



# Science of Science: Science seen as a social phenomenon

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## Some bad news . . .

A full coverage of SoS domain would require an entire school.



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Comment all the works dealing with a given topic is not possible.



## Some bad news . . .

A full coverage of SoS domain would require an entire school.

Comment all the works dealing with a given topic is not possible.

I will present my “personal perspective” on SoS.

# What are we going to talk about?

## Summary

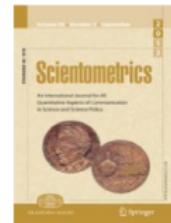
- ▶ A (very) brief history of SoS.
- ★ Topic 1: Cooperation in science.
- ▶ 4 min pause
- ★ Topic 2: Spatial scientometrics.
- ★ Topic 3: Spotting “*scientific gems*”.
- ▶ Take home messages
- ▶ Questions

# Historical notes

1956 - 1965



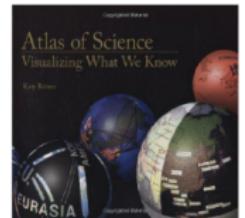
1978



1975

Sas

2010



...



1926



? 1969 ?



1964 - 2004



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KNOWLEDGE.



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FÉDÉRALE DE LAUSANNE  
4/13

A photograph of a Boeing 737 aircraft on a tarmac. A group of approximately ten people are pulling on a long, light-colored strap or tow bar attached to the front of the plane. The aircraft has a white body with blue and red stripes near the cockpit. In the background, there's a large hangar building and other smaller aircraft. The sky is clear and blue.

# Section 1

Cooperation  
in  
Science

Team assembly

# Team assembly mechanisms in science



Incumbent

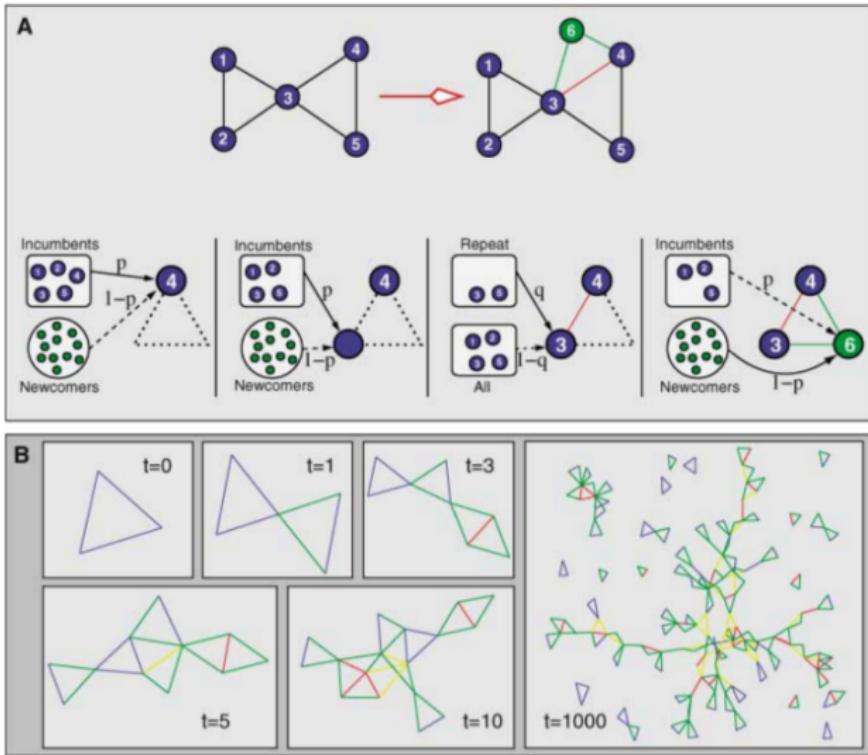


Repeat

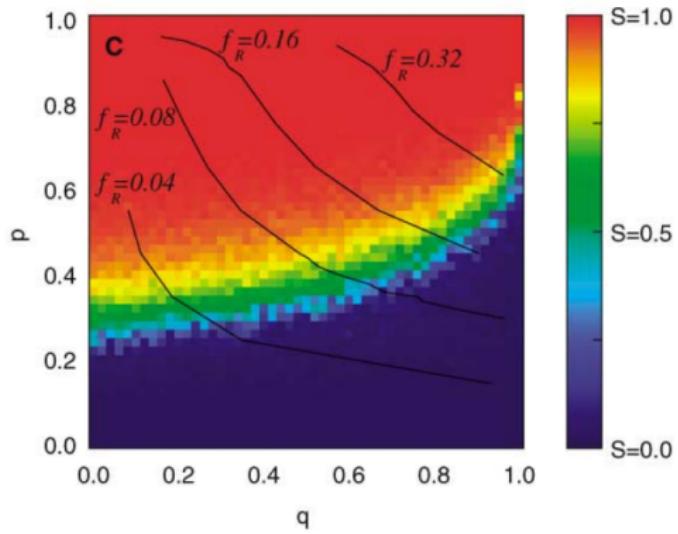
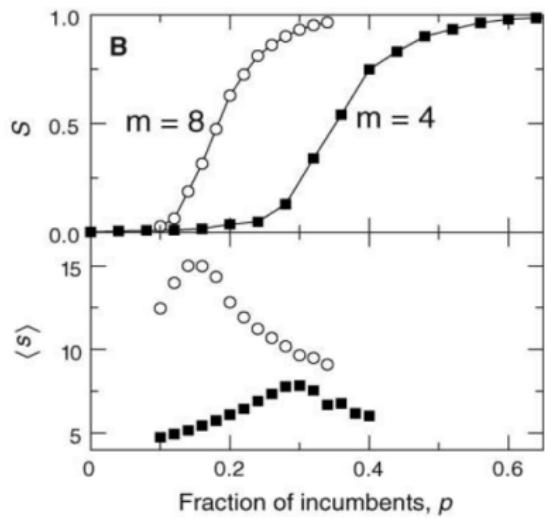
Newcomer

Guimerá, R., Uzzi, B., Spiro, J., & Amaral, L. A. N. Science, **308**, 697–702 (2005).

# Team assembly mechanisms in science

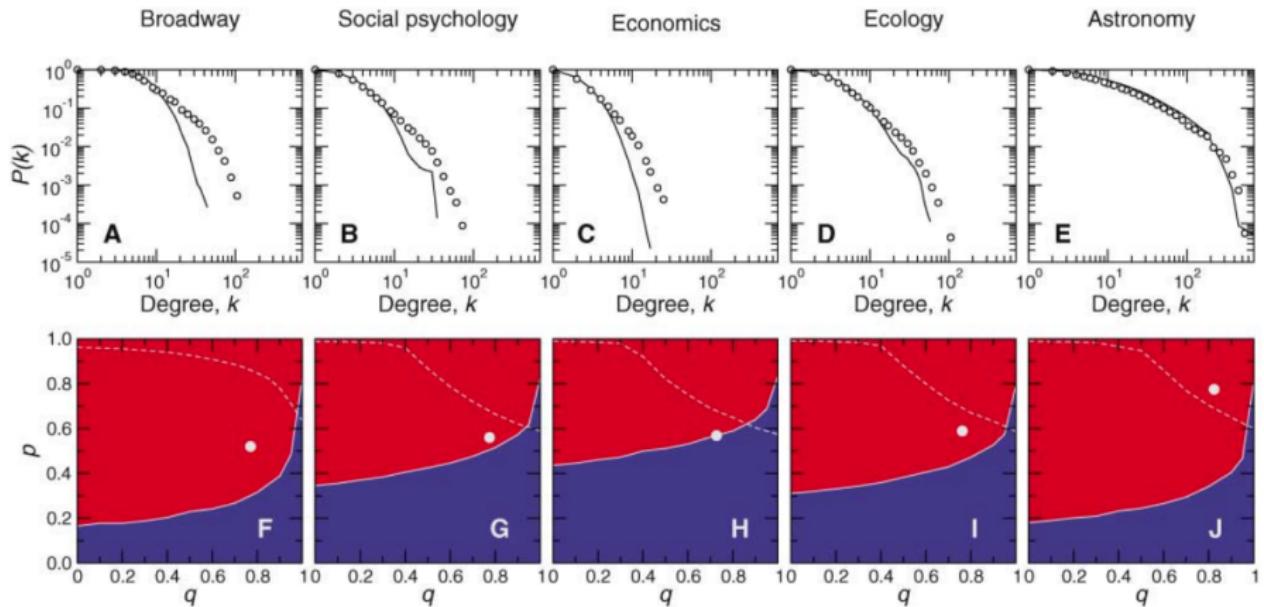


# Team assembly mechanisms in science



Guimerá, R., Uzzi, B., Spiro, J., & Amaral, L. A. N. Science, **308**, 697–702 (2005).

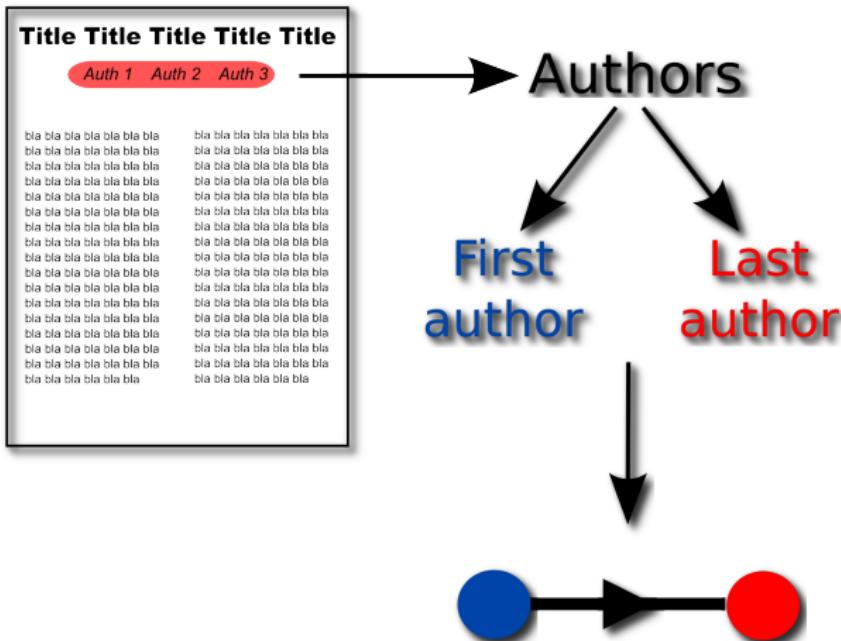
# Team assembly mechanisms in science



Guimerá, R., Uzzi, B., Spiro, J., & Amaral, L. A. N. Science, **308**, 697–702 (2005).

## Cooperation in publishing

# Cooperation in scientific publishing



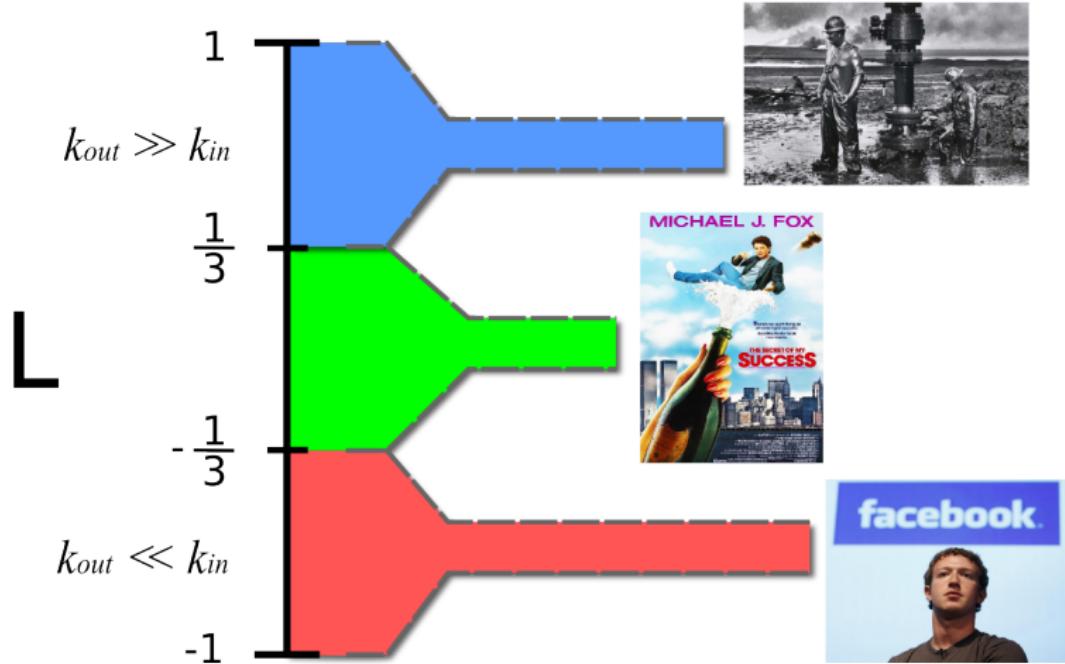
# Cooperation in scientific publishing

## Behavioral Type

$$L_i = \frac{k_{\text{out}}(i) - k_{\text{in}}(i)}{A_i} = \frac{k_{\text{out}}(i) - k_{\text{in}}(i)}{k_{\text{out}}(i) + k_{\text{in}}(i)}.$$
$$L_i \in [-1, 1].$$

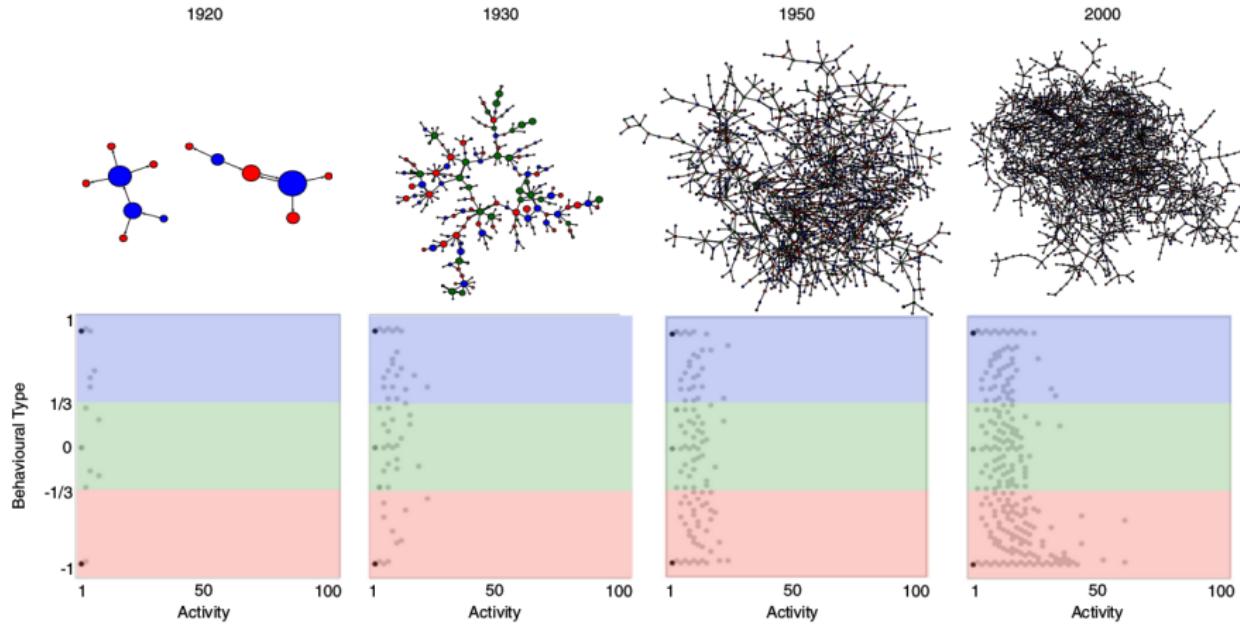
Wardil, L., & Hauert, C. Phys. Rev. E, **91**, 012825 (2015).

# Cooperation in scientific publishing



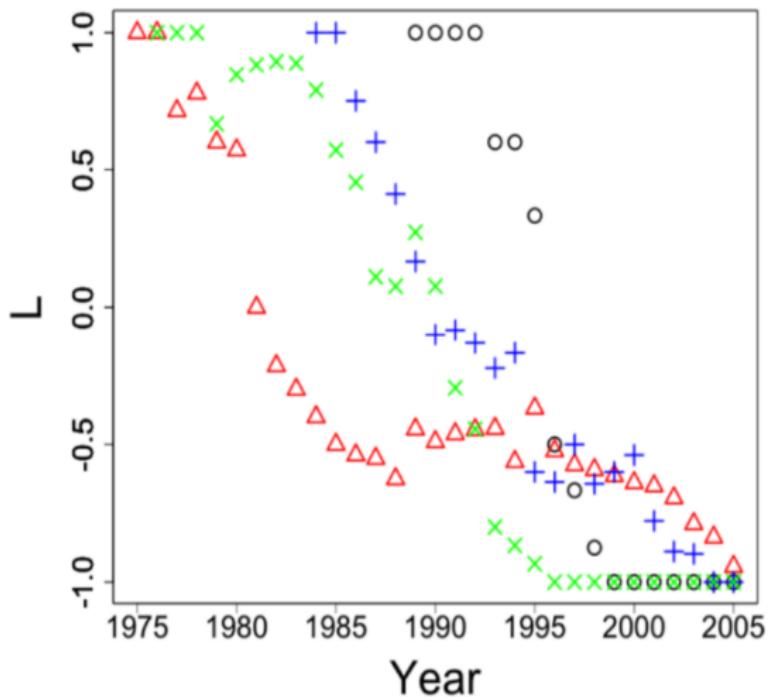
Wardil, L., & Hauert, C. Phys. Rev. E, **91**, 012825 (2015).

# Cooperation in scientific publishing



Wardil, L., & Hauert, C. Phys. Rev. E, **91**, 012825 (2015).

# Cooperation in scientific publishing

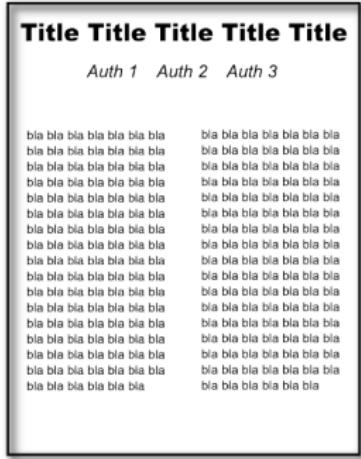


## Section 2

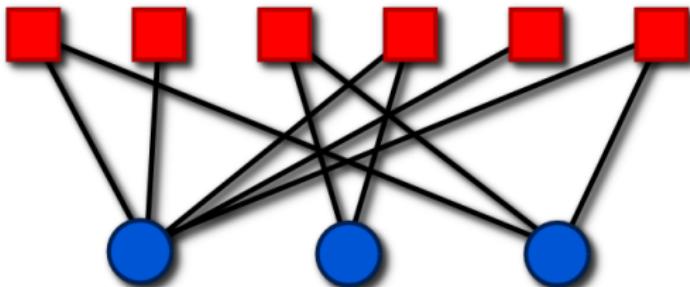


Spatiality of science

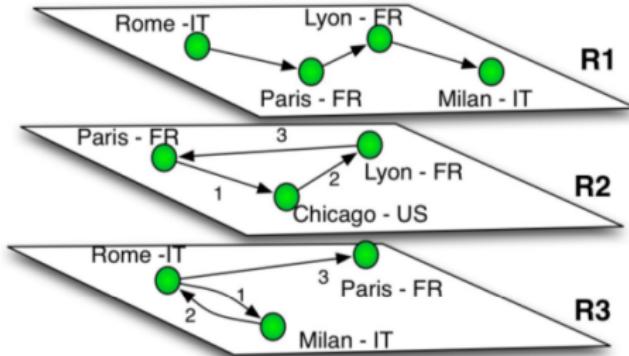
# Mobility



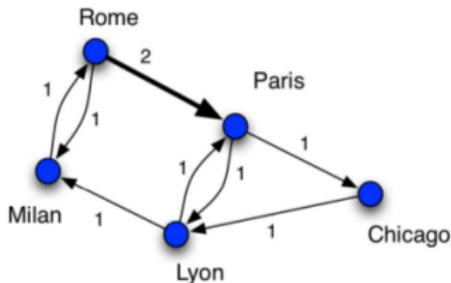
## **Authors Affiliations**



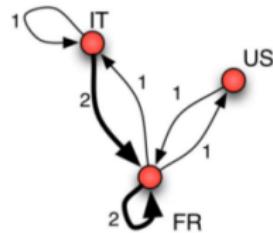
*SoS ≠ mobility*



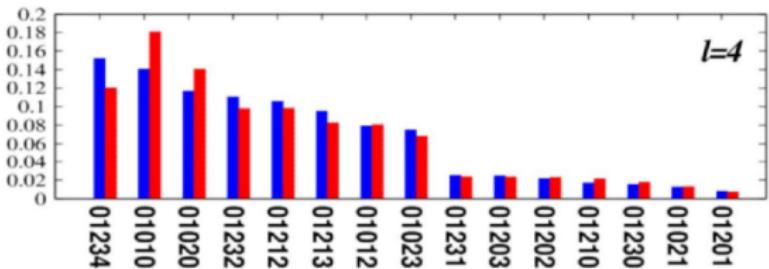
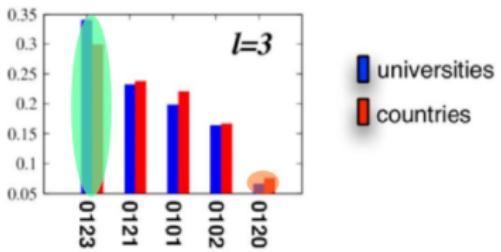
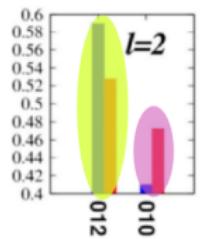
UNIVERSITIES NETWORK



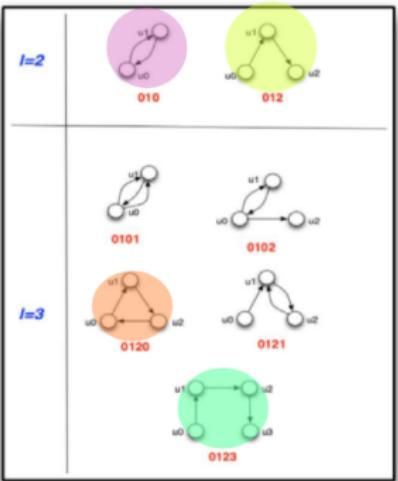
COUNTRIES NETWORK



# SoS $\neq$ mobility

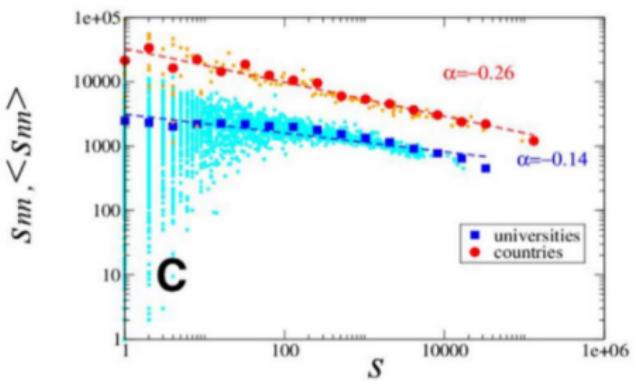
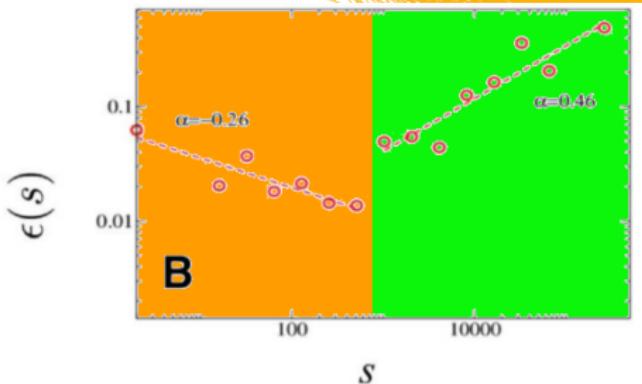


## MOTIF STRUCTURES



Gargiulo, F., & Carletti, T. Scientific Reports, 4, 4860 (2014).

*SoS  $\neq$  mobility*



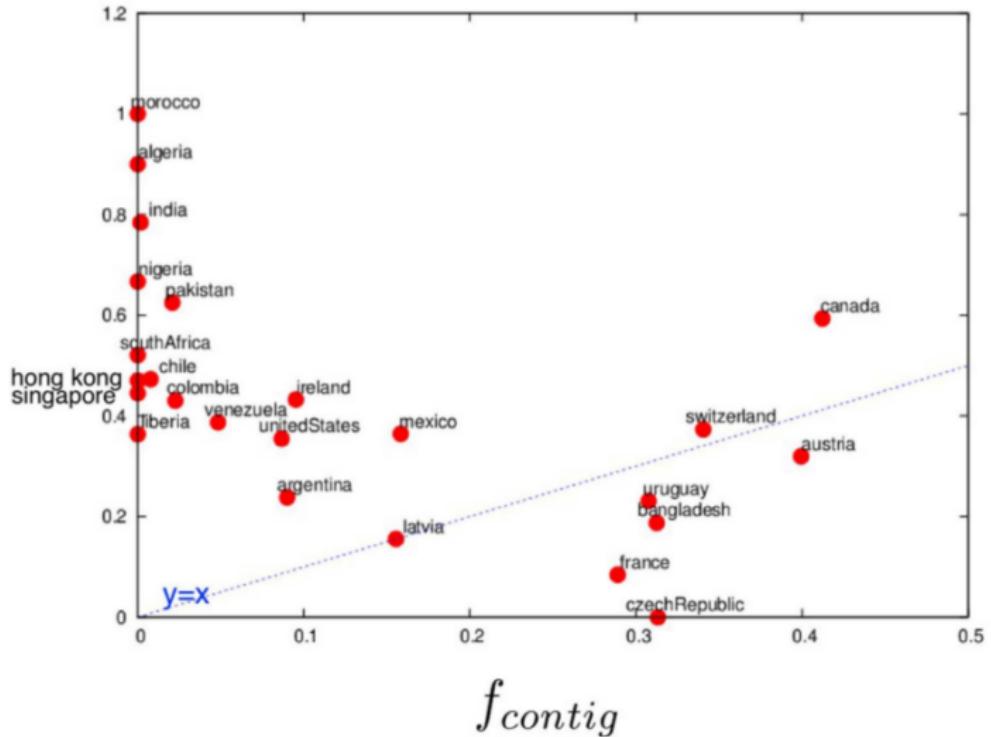
## Endogamy index

$$\epsilon_i = \frac{w_{ii}}{s_i + w_{ii}} .$$

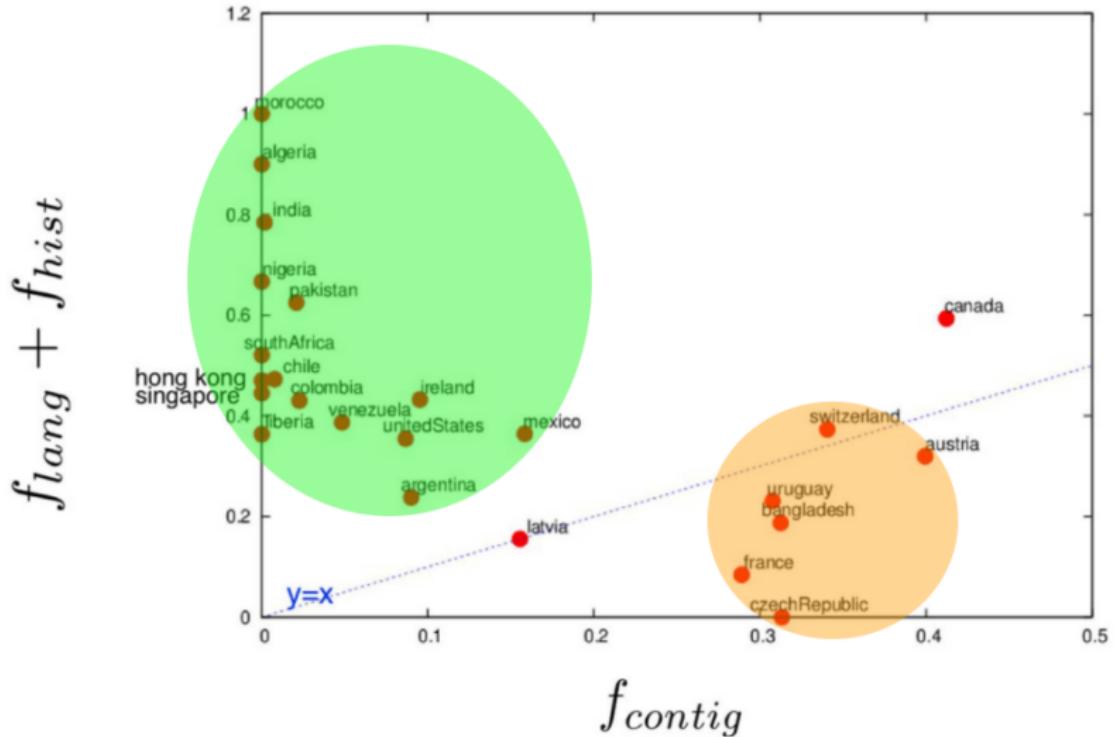
$$s_i = \sum_j w_{ij} .$$

*SoS*  $\neq$  mobility

$f_{lang} + f_{hist}$

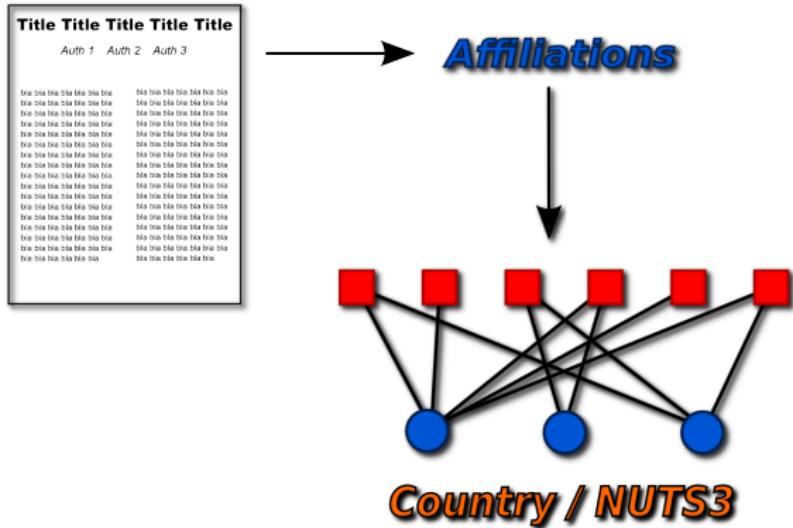


*SoS*  $\neq$  mobility



Geographical proximity

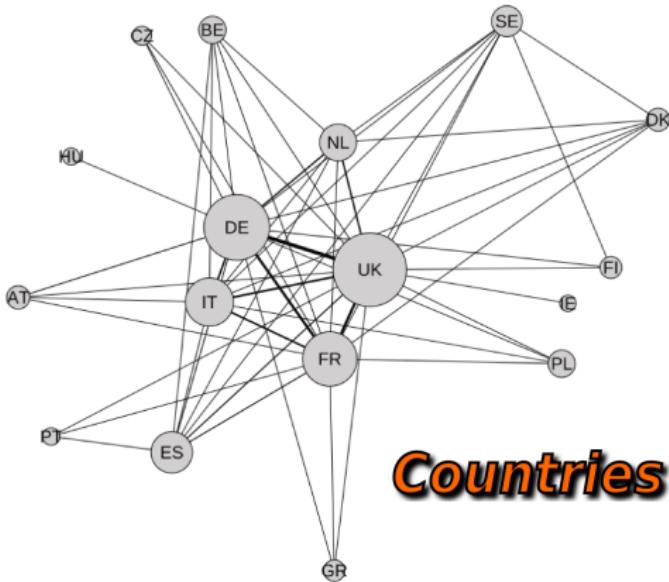
## Effects of geographical proximity



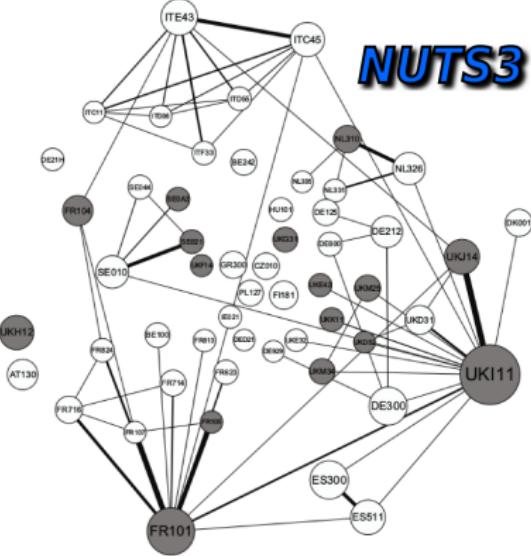
# Effects of geographical proximity

Node Type	$\Delta T_{10}$	$\Delta \text{Art}$
Hotspot	> 0	> 0
Focus on Success	> 0	< 0
Black Hole	< 0	< 0
Reputation Loss	< 0	> 0

## Effects of geographical proximity



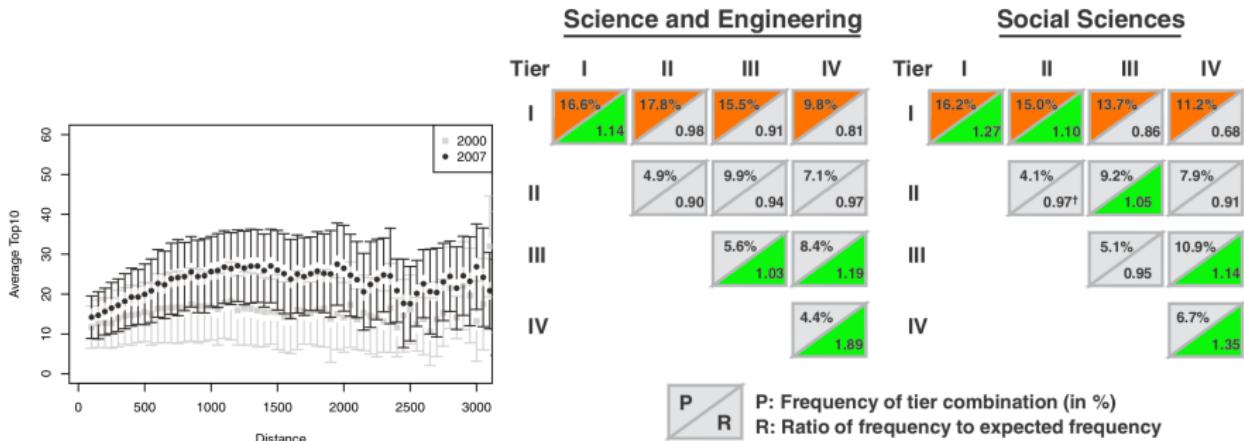
# **Countries**



# NUTS3

Apolloni, A., Rouquier, J.-B., & Jensen, P. Eur. Phys. J. Special Topics, 222, 1467–1478 (2013).

# Effects of geographical proximity



Apolloni, A., Rouquier, J.-B., & Jensen, P. Eur. Phys. J. Special Topics, **222**, 1467–1478 (2013).

Jones, B. F., Wuchty, S., & Uzzi, B. Science, **322**, 1259–1262 (2008).

A close-up photograph of a pile of colorful, faceted gemstones scattered across a light-colored surface. The gems are in various colors including red, blue, yellow, green, and purple. They have a shiny, reflective surface and are arranged in a somewhat random, overlapping pattern.

# Spotting "scientific gems"

## Section 3

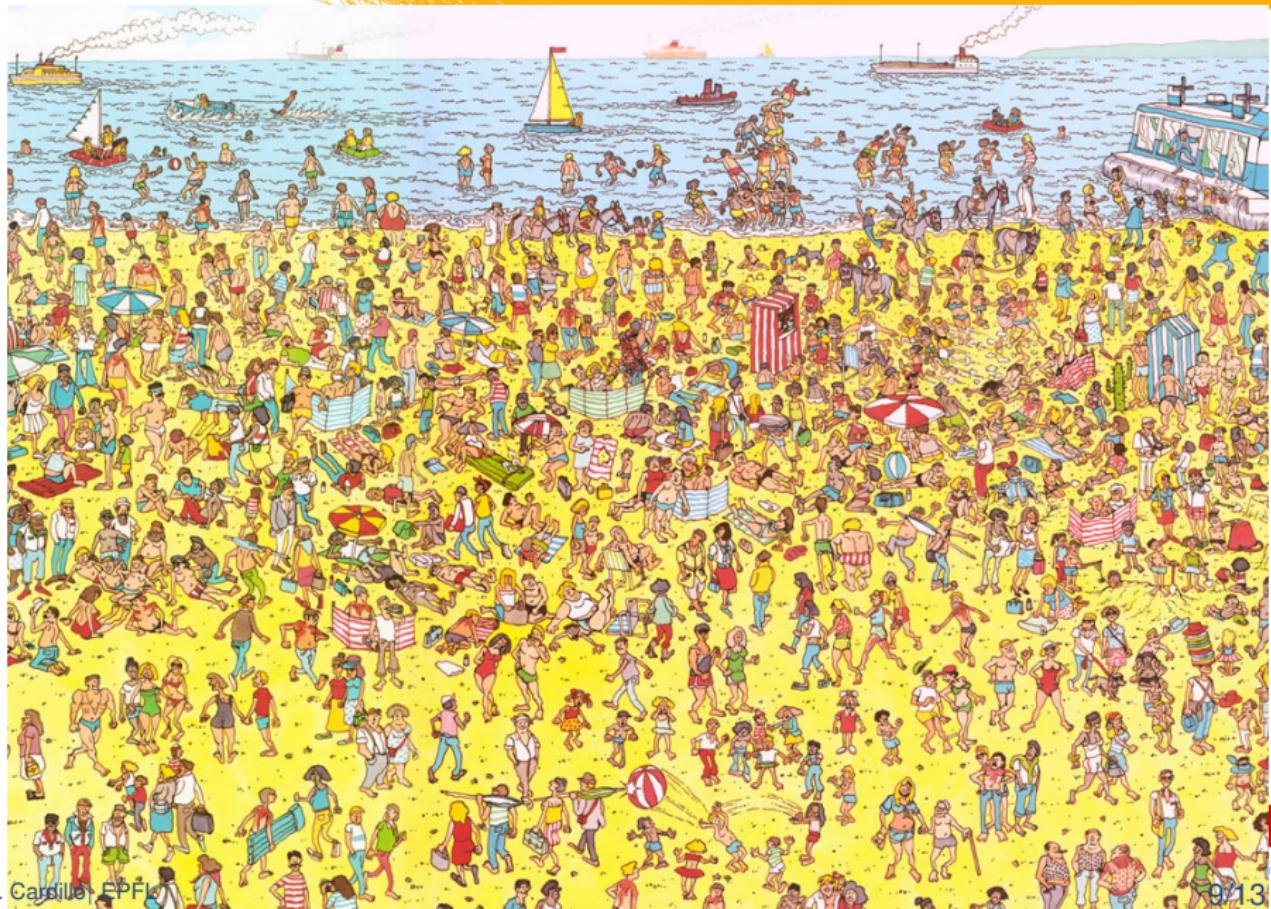
# Where is Wally/Waldo?



## Objective

You have to find Wally/Waldo among all the other people.

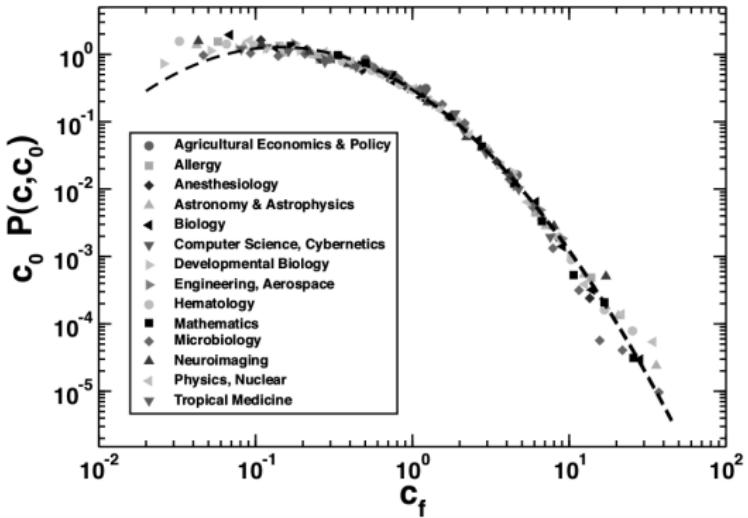
# Where is Wally/Waldo?



# Where is Wally/Waldo?



# Citations $\neq$ popularity



$$F(c_f) = \frac{1}{\sigma c_f \sqrt{2\pi}} e^{-\frac{(\log c_f - \mu)^2}{2\sigma^2}}.$$

Redner, S. Physics Today, **58**, 49–54 (2005).

Radicchi, F., Fortunato, S., & Castellano, C. Proc. Natl. Acad. Sci. USA, **105**, 17268–72 (2008).

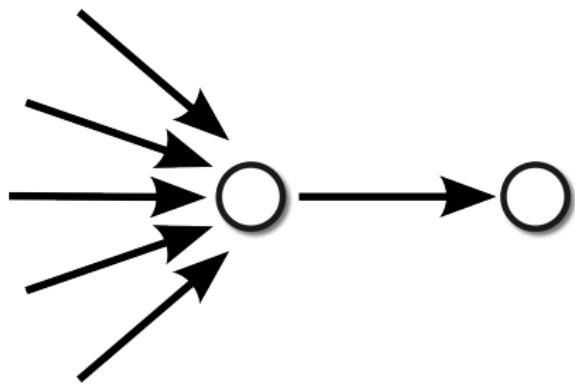
# Citations ≠ popularity

Rank	# cites	Year	Title	Author(s)
1	3227	1965	Self-Consistent Equations Including Exchange and Correlation Effects	W. Kohn, L. J. Sham
2	2460	1964	Inhomogeneous Electron Gas	P. Hohenberg, W. Kohn
3	2079	1981	Self-Interaction Correction to Density-Functional Approximations for Many-Electron Systems	J. P. Perdew, A. Zunger
4	1781	1980	Ground State of the Electron Gas by a Stochastic Method	D. M. Ceperley, B. J. Alder
5	1364	1957	Theory of Superconductivity	J. Bardeen, L. N. Cooper, J. R. Schrieffer
6	1306	1967	A Model of Leptons	S. Weinberg
7	1259	1975	Linear Methods in Band Theory	O. K. Anderson
8	1178	1961	Effects of Configuration Interaction of Intensities and Phase Shifts	U. Fano
9	1055	1985	Disordered Electronic Systems	P. A. Lee, T. V. Ramakrishnan
10	1045	1982	Electronic Properties of Two-Dimensional Systems	T. Ando, A. B. Fowler, F. Stern

# Citations $\neq$ popularity

## PageRank

$$G_i = (1 - d) \left[ \sum_{j=1}^N a_{ij} \frac{G_j}{k_j} \right] + d \left[ \frac{1}{N} \right].$$



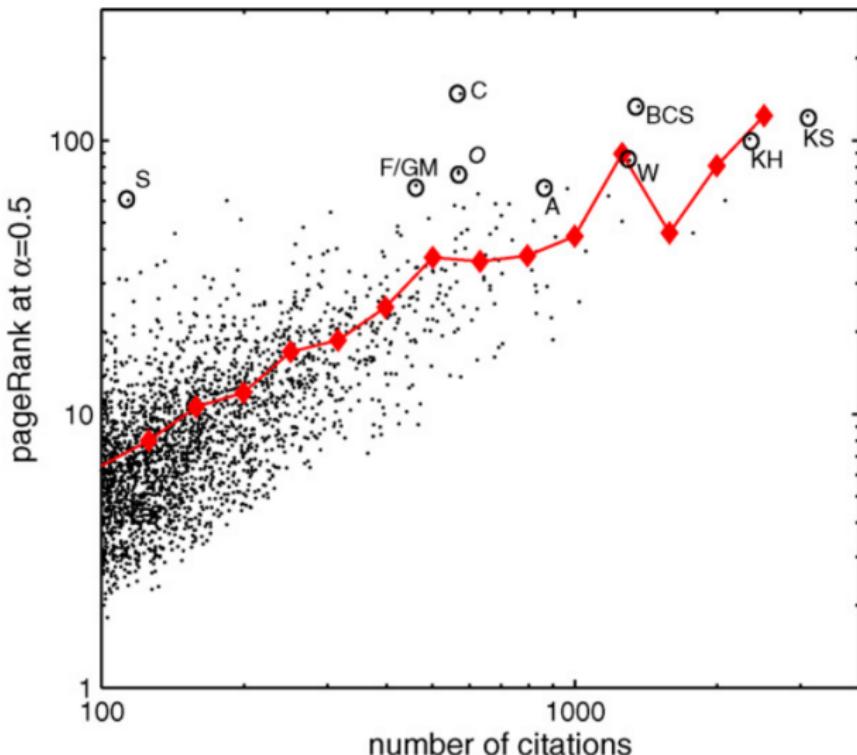
Chen, P., Xie, H., Maslov, S., & Redner, S. Journal of Informetrics, 1, 8–15 (2007).

# Citations ≠ popularity

G-Rank	C-Rank	# cites	Year	Title	Author(s)
1	54	574	1963	Unitary symmetry and leptonic ...	N. Cabibbo
2	5	1364	1957	Theory of Superconductivity	J. Bardeen, L. N. Cooper, J. R. Schrieffer
3	1	3227	1965	Self-Consistent Equations ...	W. Kohn, L. J. Sham
4	2	2460	1964	Inhomogeneous Electron Gas	P. Hohenberg, W. Kohn
5	6	1306	1967	A Model of Leptons	S. Weinberg
6	55	568	1944	Crystal statistics I	L. Onsager
7	56	568	1943	Stochastic problems in ...	S. Chandrasekhar
8	95	462	1958	Theory of the Fermi interaction	R.P. Feynman and M. Gell-Mann
9	17	871	1958	Absence of diffusion in ...	P.W. Anderson
10	1853	114	1929	The theory of complex spectra	J.C. Slater

Chen, P., Xie, H., Maslov, S., & Redner, S. Journal of Informetrics, 1, 8–15 (2007).

# Citations $\neq$ popularity



Chen, P., Xie, H., Maslov, S., & Redner, S. Journal of Informetrics, 1, 8–15 (2007).

# Sleeping Beauties in science



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Van Raan, A. F. J. *Scientometrics*, **59**, 467–472 (2004).

Redner, S. *Physics Today*, **58**, 49–54 (2005).

Ke, Q., Ferrara, E., Radicchi, F., & Flammini, A. *Proc. Natl. Acad. Sci. USA*, **112**, 1–6 (2015).

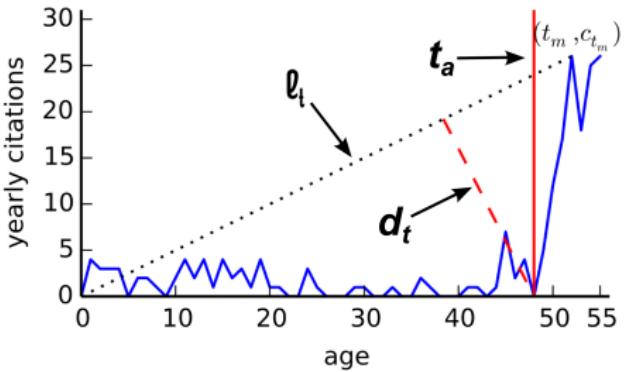
# Sleeping Beauties in science

$$B = \sum_{t=0}^{t_m} \frac{\ell_t - c_t}{\max\{1, c_t\}},$$

$$\ell_t = \frac{c_{t_m} - c_0}{t_m} \cdot t + c_0,$$

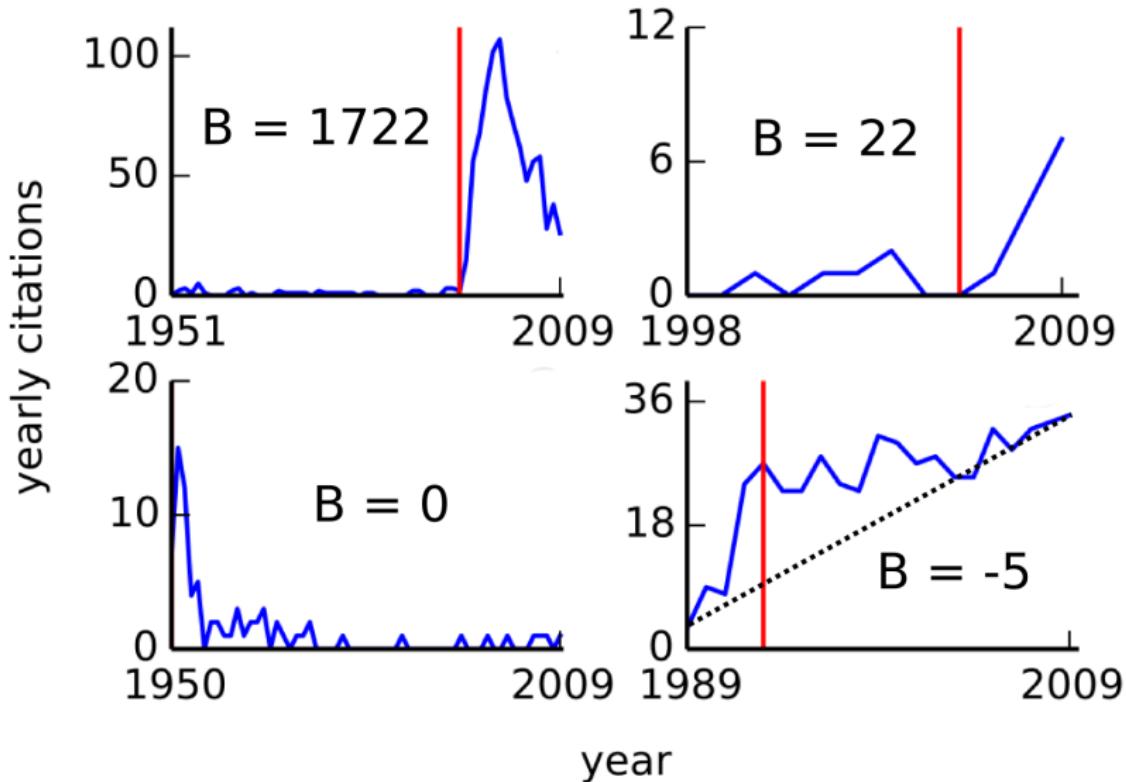
$$t_a = \arg \left\{ \max_{t \leq t_m} d_t \right\},$$

$$d_t = \frac{|(c_{t_m} - c_0)t - t_m c_t + t_m c_0|}{\sqrt{(c_{t_m} - c_0)^2 + t_m^2}}.$$

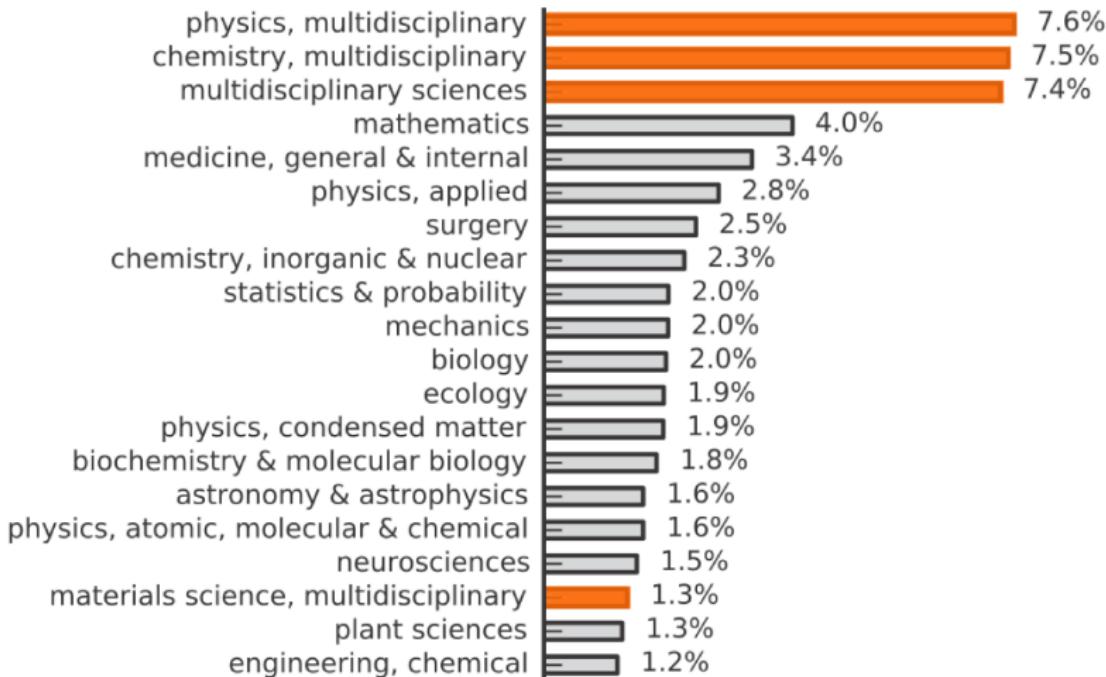


Ke, Q., Ferrara, E., Radicchi, F., & Flammini, A. Proc. Natl. Acad. Sci. USA, **112**, 1–6 (2015).

# Sleeping Beauties in science



# Sleeping Beauties in science



Ke, Q., Ferrara, E., Radicchi, F., & Flammini, A. Proc. Natl. Acad. Sci. USA, **112**, 1–6 (2015).



## Take home messages

- ▶ How scientists tend to form teams and how cooperation emerges on their inside.



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- ▶ How scientists tend to form teams and how cooperation emerges on their inside.
- ▶ What is the role of space in the networks of scientific collaboration and on migration of scientists.



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- ▶ How scientists tend to form teams and how cooperation emerges on their inside.
- ▶ What is the role of space in the networks of scientific collaboration and on migration of scientists.
- ▶ How is it possible to spot relevant contributions and identify the “sleeping beauties”.



## Take home messages

- ▶ How scientists tend to form teams and how cooperation emerges on their inside.
- ▶ What is the role of space in the networks of scientific collaboration and on migration of scientists.
- ▶ How is it possible to spot relevant contributions and identify the “sleeping beauties”.
- ▶ A scientific publication contains a lot more information than those strictly related with its content.

# Contacts

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<http://bifi.es/~cardillo/>



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