Analysis of Citation Networks

Toward the construction of “input-output tables of knowledge and economy”

Wataru Souma (CST, Nihon Univ.)
Mari Jibu (JST/OECD)

Motive

- Three types of studies in econophysics
  - Defensive: understand and control the risks
  - Neutral: understand economy in terms of physics
  - Offensive: create new industries and markets -> innovation
- What is the origin of innovation ?
  - Science
- Dynamics of science -> citation networks

Table of Contents

1. Brief review of distribution of citations
2. Data and distribution of citations
3. Toward modeling of citation networks
4. Summary and future work
   - Construction of “input-output tables of knowledge and economy”

1. Brief review...

- Distribution of citations
  - Power law
    - Redner (1998)
      - ✳ Published in 1981 catalogued by ISI (783,339 papers)
      - ✳ PRD, vols. 11-50 (24,296 papers)
  - Lognormal
    - Redner (2005)
      - ✳ Physical Review, 1983 - 30th June 2003 (353,268 papers, 3,110,839 citations)
- Problem: incompleteness of data

2. Data and degree ...

All publications
(Thomson Reuter's Web of Science (WoS), Elsevier's Scopus
Google scholar, Microsoft Academic Search, Amazon, ...)

Thomson Reuter's Web of Science (WoS)

Science Citation Index (SCI) from 1981 to 2011

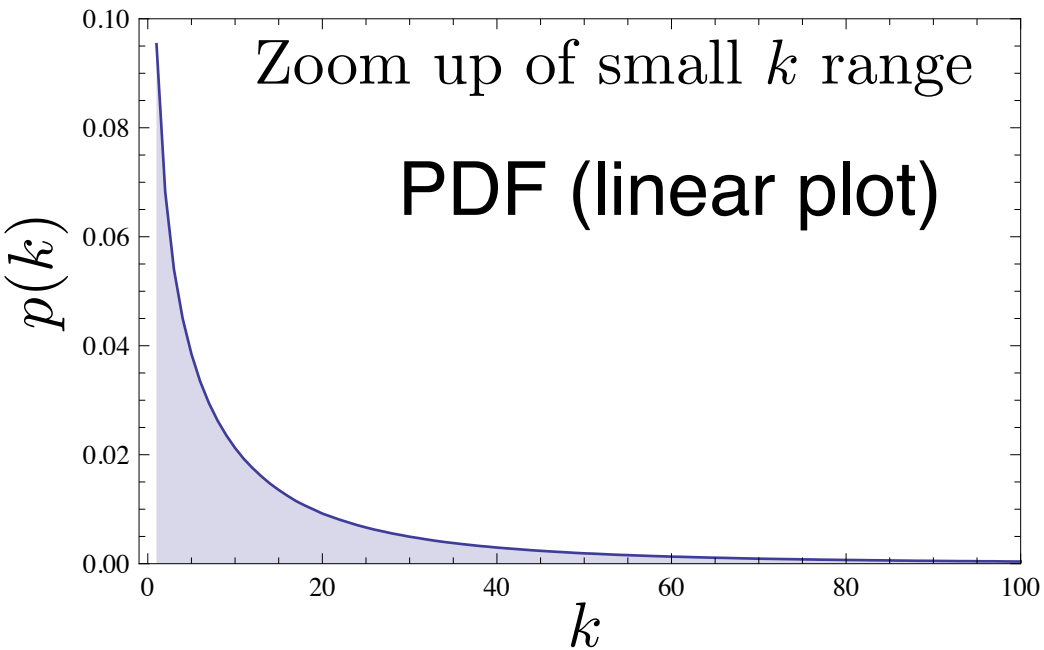
3,749 journals

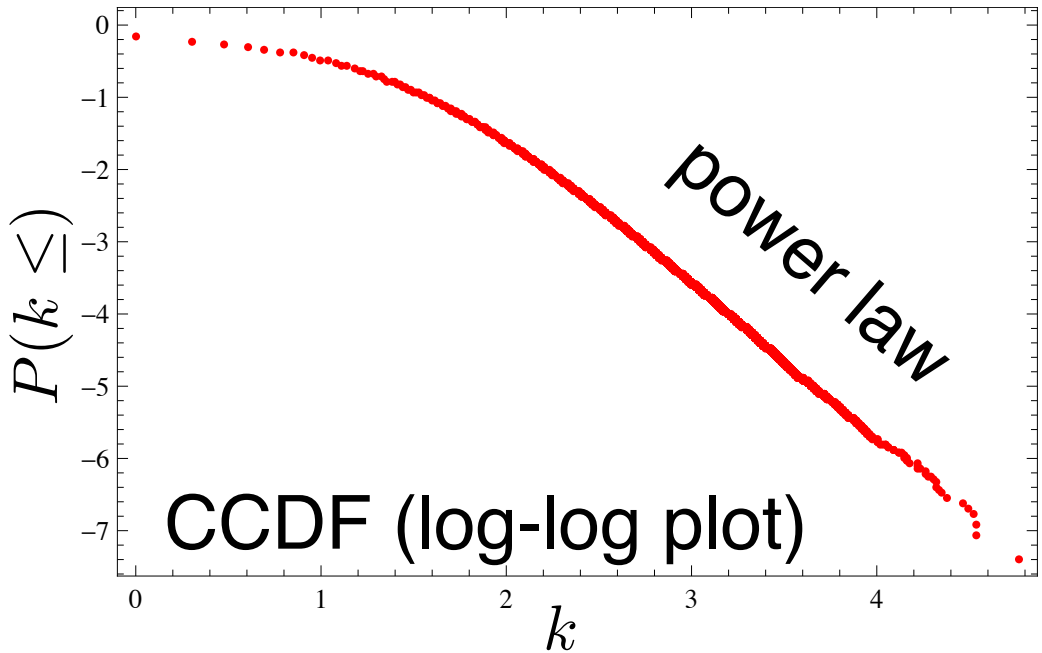
150 disciplines

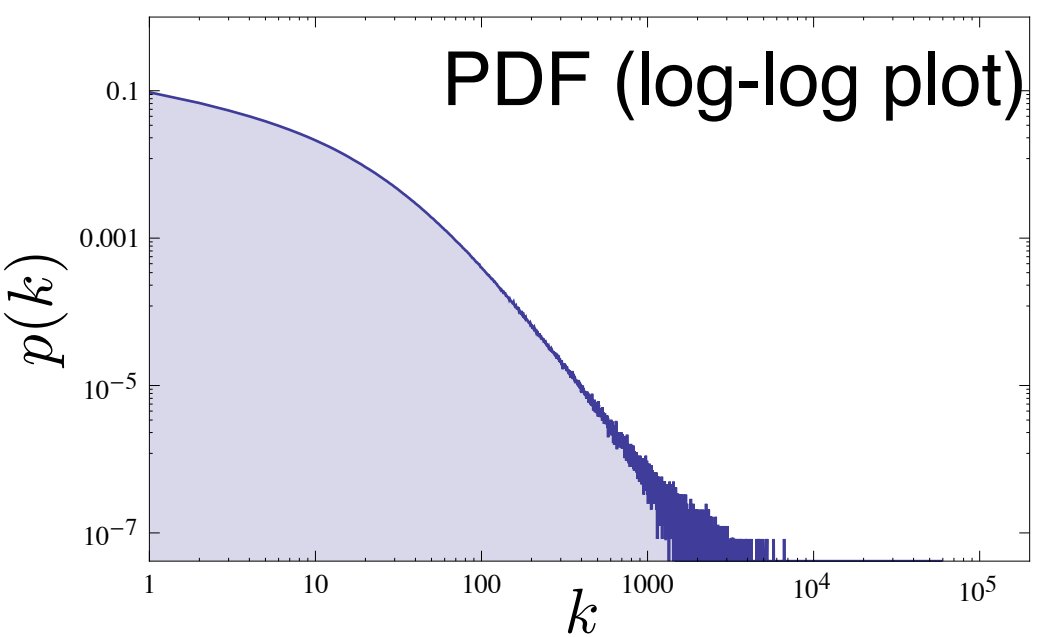
24,160,348 papers

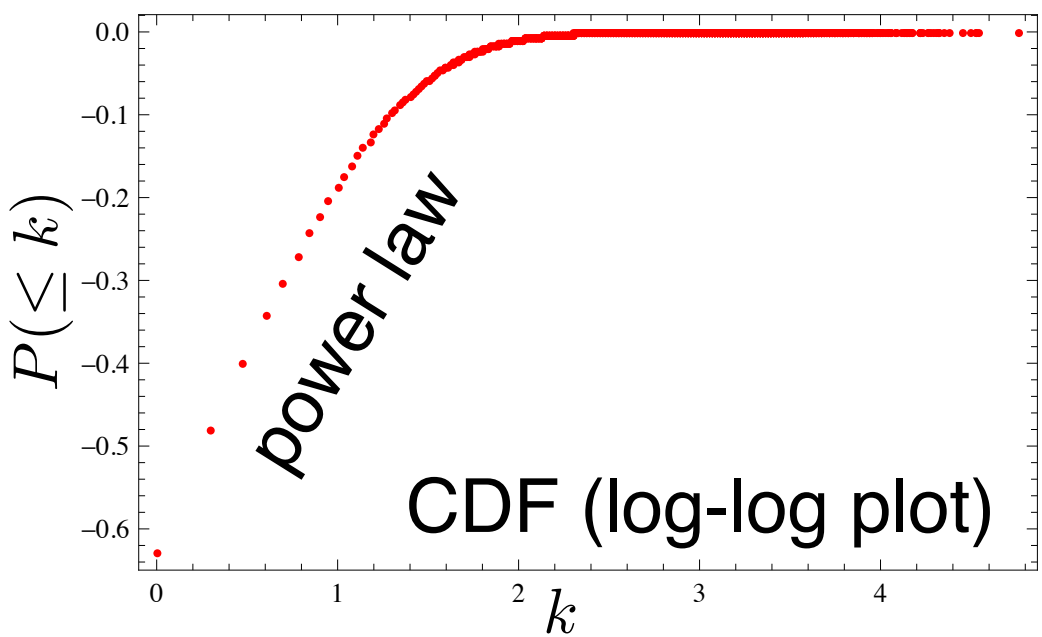
385,692,359 citations (links)

Distribution of citations







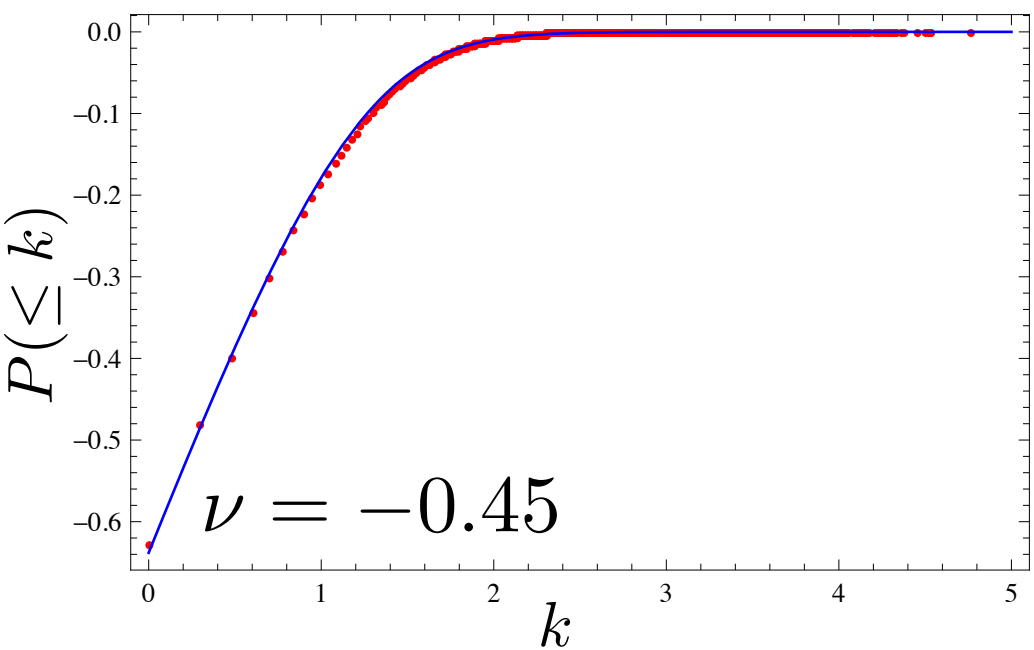


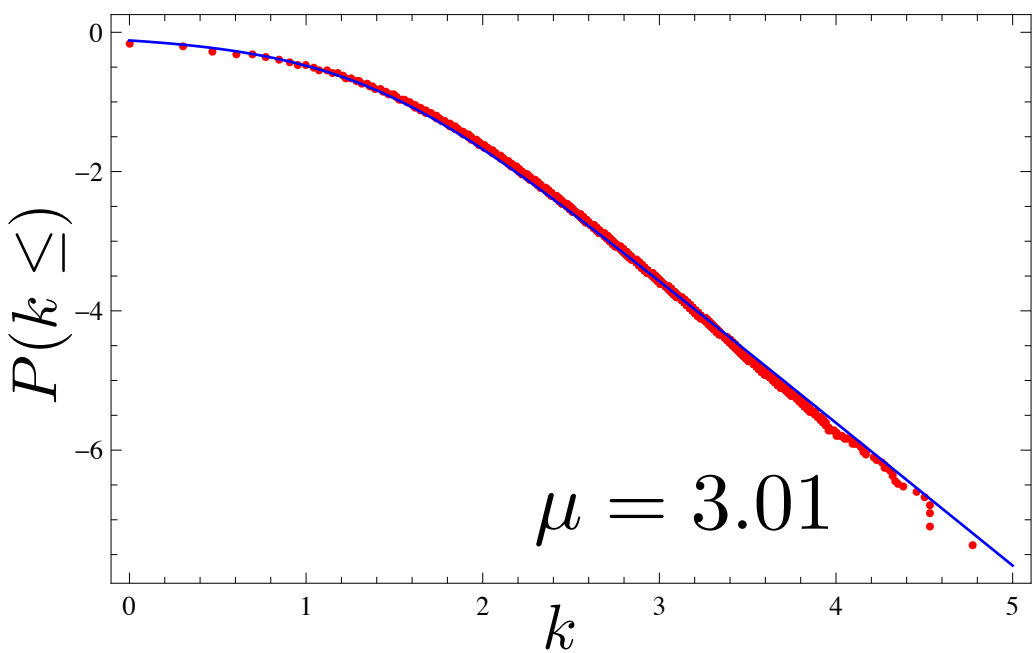
Generalized Beta functions of the second kind (GB2)

$$p(k;\mu,\nu,q,k_0) = \frac{N_B}{k}\left(\frac{k}{k_0}\right)^{\nu}\left[1+\left(\frac{k}{k_0}\right)^{q}\right]^{(\nu+\mu)/q}$$

$$N_B = \frac{q}{B(\mu/q,\nu/q)}$$

$$= \begin{cases} \dfrac{N_B}{k}\left(\dfrac{k}{k_0}\right)^{\nu} & \text{for} \quad x \to 0 \\ \dfrac{N_B}{k}\left(\dfrac{k}{k_0}\right)^{-\mu} & \text{for} \quad x \to \infty \end{cases}$$





Distribution of citations is well explained by GB2

3. Hint for modeling...

- BA model

$$\frac{dk_i}{dt} = m\Pi(k_i)$$

- One example of attachment rate

  H. Jeoung et al., Eur. Phys. Lett., 61, pp. 567-572 (2003)

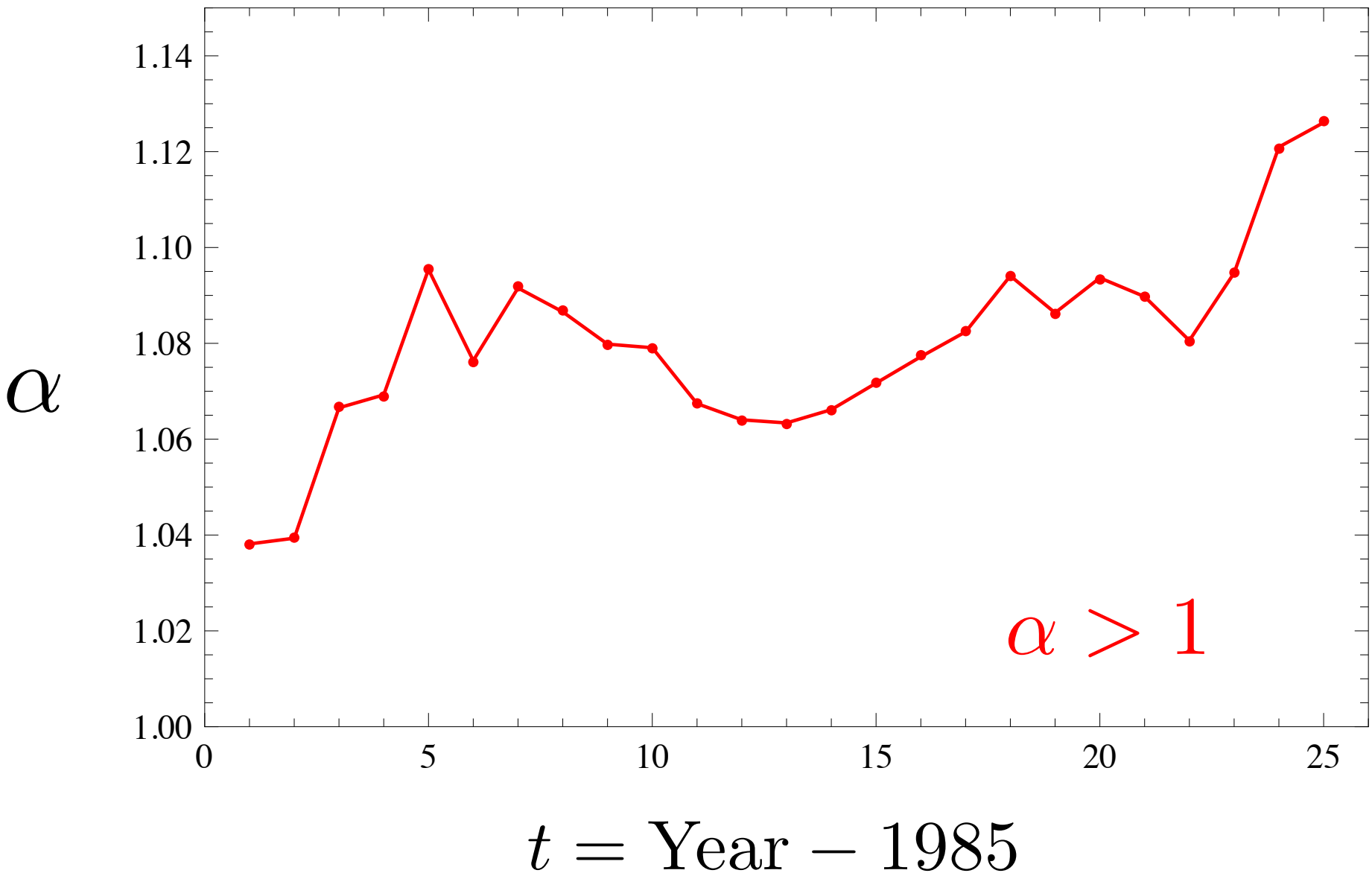
$$m\Pi(k_i) = A_t k_i^{\alpha}$$

aging effect

existing links

- We investigate 449,432 papers published in 1985

Change of α



- P.L. Krapivsky, et al., PRL 85, pp. 4629-4632 (2000)

$\alpha < 1$ stretched exponential

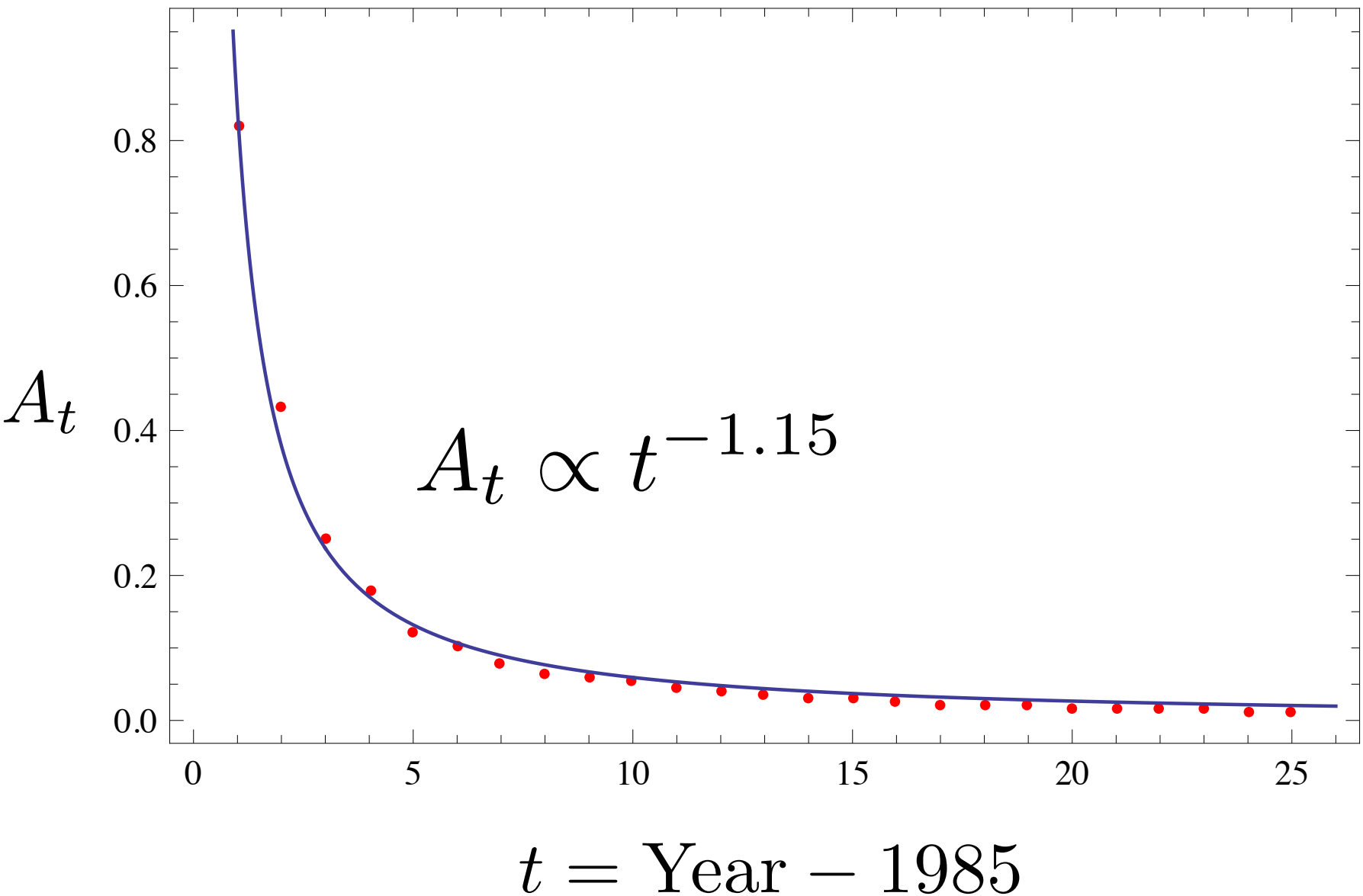
$$p(k) \propto \exp(k^{\beta}), \quad \beta < 0$$

$\alpha = 1$ scale free

$$p(k) \propto k^{-\mu}$$

$\alpha > 1$ phenomena is akin to gelation in which a single “gel” site connects to nearly every other site

Change of A_t



4. Summary and ...

- We investigated citation networks
  - Distribution of citations follows GB2

$$p(k;\mu,\nu,q,k_0) = \frac{N_B}{k}\left(\frac{k}{k_0}\right)^{\nu}\left[1+\left(\frac{k}{k_0}\right)^{q}\right]^{(\nu+\mu)/q}$$

  - Attachment rate

$$\Pi(k_i) = A_t k_i^{\alpha} \qquad \alpha > 1$$

$$A_t \propto t^{-1.15}$$

4. … and Future work

Toward the construction of "input-output tables of knowledge and economy"