# Lecture 10

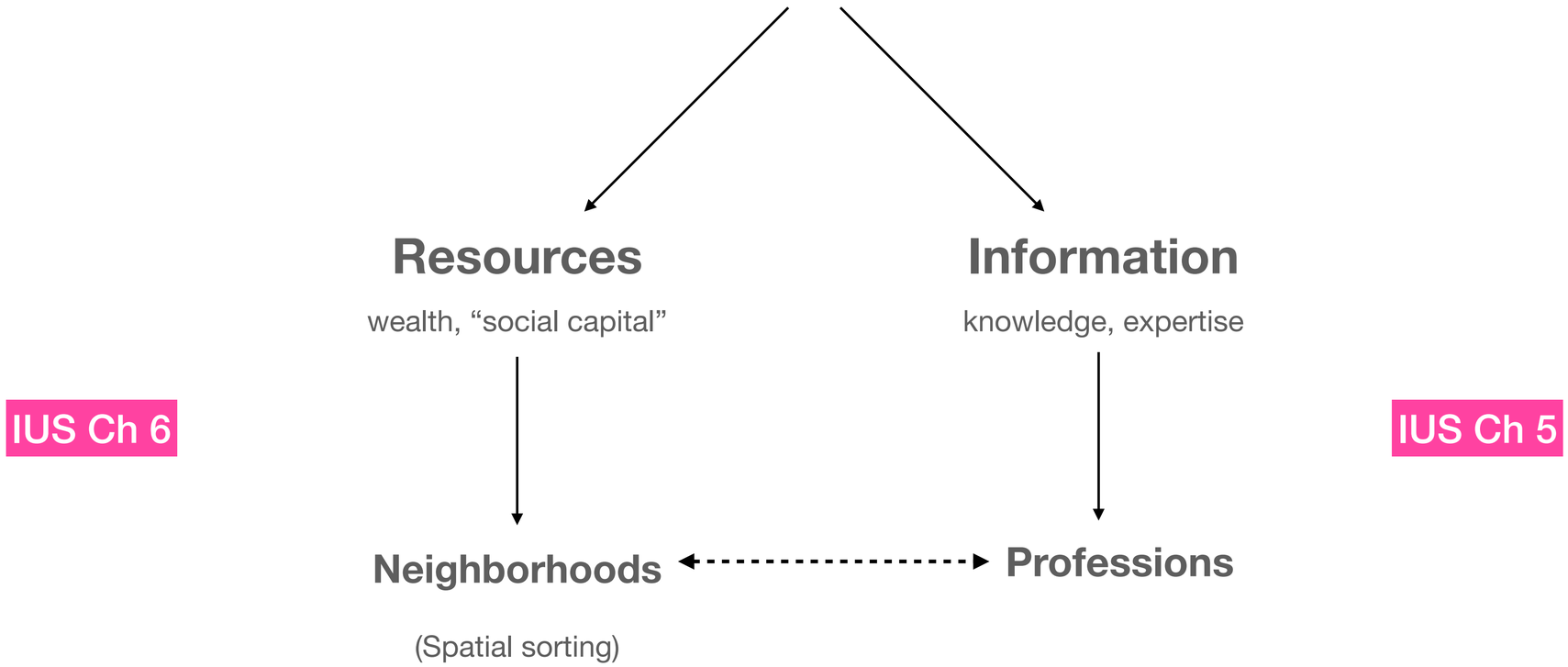
## Looking inside Cities: Professional Diversity and Productivity

## 10.2 Professional and Business Diversity and the Productivity of Cities

IUS 5

Luís M. A. Bettencourt 2023

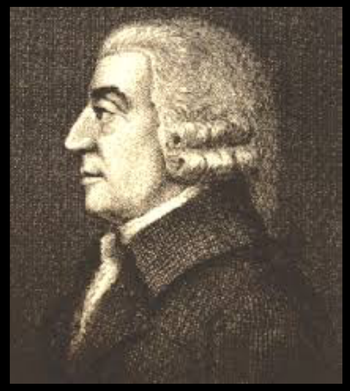
**Inequality and statistics of variation in cities**



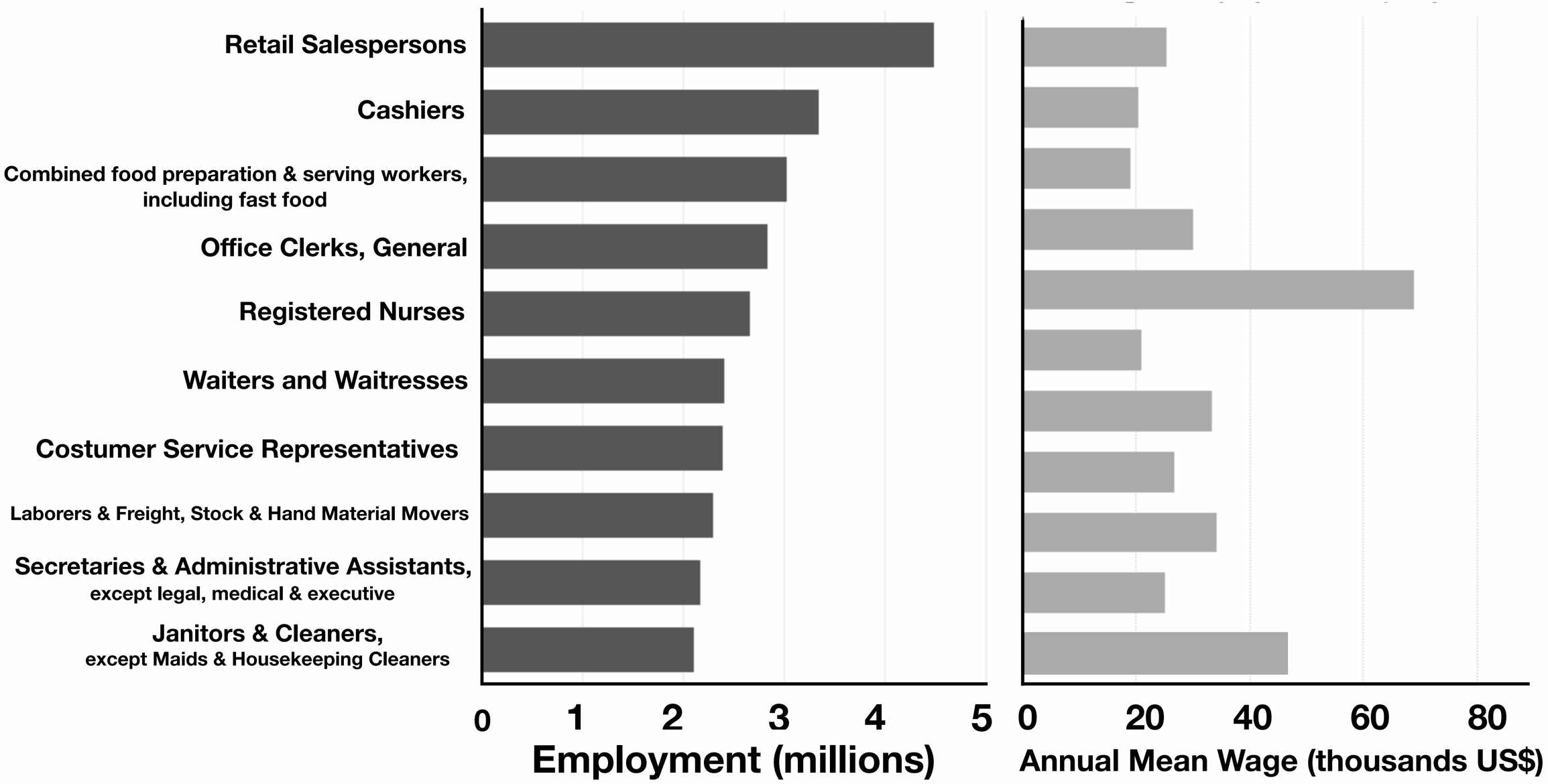
Observe the accommodation of most day laborers in a civilized and thriving country, and you will perceive that the number of people of whose industry a part, though but a small part, has been employed in procuring him this accommodation, exceeds all computation. […]

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)



# Occupations with the highest employment, USA 2013




IUS Fig 5.7

**Sector 71 — Arts, Entertainment, and Recreation** ····· $r_s = 2$

**711 Performing Arts, Spectator Sports, and Related Industries** ····· $r_s = 3$

**7111 Performing Arts Companies** ····· $r_s = 4$

71111 Theater Companies and Dinner Theaters ····· $r_s = 5$

711110 Theater Companies and Dinner Theaters ····· $r_s = 6$

71112 Dance Companies

711120 Dance Companies

71113 Musical Groups and Artists

711130 Musical Groups and Artists

71119 Other Performing Arts Companies

711190 Other Performing Arts Companies

**7112 Spectator Sports**

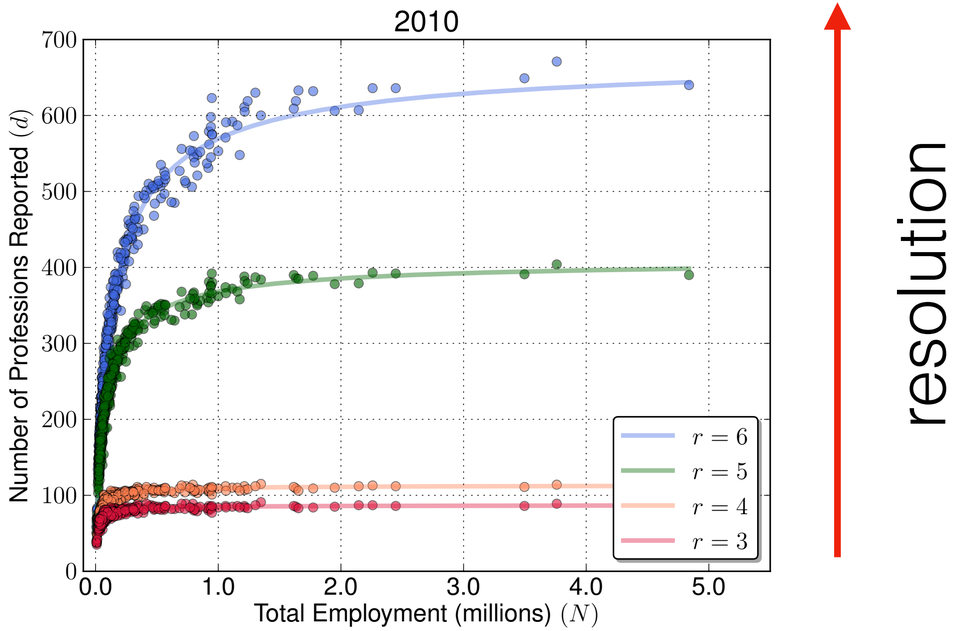
71121 Spectator Sports

711211 Sports Teams and Clubs
711212 Racetracks
711219 Other Spectator Sports

resolution

# Professional Diversity and Classification Resolution

# of different occupations in US Metropolitan Statistical Areas



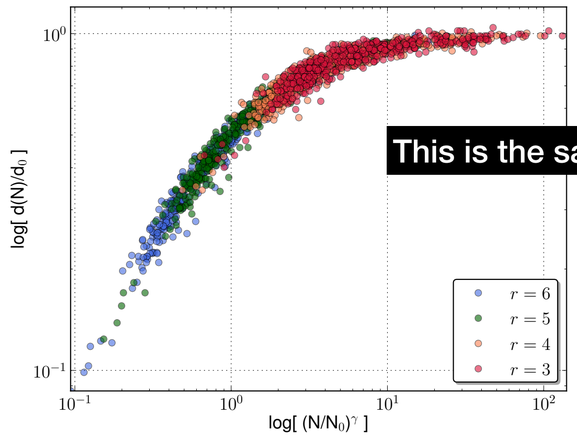

resolution

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: count different professions

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




This is the same curve but with different parameters

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

IUS Fig 5.9

# Inferring actual diversity *D*(*N*):

$$D(N) = d_0 h \left(\frac{N}{N_0}\right) \left(\frac{N}{N_0}\right)^{\gamma} \rightarrow \begin{cases} D_0 N^{\gamma}, & N << N_0, \\ d_0(r), & N >> N_0, \end{cases}$$

In the limit of no saturation:

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

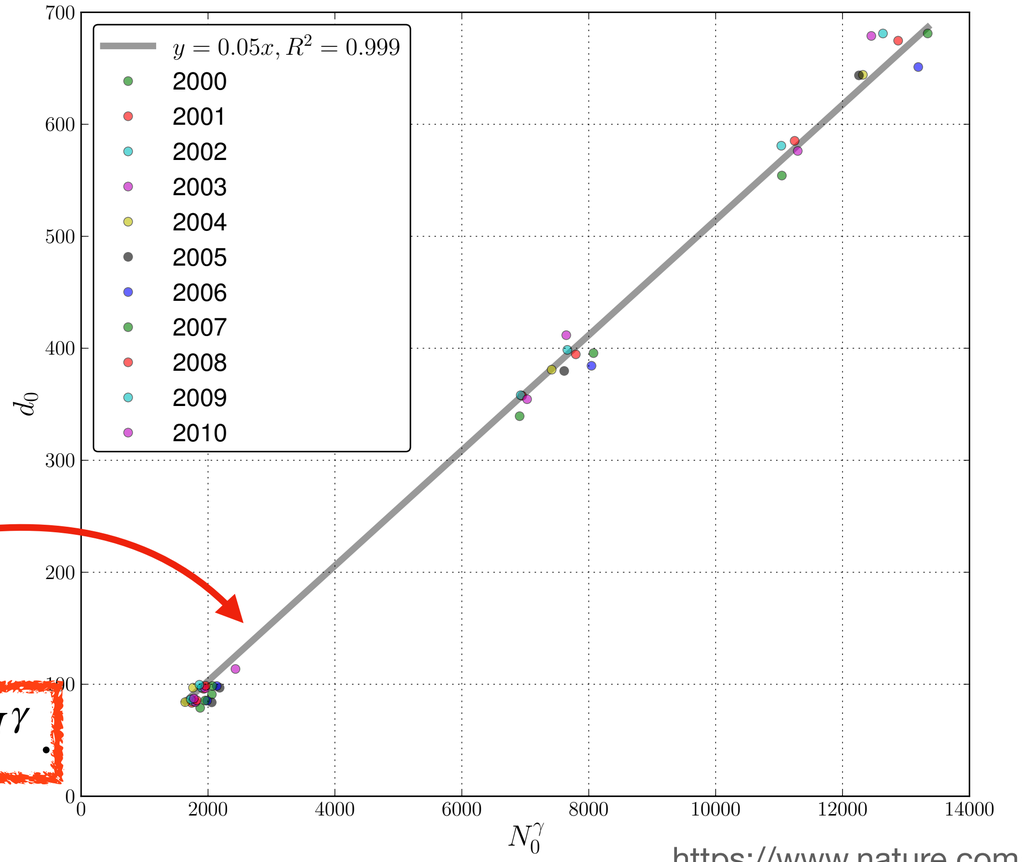
In the limit of full saturation:

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

**A scaling limit exists if:**

$$D_0 \rightarrow \frac{d_0}{N_0{}^{\gamma}} = const.$$ with $$D(N) = D_0 N^{\gamma}.$$

Test !




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

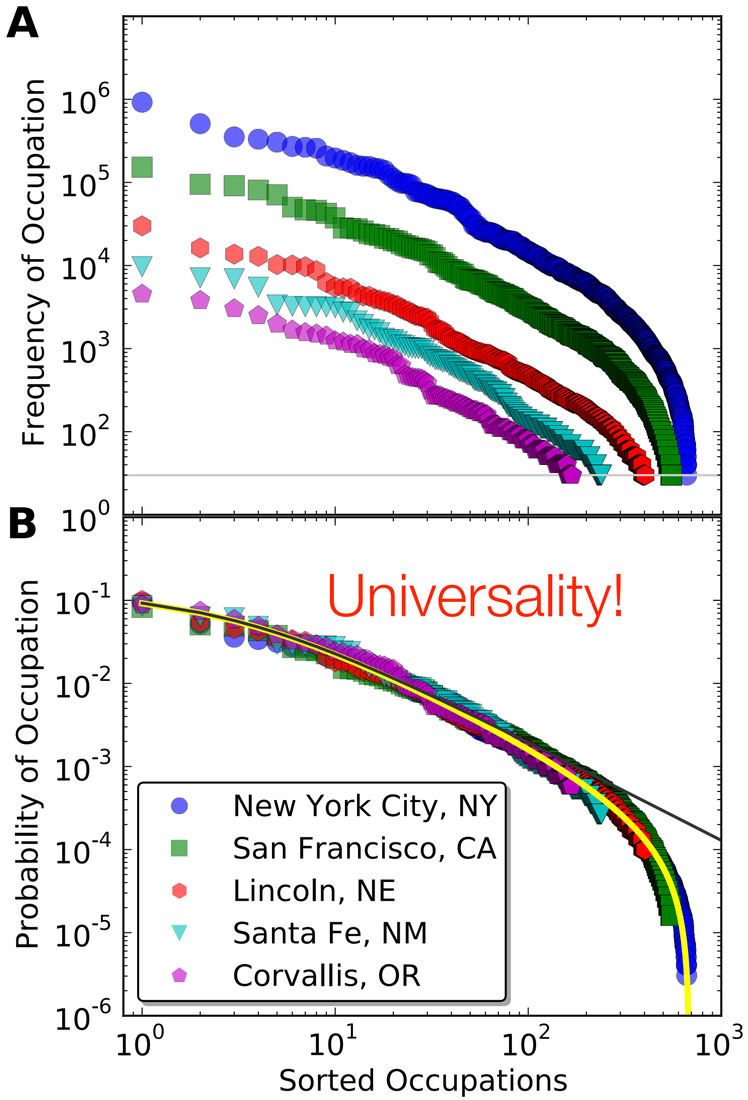
# The distribution of professions (more common / less common)

IUS Fig 5.10

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

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

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




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

# Professional Diversity and Urban Productivity (back to Adam Smith)

## Specialization as the Division of Labor

as sources of increases in urban **productivity**

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

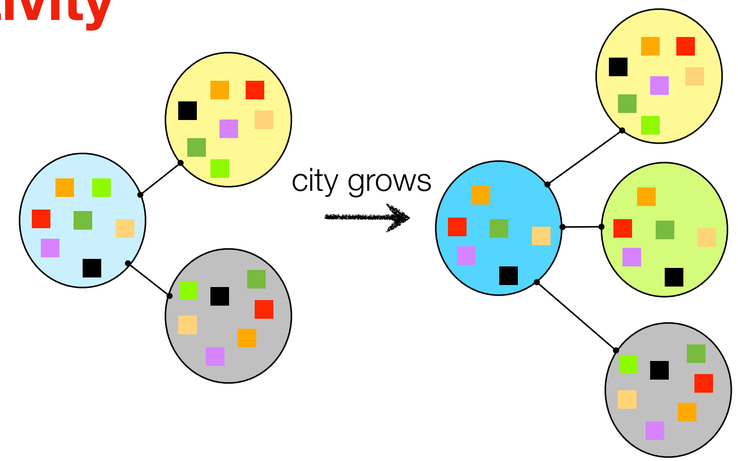
Diversification comes from specialization

specialization

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

productivity

**interactions per capita**




Less specialization
Less information
Less productivity

More specialization
More information
Greater productivity

This tells us that there is an invariant quantity (total functions):

$$y(N) * \frac{D(N)}{N} = F$$

**independent of city size**

**better quality, more segmented functions**

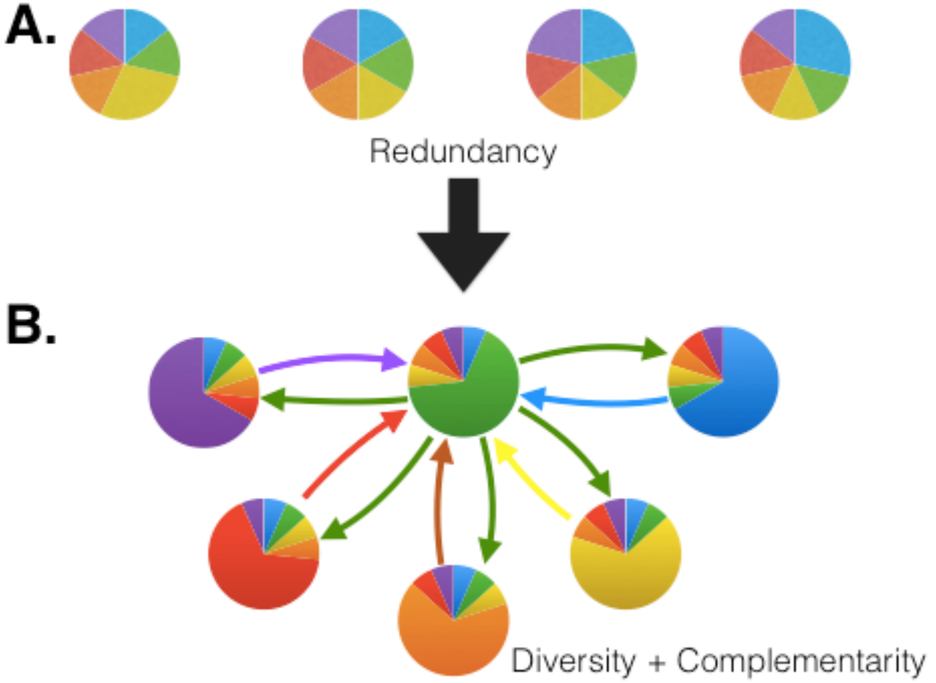
**In a larger city I get more different things from more different people, to satisfy same needs**

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

# **Generalizing:** Information, Connectivity & Productivity

**Poor**

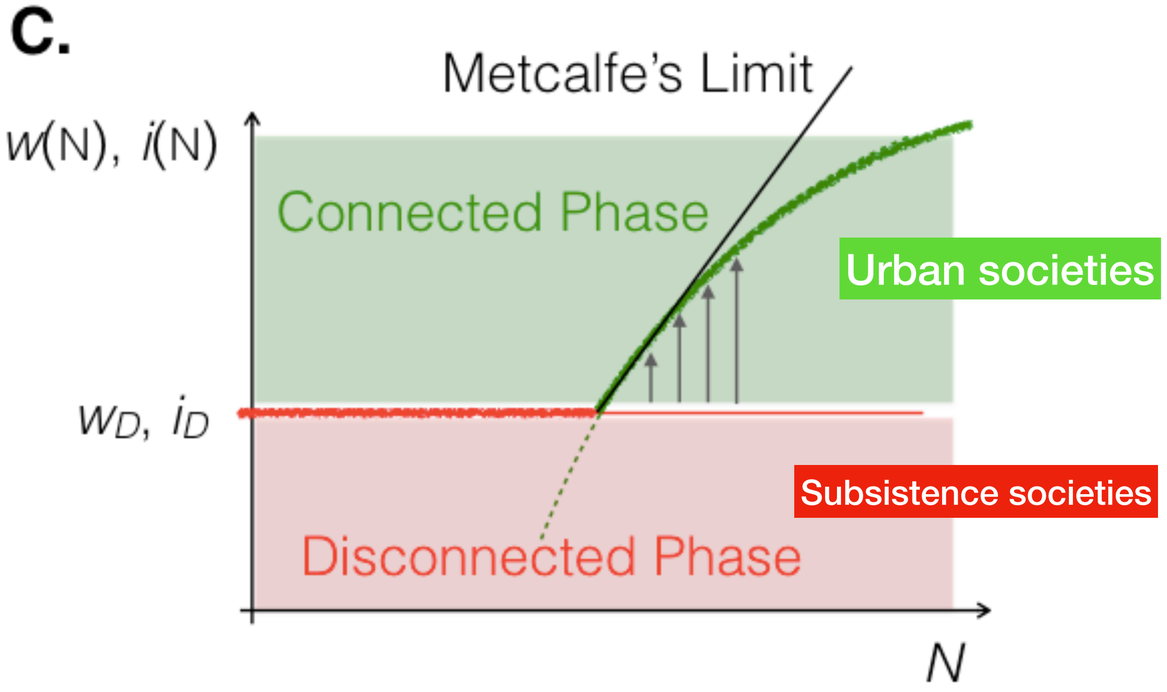
Jack/Jane of all trades




**Rich**

Interdependent, dynamical overload

IUS Fig 5.12




IUS Fig 5.13

https://mae.engr.ucdavis.edu/dsouza/Pubs/PIEEE_vol102_12.pdf#page=8

# A Network Theory of Development:

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 $\delta \rightarrow 1$, see Figure 1.

IUS Table 5.3

https://mae.engr.ucdavis.edu/dsouza/Pubs/PIEEE_vol102_12.pdf#page=8

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.

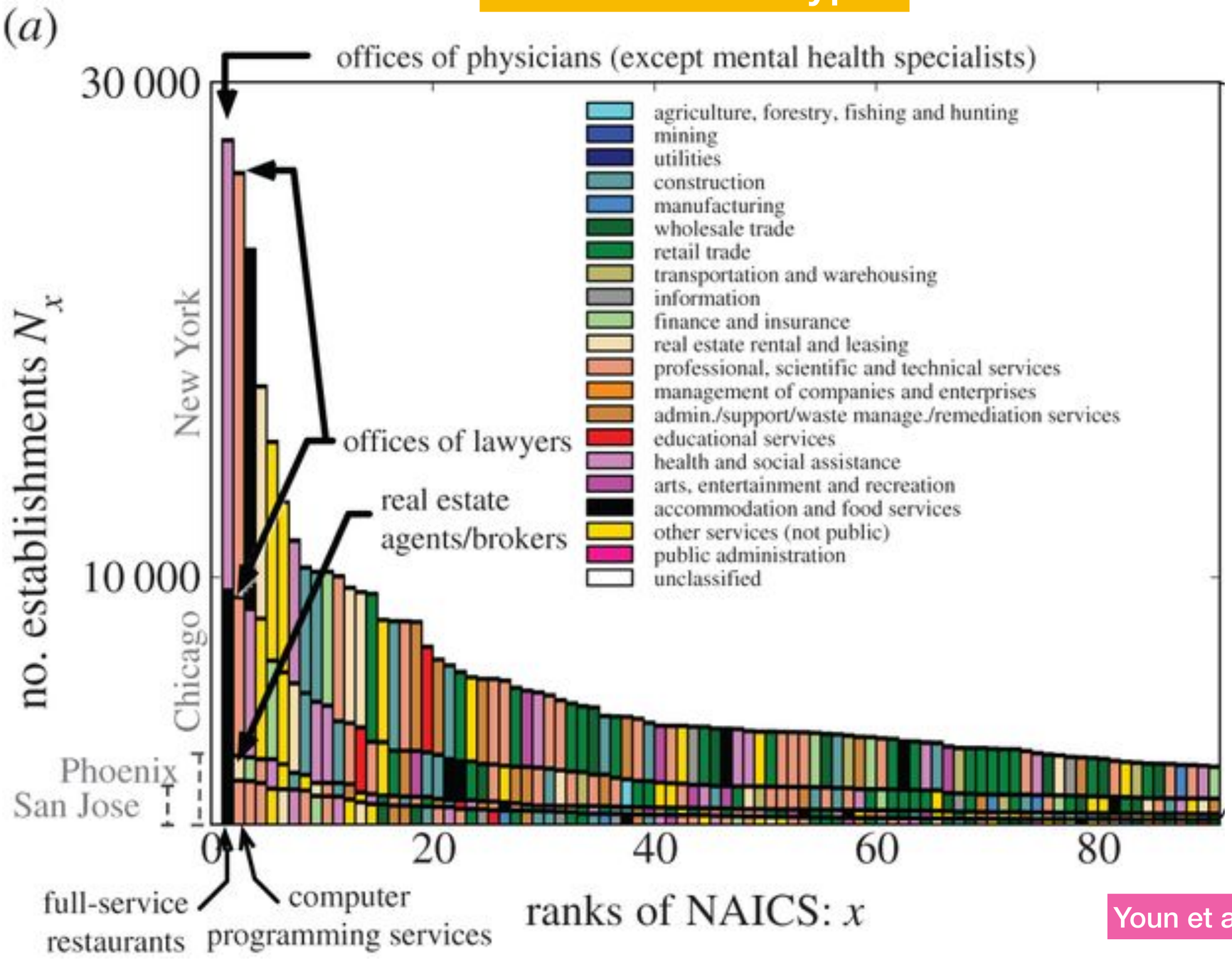
I can never be what I ought to be until you are what you ought to be, and you can never be what you ought to be until I am what I ought to be...

This is the inter-related structure of reality.

- Martin Luther King Jr,  Letter from Birmingham Jail.

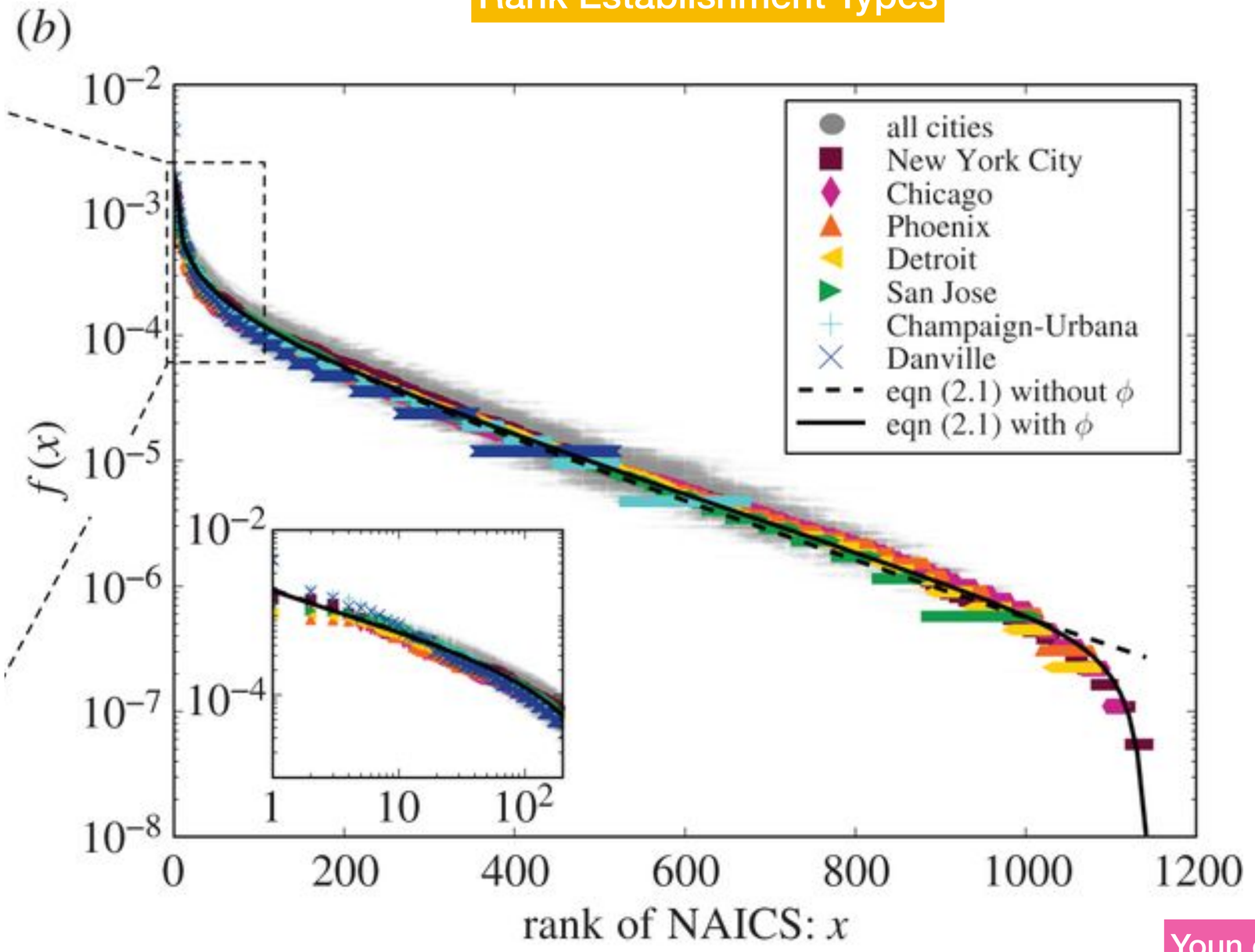
# Business Diversity

# Establishment Types

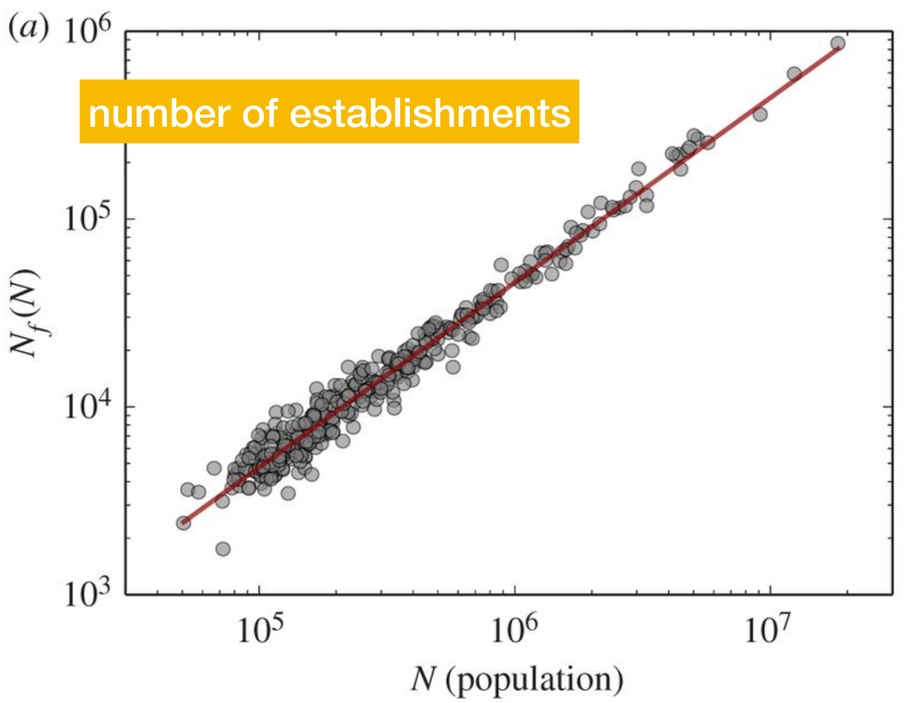


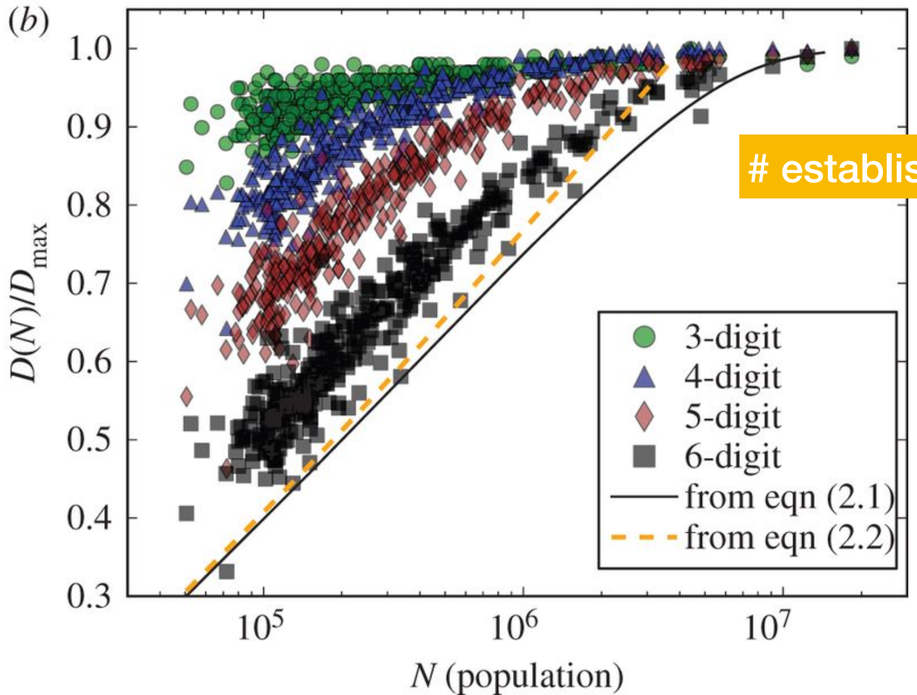

Youn et al 2016

## Rank Establishment Types



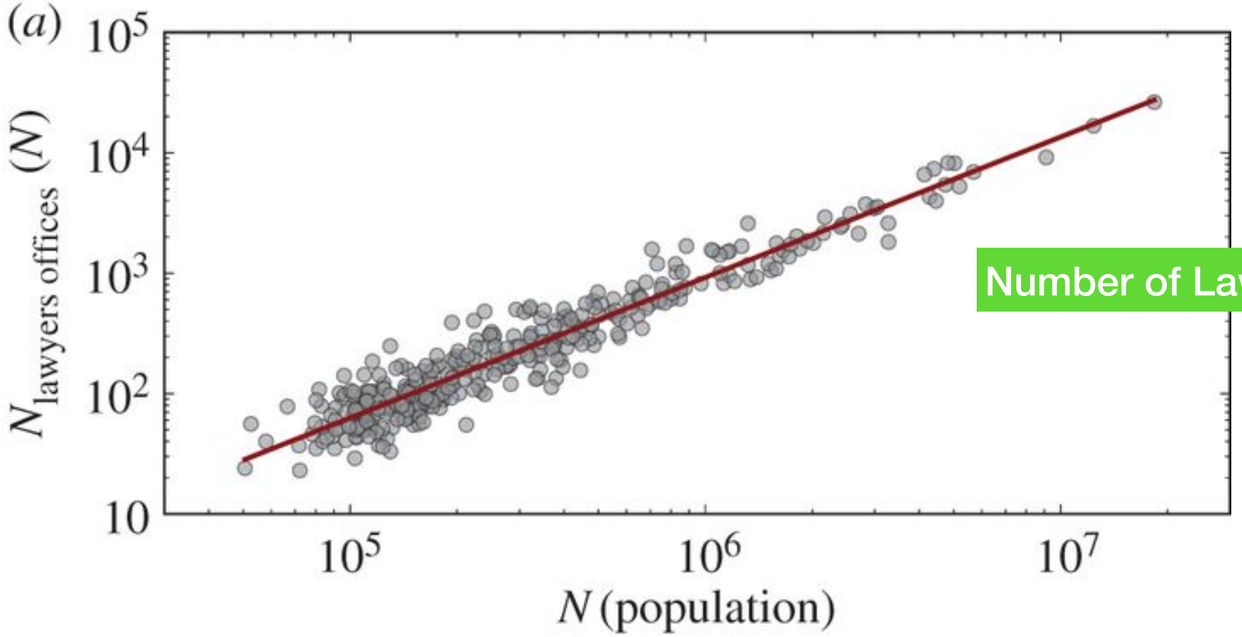

Youn et al 2016



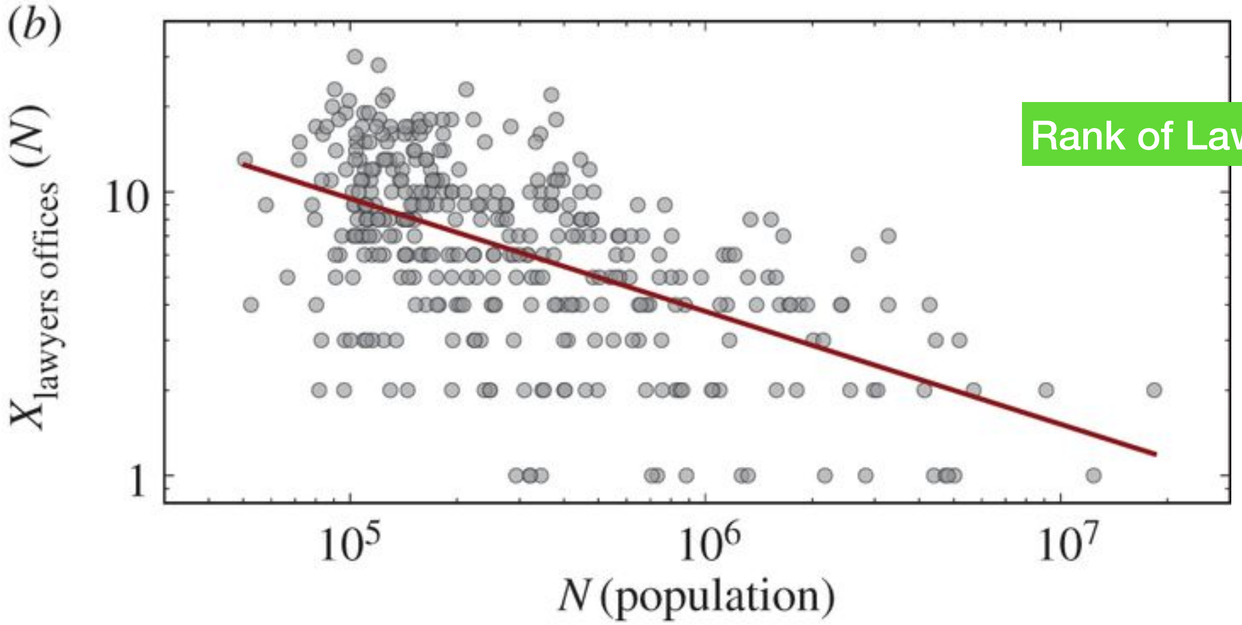




Youn et al 2016

Scale each business type on population

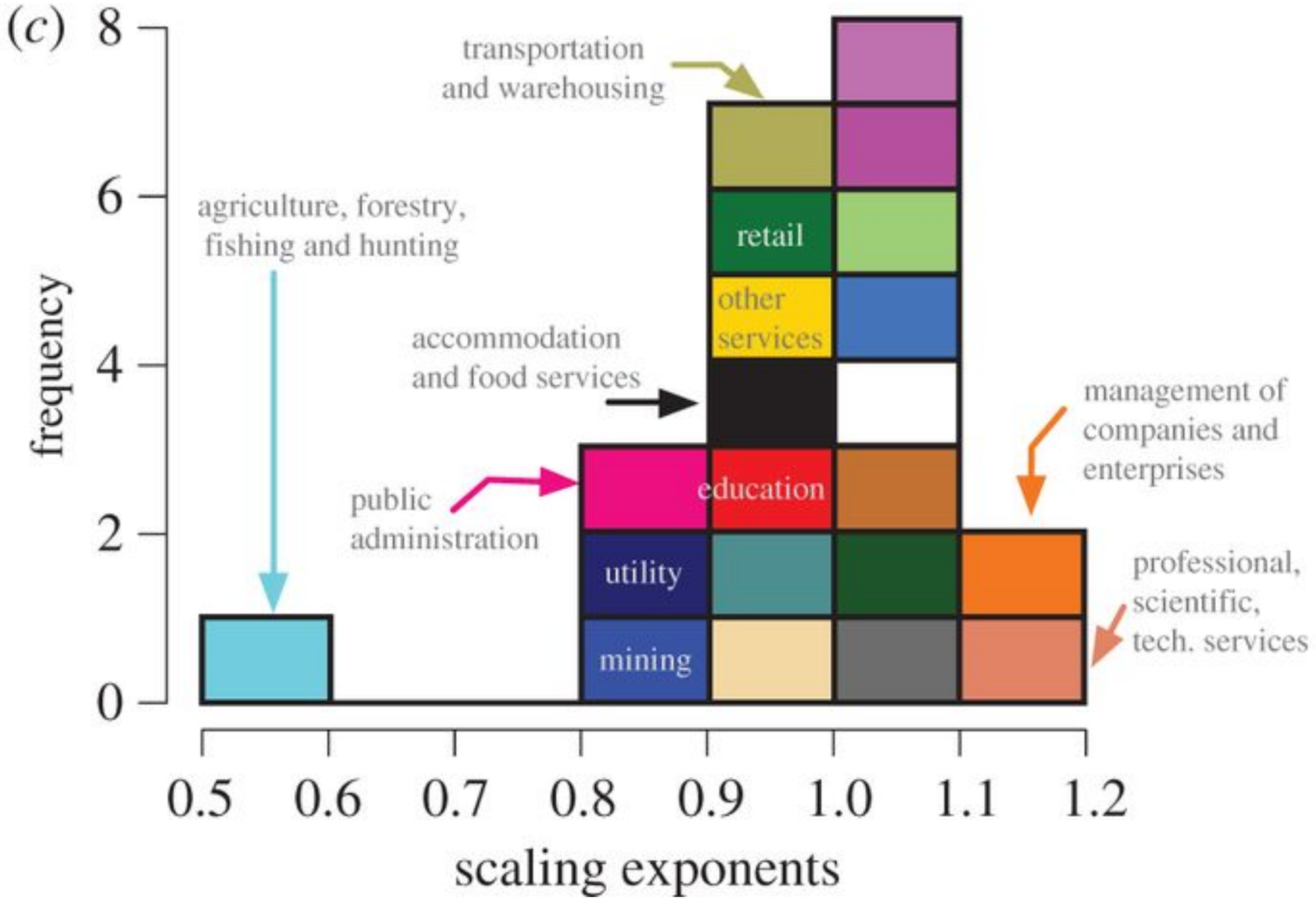



Number of Lawyers Offices



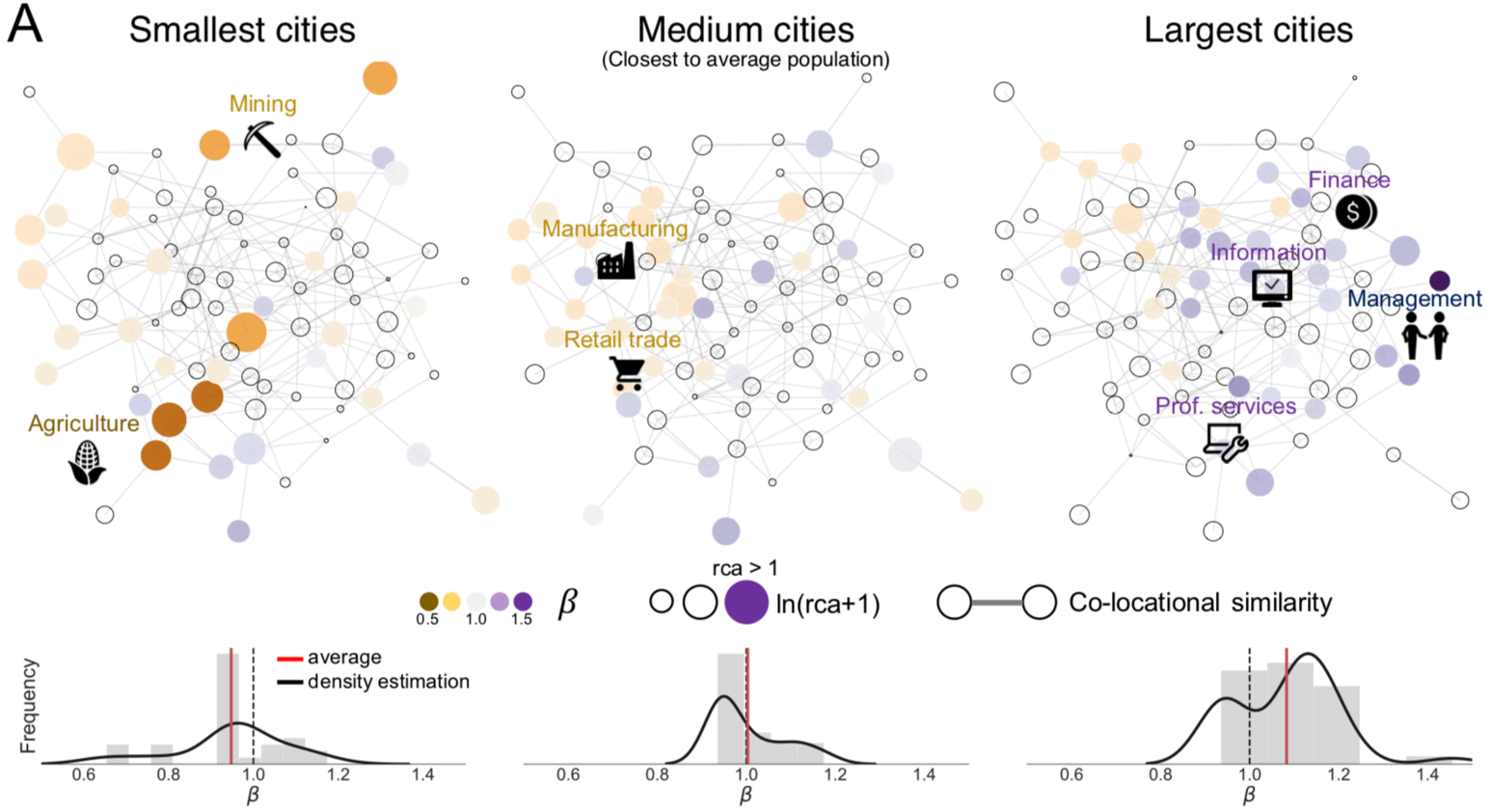

Rank of Lawyers Offices

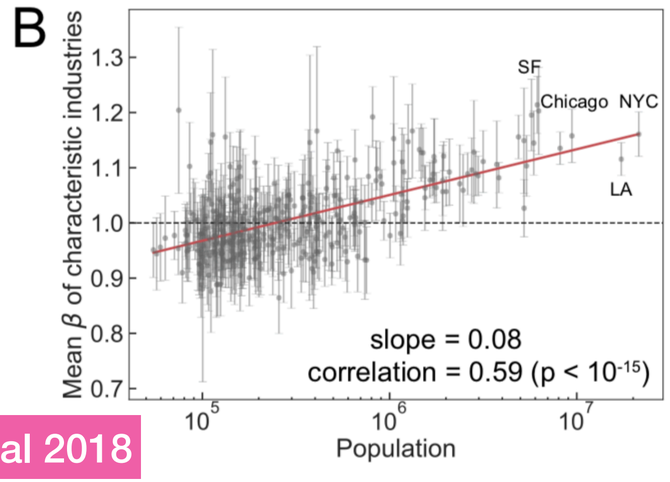
Youn et al 2016

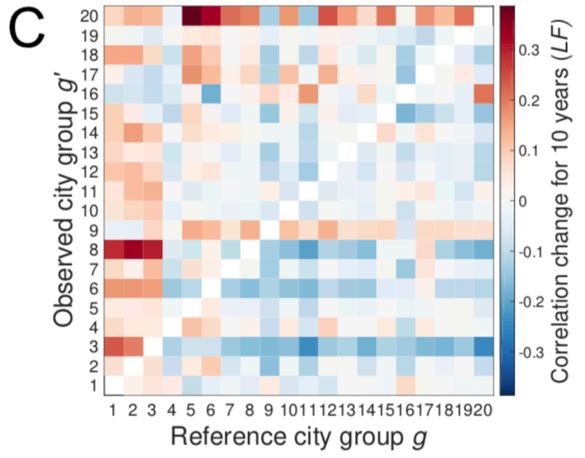



Youn et al 2016

# Recapitulation of Business Sectors




**Smallest cities**
Carson City, NV
Enid, OK
Lewiston, ID

**Medium cities**
Knoxville, TN
El Paso, TX
Baton Rouge, LA

**Largest cities**
New York, NY
Los Angeles, CA
Chicago, IL

Hong et al 2018

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 quantitatively 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 a structural transformation predicted by urban scaling**