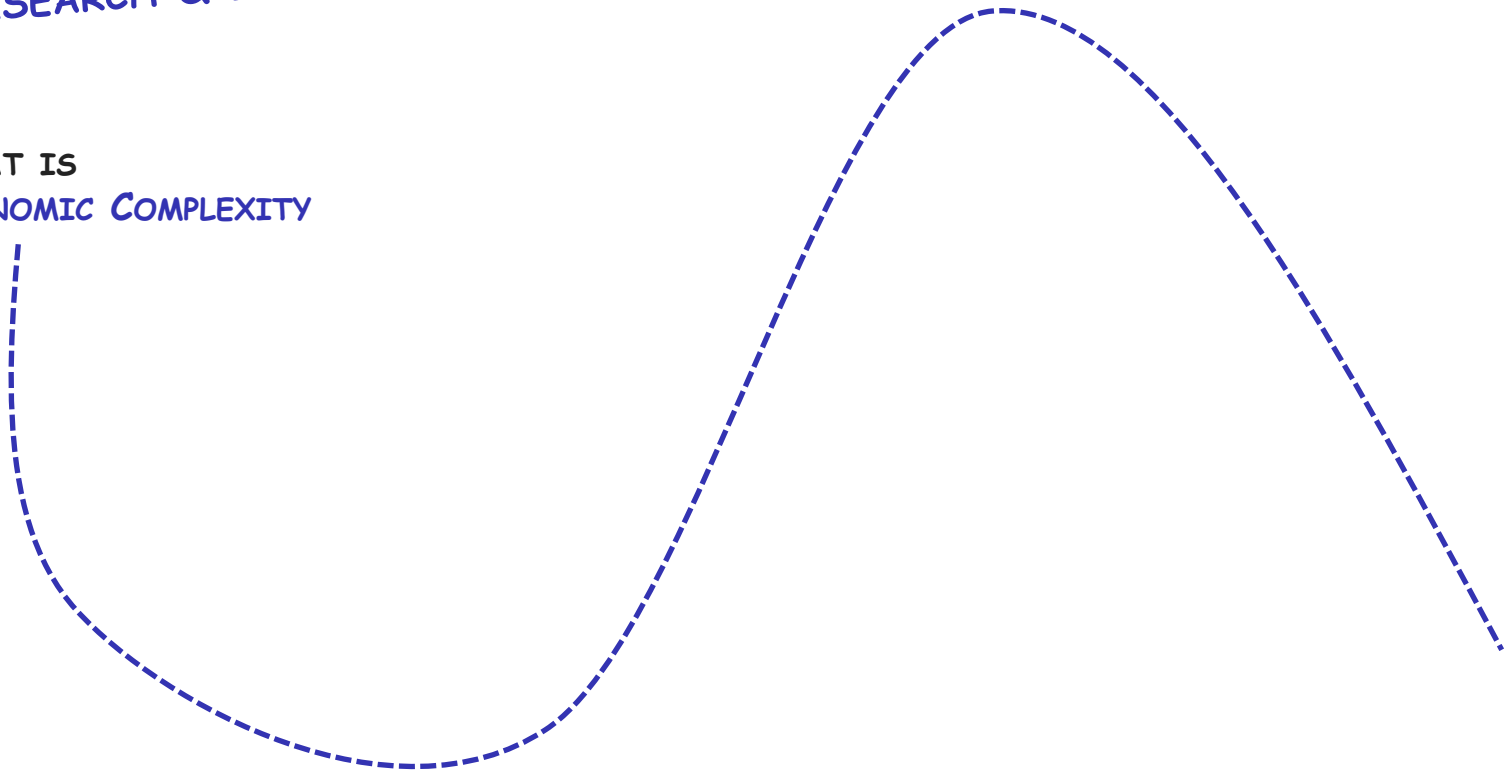
PART III: RELATEDNESS AND COMPLEXITY

Key concepts from Economic Complexity For Research & Innovation Policy

1. What is Economic Complexity



Recent reads

ELSEVIER

Research Policy
Volume 51, Issue 3, April 2022, 104450

The new paradigm of economic complexity ☆

Pierre-Alexandre Balland [a, b], Tom Broekel [c], Dario Diodato [d, #], Elisa Giuliani [e], Ricardo Hausmann [f], Neave O'Clery [g], David Rigby [h]

Research Policy

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Special Issue on Economic Complexity

Edited by Pierre-Alexandre Balland, Tom Broekel, Dario Diodato, Ricardo Hausmann, Neave O'Clery, David Rigby
Last update 17 January 2022

YSI Workshop: Innovation, Economic Complexity and Economic Geography

In collaboration with the Collective Learning Group at the MIT Media Lab in Cambridge, Massachusetts.

Aug 5–7, 2018

MIT Media Lab

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the OBSERVATORY *of* ECONOMIC COMPLEXITY

The world's leading visualization engine for international trade data

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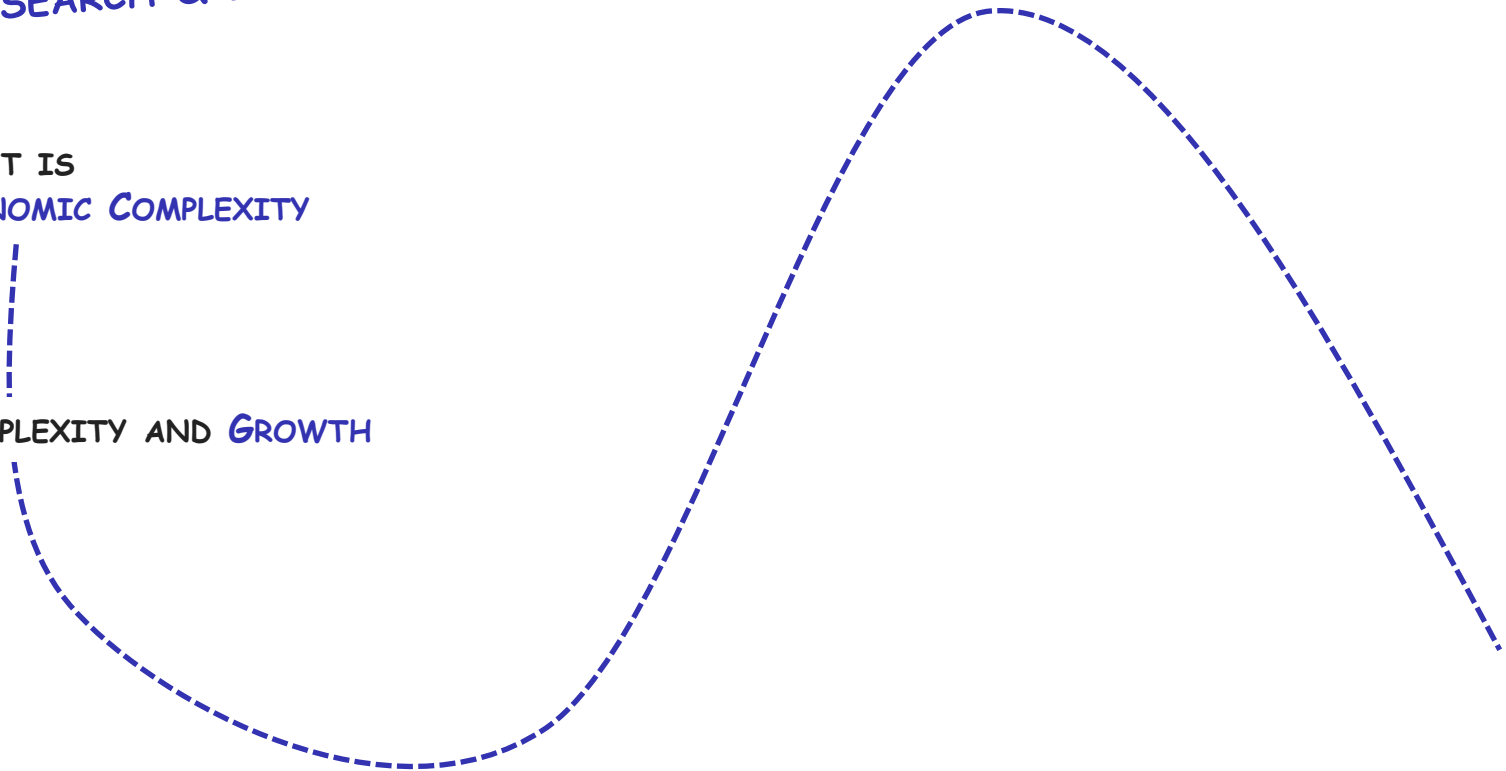
Datawheel

Key concepts from Economic Complexity For Research & Innovation Policy

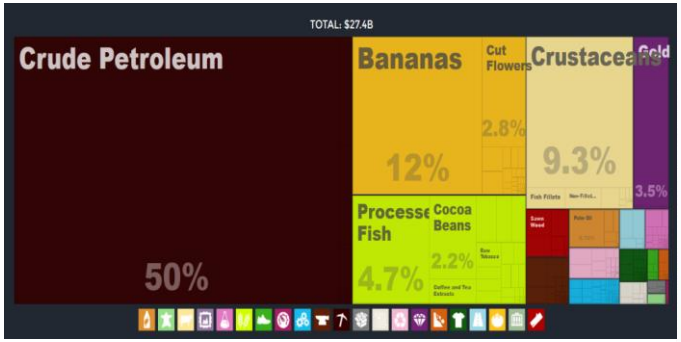
1. What is Economic Complexity
2. Complexity and Growth



Reframing economic development

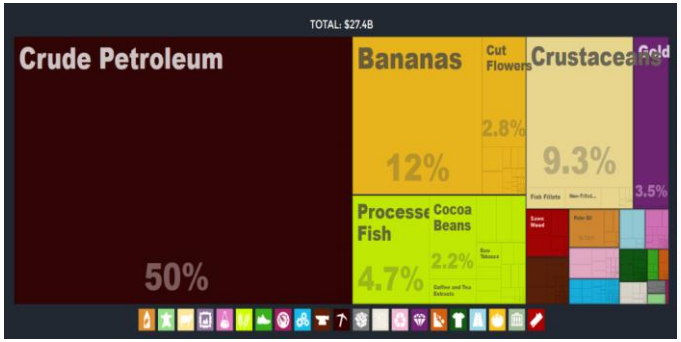
Data Source: PovcalNet - World Bank

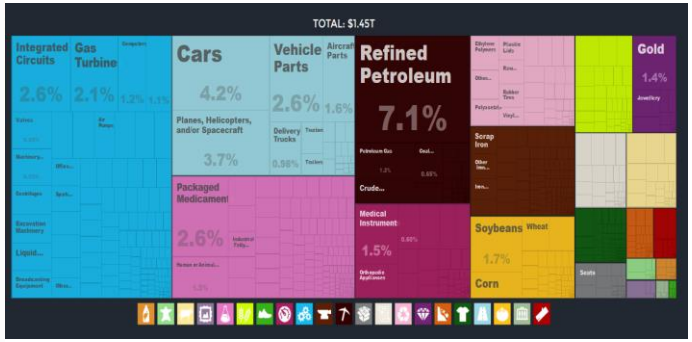
Reframing economic development



Data Source: atlas.media.mit.edu

Reframing economic development





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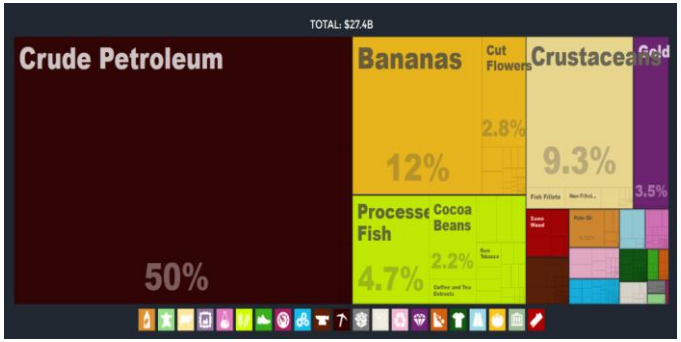
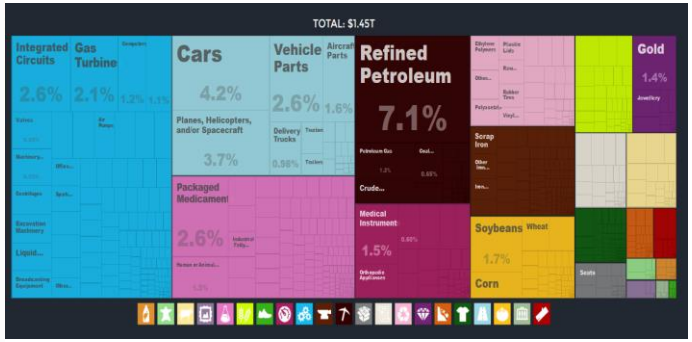
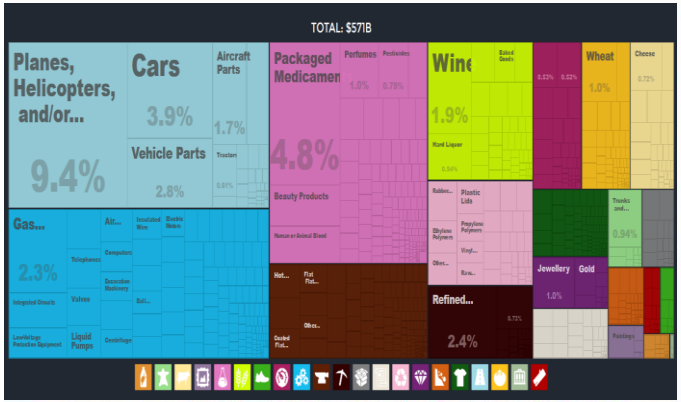
Reframing economic development

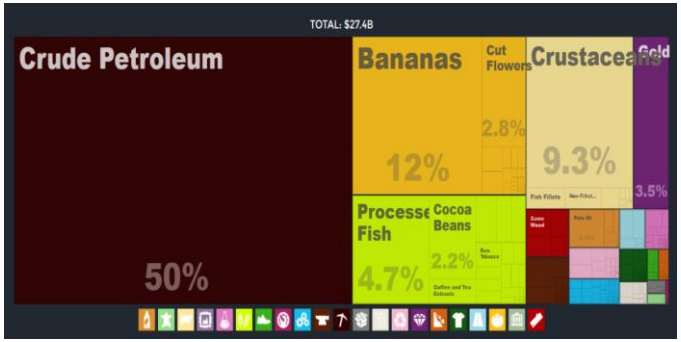


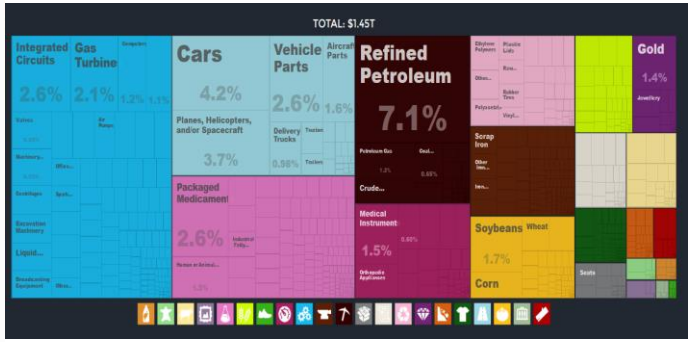


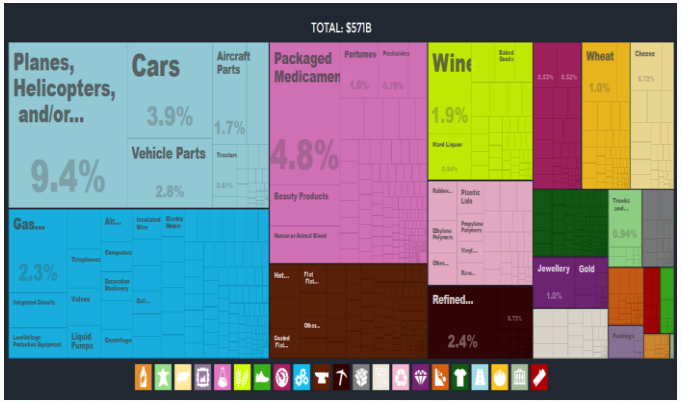


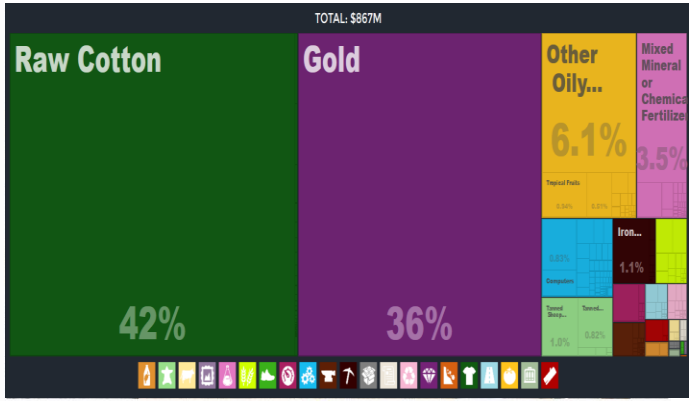
Data Source: atlas.media.mit.edu

Reframing economic development

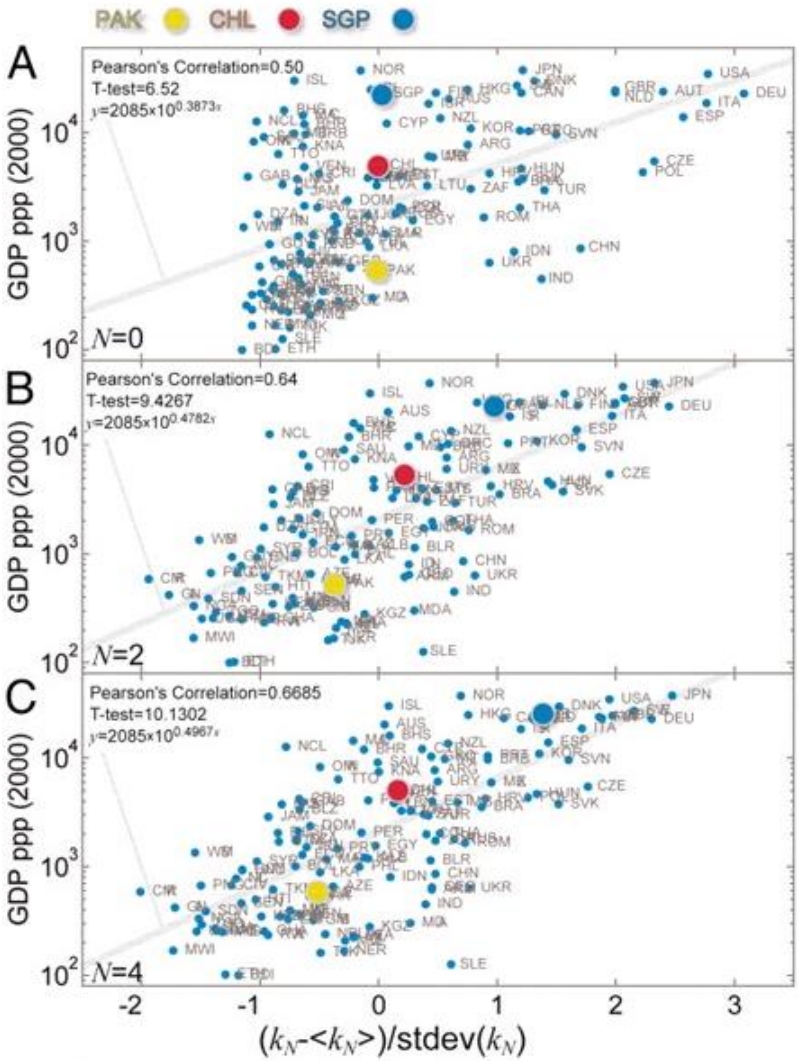






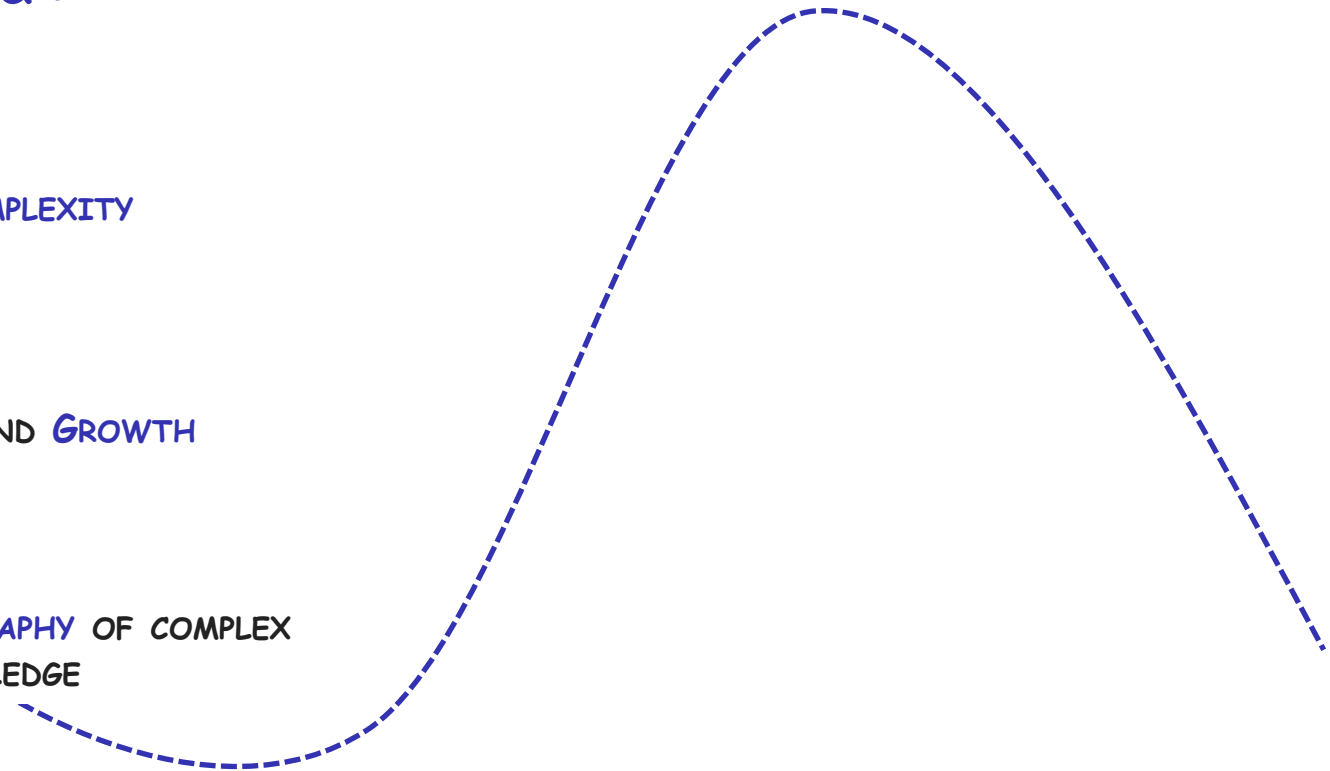


Data Source: atlas.media.mit.edu

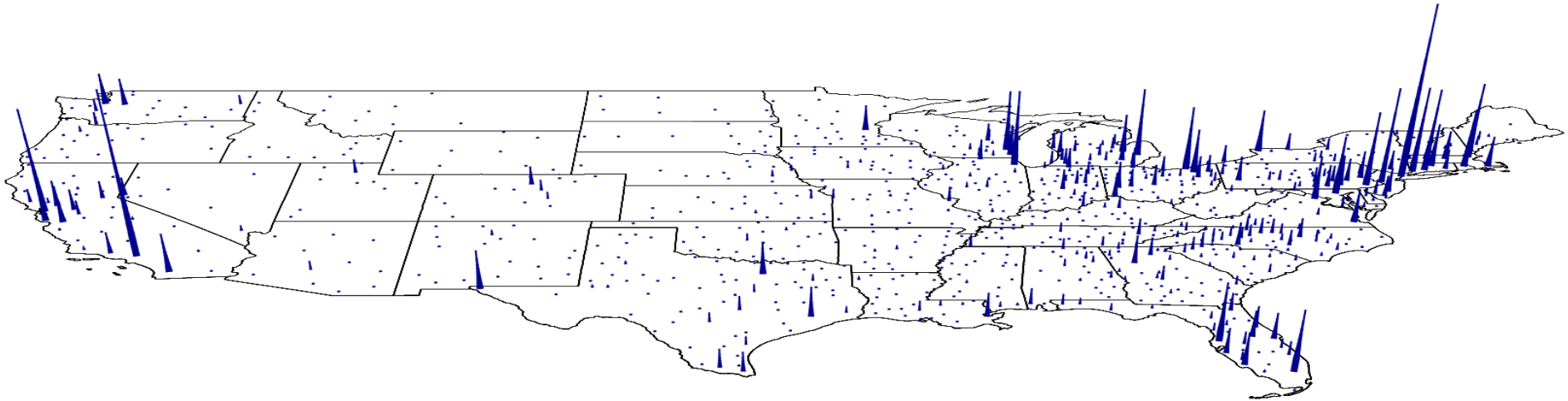

PAK
CHL
SGP
A
Pearson's Correlation=0.50
T-test=6.52
y=2085×10^0.3873x
N=0
B
Pearson's Correlation=0.64
T-test=9.4267
y=2085×10^0.4782x
N=2
C
Pearson's Correlation=0.6685
T-test=10.1302
y=2085×10^0.4967x
N=4
GDP ppp (2000)
(kN-<kN>)/stdev(kN)

Key concepts from Economic Complexity For Research & Innovation Policy

1. What is Economic Complexity
2. Complexity and Growth
3. Geography of complex knowledge



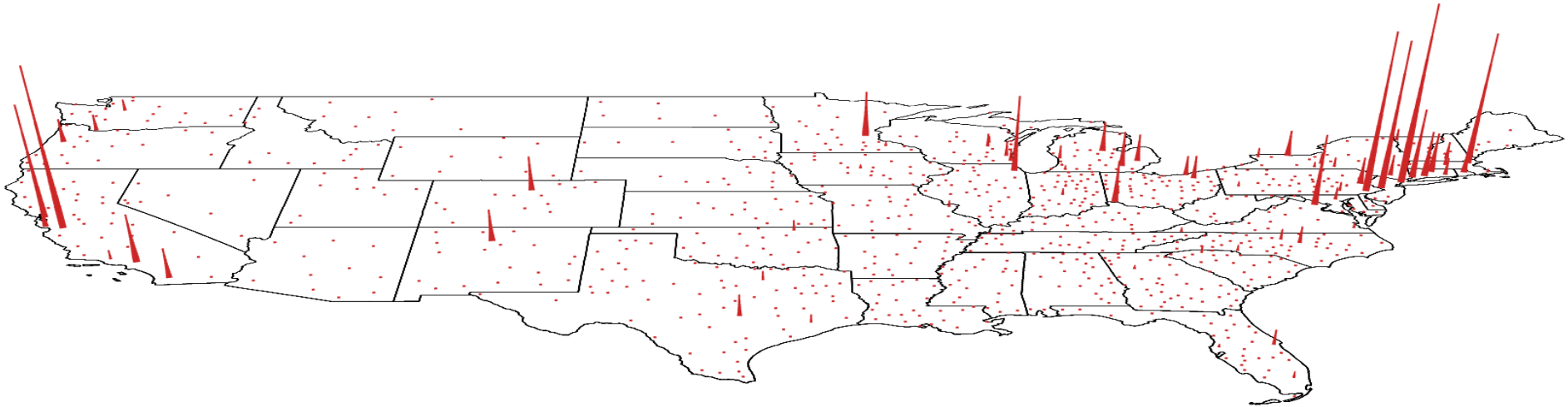
Where America Lives



Population Density per Metropolitan Statistical Area (MSA) in 2010

Data Source: United States Census Bureau

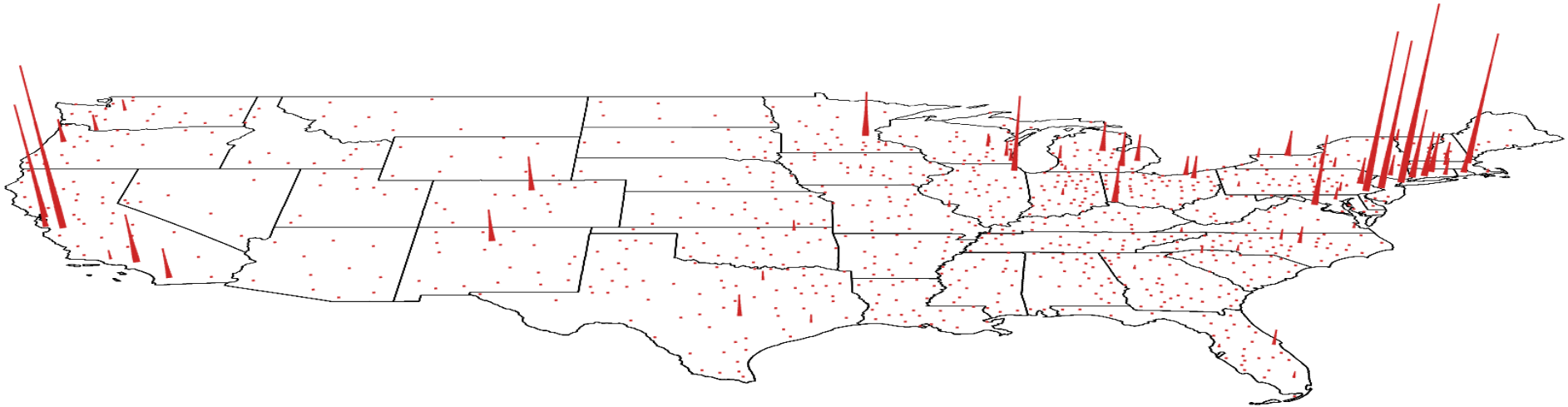
Where America Innovates



Patent Density per Metropolitan Statistical Area (MSA) in 2010

Data Source: United States Patent Office

Where America Innovates



Worldwide, Tokyo, San Jose, New York, Boston, Kanagawa, Shenzhen, Osaka, San Diego, Los Angeles, and Seoul account for 2 % of the population but 24 % of the world's patent applications

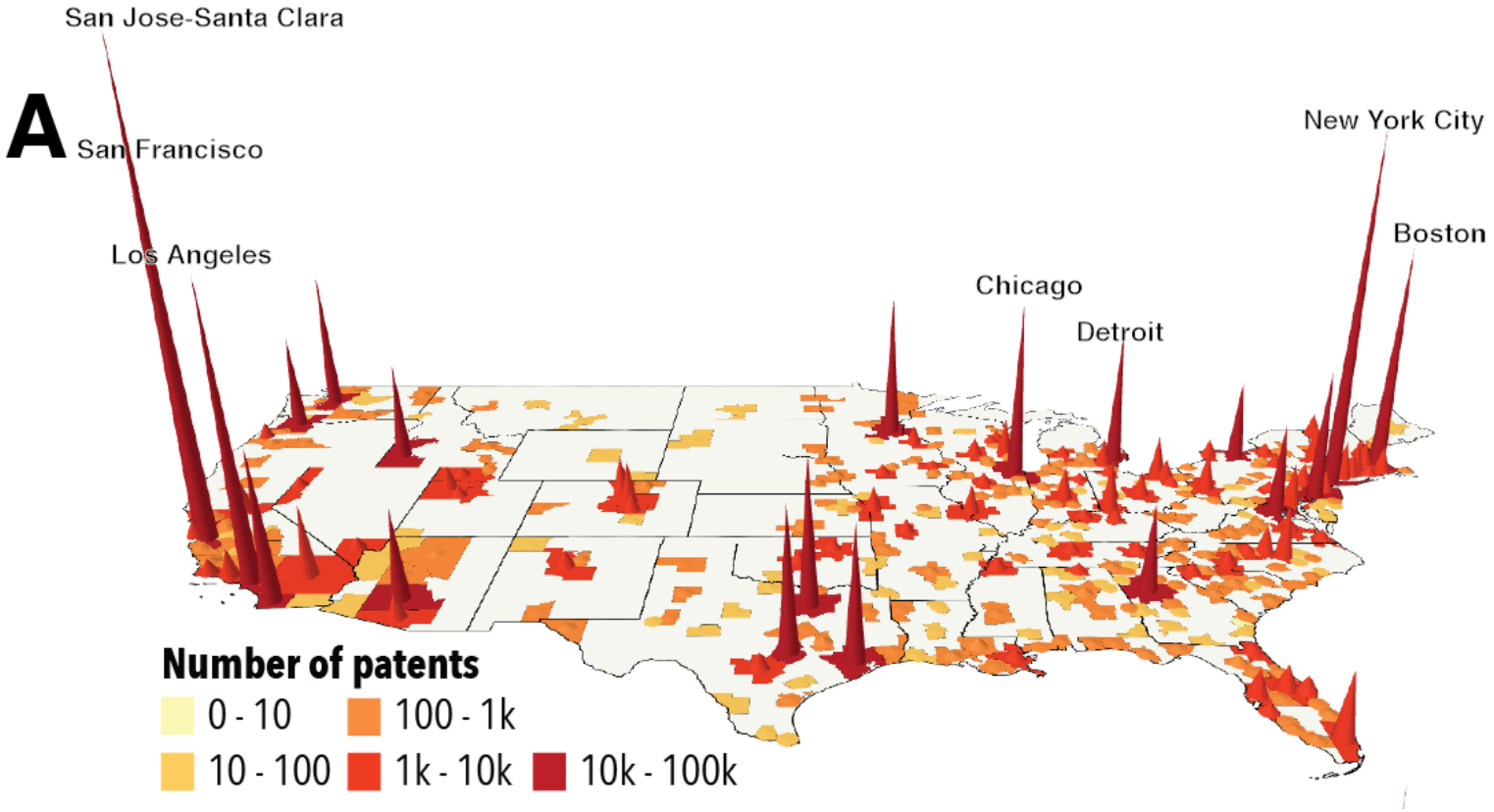
Patent Density per Metropolitan Statistical Area (MSA) in 2010

Data Source: United States Patent Office

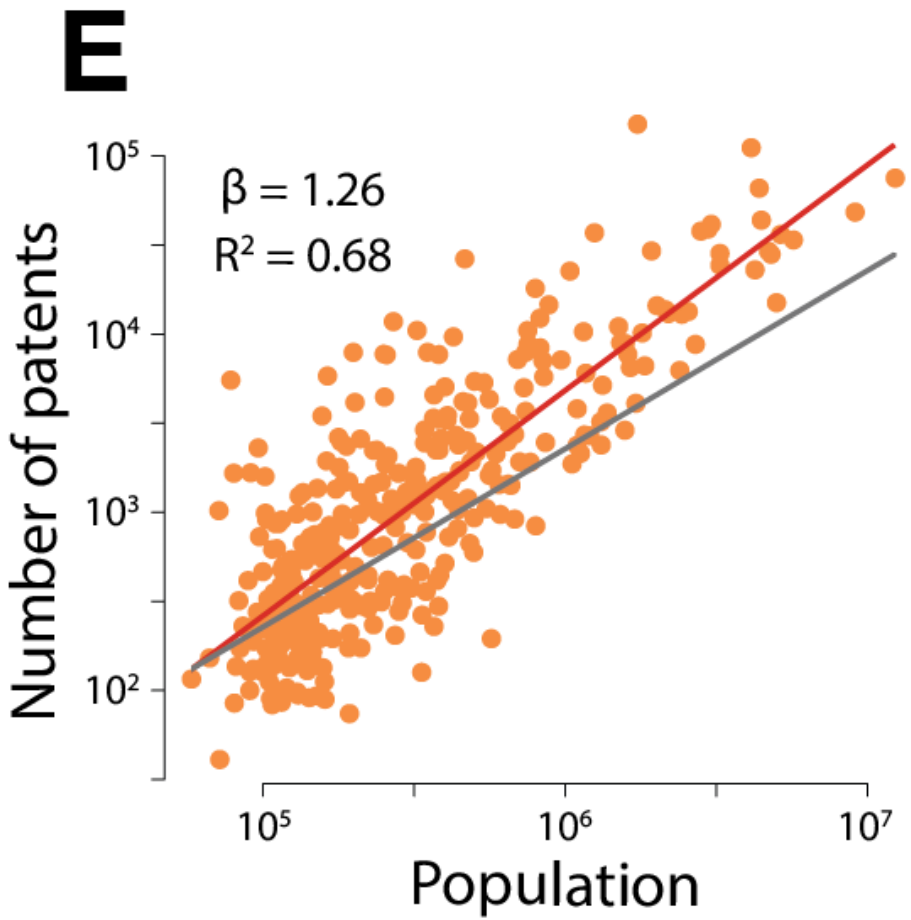
Key pieces

- Scaling = spatial concentration in large cities
- Knowledge complexity = difficulty to recombine knowledge
- Historical Patent Dataset (HistPat): 1790-2010

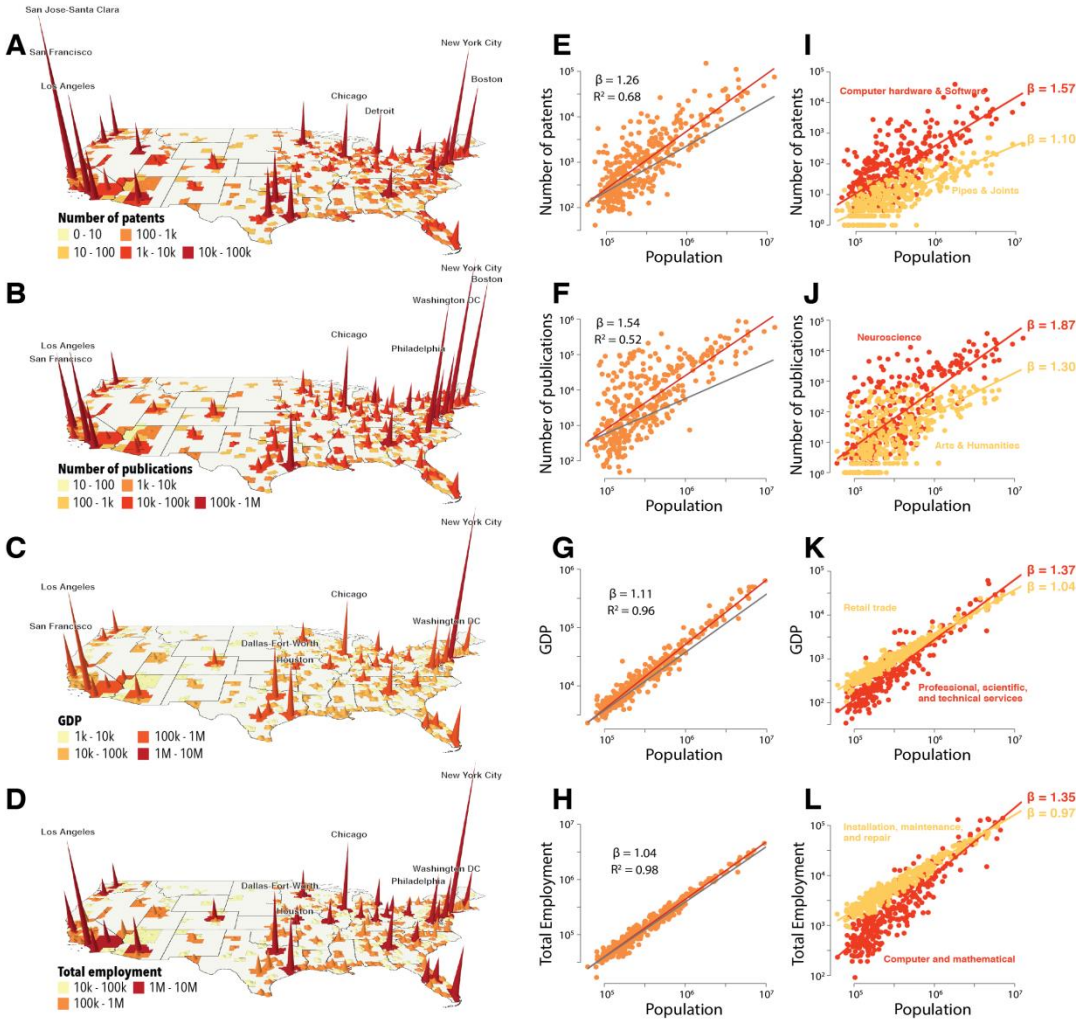
Unequal distribution of econ. activities



Unequal distribution of econ. activities

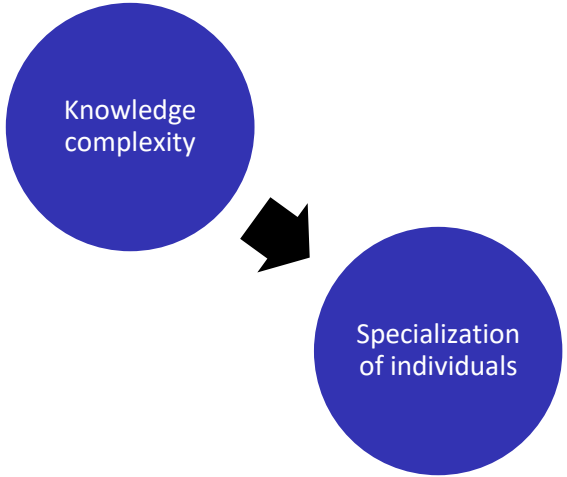


How economic activities scale in cities

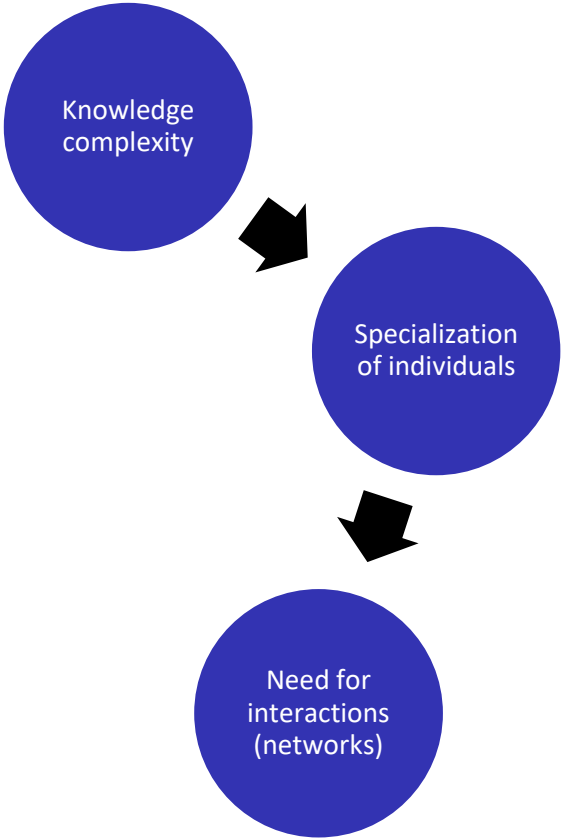


From Complexity to Spatial Inequality

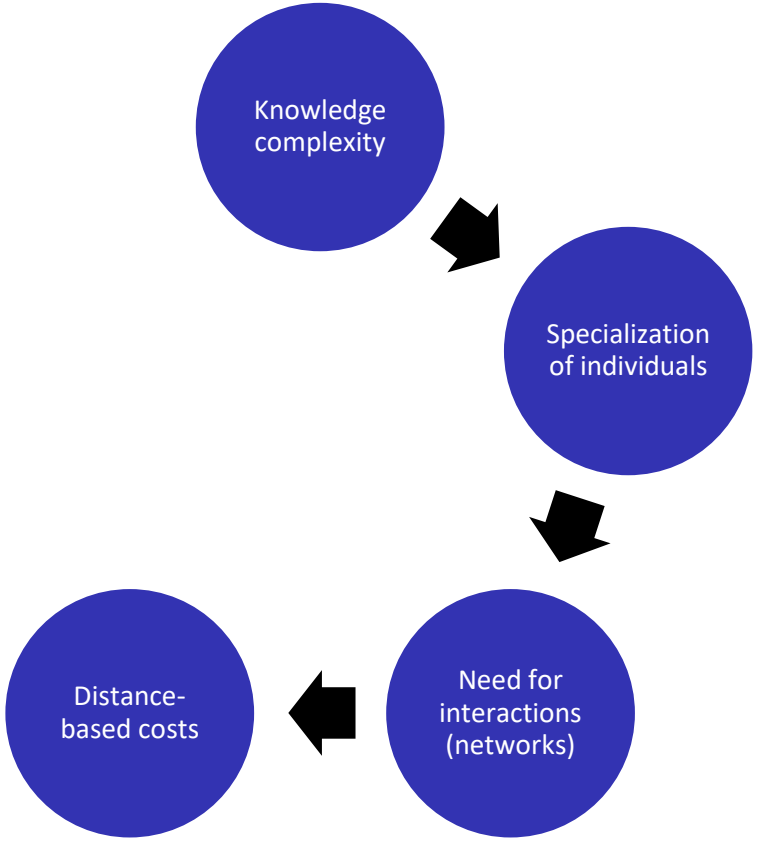
From Complexity to Spatial Inequality



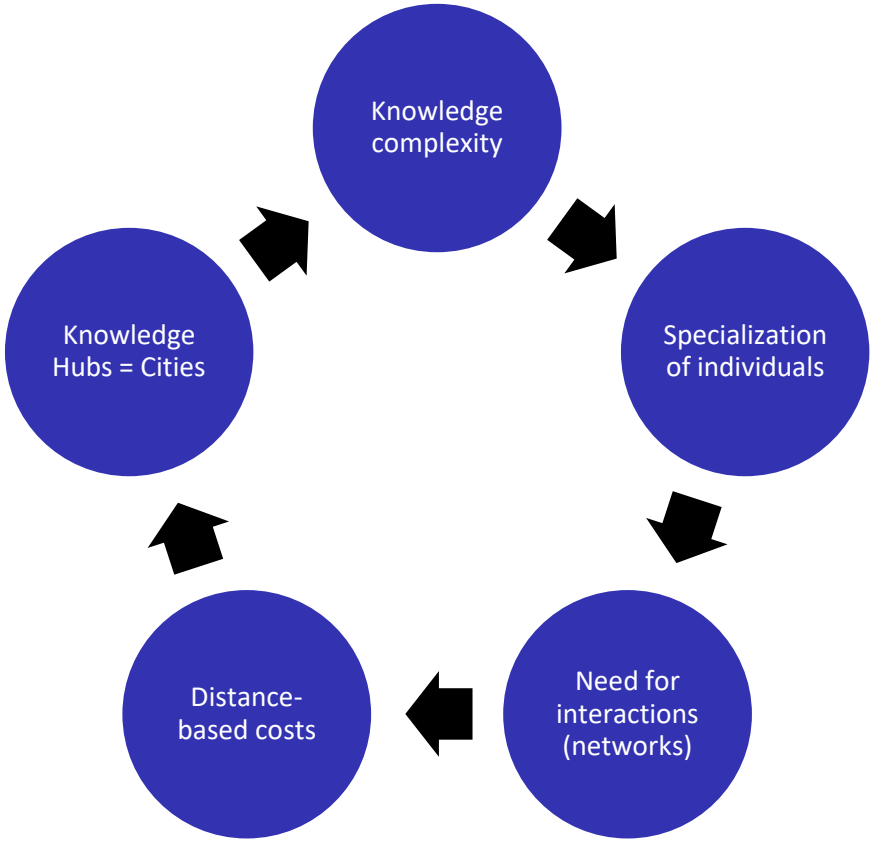
From Complexity to Spatial Inequality

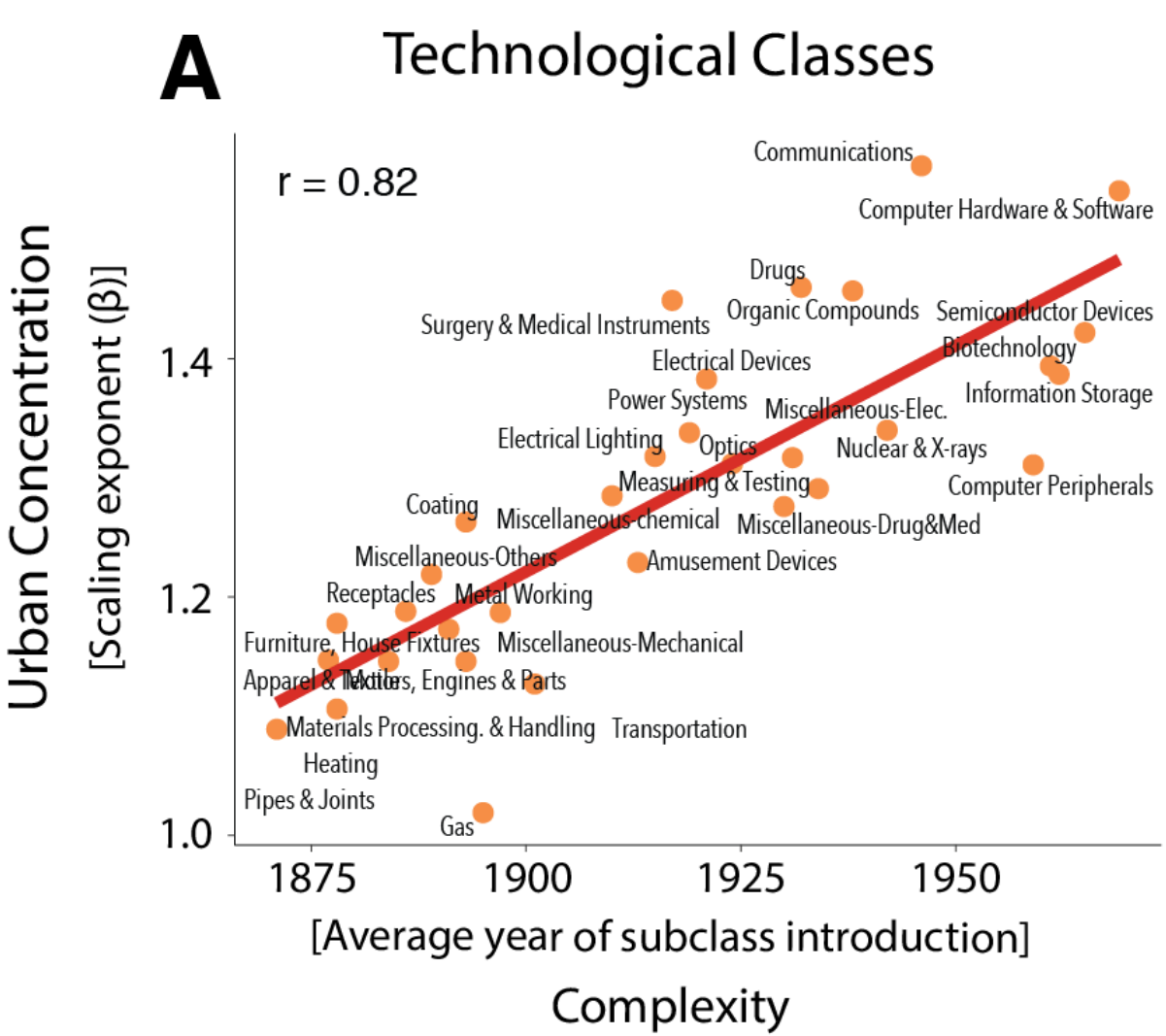


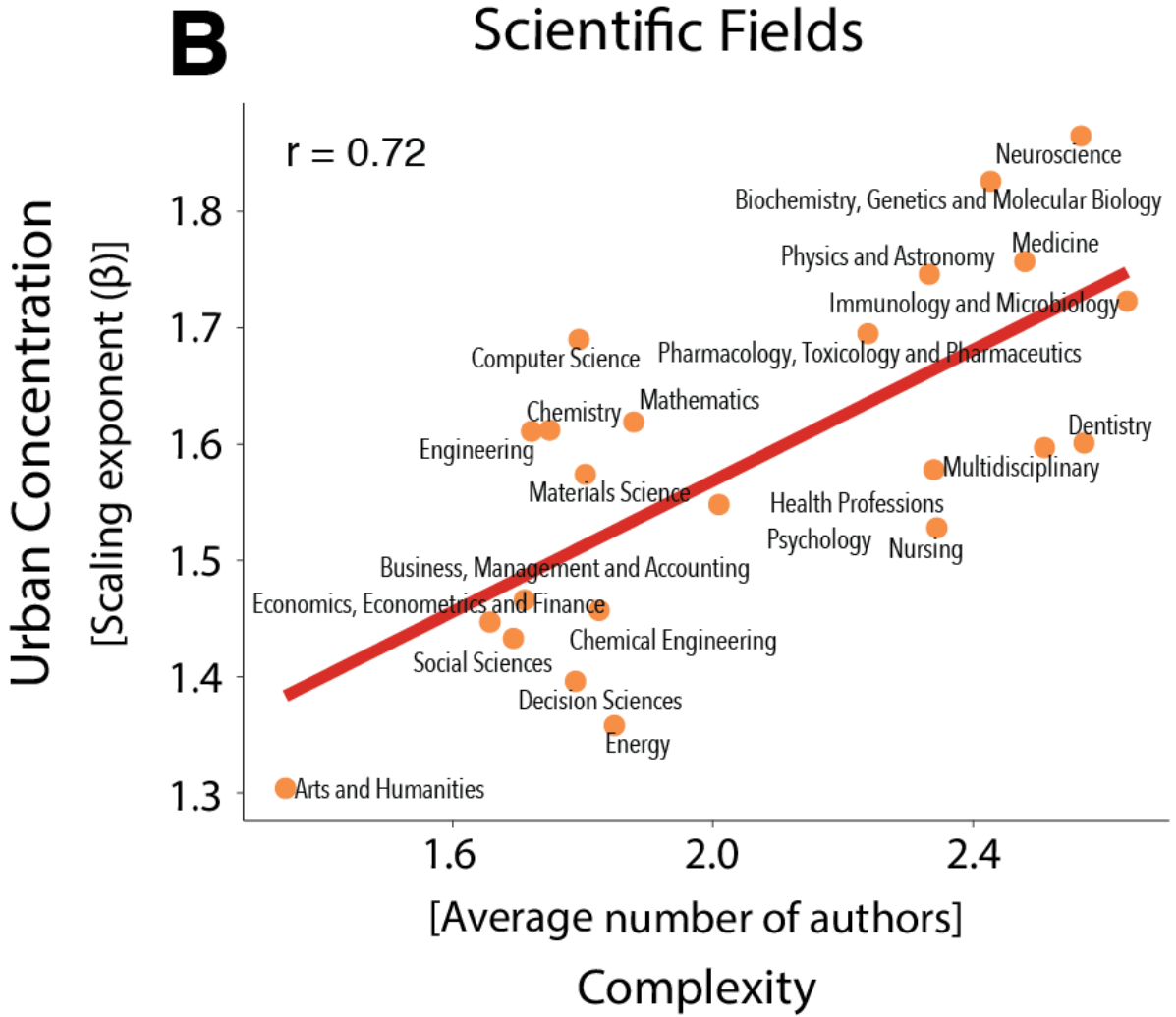
From Complexity to Spatial Inequality

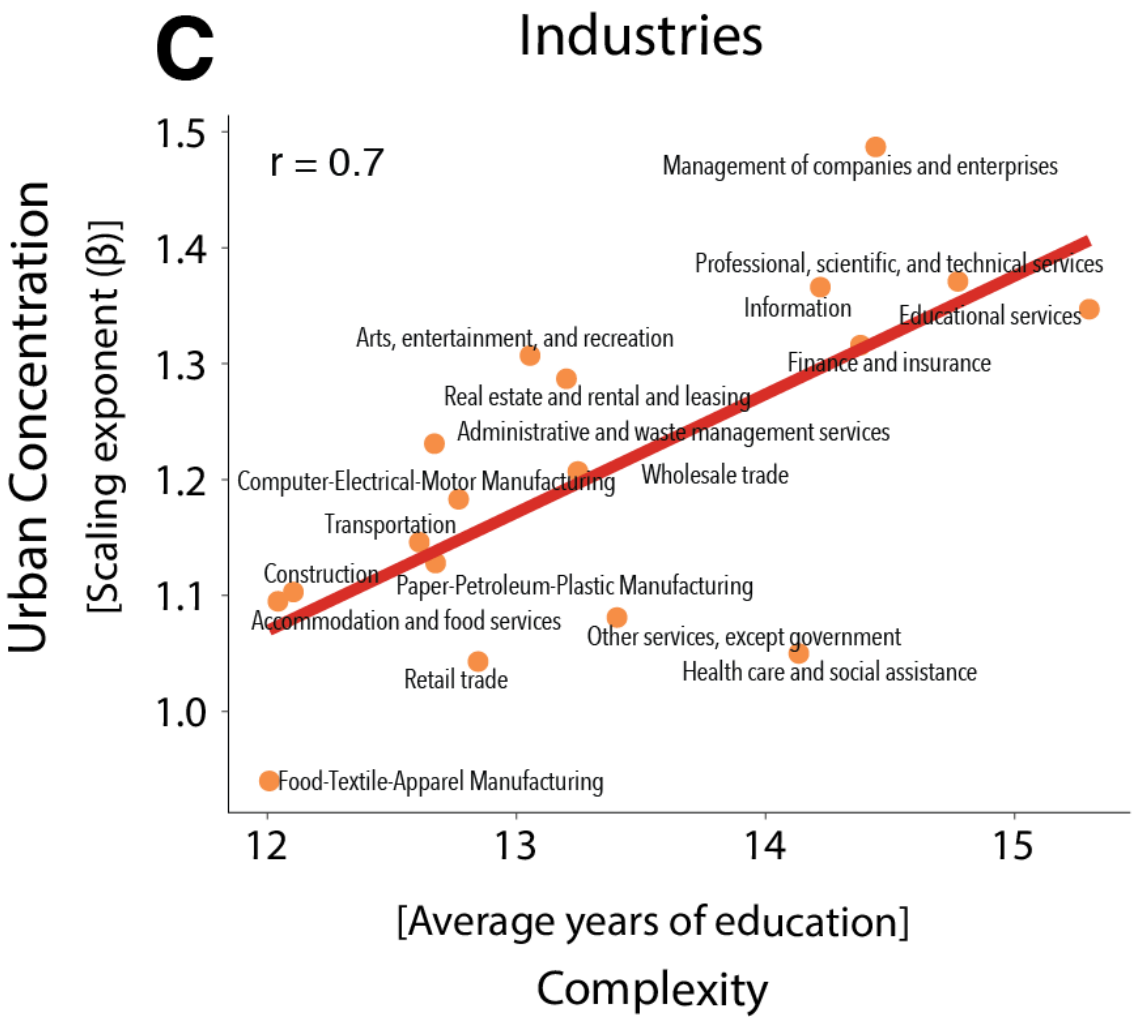


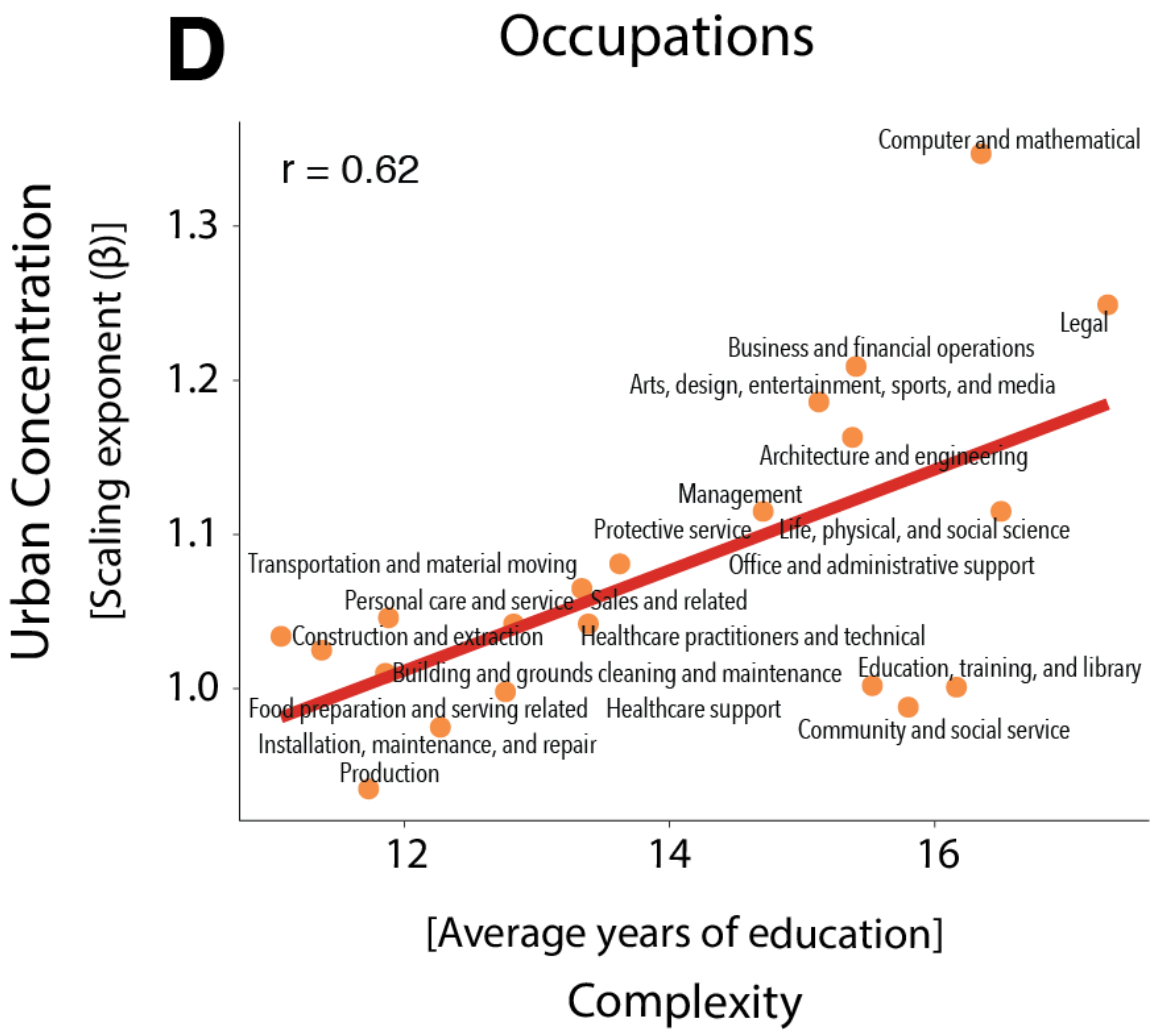
From Complexity to Spatial Inequality




A
Technological Classes
r = 0.82
Communications
Computer Hardware & Software
Drugs
Organic Compounds
Surgery & Medical Instruments
Semiconductor Devices
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
1.4
1.2
1.0
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
Computer Science
Pharmacology, Toxicology and Pharmaceutics
Chemistry
Mathematics
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**

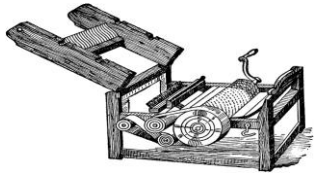
1st U.S. Patent

Information & Communication

The Historical Gap

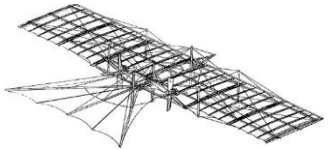
There is virtually no historical and systematic analysis on the geography of innovation and technological change prior to 1975.

Cotton Gin



Telephone

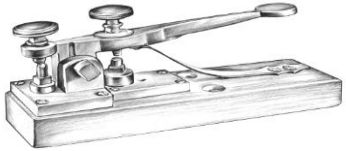
Airplane



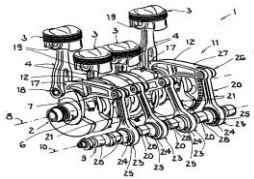
Biotechnology

1790 1820 1850 1880 1910 1940 1975 2010

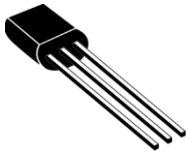
1st U.S. Patent



Telegraph



Internal combustion engine

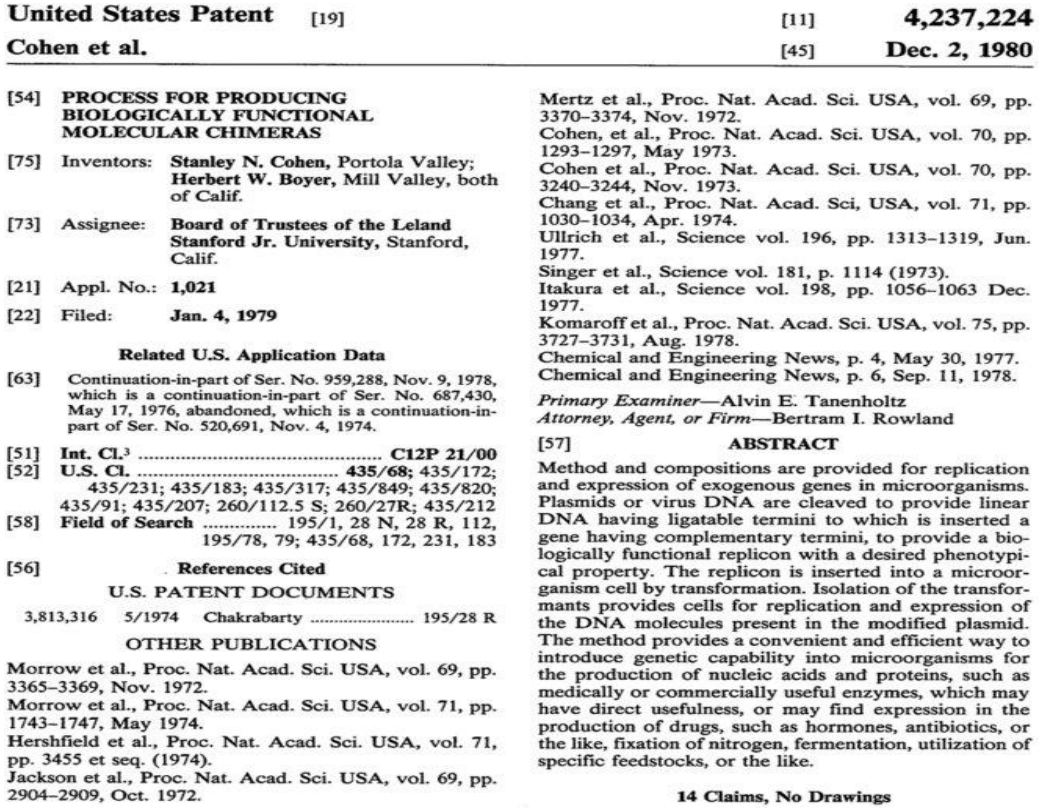


Semiconductor

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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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

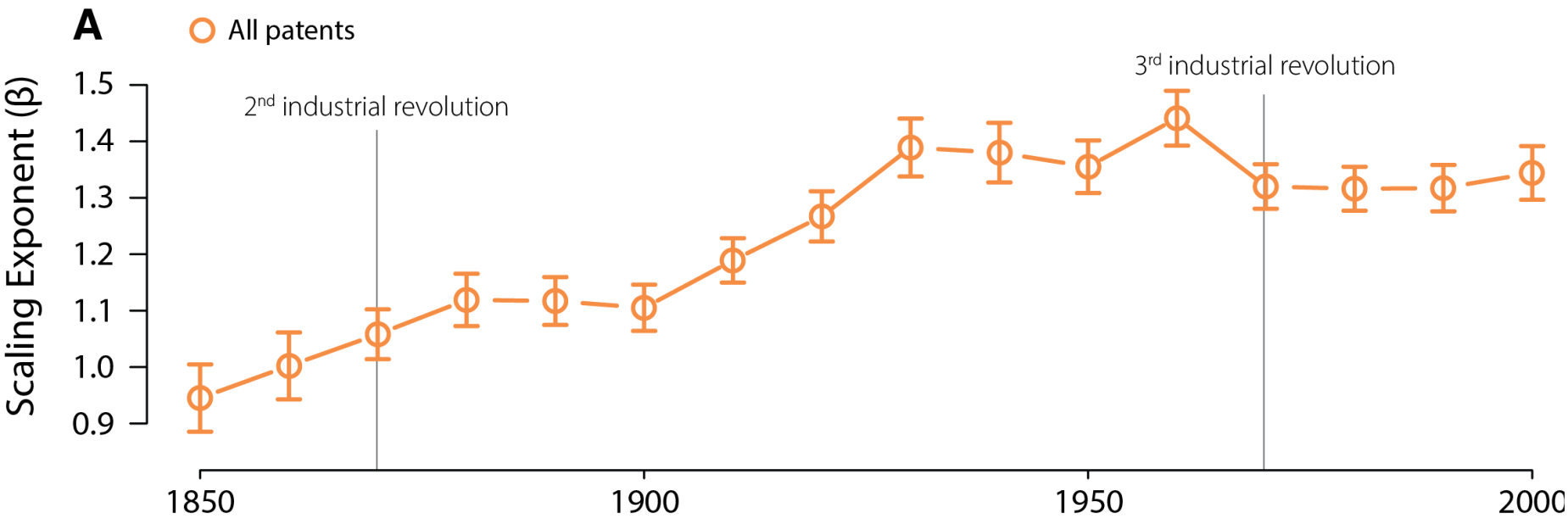
[57] **ABSTRACT**

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.

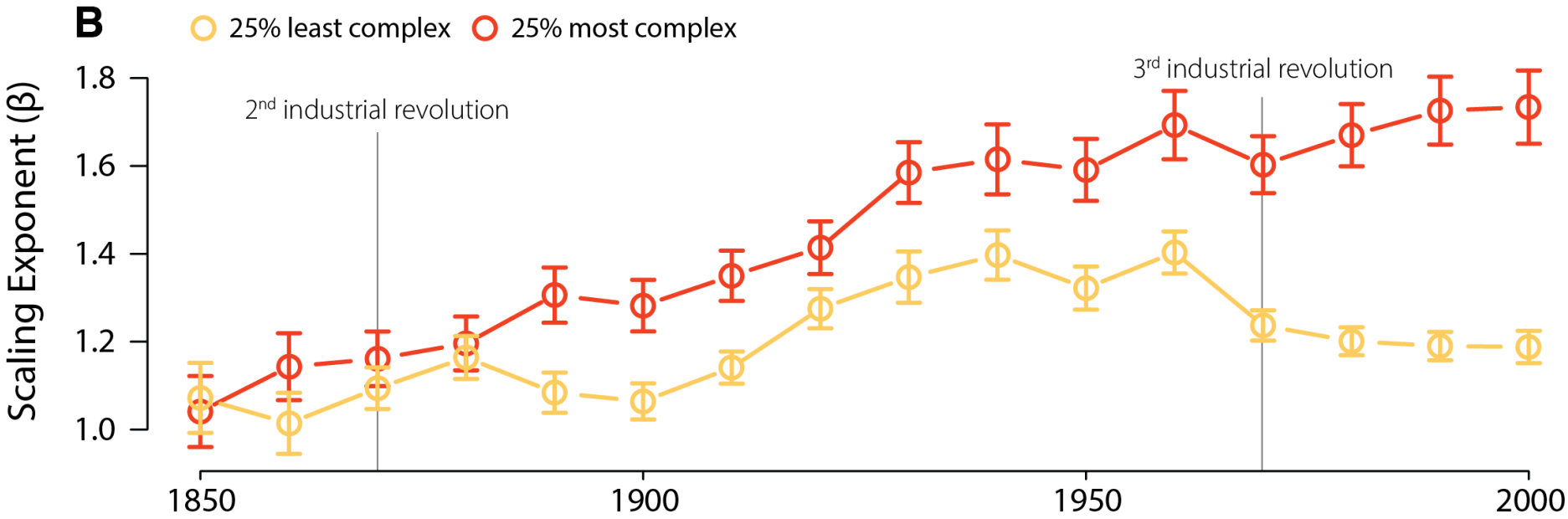
14 Claims, No Drawings

- ~ 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)
- …

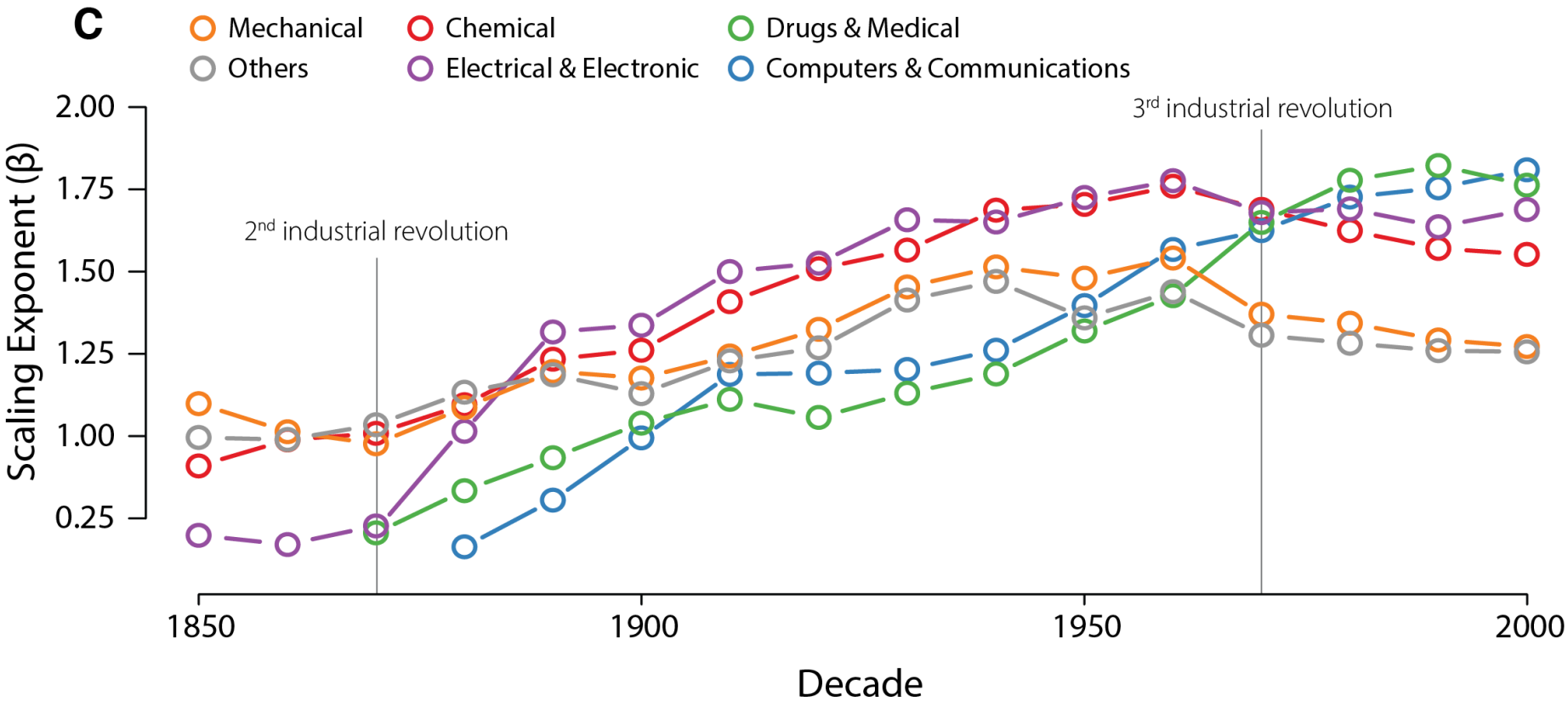
Complexity and scaling (1850-2000)



Complexity and scaling (1850-2000)

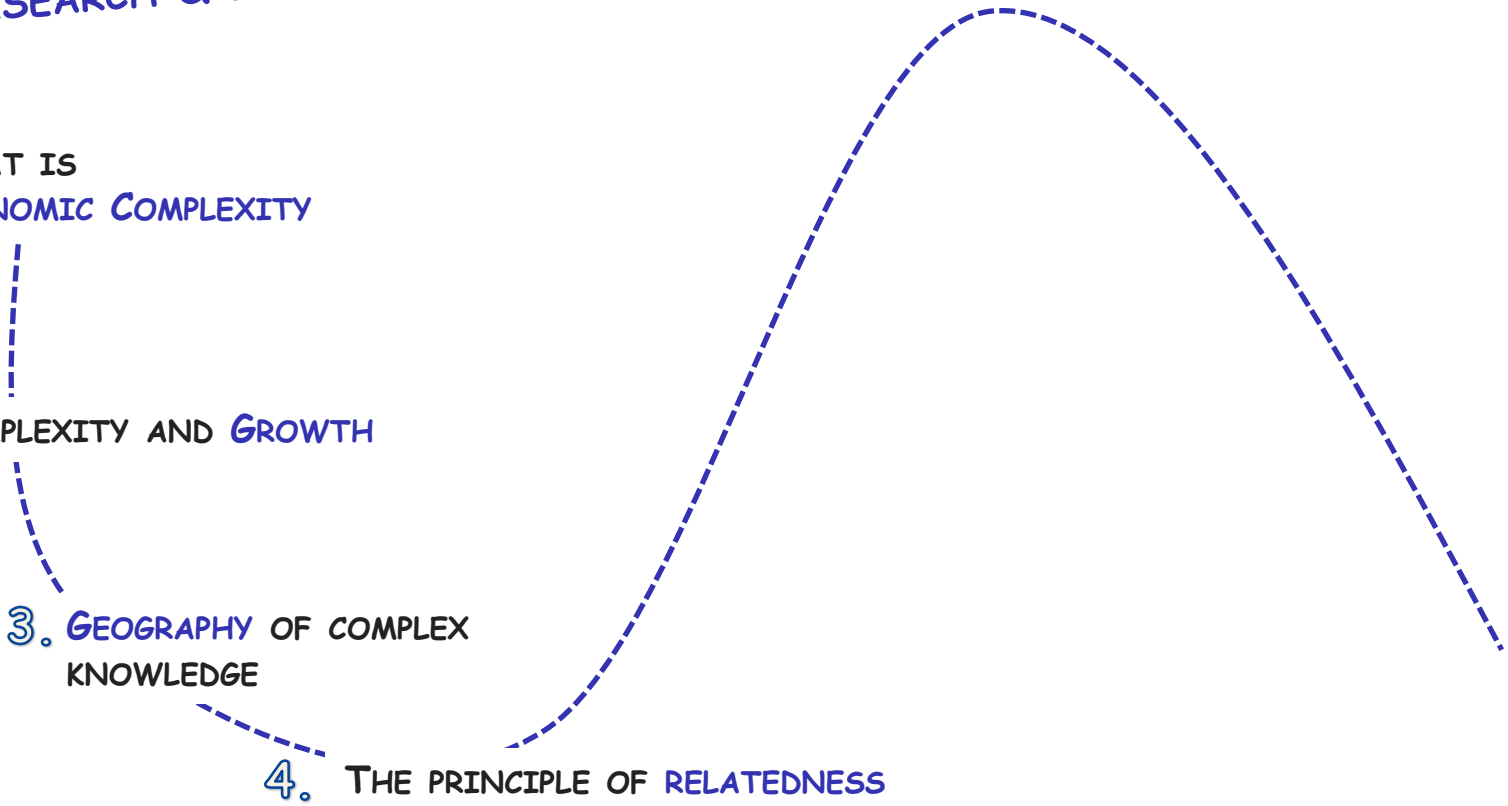


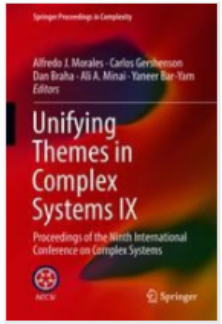
Complexity and scaling (1850-2000)



Key concepts from Economic Complexity For Research & Innovation Policy

1. What is Economic Complexity
2. Complexity and Growth
3. Geography of complex knowledge
4. The principle of relatedness





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The Principle of Relatedness

Authors | Authors and affiliations

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Conference paper

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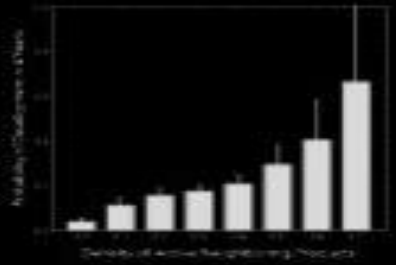
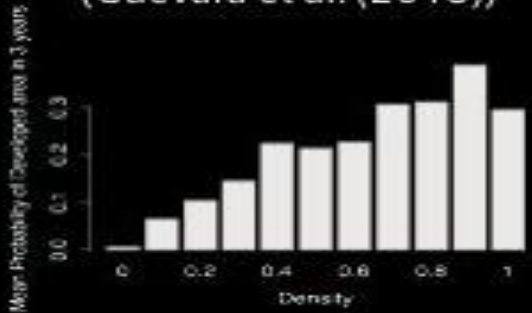
PRODUCTS

(Hidalgo et al 2007)



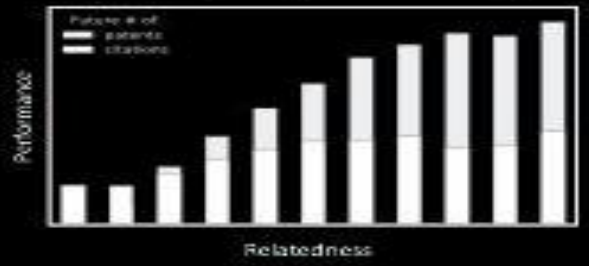
RESEARCH AREAS

(Guevara et al. (2016))



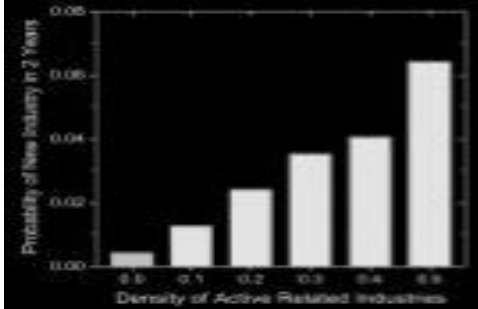
PATENTS

(Kogler et al. (2013), Boschma et al. (2015), Alstott et al. (2016))

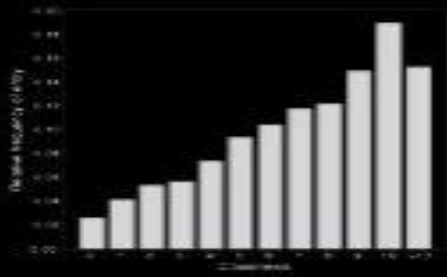


INDUSTRIES

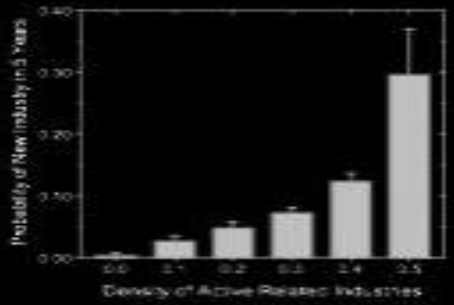
BRAZIL (Gao et al. 2017)



SWEDEN: (Neffke, Henning, Boschma 2011)



CHINA: (He et al. 2017 Gao et al. 2017)



$$Entry_{i,c,t} = \beta_1 Density_{i,c,t-1} + \beta_2 City_{c,t-1} + \beta_3 Techno_{i,t-1} + \phi_c + \psi_i + \alpha_t + \varepsilon_{i,c,t}$$

Table 3 Emergence of new technologies in US cities (1981–2010)

Dependent variable is: $Entry_t$	Model 1 Rel. density	Model 2 City variables	Model 3 Tech. variables	Model 4 Full model	Model 5 Full model (F.E.)
Relatedness $density_{t-1}$	0.00515979**			0.00373407**	0.00271463**
	(0.00012770)			(0.00014135)	(0.00016884)
Log $(Employment)_{t-1}$		0.04934166**		0.03611889**	0.04633250**
		(0.00286818)		(0.00247147)	(0.00782869)
Population $density_{t-1}$		0.00001106		0.00002520**	−0.00021341**
		(0.00000997)		(0.00000843)	(0.00003836)
Inventive $capacity_{t-1}$		0.07718815**		0.03883926**	−0.08487966**
		(0.01294204)		(0.0078352020)	(0.01505564)
Tech. $Specialization_{t-1}$		−0.00089296**		−0.00047160**	0.00005120
		(0.00011548)		(0.00009315)	(0.00011022)
MSA growth $rate_{t-1}$		0.04443962**		0.04032813**	0.00865397**
		(0.00355534)		(0.00353667)	(0.00298386)

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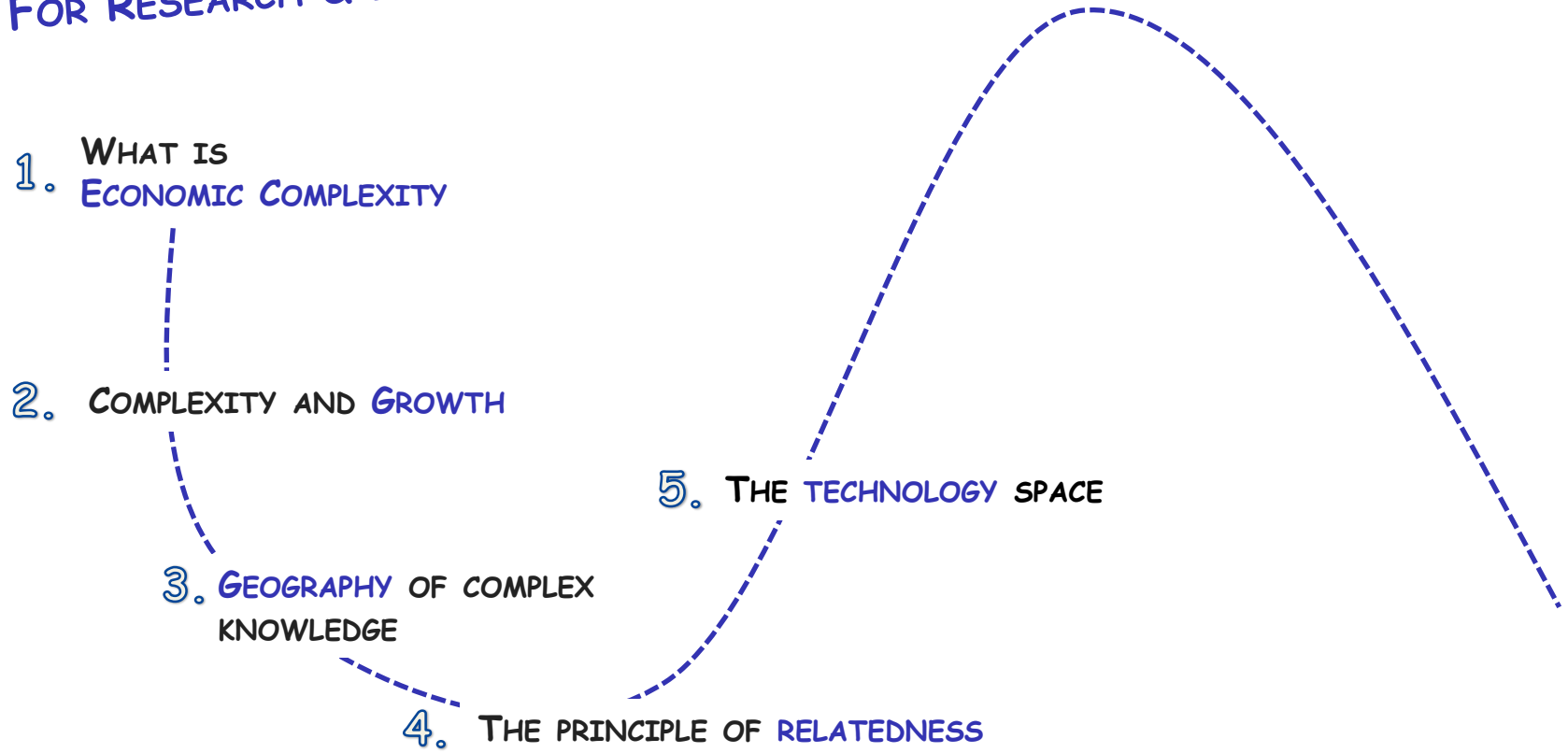
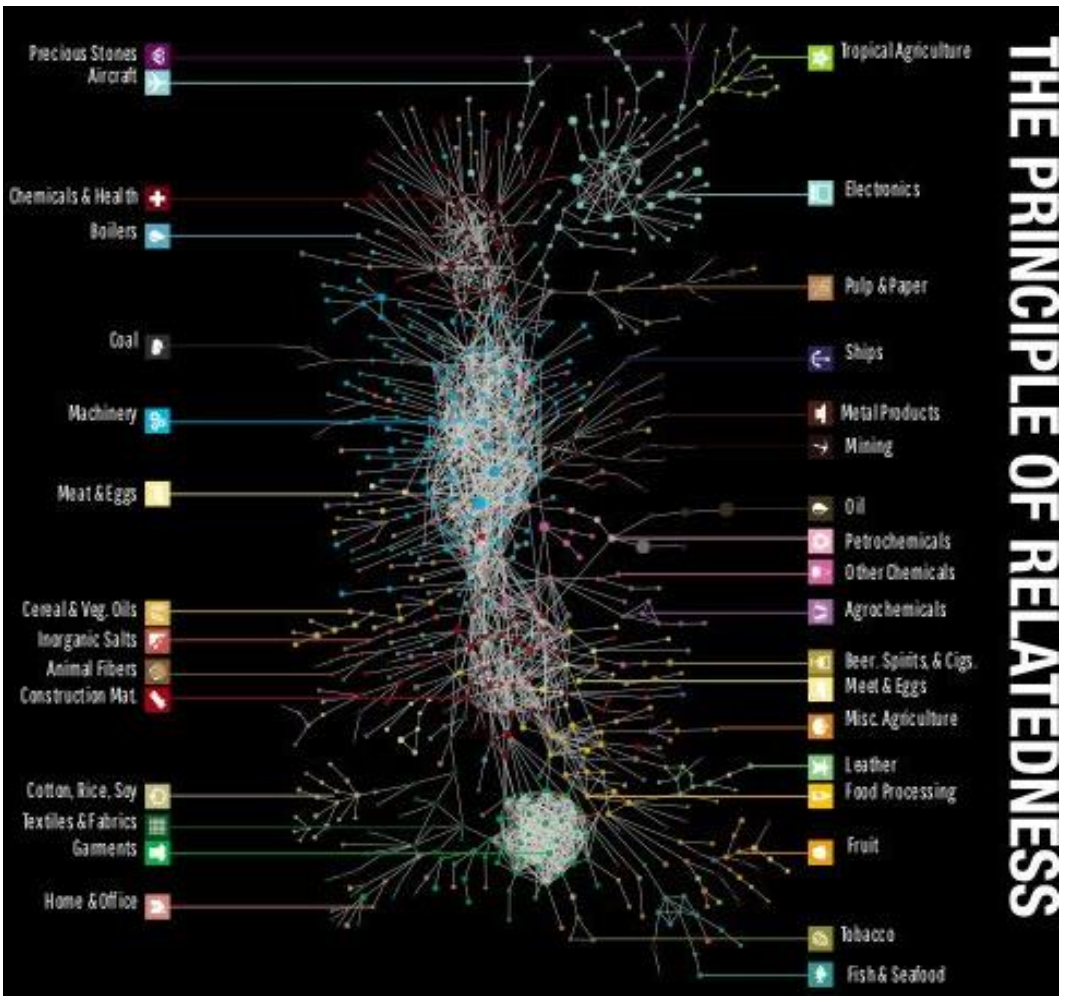
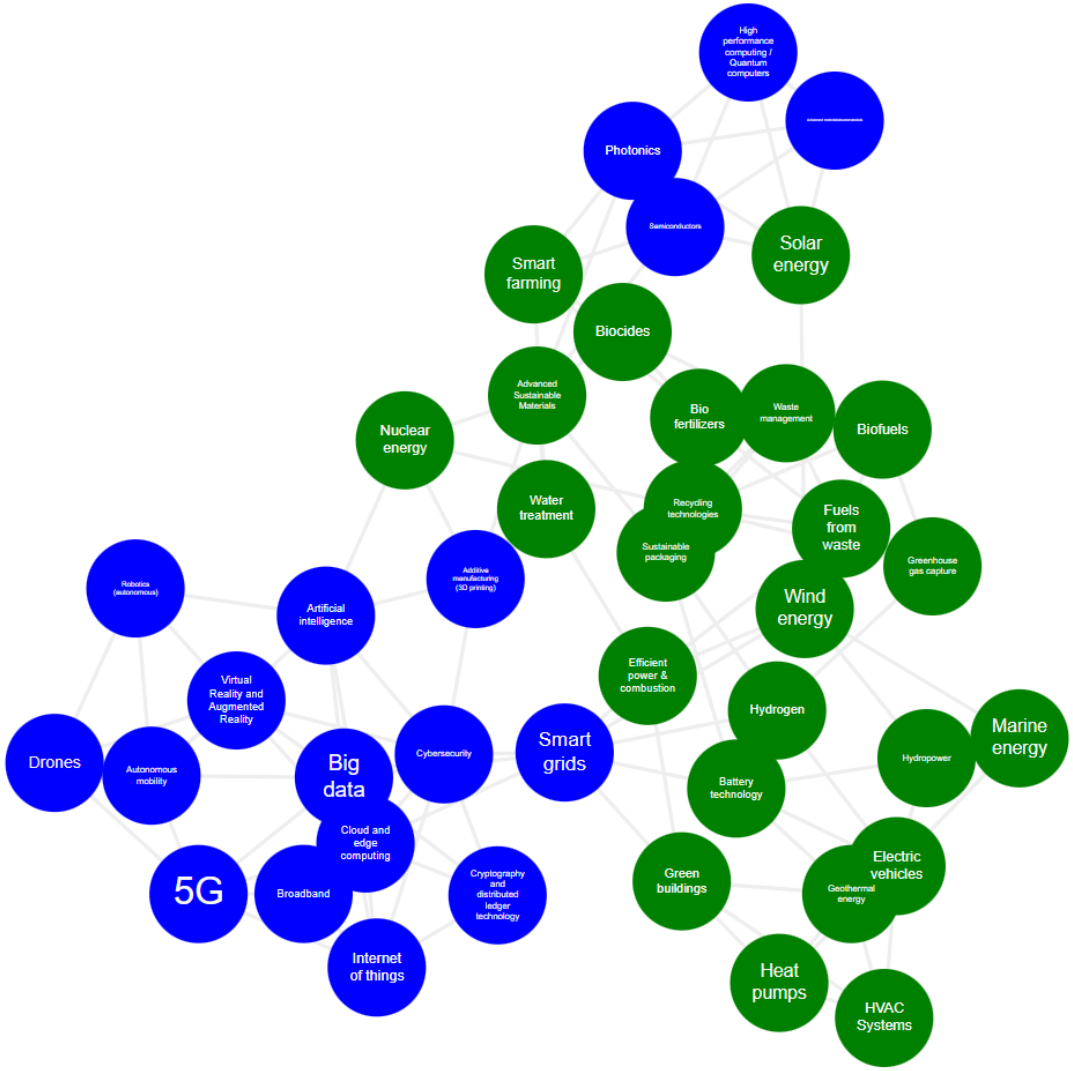



THE PRINCIPLE OF RELATEDNESS
Precious Stones
Aircraft
Chemicals & Health
Boilers
Coal
Machinery
Meat & Eggs
Cereal & Veg. Oils
Inorganic Salts
Animal Fibers
Construction Mat.
Cotton, Rice, Soy
Textiles & Fabrics
Garments
Home & Office
Tropical Agriculture
Electronics
Pulp & Paper
Ships
Metal Products
Mining
Oil
Petrochemicals
Other Chemicals
Agrochemicals
Beer, Spirits, & Cigs.
Meat & Eggs
Misc. Agriculture
Leather
Food Processing
Fruit
Tobacco
Fish & Seafood


High performance computing / Quantum computers
Photonics
Semiconductors
Solar energy
Smart farming
Biocides
Advanced Sustainable Materials
Bio fertilizers
Waste management
Biofuels
Nuclear energy
Water treatment
Recycling technologies
Sustainable packaging
Fuels from waste
Greenhouse gas capture
Wind energy
Robotics (autonomous)
Artificial intelligence
Additive manufacturing (3D printing)
Efficient power & combustion
Hydrogen
Marine energy
Hydropower
Virtual Reality and Augmented Reality
Drones
Autonomous mobility
Big data
Cybersecurity
Smart grids
Battery technology
Cloud and edge computing
5G
Broadband
Cryptography and distributed ledger technology
Green buildings
Electric vehicles
Geothermal energy
Internet of things
Heat pumps
HVAC Systems

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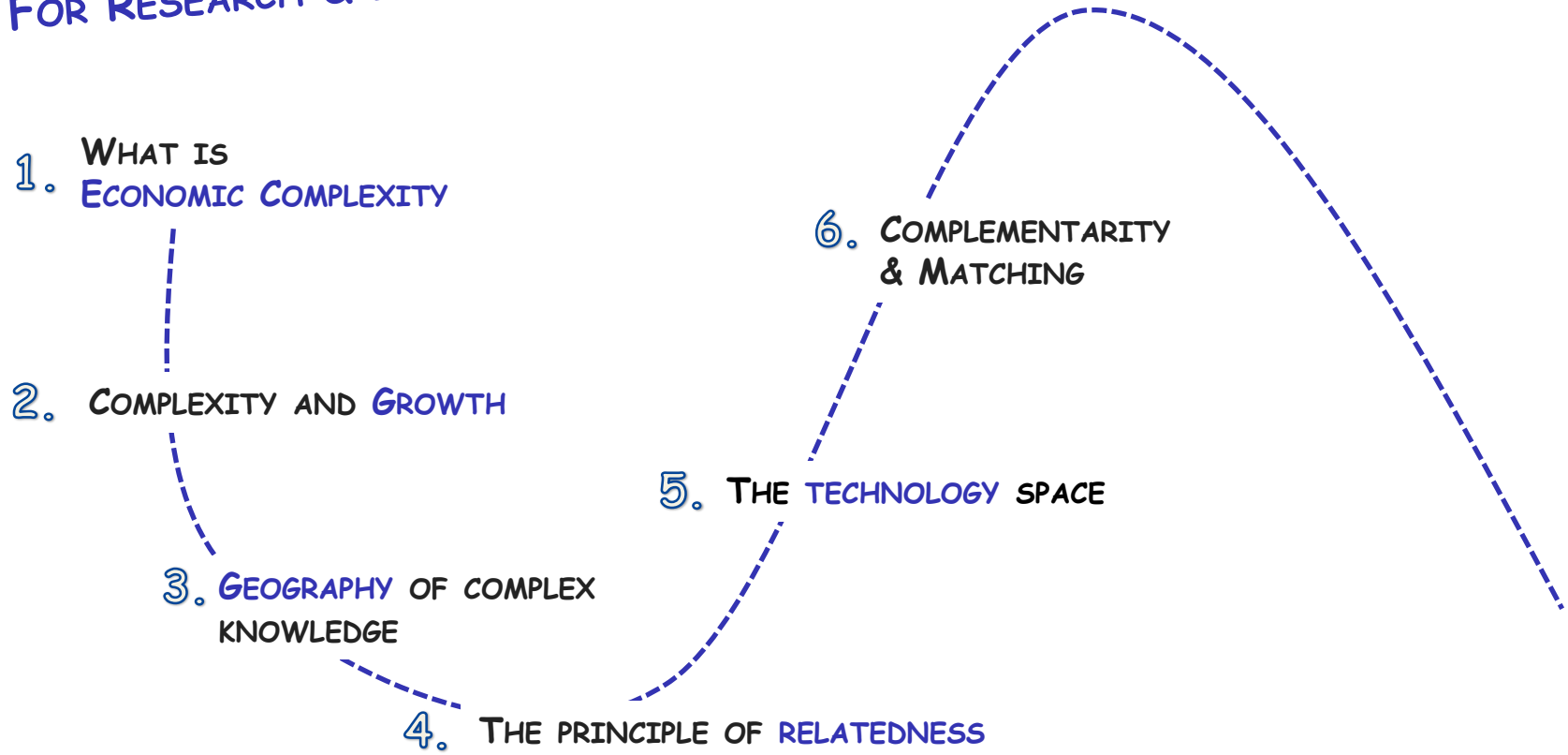

Beyond relatedness

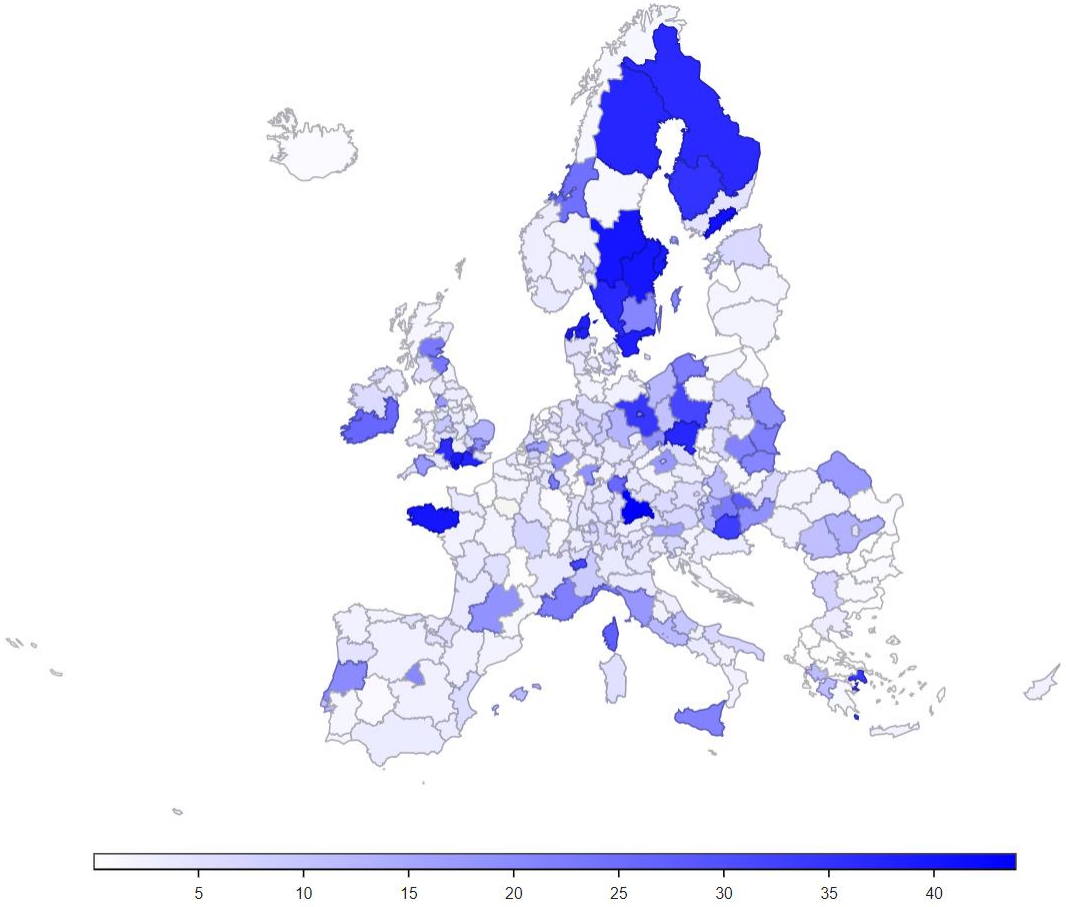

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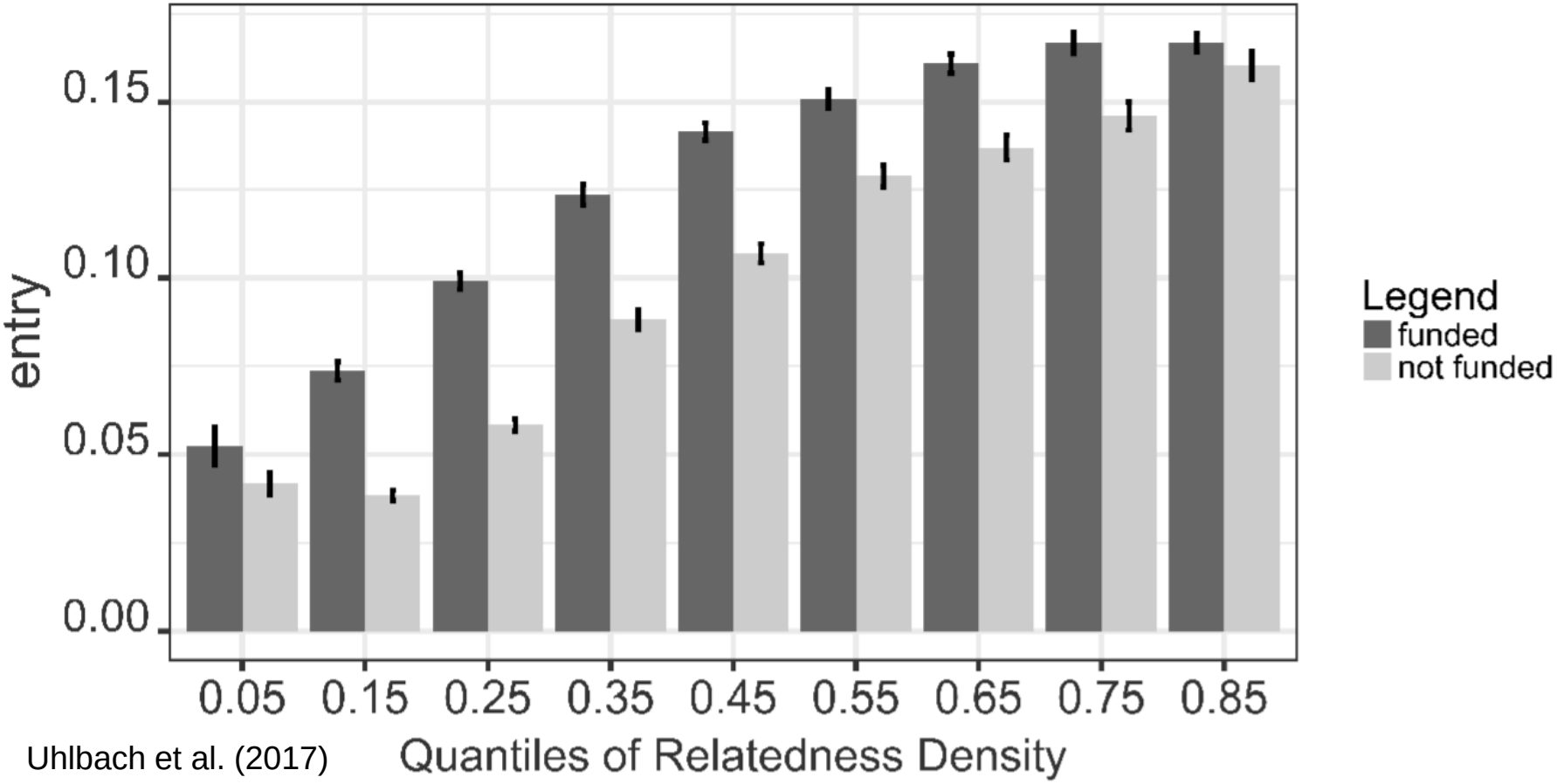
Figure 2: **Differences of Mean Entry Probabilities**



Uhlbach et al. (2017)

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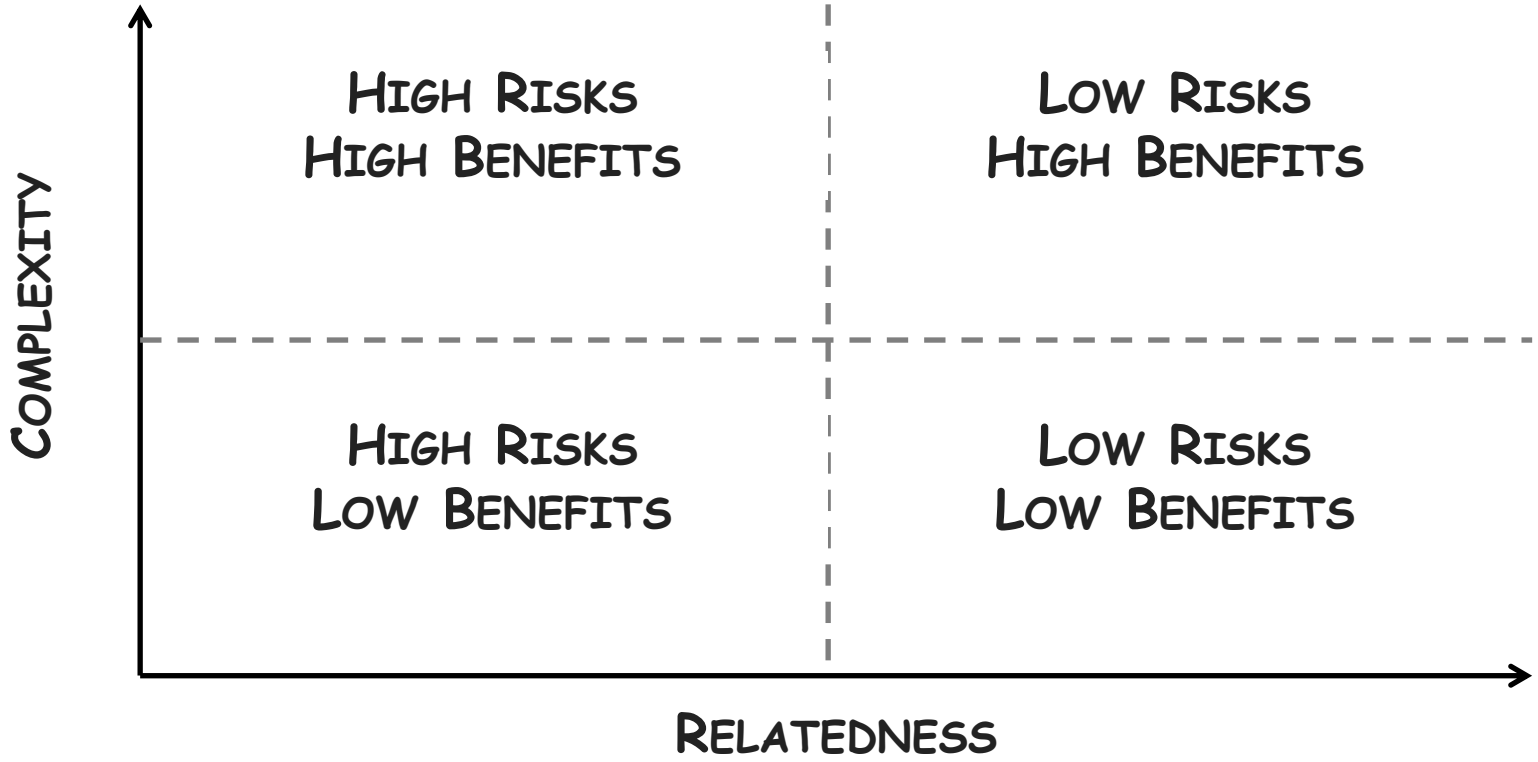
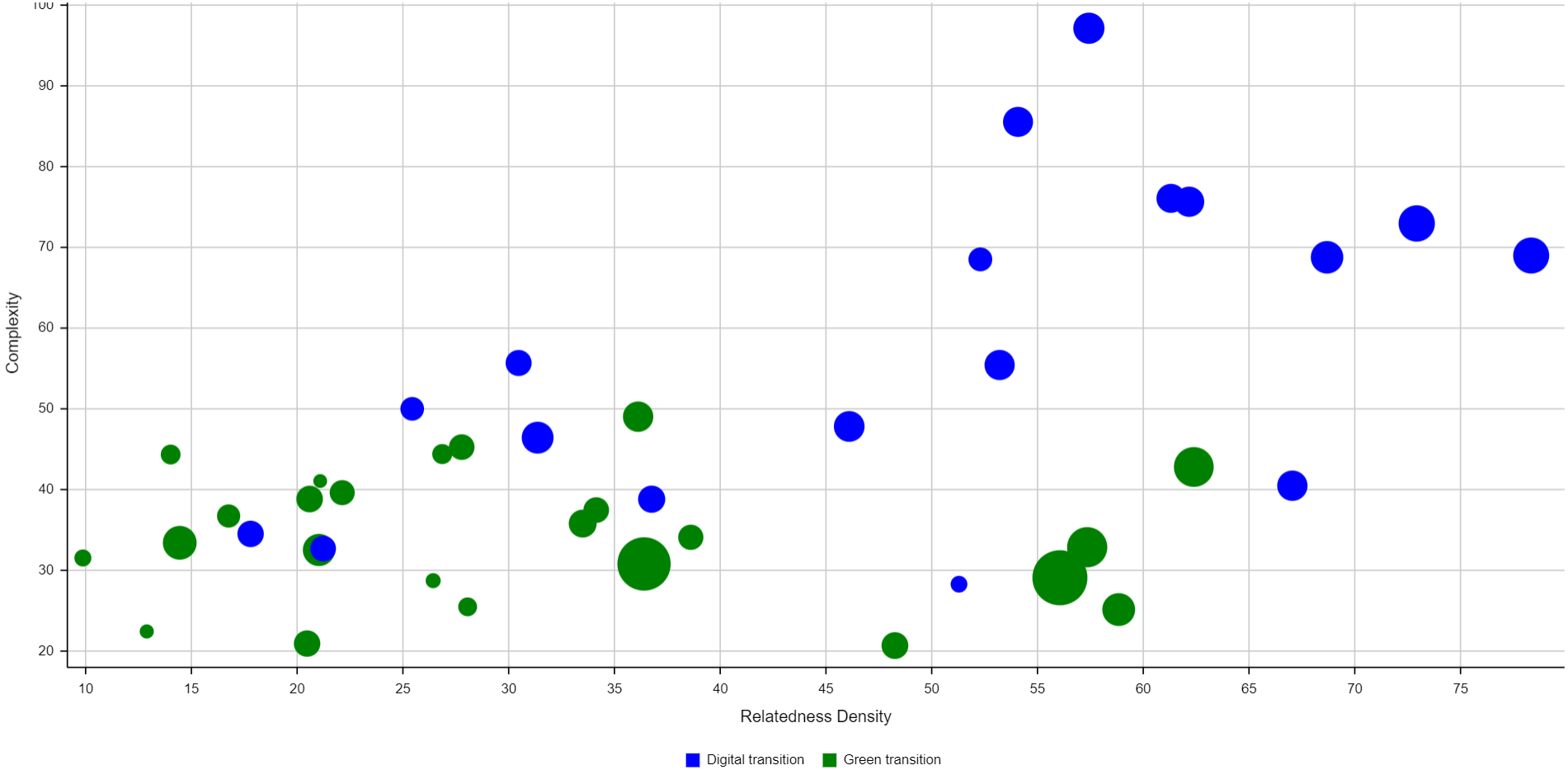
7. Innovation policy and diversification
8. A framework for Smart R&I

Smart Investment Framework



Balland et al. (2019)

Smart digital & green transition for Ile de France



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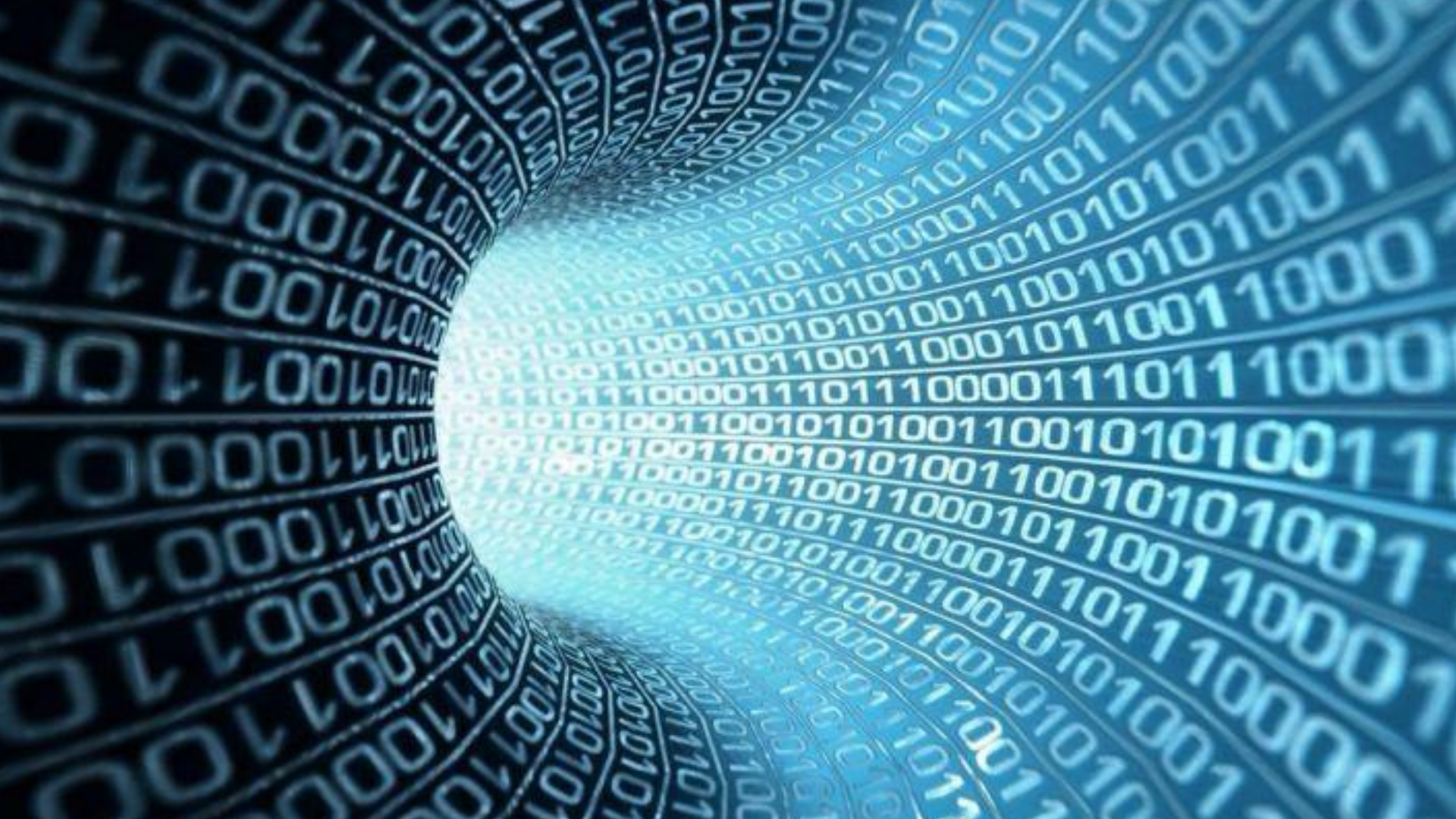
5. The technology space
6. Complementarity & Matching
7. Innovation policy and diversification
8. A framework for Smart R&I
9. Data, data, data



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7. Innovation policy and diversification
8. A framework for Smart R&I
9. Data, data, data
10. Your big challenge