Lecture 15

Urban Hierarchy and Division of Labor in and Across Cities

15.2 Professional and Business Hierarchies and the Productivity of Cities

Observe the accommodation of most day laborers in a civilized and thriving country, and you will perceive that the number of people of whose industry a part, though but a small part, has been employed in procuring him this accommodation, exceeds all computation. […]

if we examine, all these things, and consider what a variety of labour is employed about each of them, we shall be sensible that without the assistance and co-operation of many thousands, the very meanest person in a civilized country could not be provided

Adam Smith (wealth of nations, ch 2)
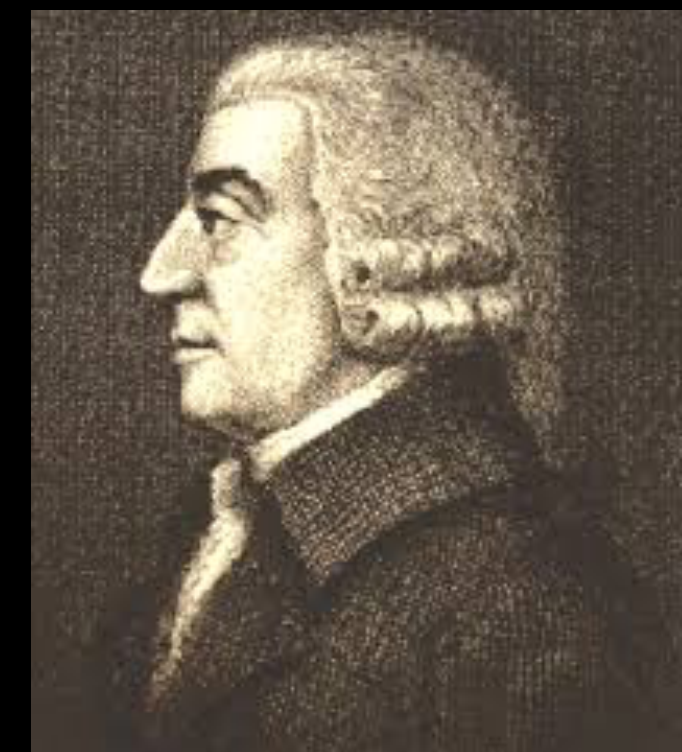
Professions in the USA

Chart 1. Employment and Annual Mean Wages for the Largest U.S. Occupations, May 2010

https://www.bls.gov/news.release/archives/ocwage_05172011.pdf
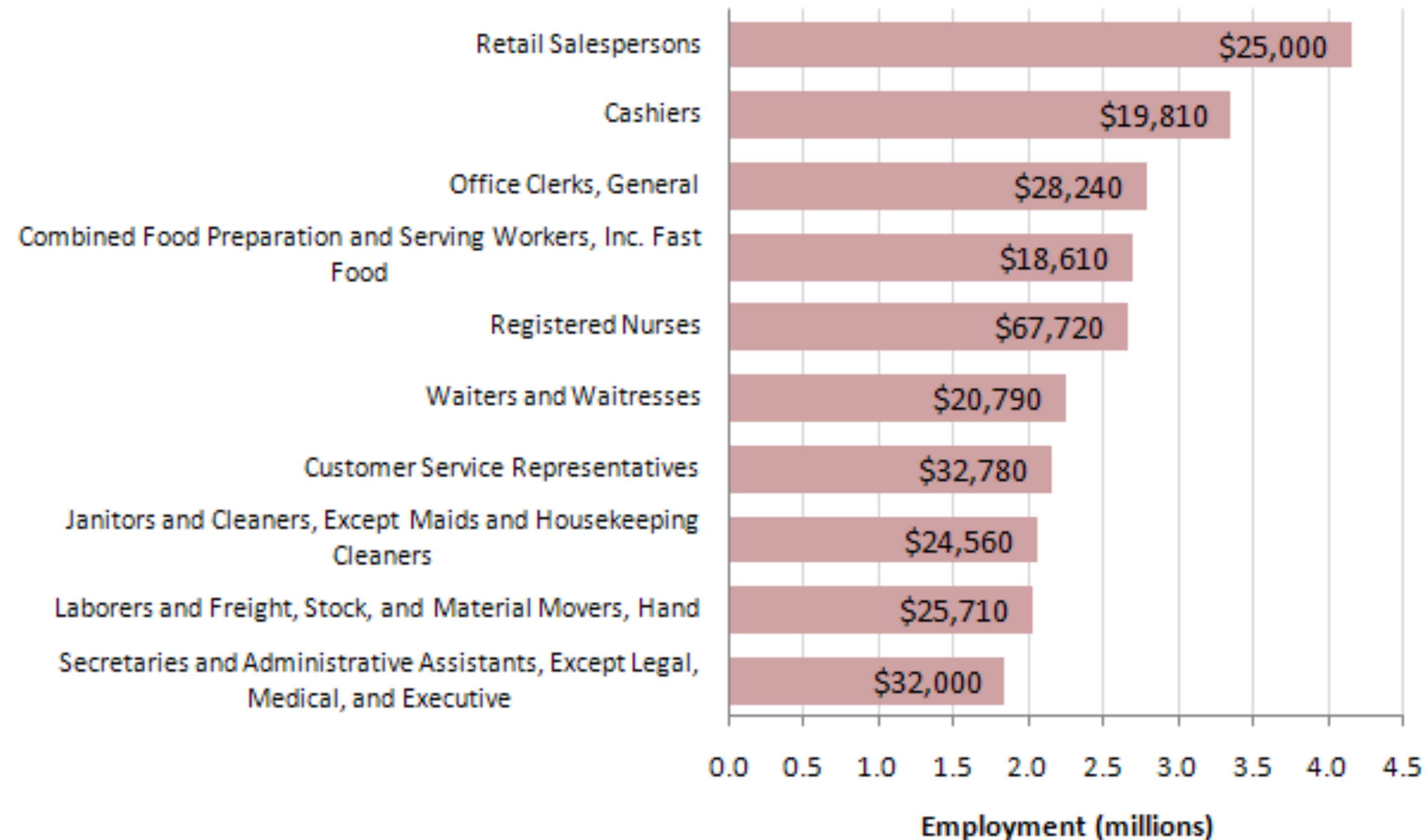
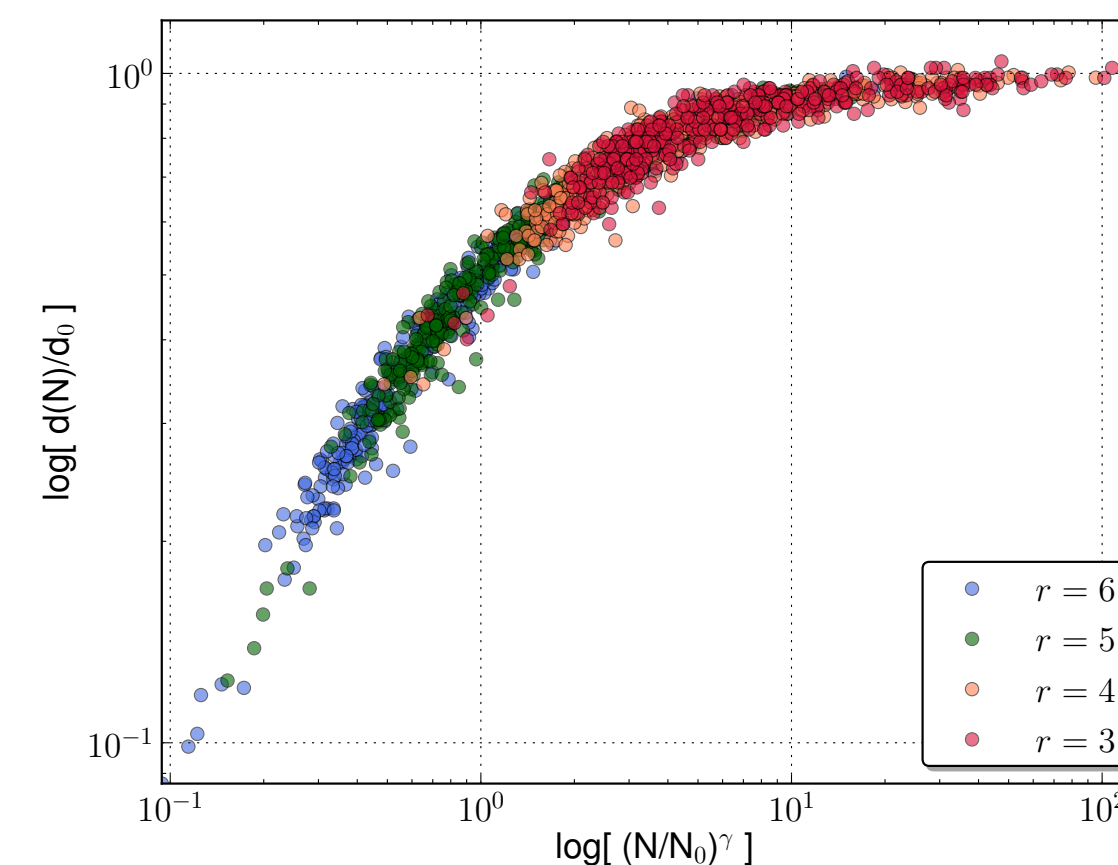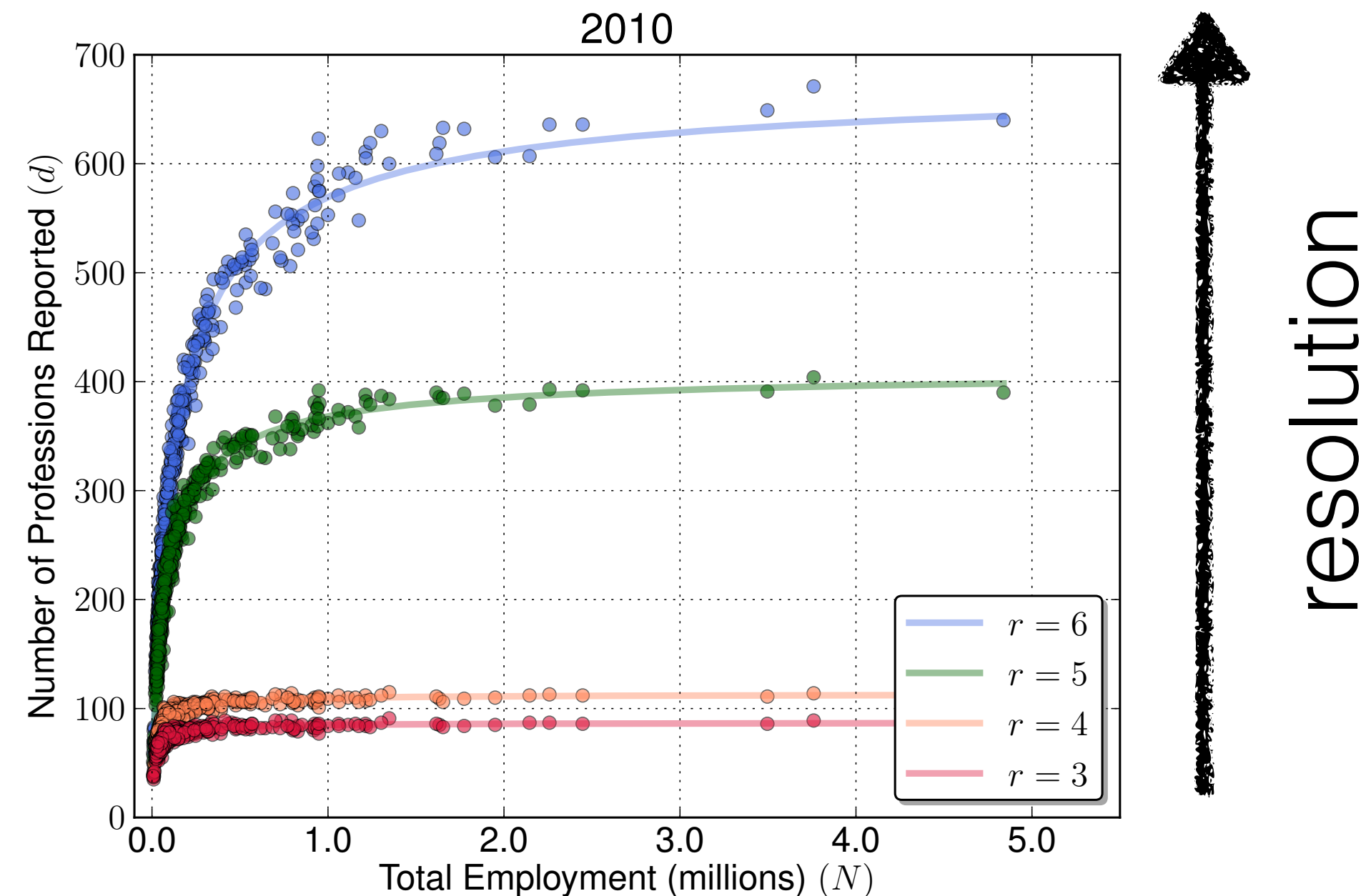# Professional Diversity and Classification Resolution

Occupations in US Metropolitan Statistical Areas

A good fit at all resolutions:

$$D(N_e) = d_0 \frac{\left(\frac{N_e}{N_0}\right)^\gamma}{1 + \left(\frac{N_e}{N_0}\right)^\gamma}.$$

occupation richness

$$\gamma = 1 - \delta \simeq \frac{5}{6}$$

https://www.nature.com/articles/srep05393

resolution

Inferring actual diversity $D(N)$:

$$D(N) = d_0 h\left(\frac{N}{N_0}\right)\left(\frac{N}{N_0}\right)^{\gamma} \rightarrow \begin{cases} D_0 N^{\gamma}, & N \ll N_0, \\ d_0(r), & N \gg N_0, \end{cases}$$
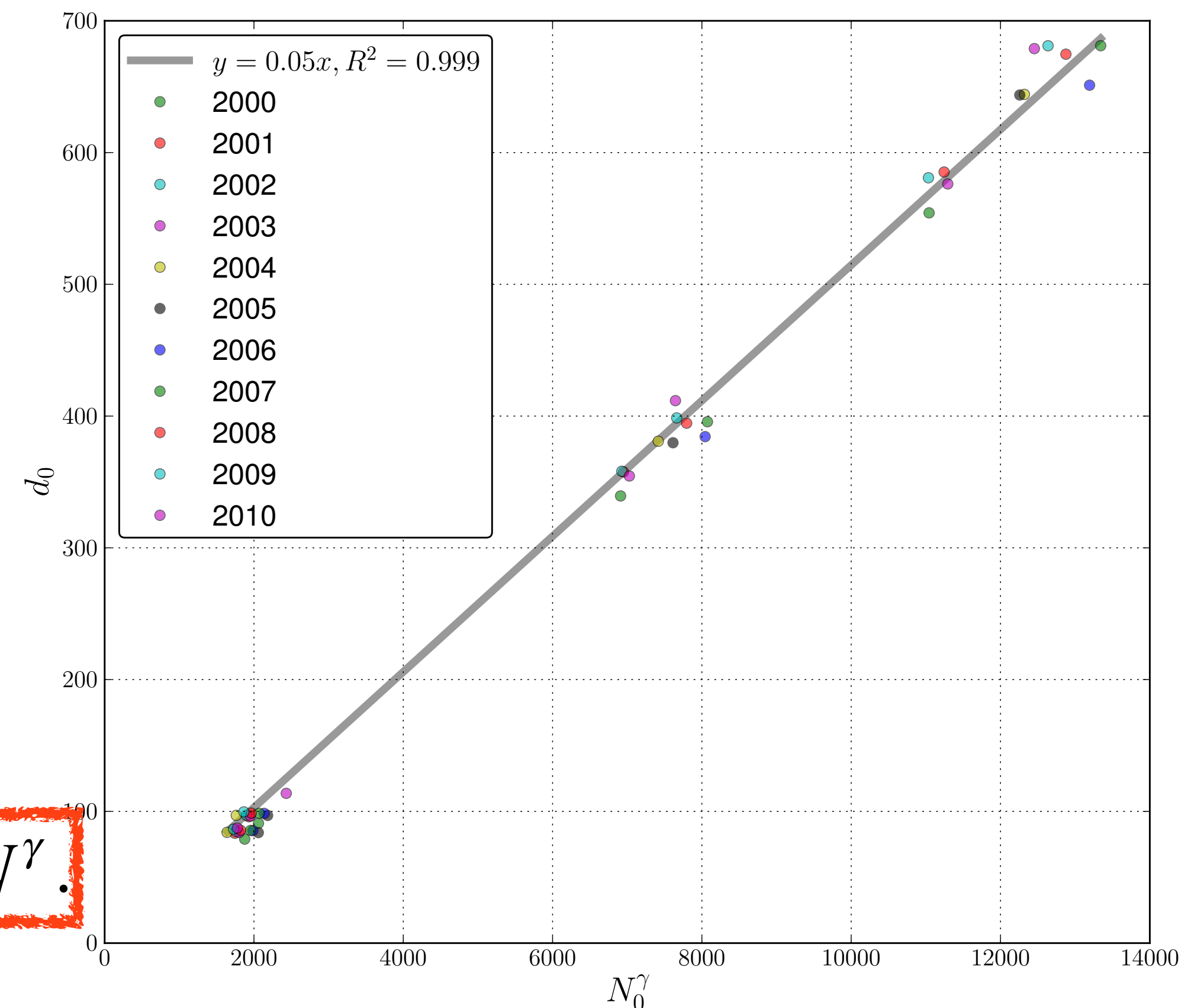
In the limit:

$$\frac{N}{N_0} \rightarrow 0; \qquad h \rightarrow 1, \qquad D_0 \rightarrow \frac{d_0}{N_0{}^{\gamma}}$$

In the limit:

$$\frac{N}{N_0} \rightarrow +\infty; \qquad h \rightarrow \left(\frac{N_0}{N}\right)^{\gamma},$$

A scaling limit exists iff:

$$D_0 \rightarrow \frac{d_0}{N_0{}^{\gamma}} = const. \quad \text{with} \quad \boxed{D(N) = D_0 N^{\gamma}.}$$
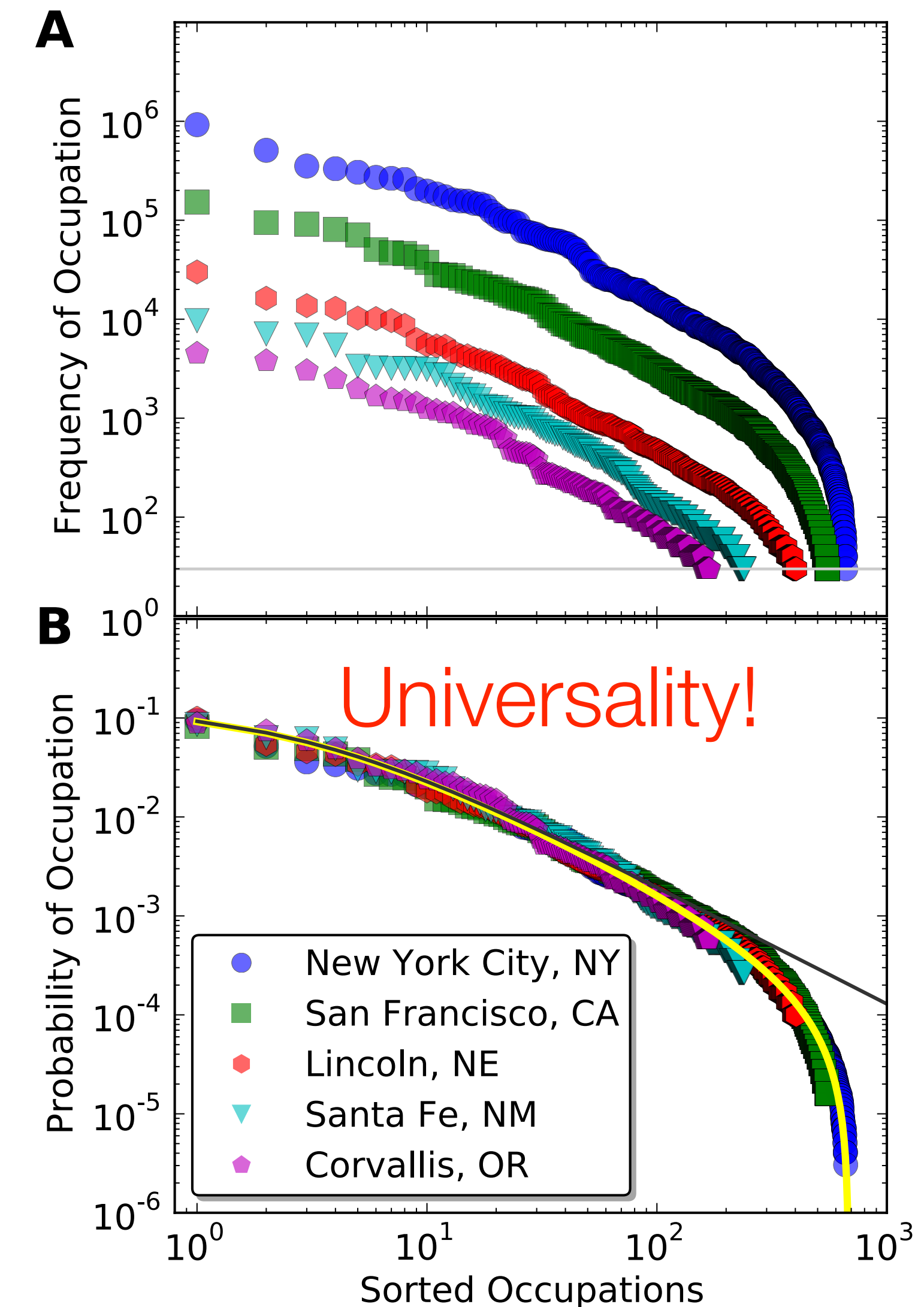
The rank size distribution of professions

From $D(N)$, for all N, derive frequency distribution

$$f(i) = \frac{N_e}{N_0} \left(\frac{d_0 - i}{i} \right)^{1/\gamma}.$$

$$p(i) = \frac{f(i)}{\sum_{j=1}^{D(N)} f(j)} = \frac{1-\gamma}{\gamma} \frac{i^{-1/\gamma}}{1 - D(N)^{-\frac{1-\gamma}{\gamma}}};$$

A — Frequency of Occupation vs Sorted Occupations

B — Probability of Occupation vs Sorted Occupations

Universality!

- New York City, NY
- San Francisco, CA
- Lincoln, NE
- Santa Fe, NM
- Corvallis, OR

Professional Diversity and Urban Productivity

Specialization and Division of Labor
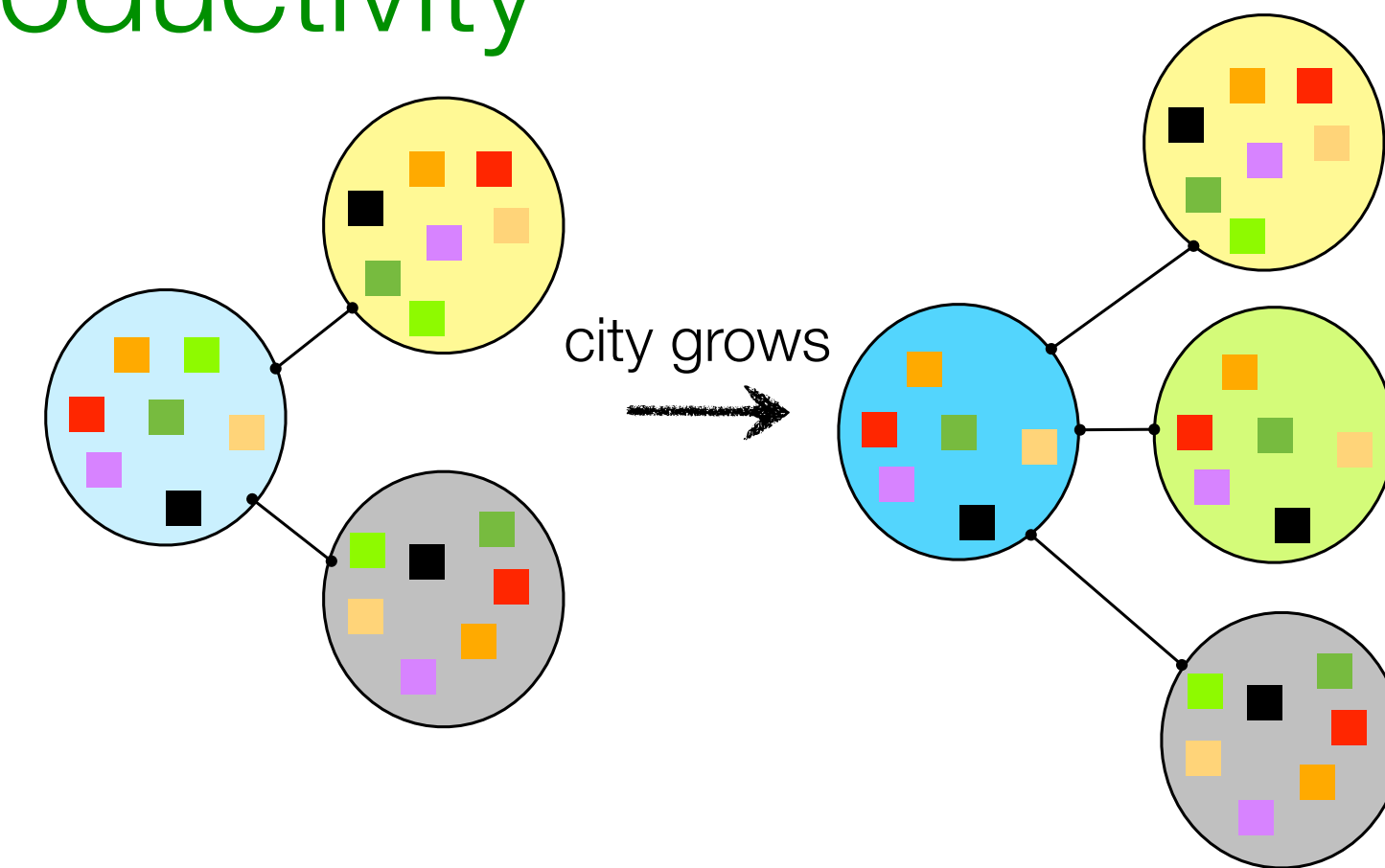as sources of increases in urban productivity

$$D/N = D_0 N^{-\delta}$$

specialization

$$y = Y_0 N^{\delta} = G \ I(N)$$

productivity

interactions per capita

city grows

$$I(N) * \frac{D(N)}{N} = F$$
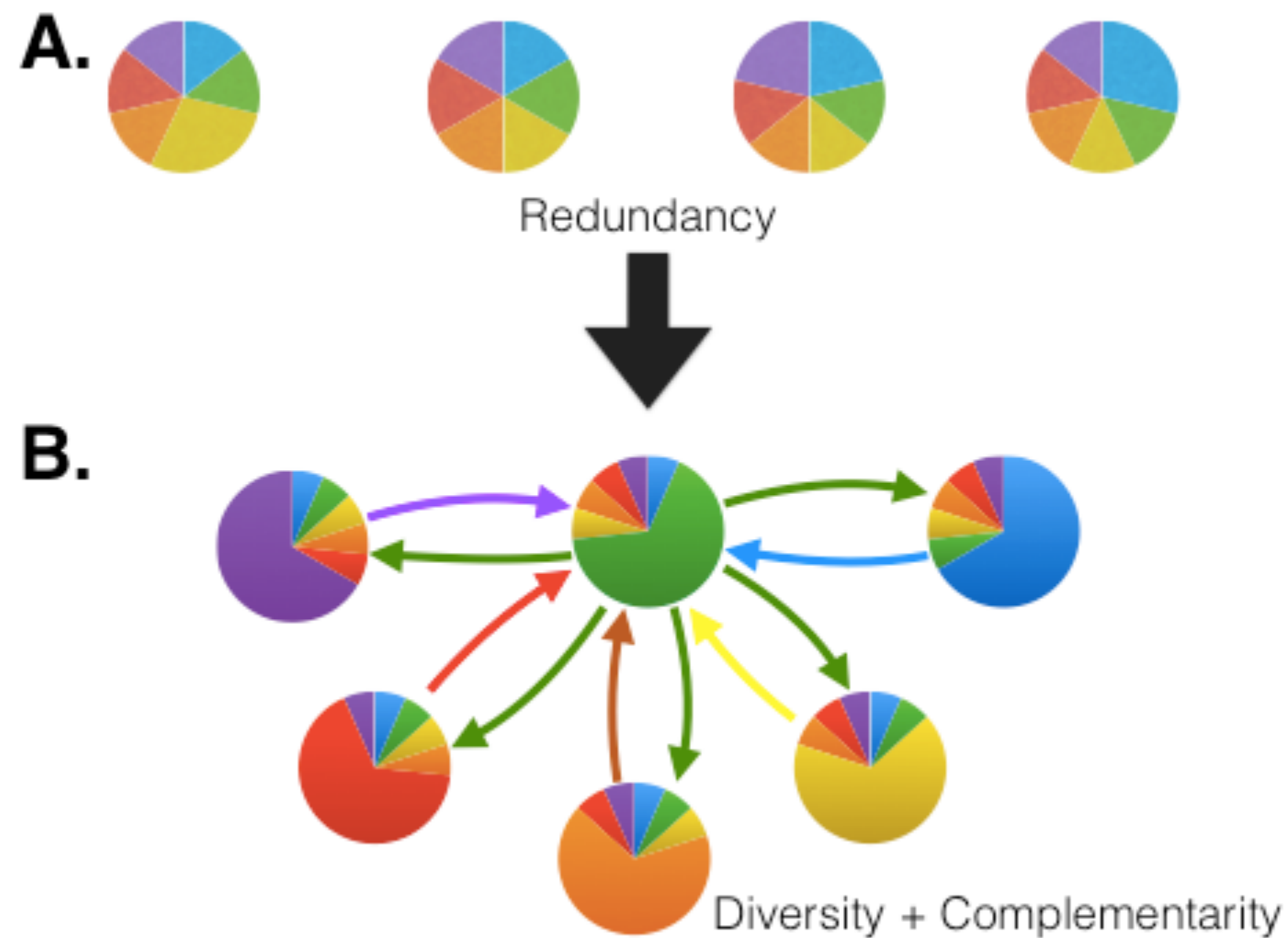
independent of city size

better quality, more segmented functions

In a larger city I get more different things from more different people, to satisfy same needs
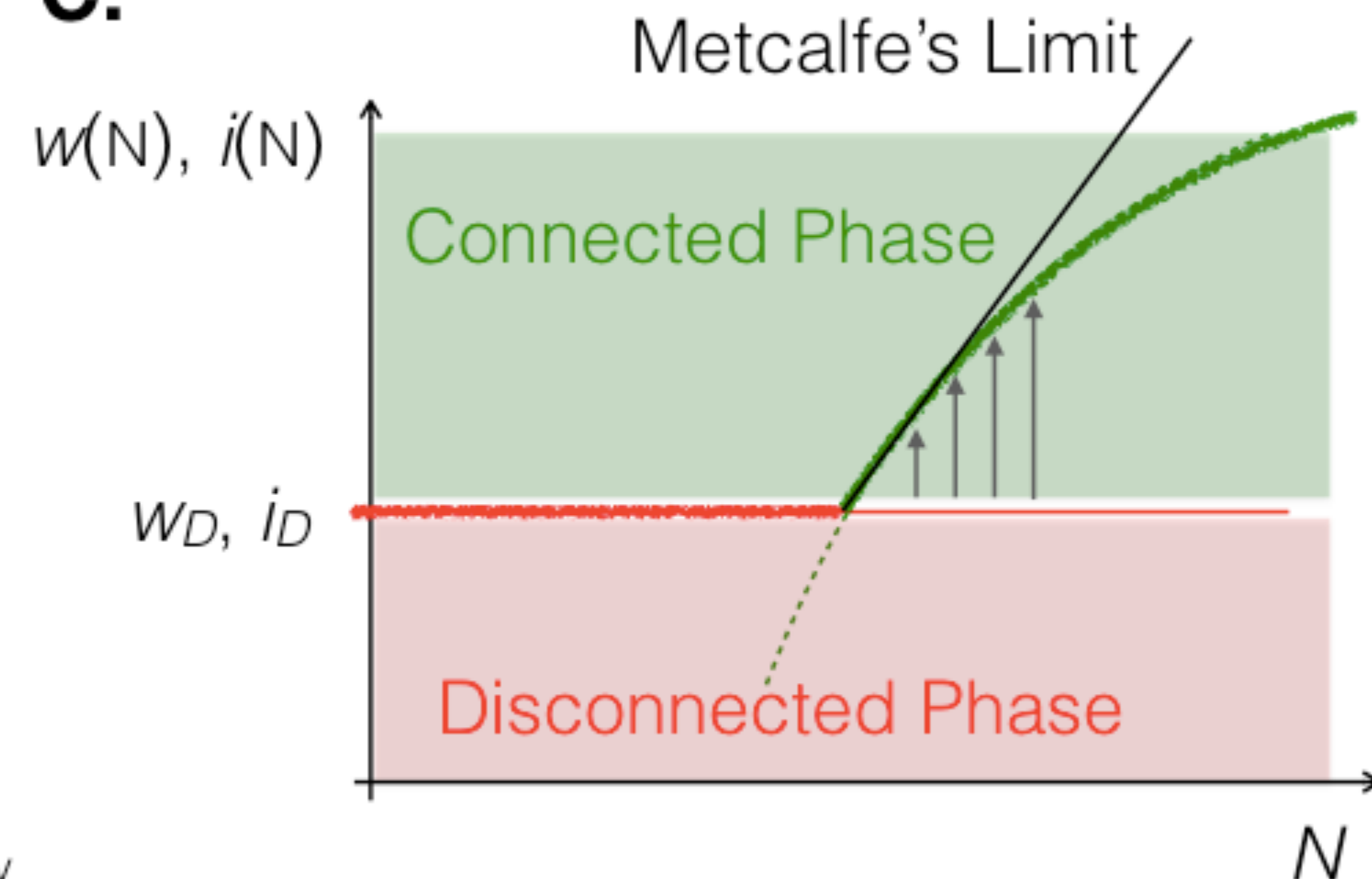
Information, Connectivity & Productivity Growth

Poor

A. Redundancy

B. Diversity + Complementarity

Rich

C.

$w(N), i(N)$

Metcalfe's Limit

Connected Phase

w_D, i_D

Disconnected Phase

N

Interconnected human societies
contain more information at higher connectivity costs

CHARACTERISTICS OF COMPLEX NETWORK PHASES

Symbol	Node Property	Disconnected Phase	Connected Phase
k	connectivity (degree)	k_D (small)	$k(N) = k_c(t)N^\delta$ (increasing)
d	number of functions	d_D (large)	$d(N) = d_c(t)N^{-\delta}$ (decreasing)
i	information	i_D (small)	$i(N) = i_c(t)N^\delta$ (increasing)
w	productivity	w_D (low)	$w(N) = w_c(t)N^\delta$ (increasing)
t	time per function	t_D (small)	$t(N) = t_c(t)N^\delta$ (increasing)
c	cost per connection	c_D (large)	$c(N) = c_c(t)N^\delta$ (increasing)

Metcalfe's limit of the connected phase is obtained as $\delta \to 1$, see Figure 1.

In a real sense all life is inter-related.

All people are caught in an inescapable network of mutuality, tied in a single garment of destiny.

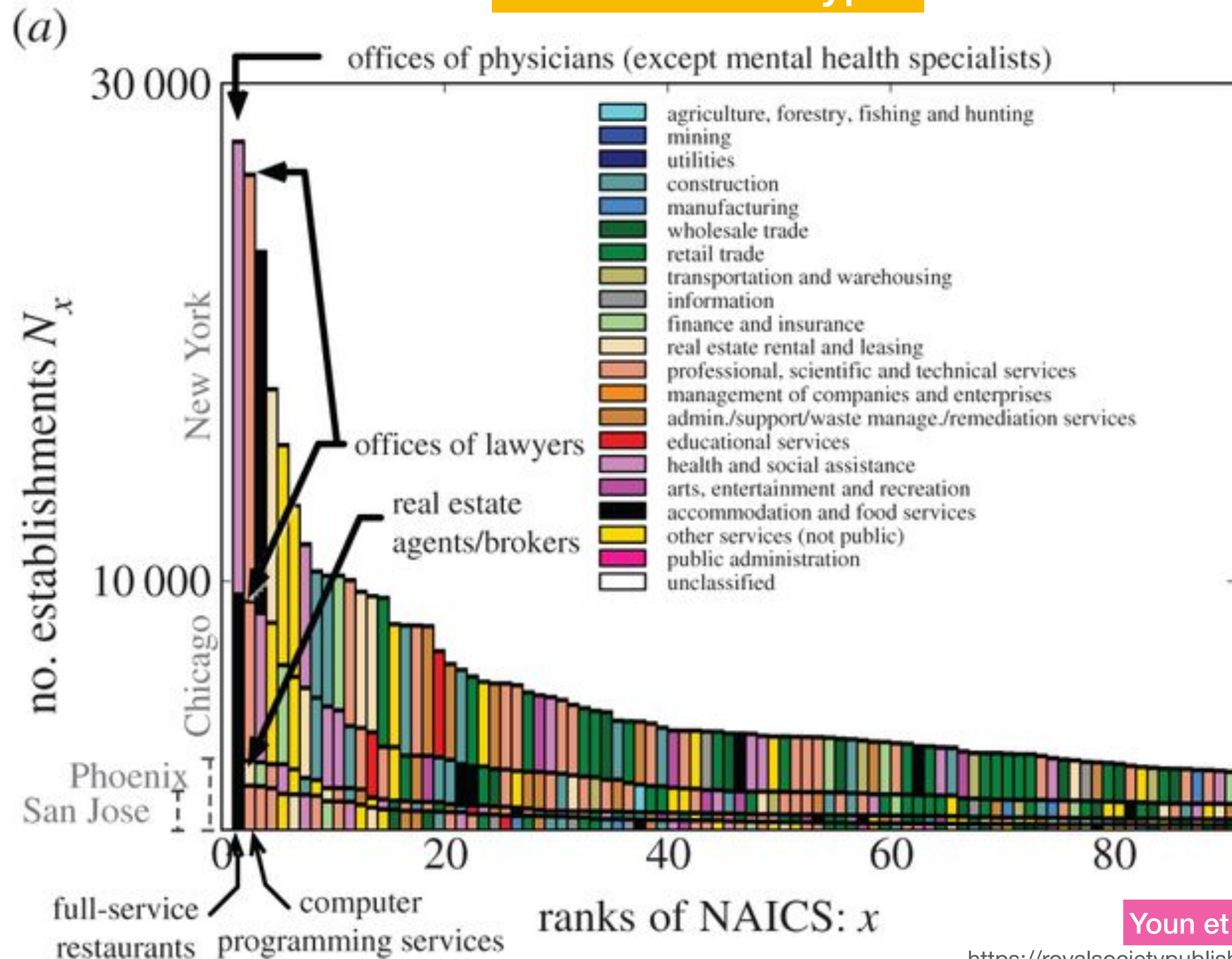Whatever affects one directly, affects all indirectly.

I can never be what I ought to be until you are what you ought to be, and you can never be what you ought to be until I am what I ought to be...

This is the inter-related structure of reality.

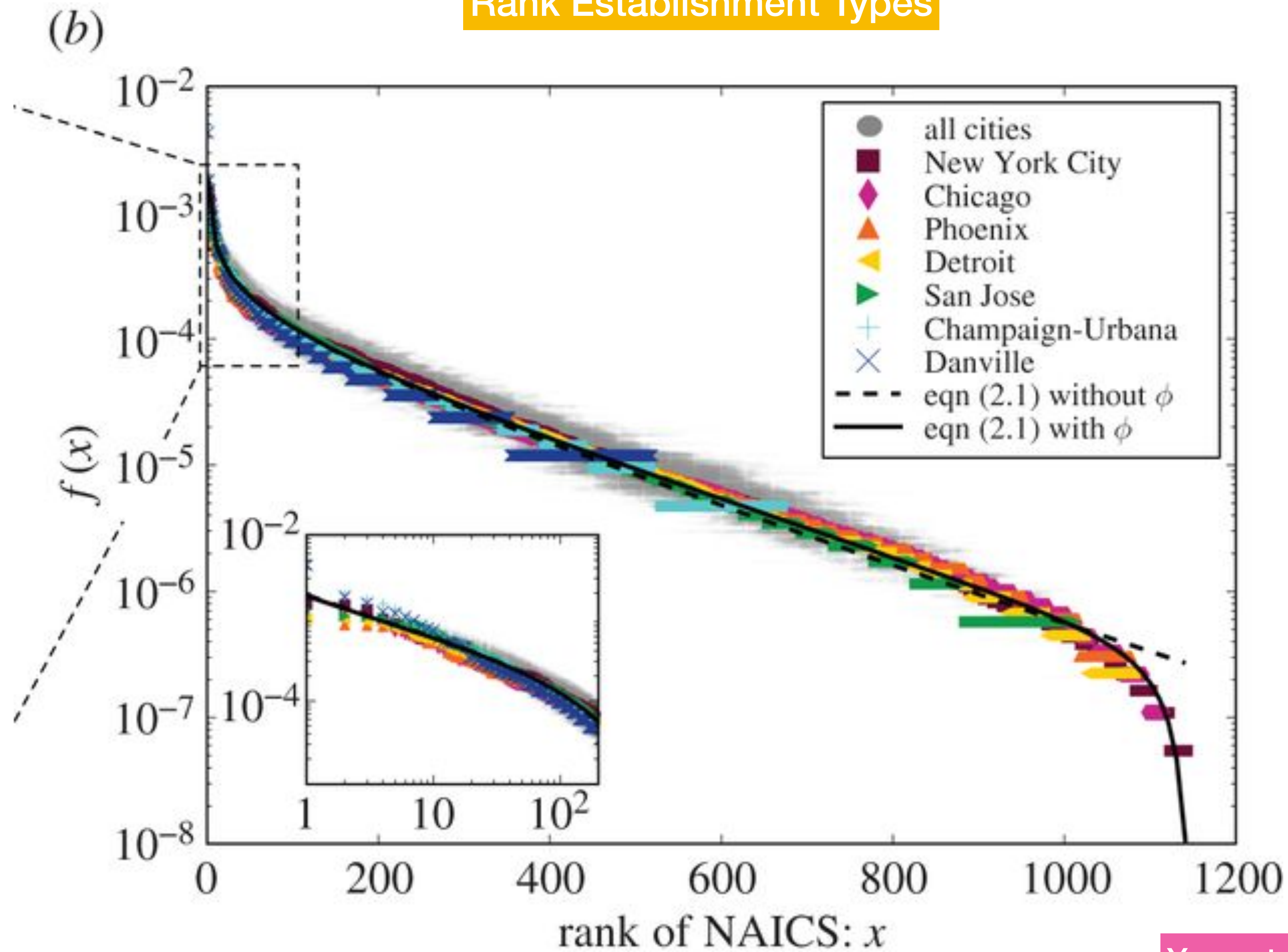- Martin Luther King Jr, Letter from Birmingham Jail.
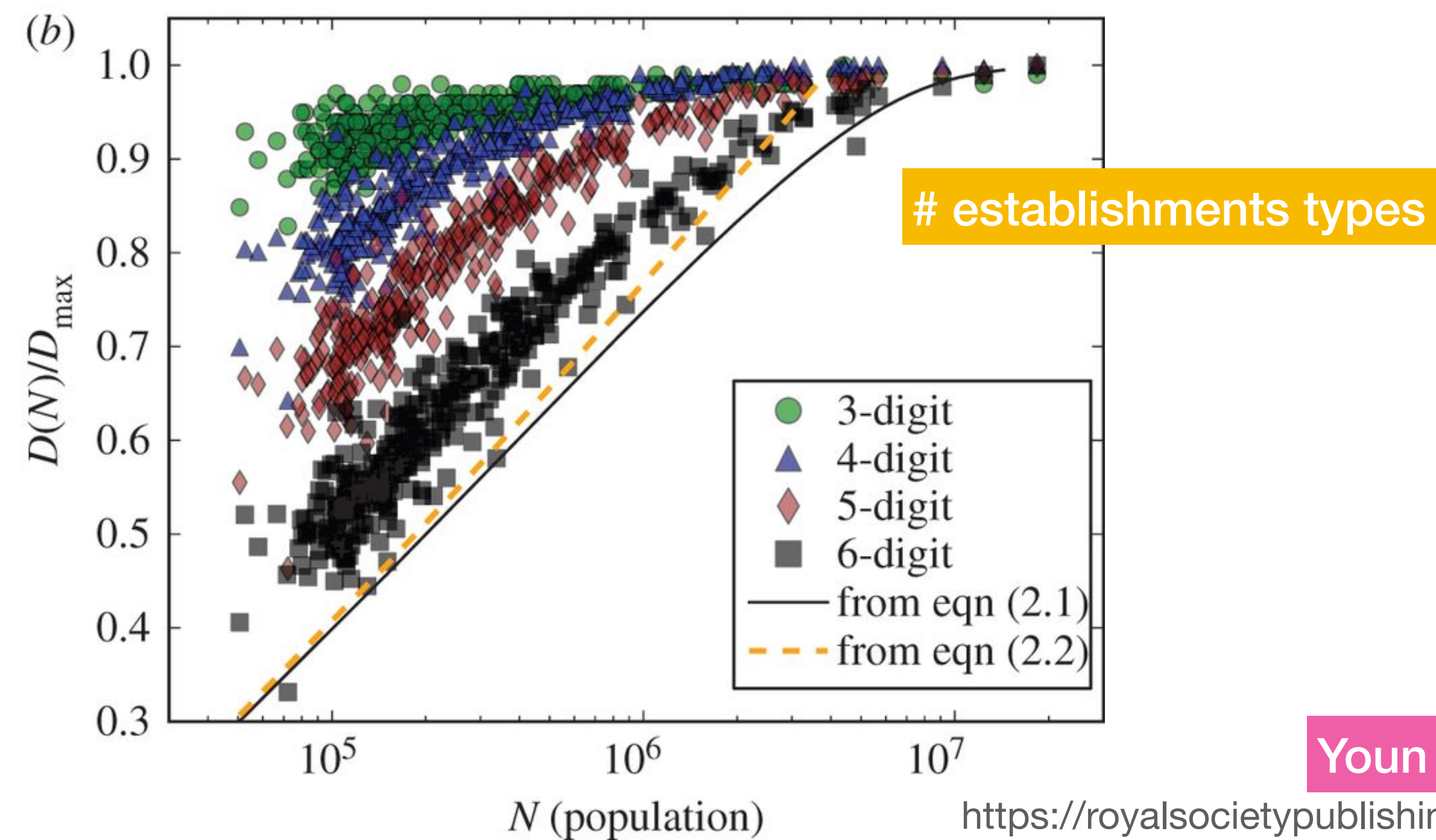
Business Diversity

Establishment Types

(a) offices of physicians (except mental health specialists)

no. establishments N_x

30 000

10 000

New York

Chicago

Phoenix

San Jose

Legend:
- agriculture, forestry, fishing and hunting
- mining
- utilities
- construction
- manufacturing
- wholesale trade
- retail trade
- transportation and warehousing
- information
- finance and insurance
- real estate rental and leasing
- professional, scientific and technical services
- management of companies and enterprises
- admin./support/waste manage./remediation services
- educational services
- health and social assistance
- arts, entertainment and recreation
- accommodation and food services
- other services (not public)
- public administration
- unclassified

offices of lawyers

real estate agents/brokers

full-service restaurants

computer programming services

ranks of NAICS: x

0   20   40   60   80

(a) number of establishments

(b) # establishments types

Legend:
- 3-digit (green circle)
- 4-digit (blue triangle)
- 5-digit (red diamond)
- 6-digit (black square)
- from eqn (2.1) (solid line)
- from eqn (2.2) (dashed line)

Youn et al 2016
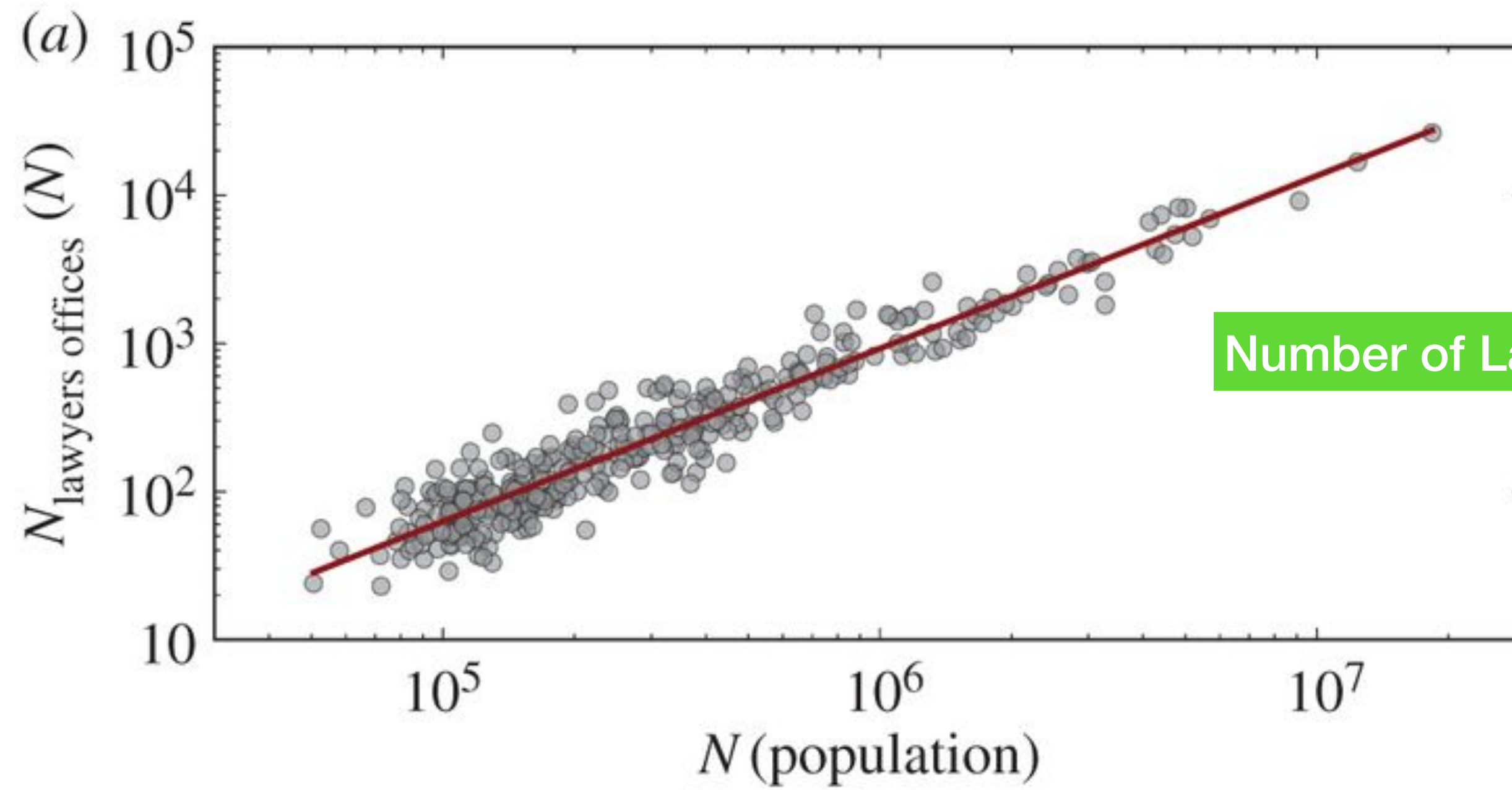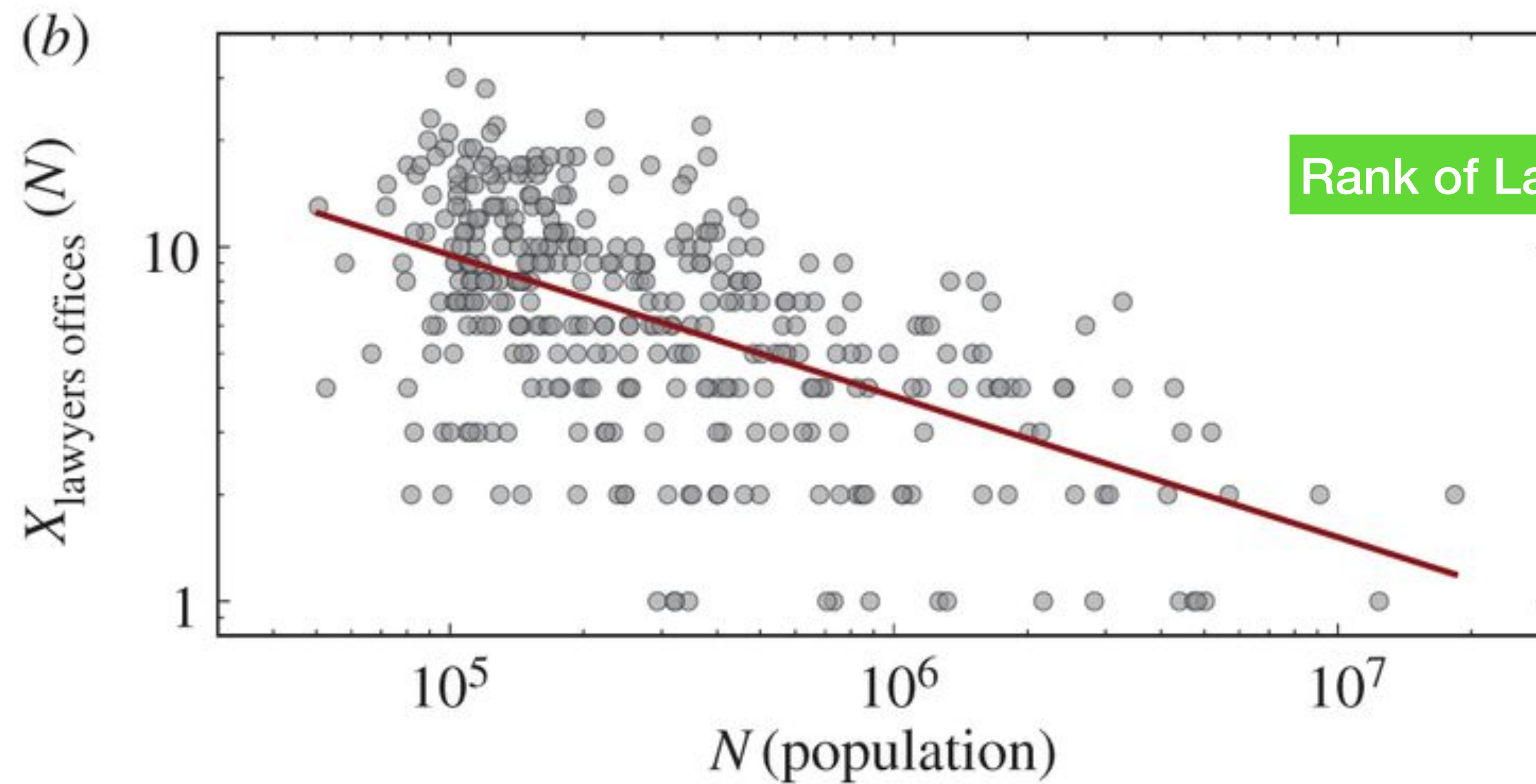
https://royalsocietypublishing.org/doi/10.1098/rsif.2015.0937

Scale each business type on population

(a) Number of Lawyers Offices

(b) Rank of Lawyers Offices

Youn et al 2016

https://royalsocietypublishing.org/doi/10.1098/rsif.2015.0937

(c)

Figure (c): Histogram of scaling exponents across industry sectors. Sectors labelled include agriculture, forestry, fishing and hunting; transportation and warehousing; accommodation and food services; public administration; retail; other services; education; utility; mining; management of companies and enterprises; professional, scientific, tech. services. X-axis: scaling exponents (0.5–1.2). Y-axis: frequency (0–8).

A. Smallest cities / Medium cities (Closest to average population) / Largest cities

https://www.science.org/doi/10.1126/sciadv.aba4934

Recapitulation of Business Sectors

Hong et al 2018

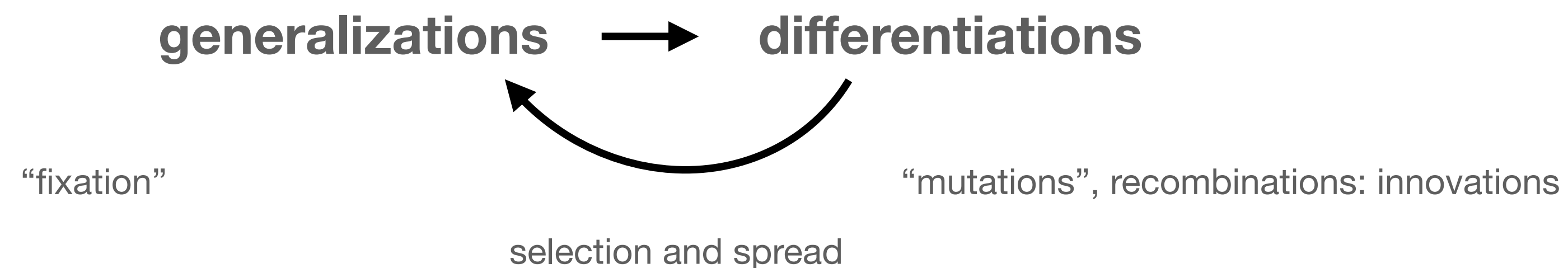https://www.science.org/doi/10.1126/sciadv.aba4934
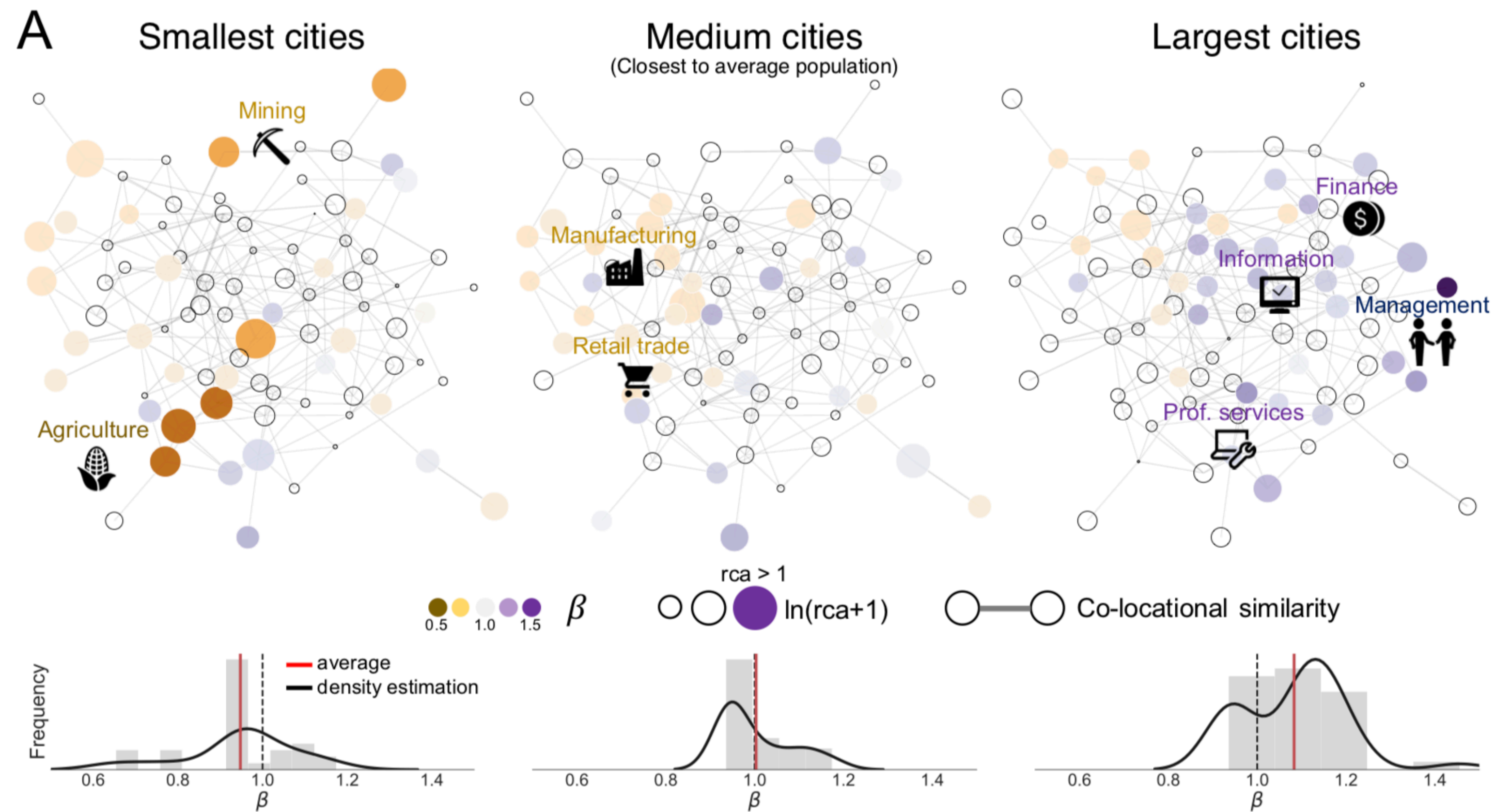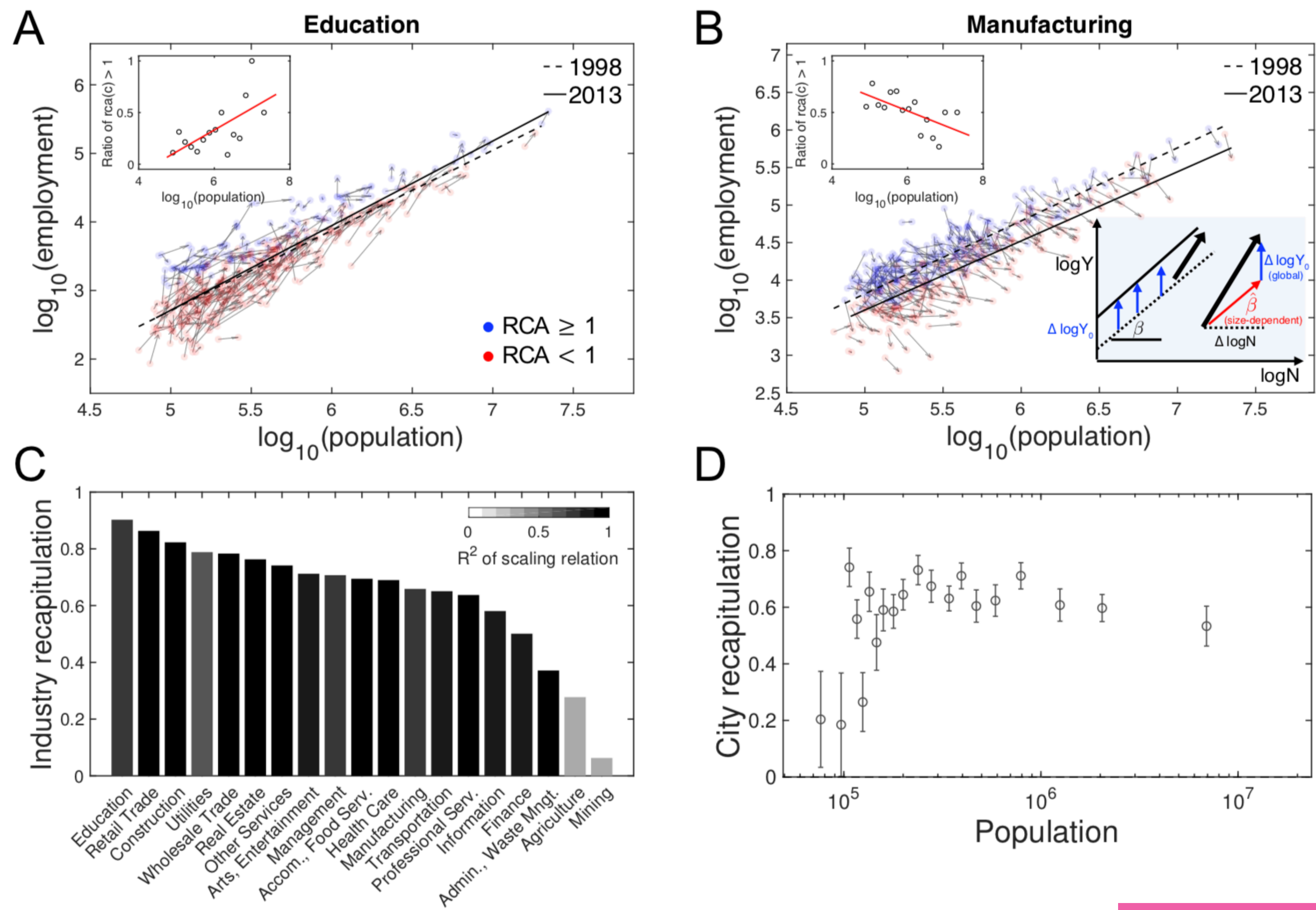
Frank Lennon/Getty Images

I'm convinced that economic life is ruled by processes and principles we didn't invent and can't transcend,

whether we like that or not,

and that the more we learn about these processes and the better we respect them, the better our economies will get along.

- Jane Jacobs, Cities and the Wealth of Nations, 1984

generalizations ➝ **differentiations**

"fixation"   "mutations", recombinations: innovations

selection and spread

functional hierarchy

complementarities + interdependence

Functional Diversity is related to **Complementarities**

Division of labor, knowledge, interdependence

(second reason (Marshall) for agglomeration economies)

This creates an "ecology" of functions in cities that is quite predictable, with small cities disproportionally dedicated to primary sectors and large cities to informational activities

Interactions, degree of specialization and economic productivity are facets of transformation predicted by urban scaling