QUANTIFYING PATTERNS OF SCIENTIFIC EXCELLENCE

ROBERTA SINATRA

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Percy Spencer

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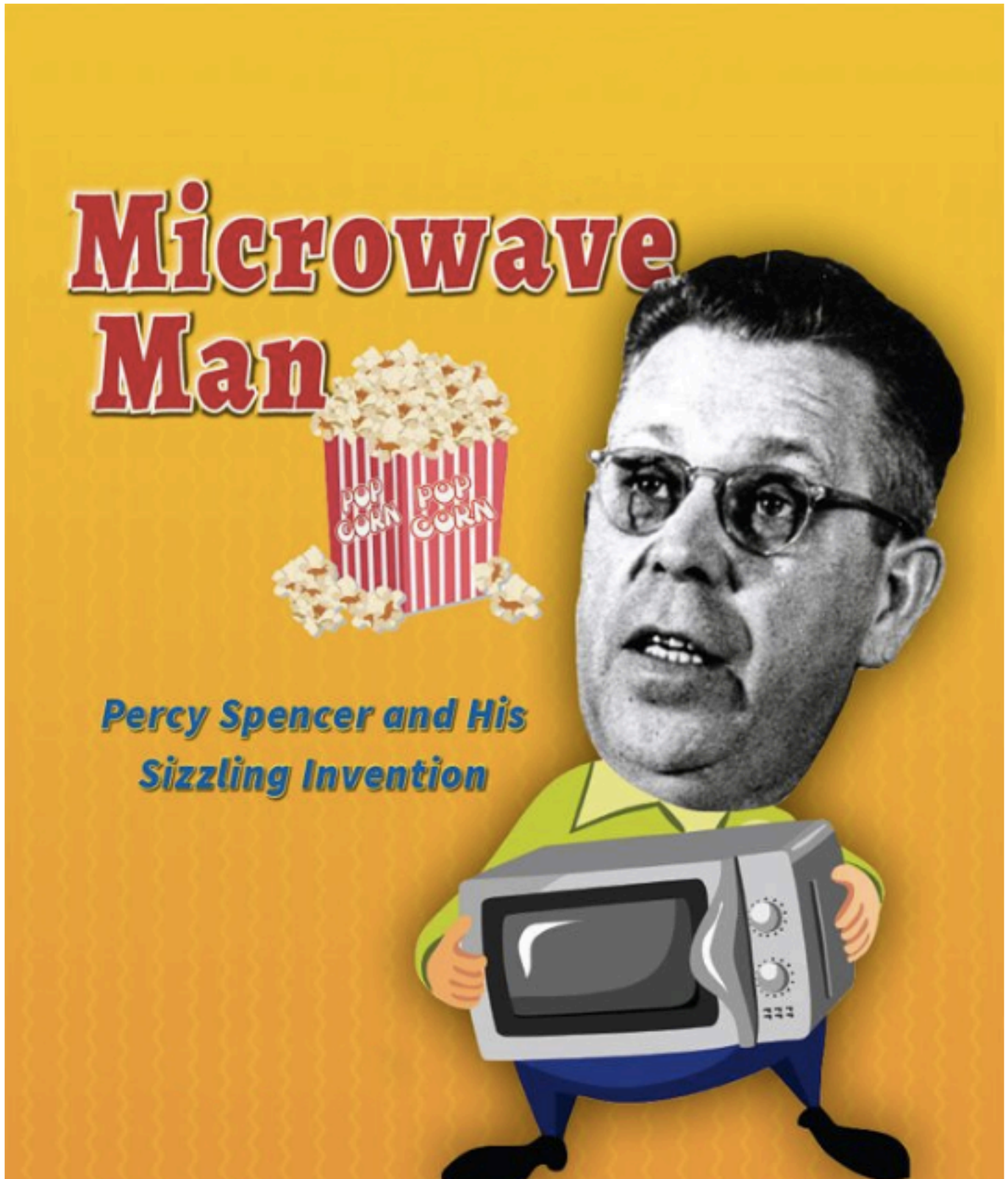

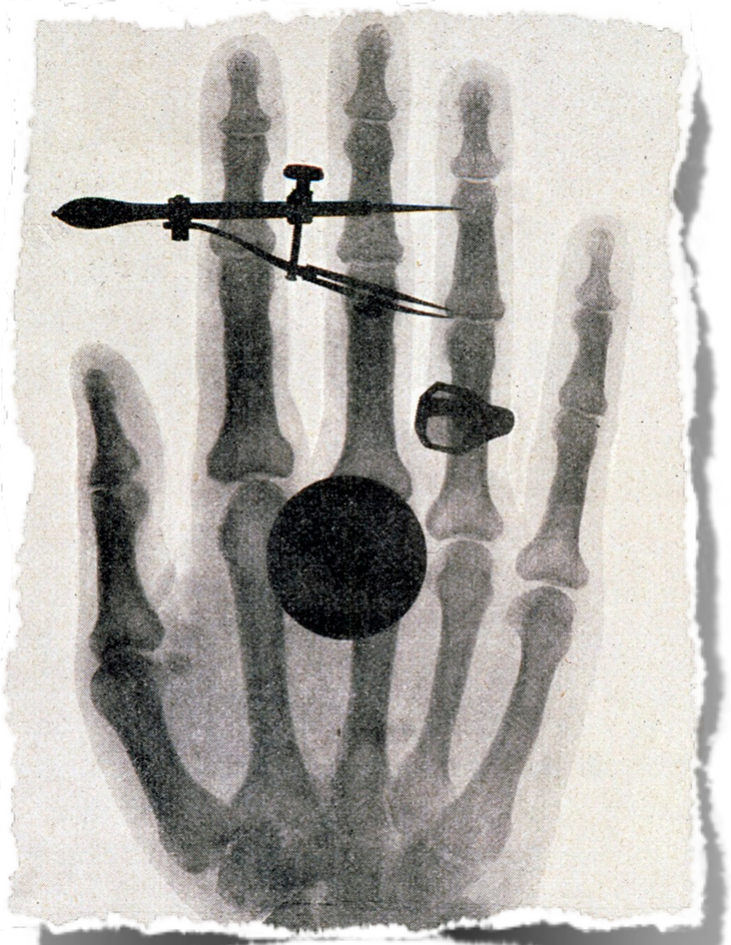

Are scientific hits predictable?

Hurricane Irene

8 PM - 8/25/11

115 mph - 946 mb

Sun

Sat

Fri

75 mph

105 mph

120 mph

Intensity Key:

- TD
- TS
- Cat 1
- Cat 2
- Cat 3
- Cat 4
- Cat 5

NYC Area Weather

Tropical Weather


Alvarez Photography
Stephen Alvarez

Success is a collective phenomenon

Success is measurable


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Nitrogen
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A quantitative approach is provided by publication data

PHYSICAL REVIEW B VOLUME 4, NUMBER 9 1 NOVEMBER 1971

Renormalization Group and Critical Phenomena. I. Renormalization Group and the Kadanoff Scaling Picture*

Kenneth G. Wilson
Laboratory of Nuclear Studies, Cornell University, Ithaca, New York 14850
(Received 2 June 1971)

The Kadanoff theory of scaling near the critical point for an Ising ferromagnet is cast in differential form. The resulting differential equations are an example of the differential equations of the renormalization group. It is shown that the Widom-Kadanoff scaling laws arise naturally from these differential equations if the coefficients in the equations are analytic at the critical point. A generalization of the Kadanoff scaling picture involving an "irrelevant" variable is considered; in this case the scaling laws result from the renormalization-group equations only if the solution of the equations goes asymptotically to a fixed point

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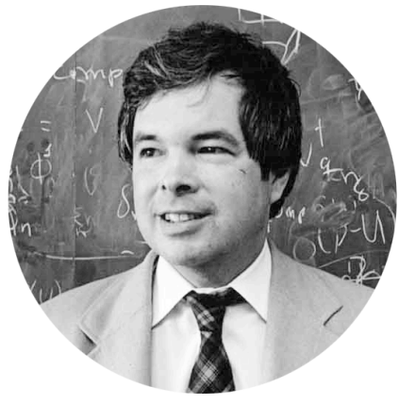
More than 100 years of Data

- ~500,000 papers since 1893
- All citations among these papers
- ~200,000 unique authors (after disambiguation)

Kenneth G. Wilson

Nobel in physics in 1982



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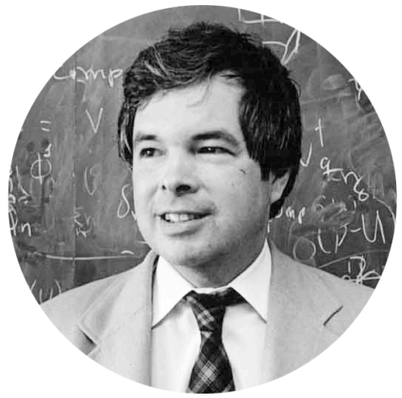

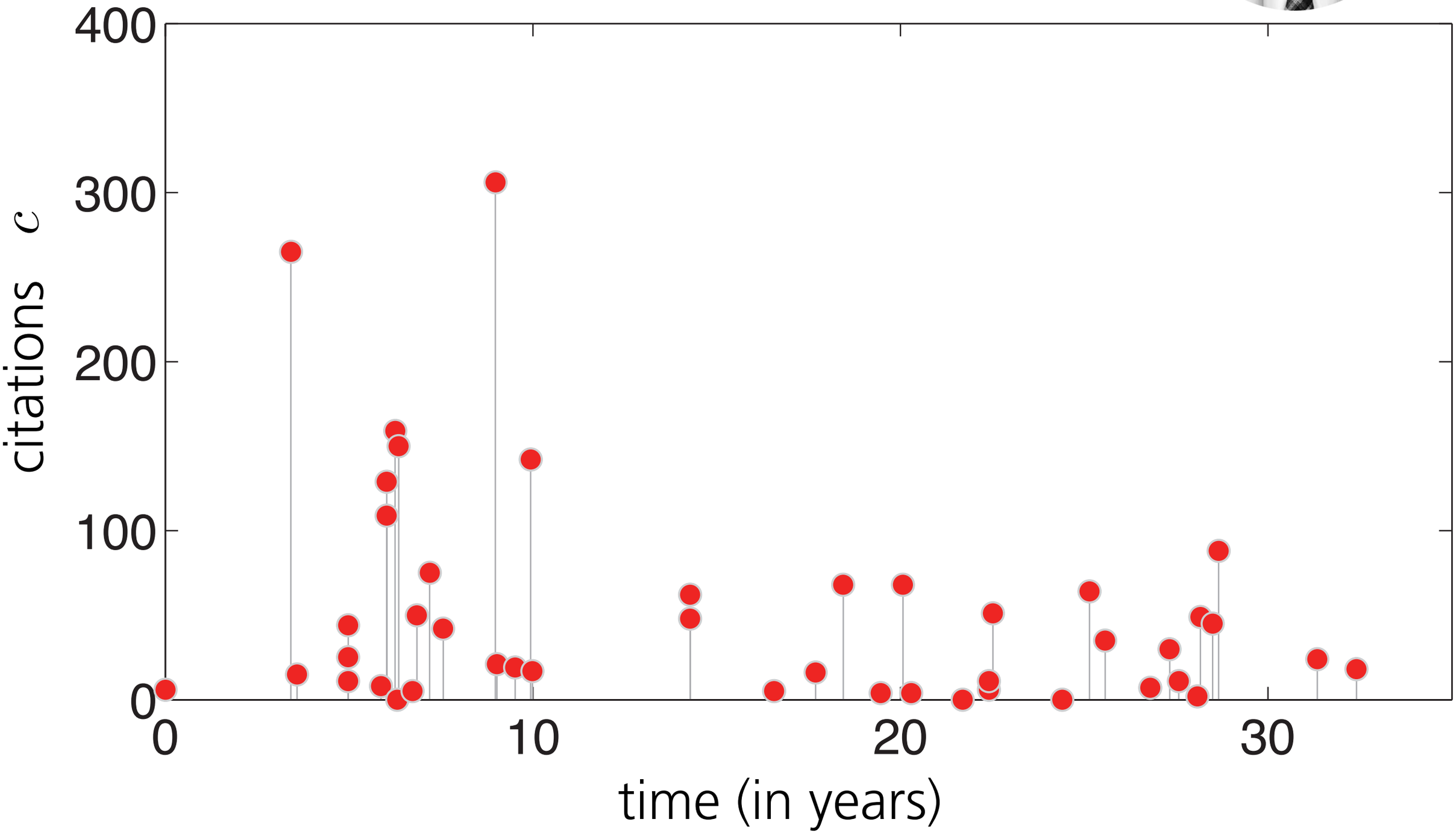

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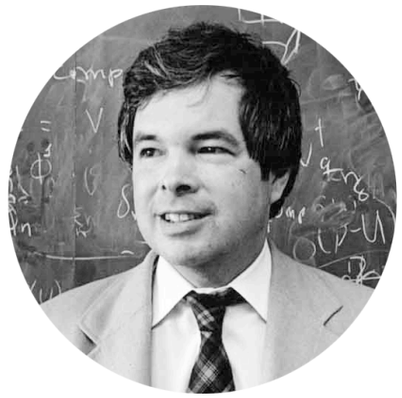

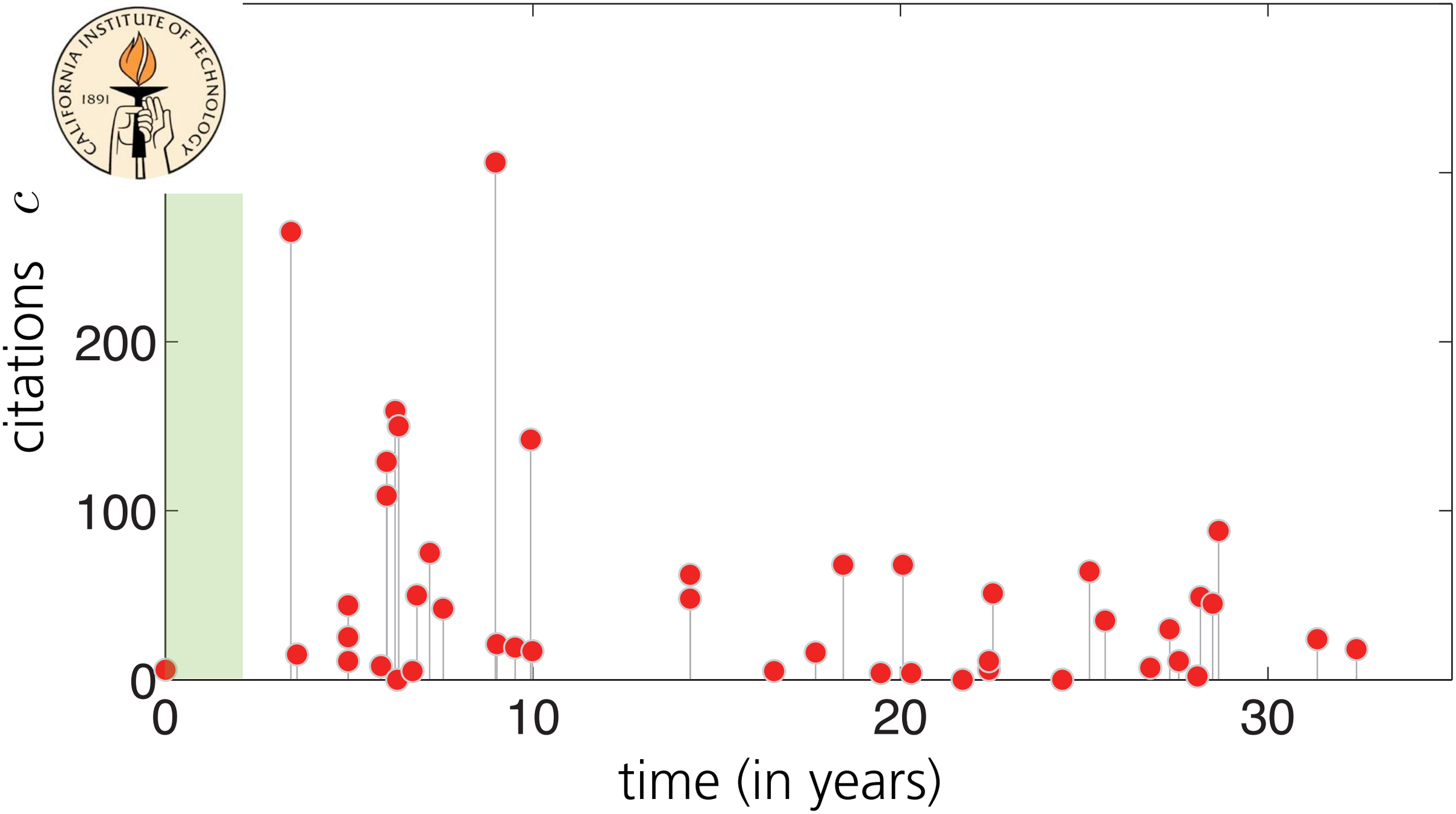

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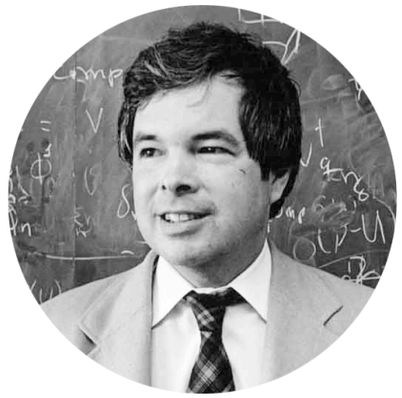

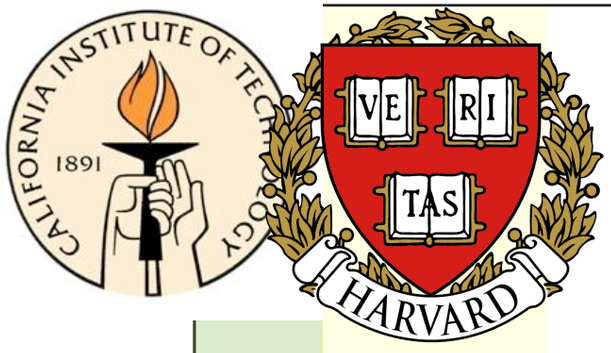

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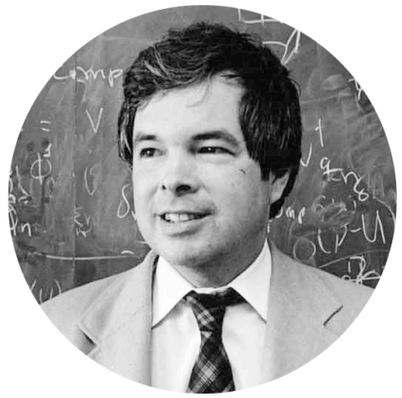

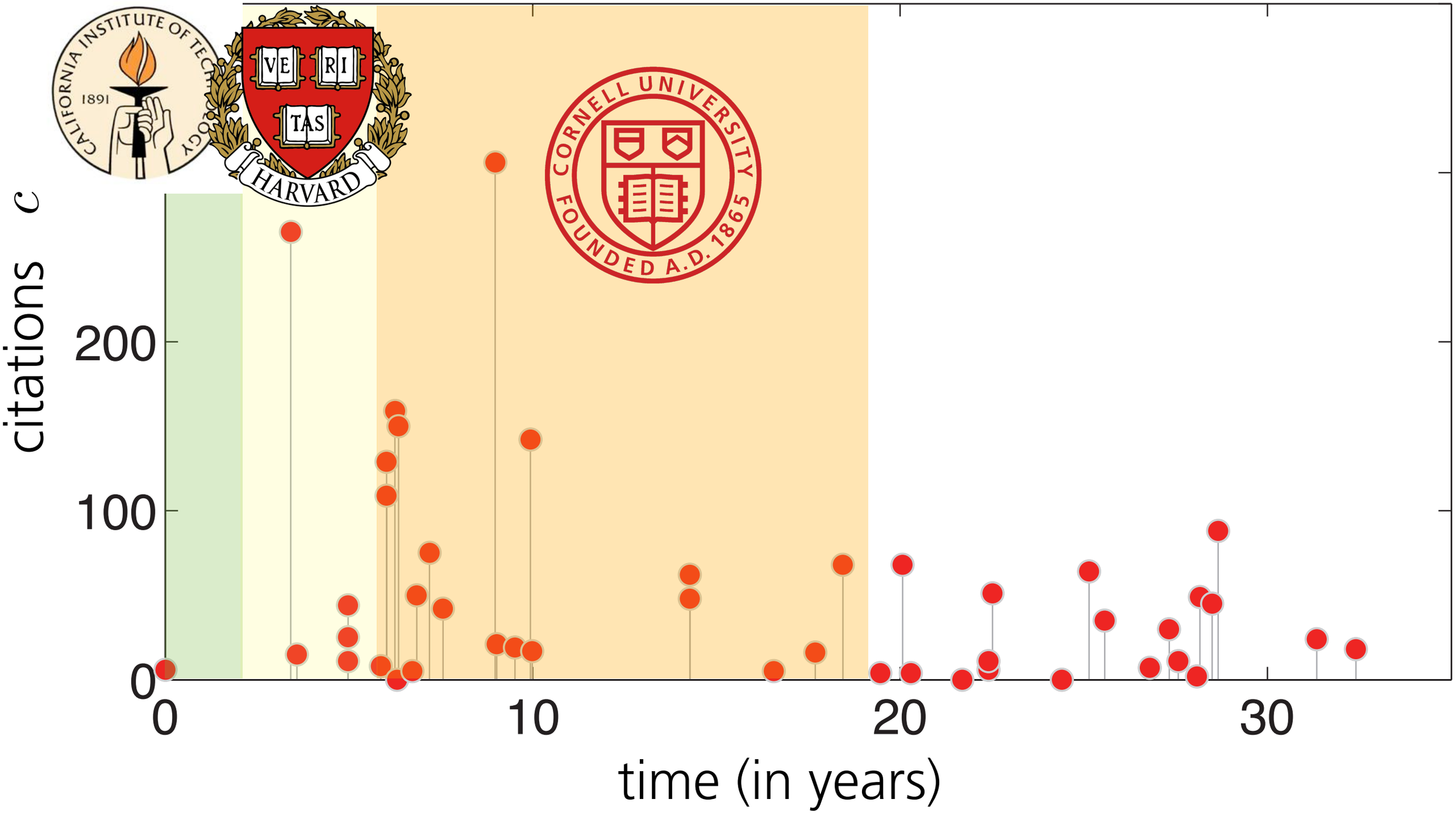

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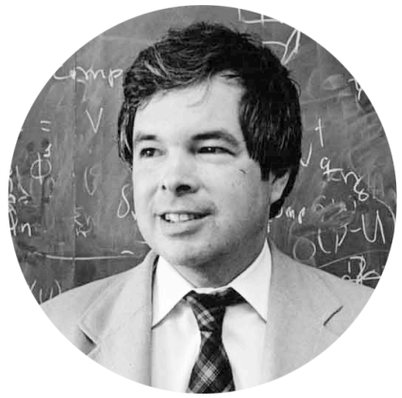

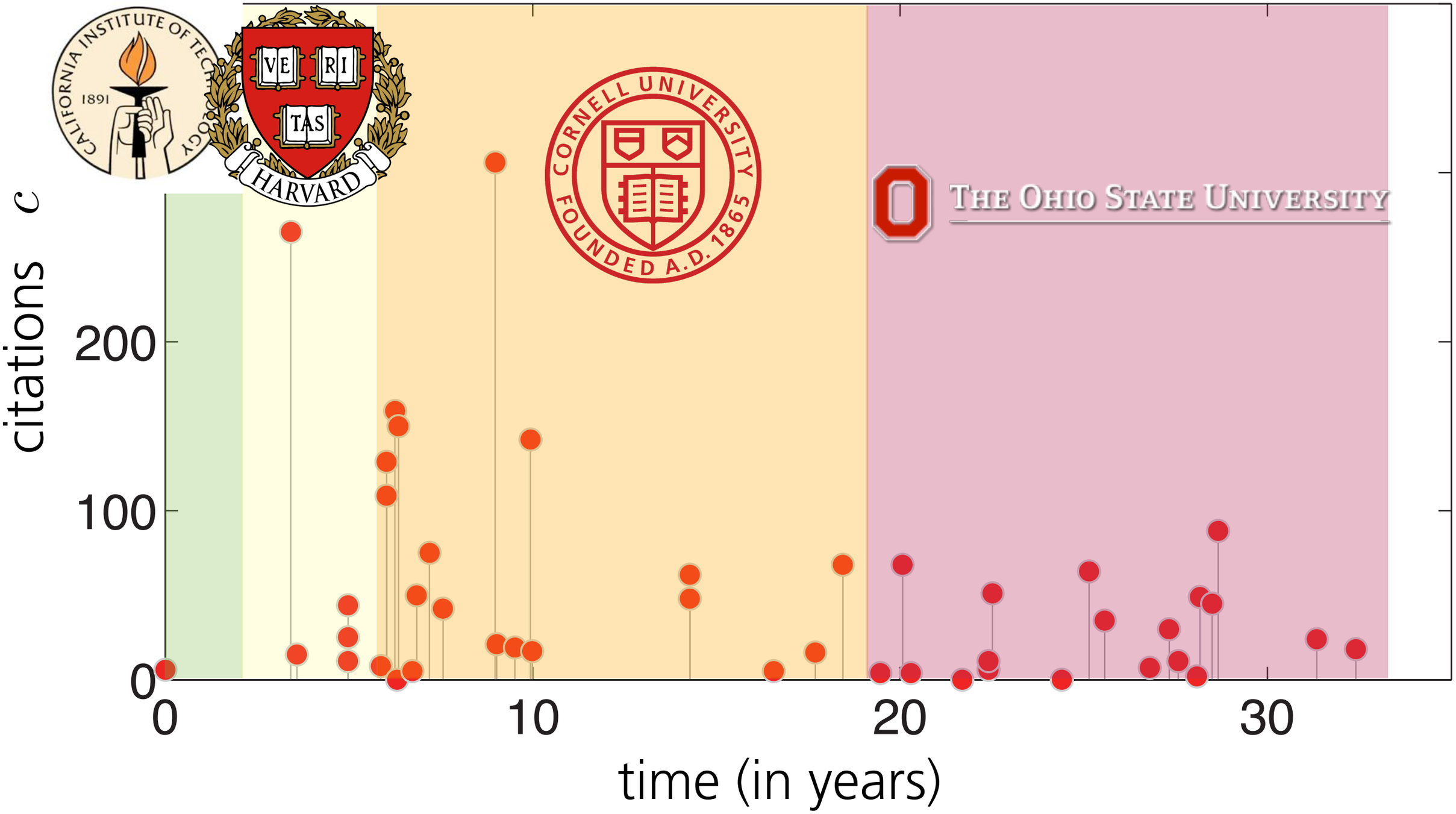

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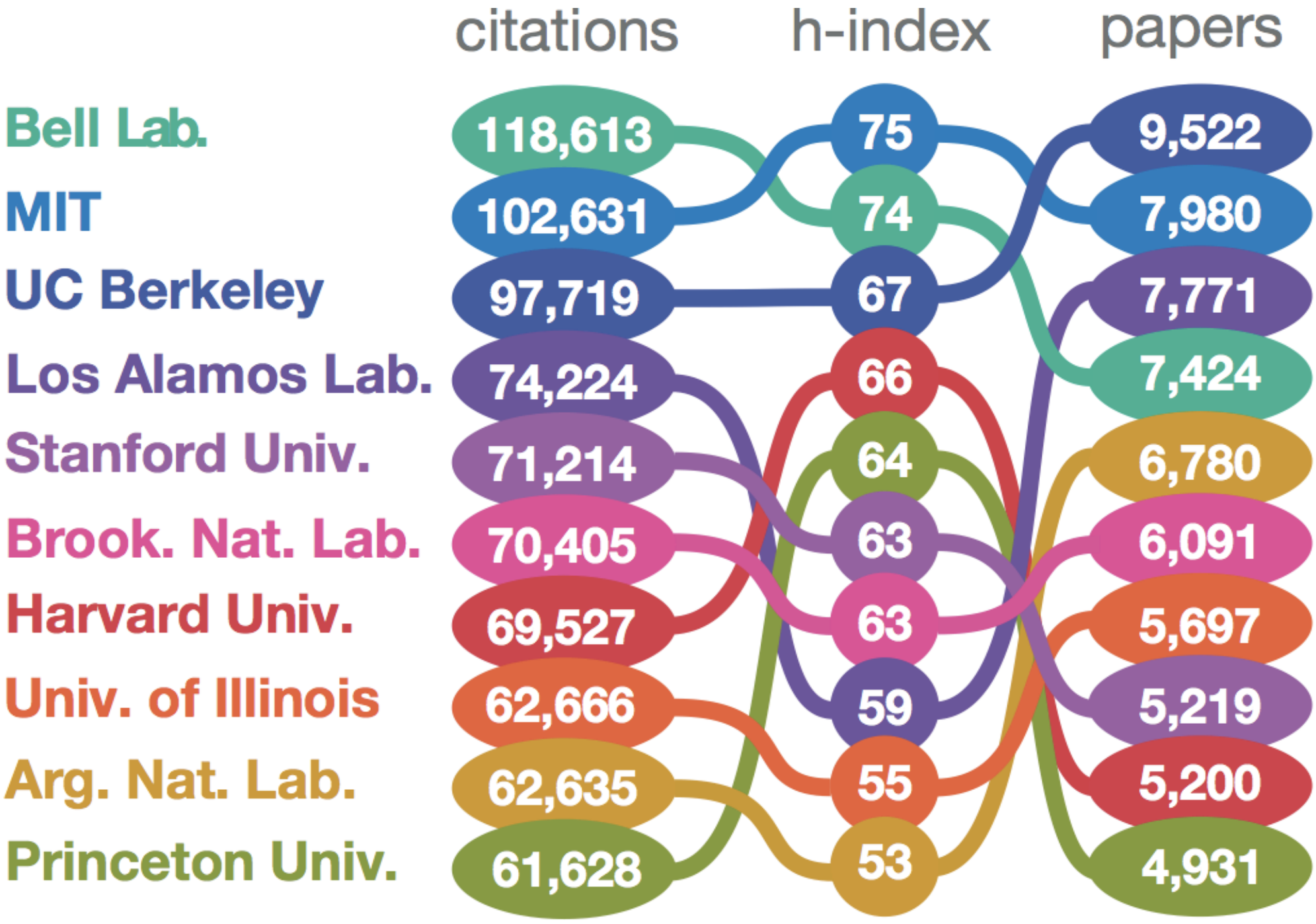
Does mobility influence scientists' impact?

Most Nobel Laureates come from a handful of institutions

Rank	University (Country)	Total Prizes
1	Harvard University, USA	34
2	Stanford University, USA	20
3	University of Chicago, USA	19
4	Massachusetts Institute of Technology,	18
4	UC Berkeley, USA	18
6	Rockefeller University, USA	17
6	University of Cambridge, UK	17
8	California Institute of Technology, USA	16
9	Columbia University, USA	16
10	Princeton University, USA	12
10	Max Planck Institutes, Germany	12

Sources: Huffington Post, 2013-11-02
http://www.nobelprize.org/ (accessed January 2015)

Rankings are highly correlated



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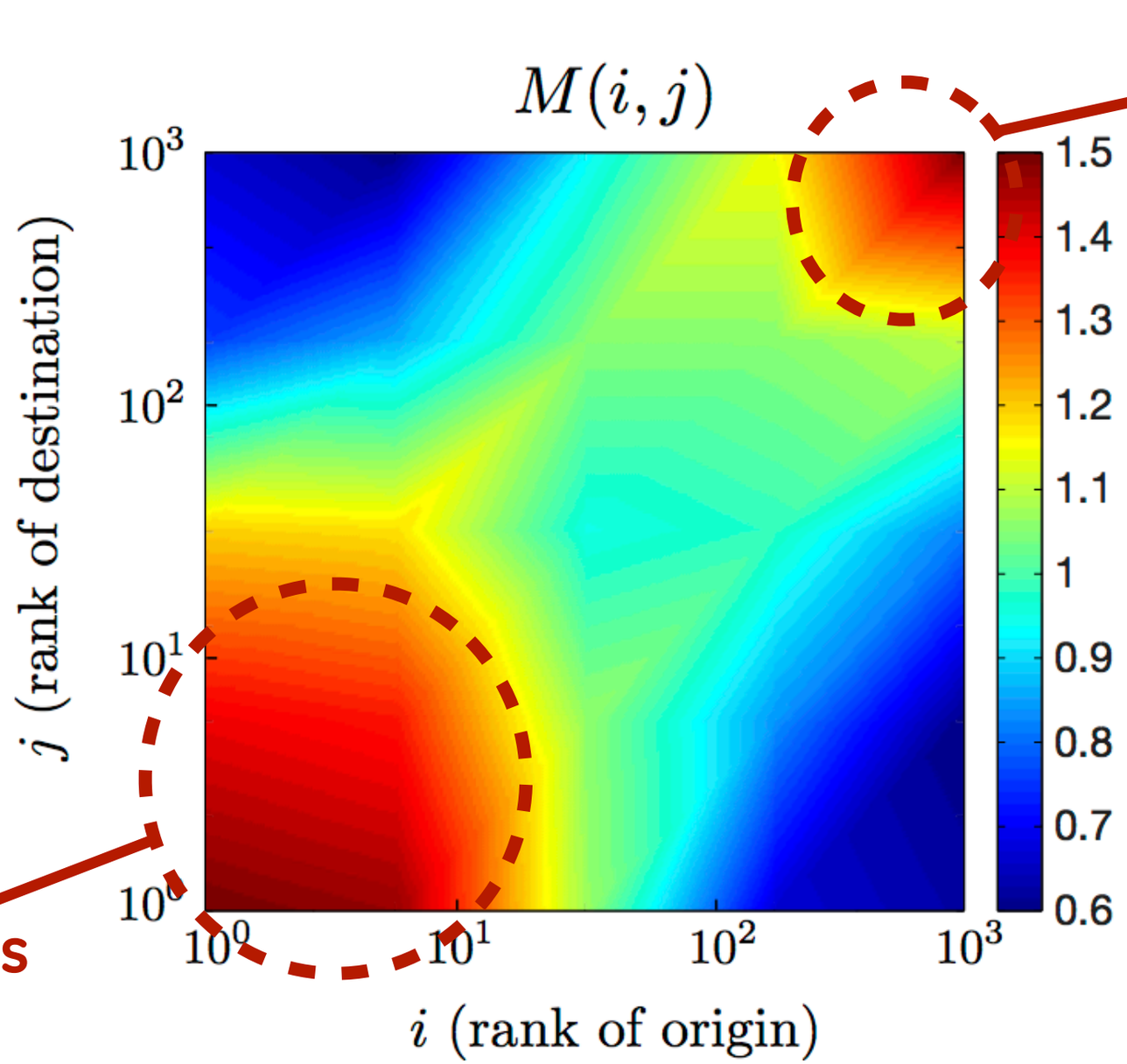
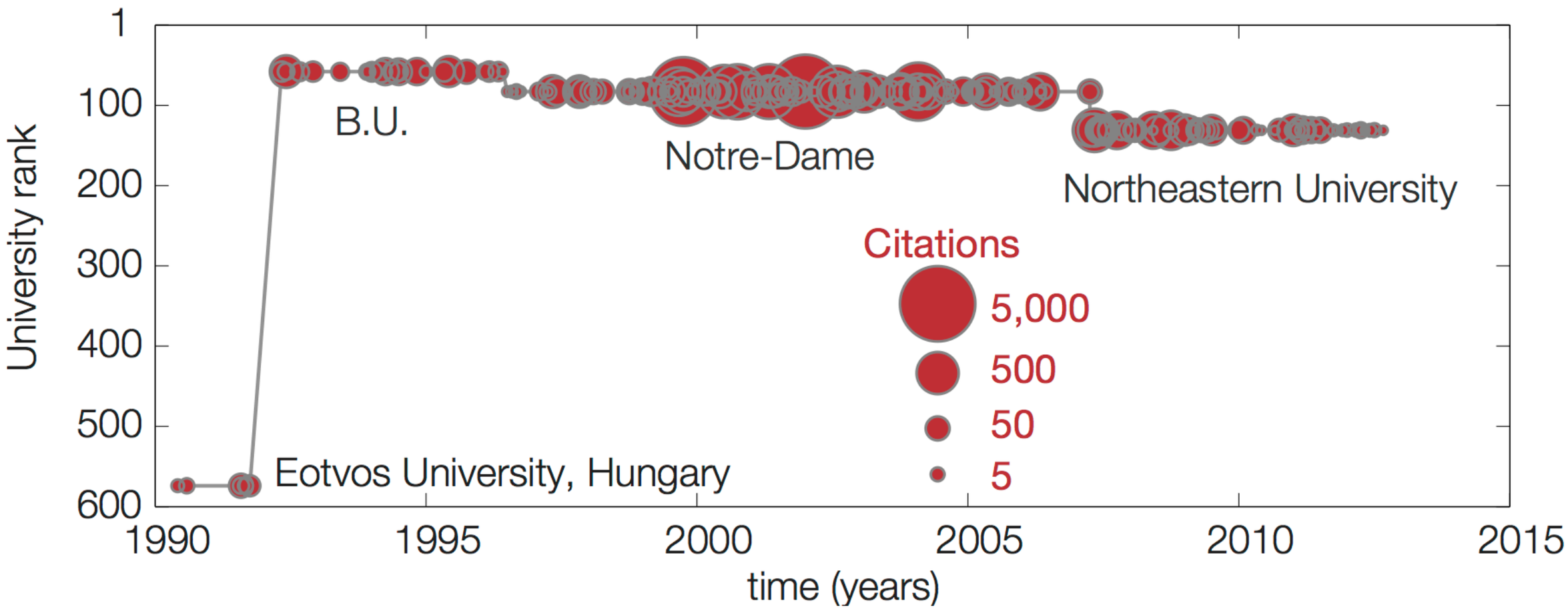
Scientists move among institutions of similar rank



Deville, Wang, Sinatra, Song, Barabási, *Sci. Rep.* 4:4770, (2014)

Career on the Move



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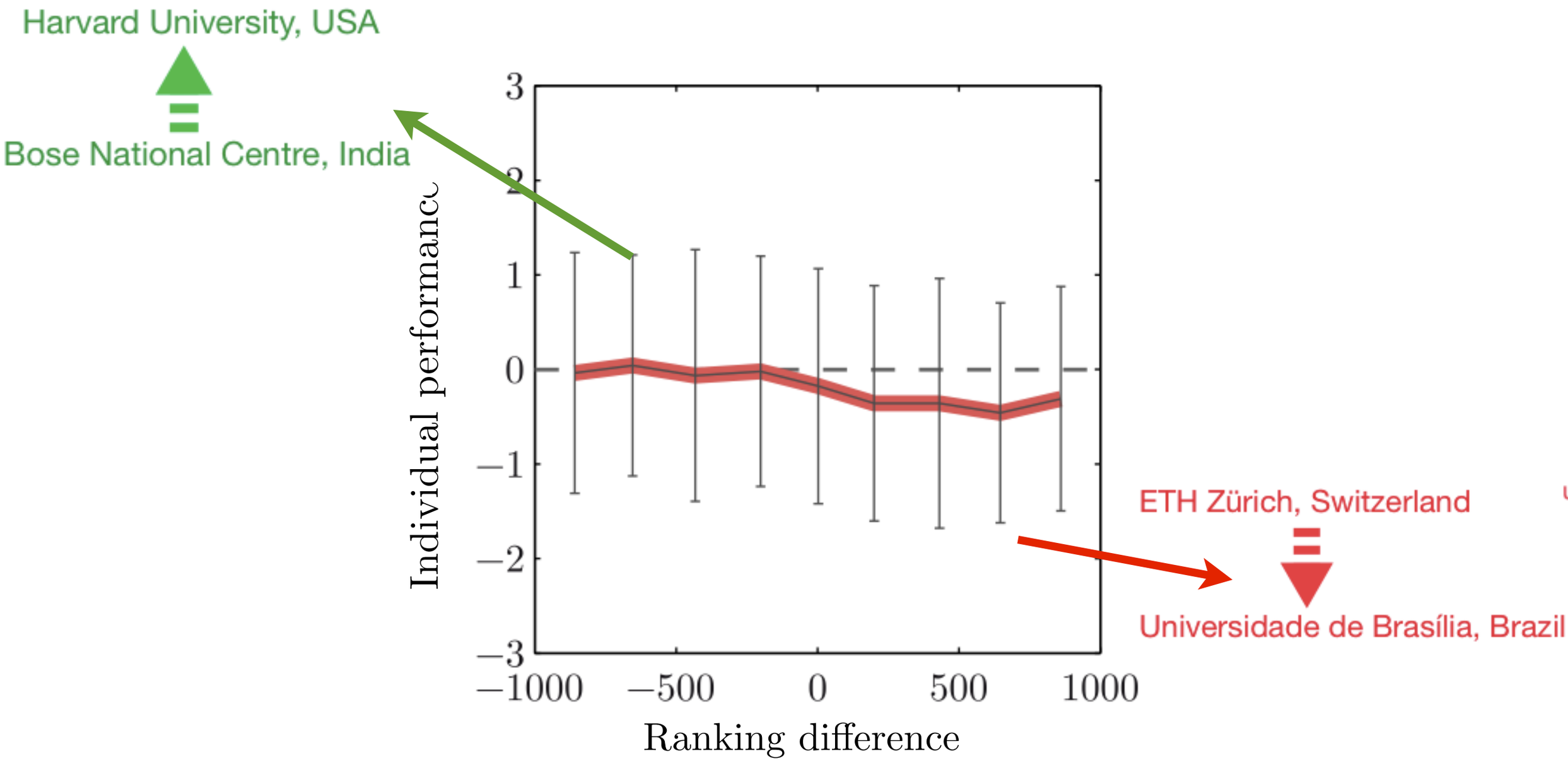
Movements to higher-ranked institutions do not induce impact changes



Academic prestige

Why climb the greasy pole?

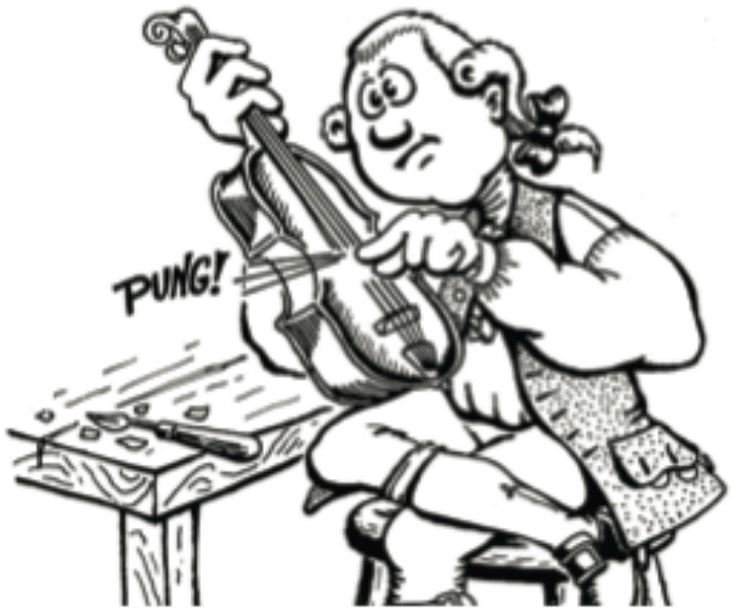
Getting a job at a top university will not make you a better researcher

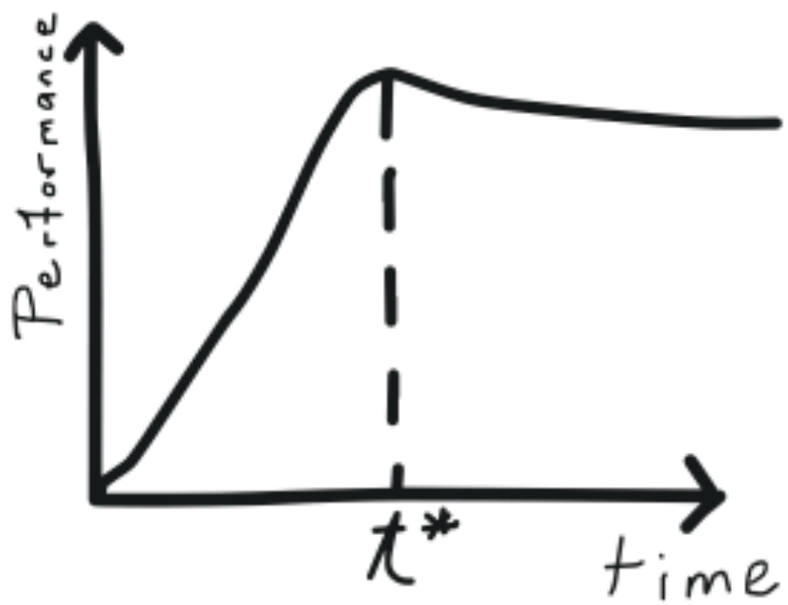
May 10th 2014 | From the print edition

Timekeeper

MOST academics would view a post at an elite university like Oxford or Harvard as the crowning achievement of a career—bringing both accolades and access to better wine cellars. But scholars covet such places for reasons beyond glory and gastronomy. They believe perching on one of the topmost branches of the academic tree will also improve the quality of their work, by bringing them together with other geniuses with whom they can collaborate and who may help spark new ideas. This sounds plausible. Unfortunate as Albert-Laszlo Barabasi of Northeastern University, in Boston (and also, it must be sa of Harvard), shows in a study published in *Scientific Reports*, it is not true.

Are there patterns of performance?





Ericsson et al. Psychological review 100, 363 (1993)
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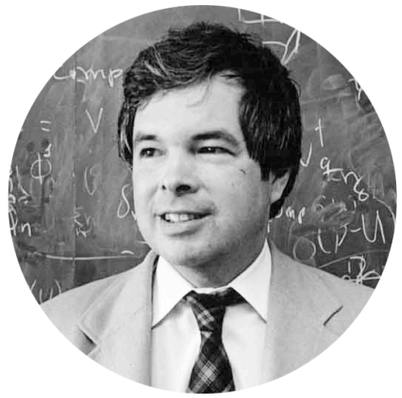
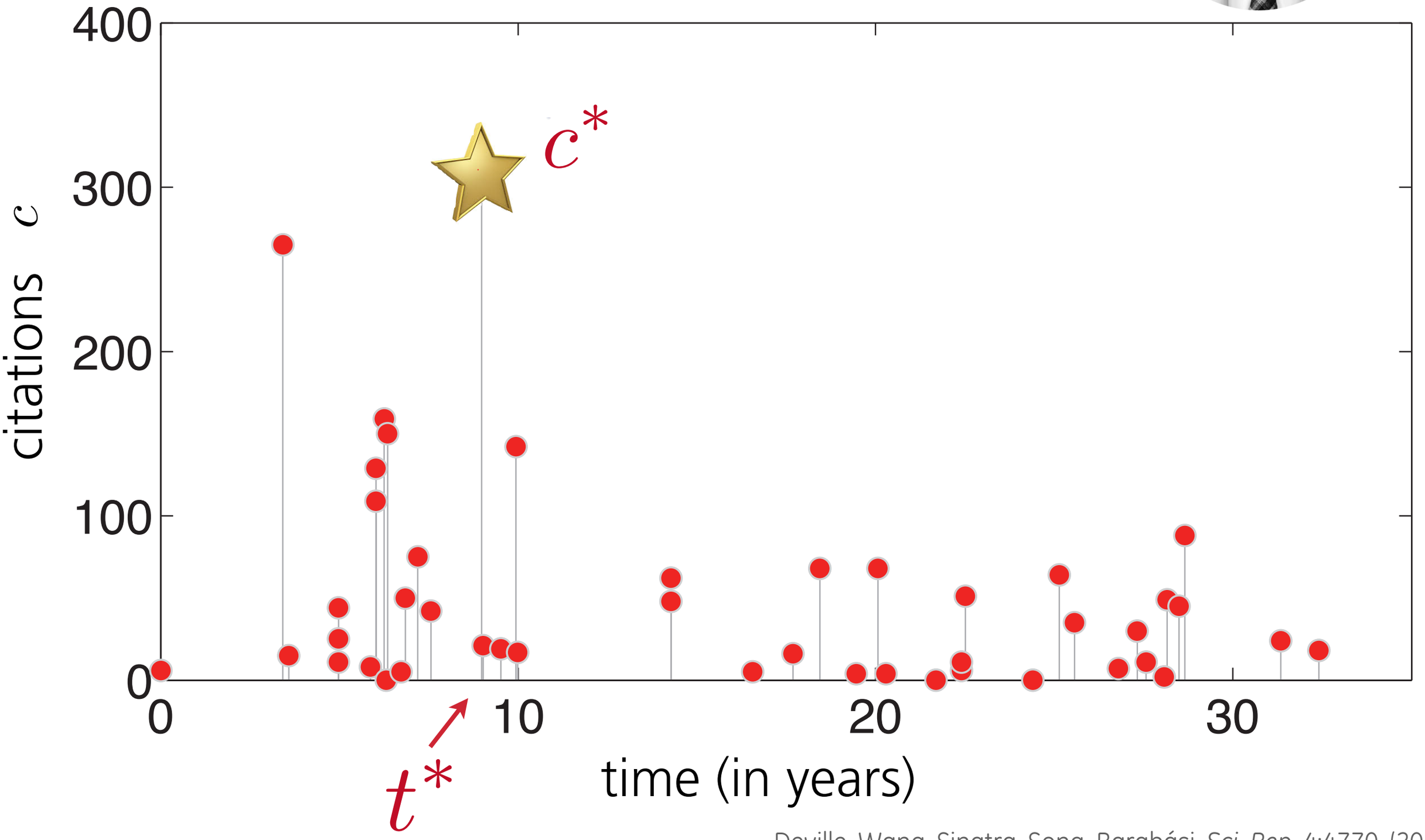
Kenneth G. Wilson

Nobel in physics in 1982





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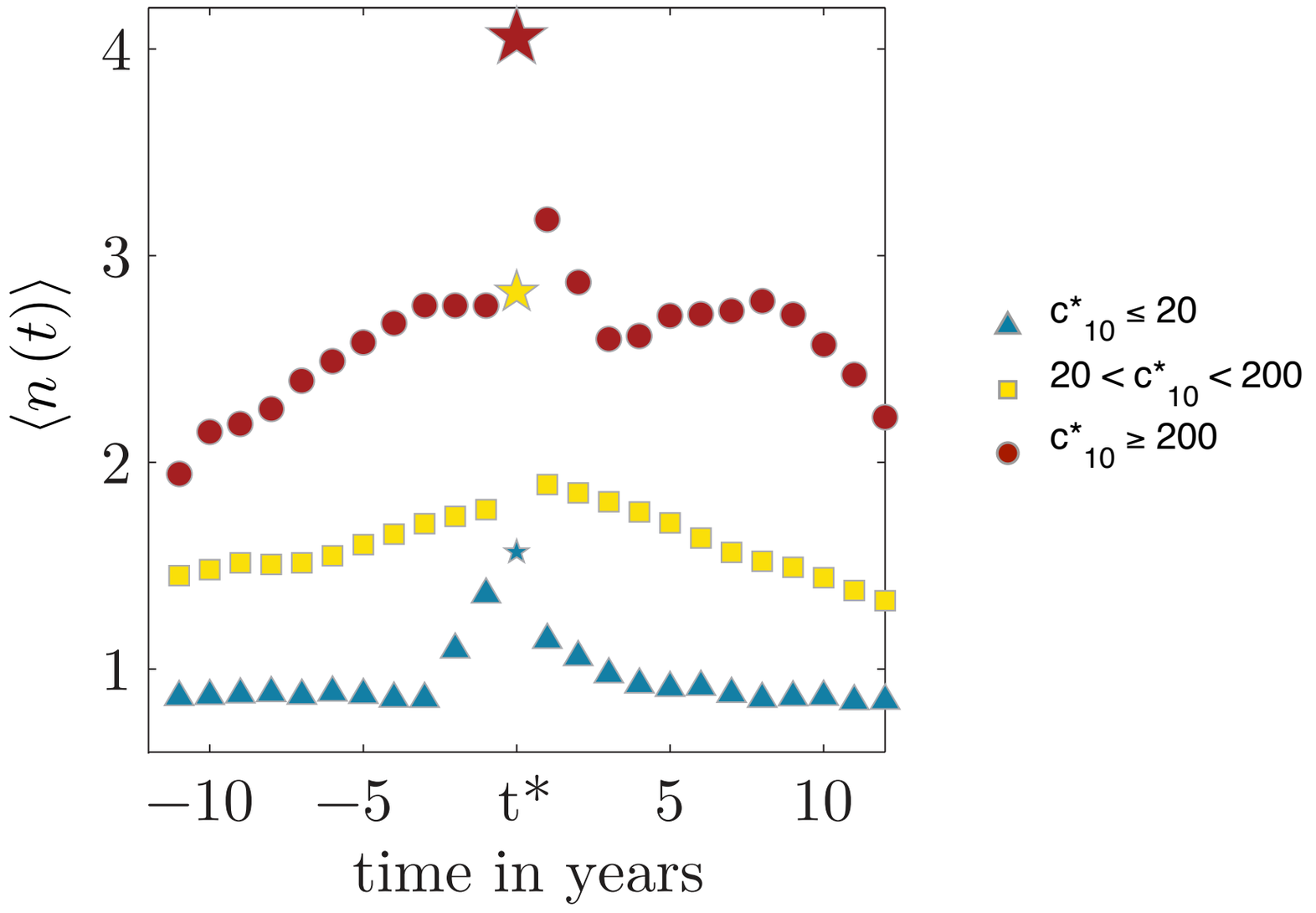
Measuring performance

Productivity

Impact

There are patterns of productivity



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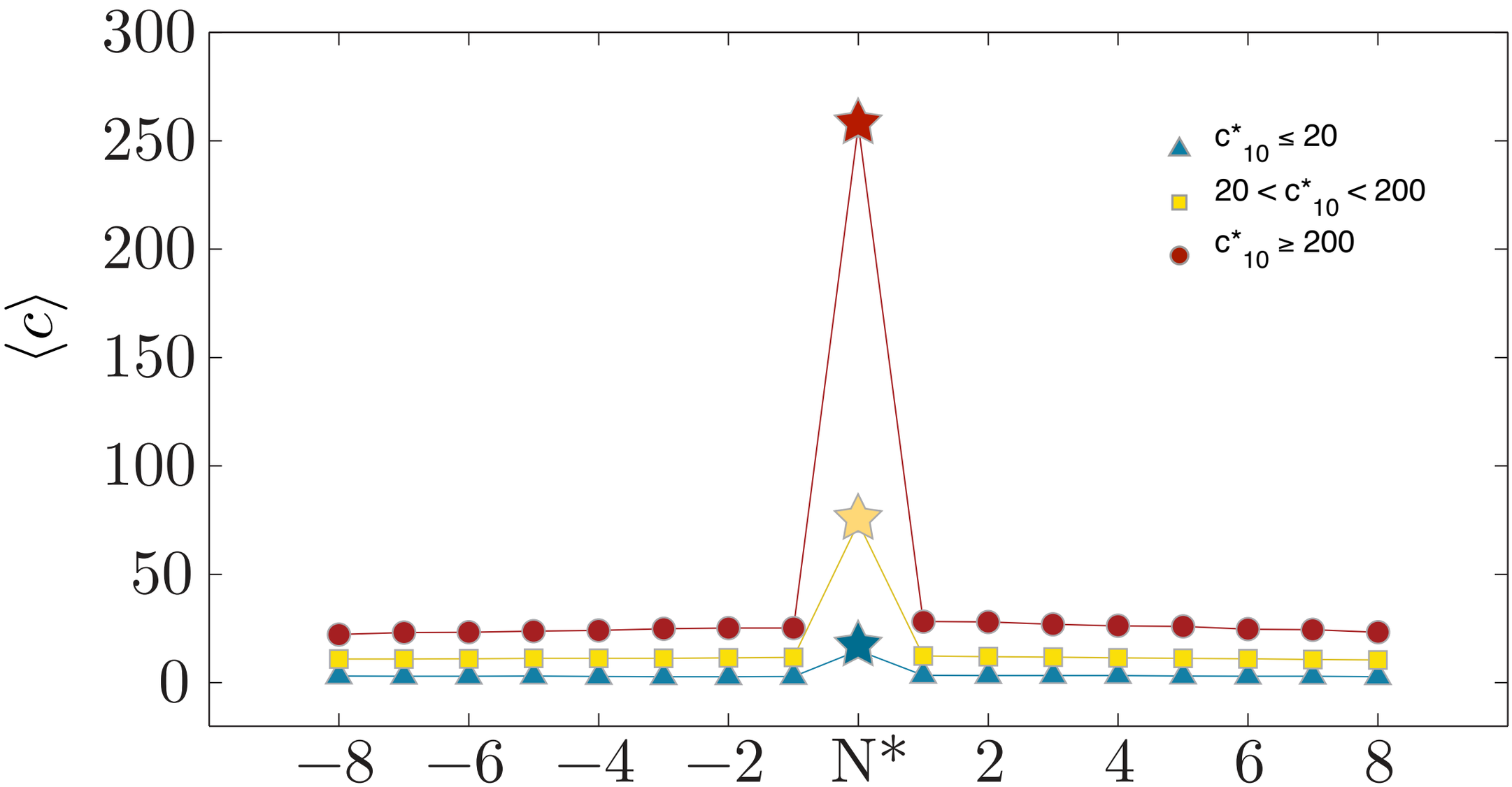
There are no patterns of impact



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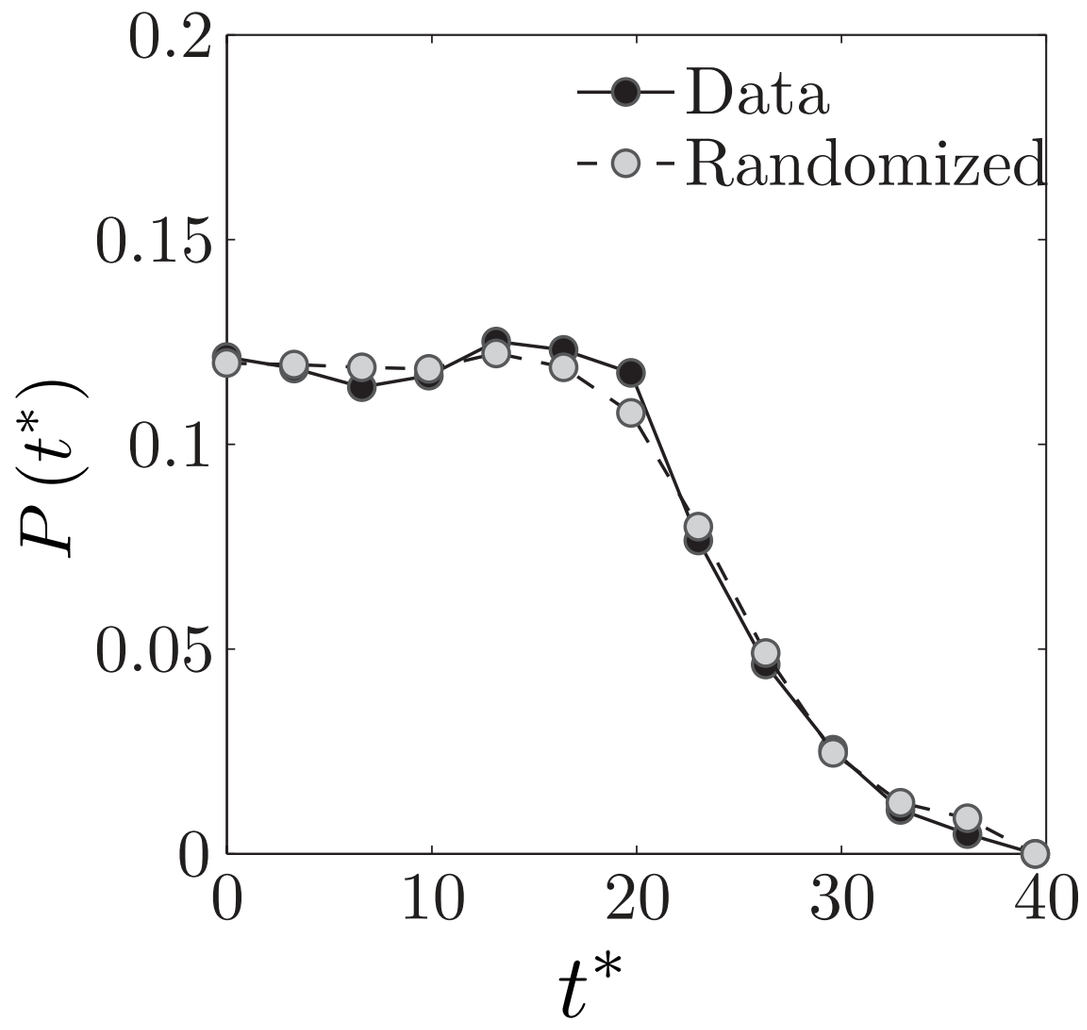
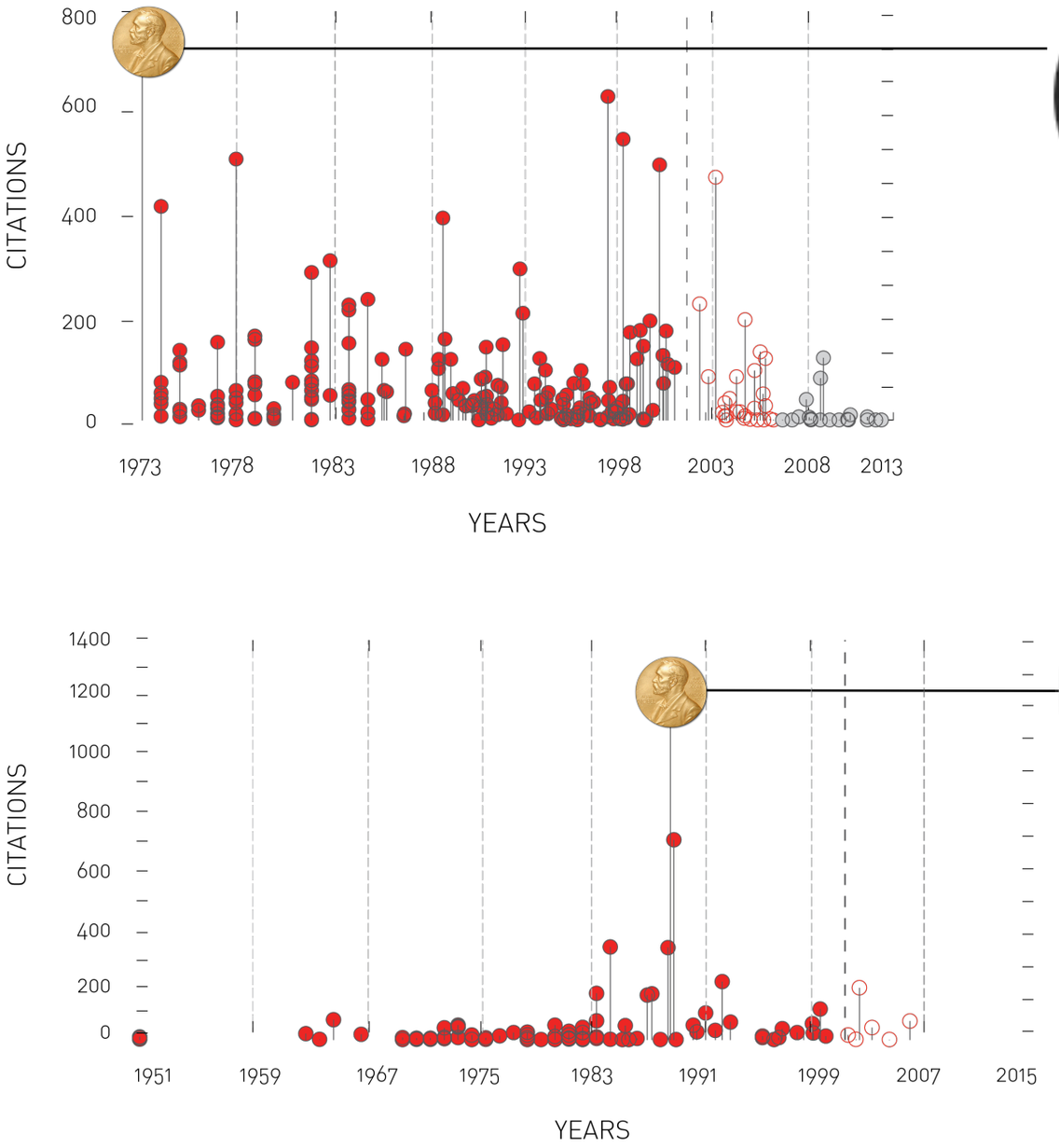
Timing of the the highest impact paper is random



Sinatra, Wang, Deville, Song, Barabási, *in review* (2015)

Impact is random within a scientist's career

Each paper has the same probability to be the best one



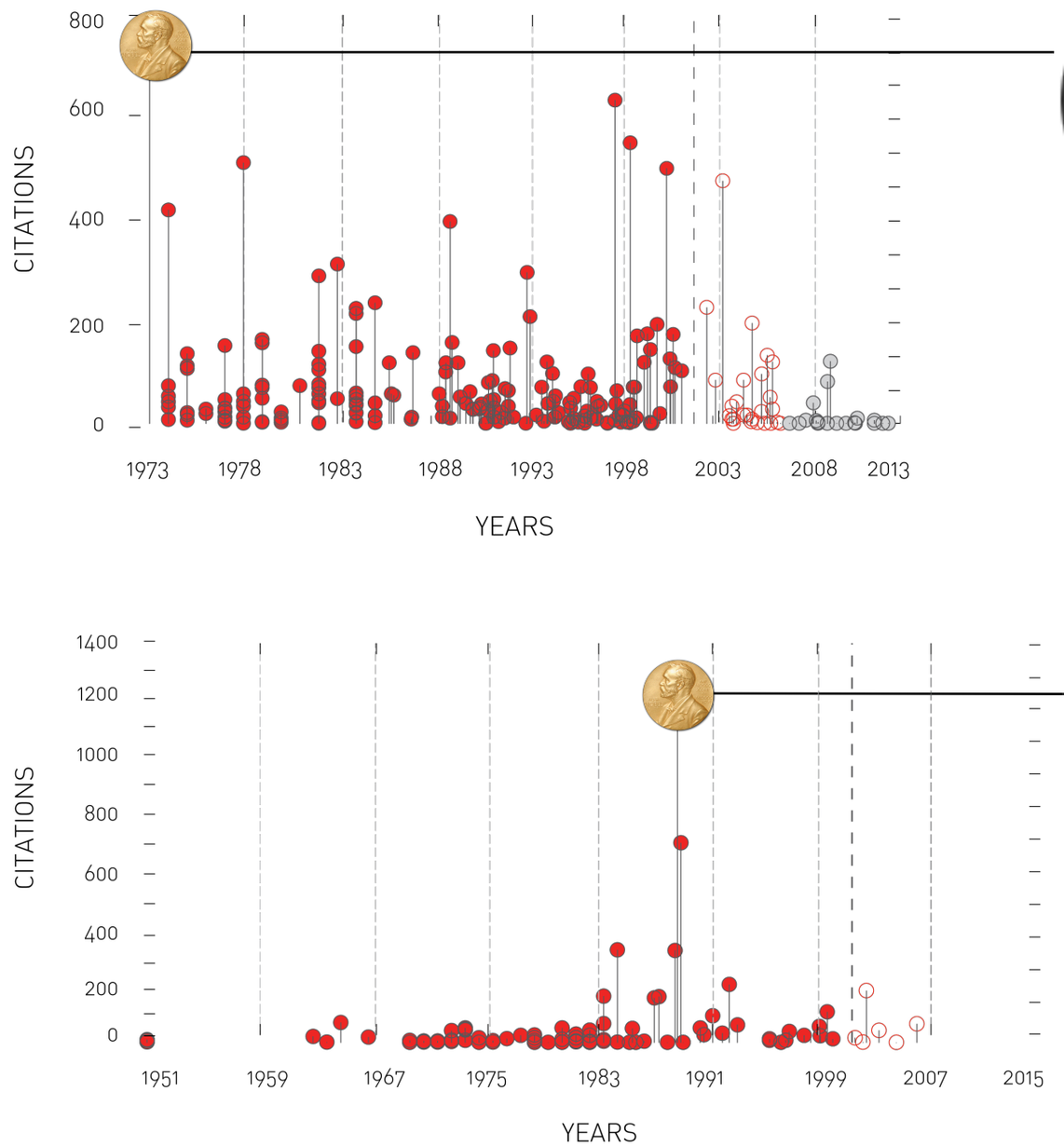
Frank G. Wilczek

Physics Nobel, 2004

John B. Fenn

Chemistry Nobel, 2002

Each paper has the same probability to be the best one

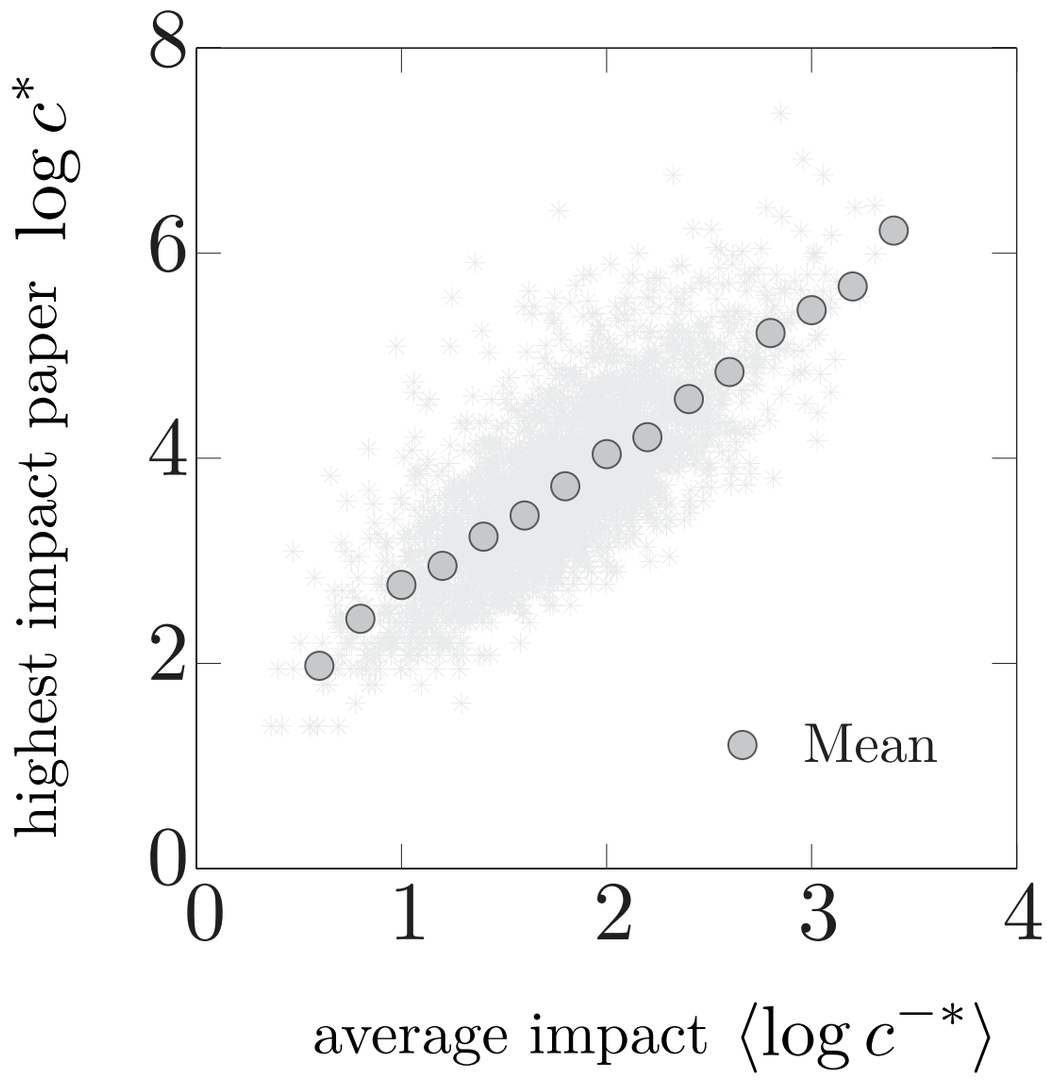


Frank G. Wilczek
Physics Nobel, 2004

John B. Fenn
Chemistry Nobel, 2002

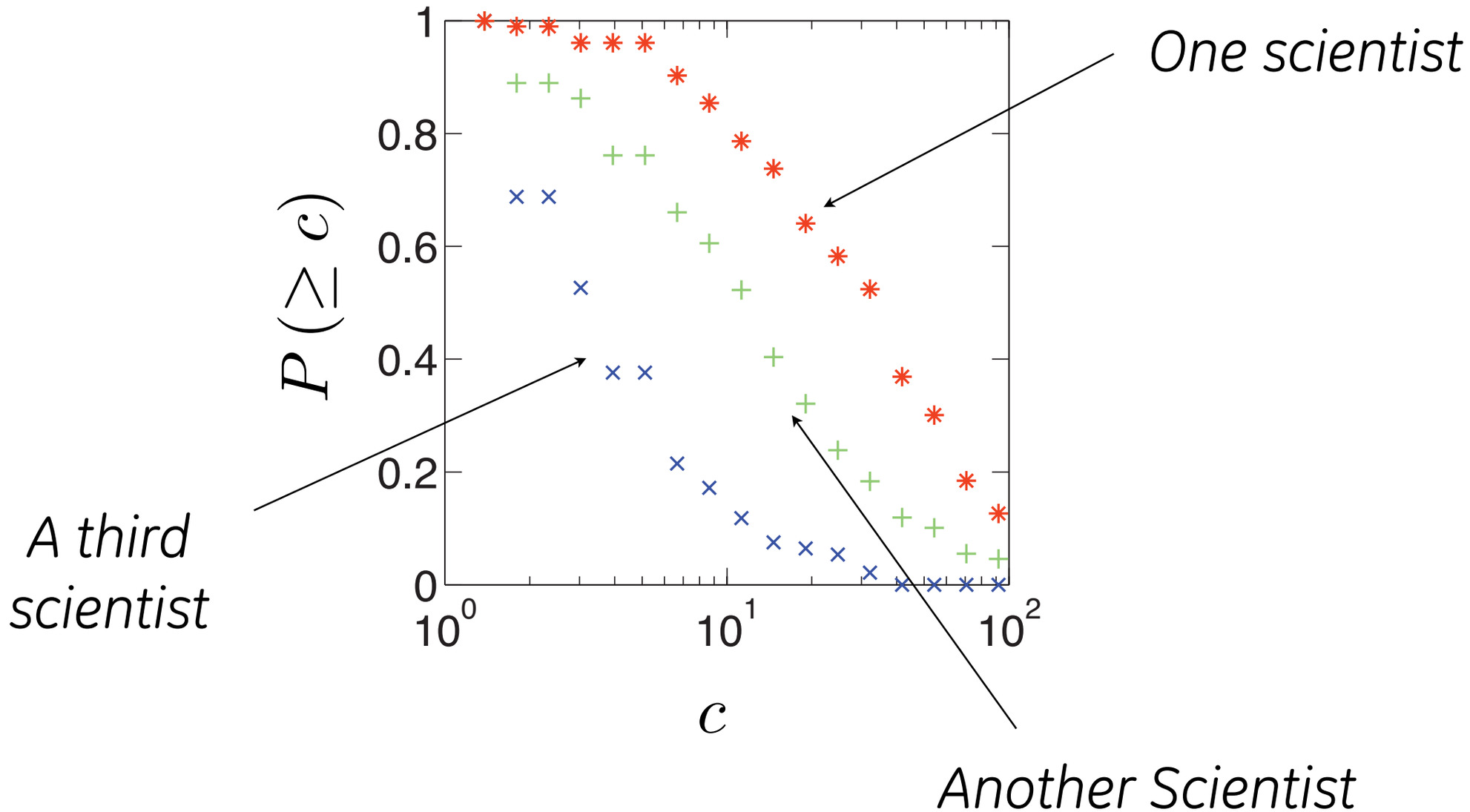
There is always hope!

We observe regularities when comparing different scientists



Sinatra, Wang, Deville, Song, Barabási, *in review* (2015)

Individuals have different impact distributions

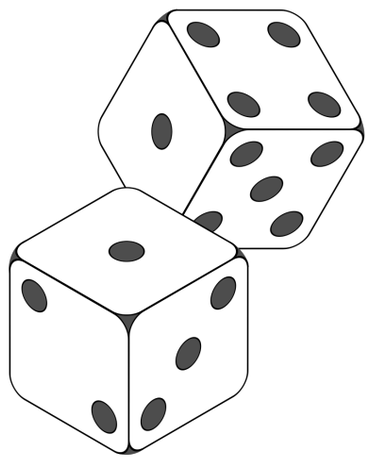


Sinatra, Wang, Deville, Song, Barabási, *in review* (2015)

A universal stochastic principle driving individual impact?

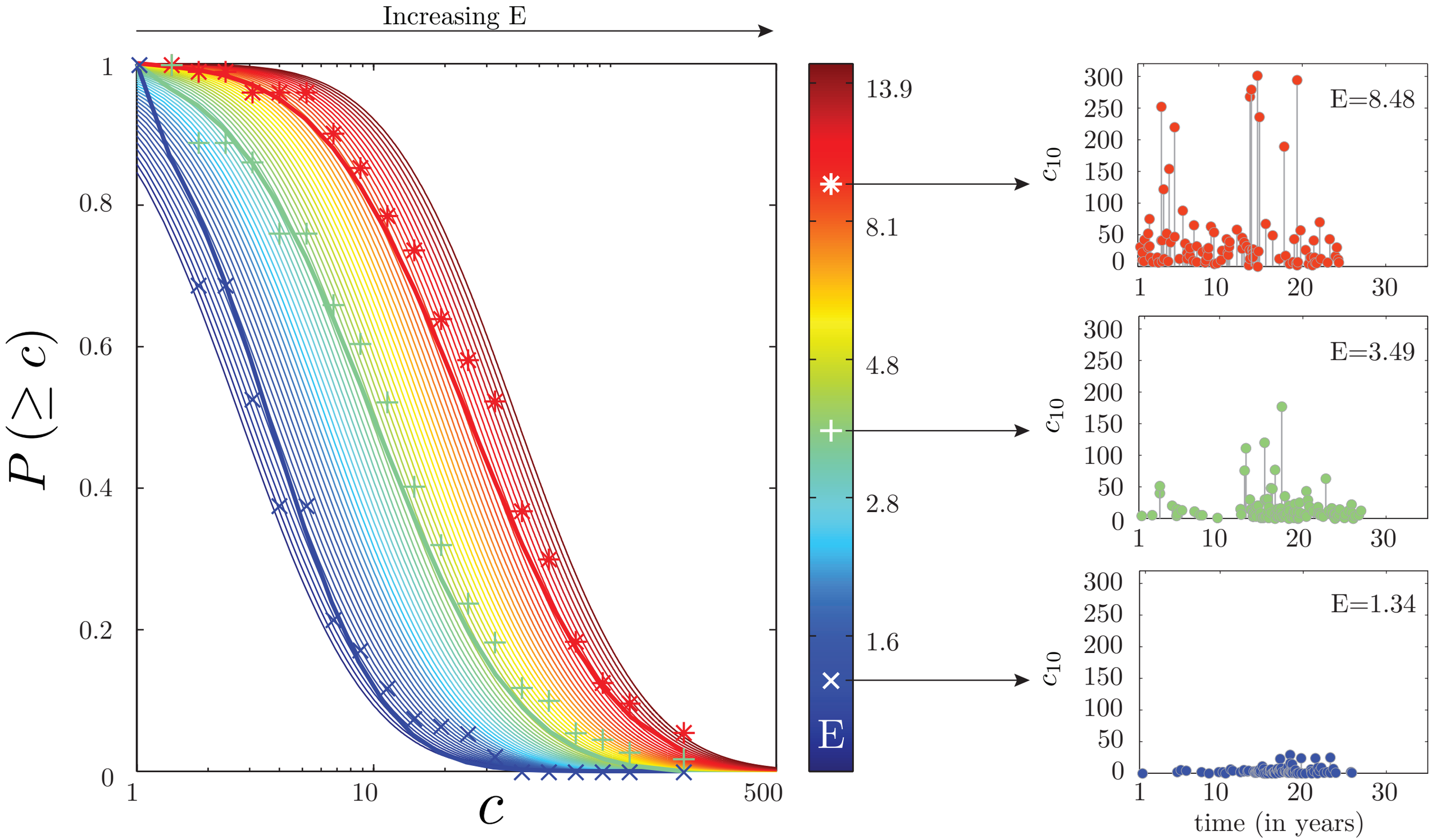
Excellence model untangles luck from skill

$$c_{ij} = p_j E_i$$



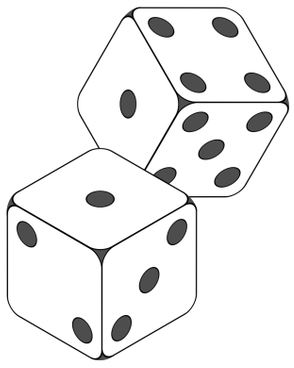
Sinatra, Wang, Deville, Song, Barabási, *in review* (2015)

Excellence model



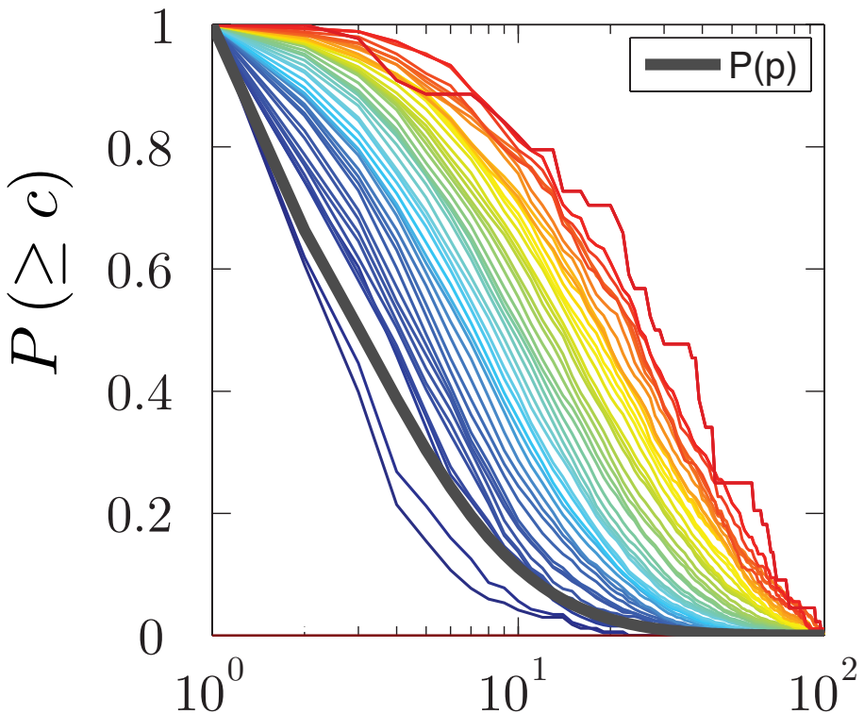
Sinatra, Wang, Deville, Song, Barabási, *in review* (2015)

We untangle skill and luck

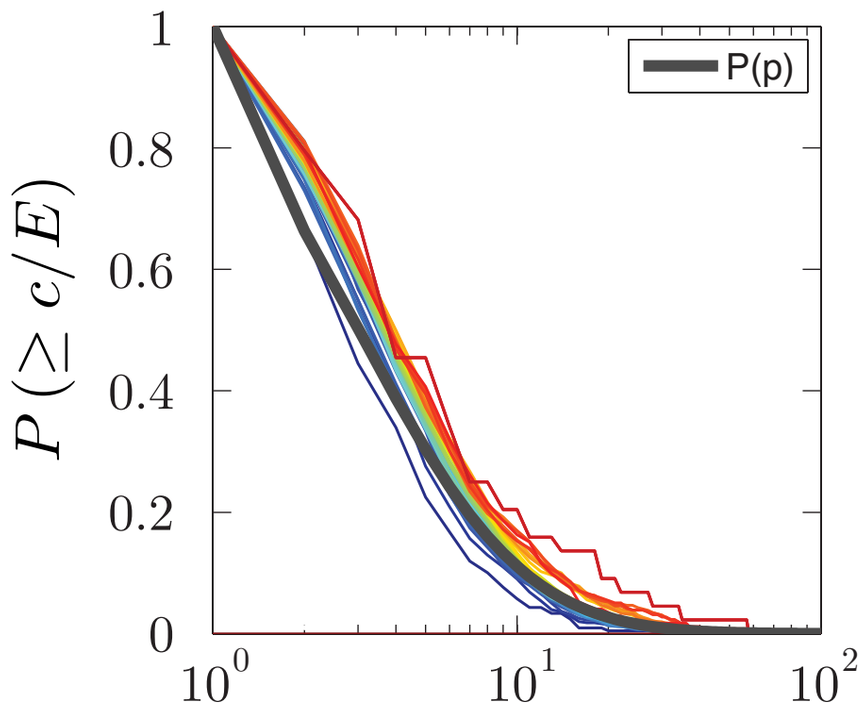


Luck is universal

Data

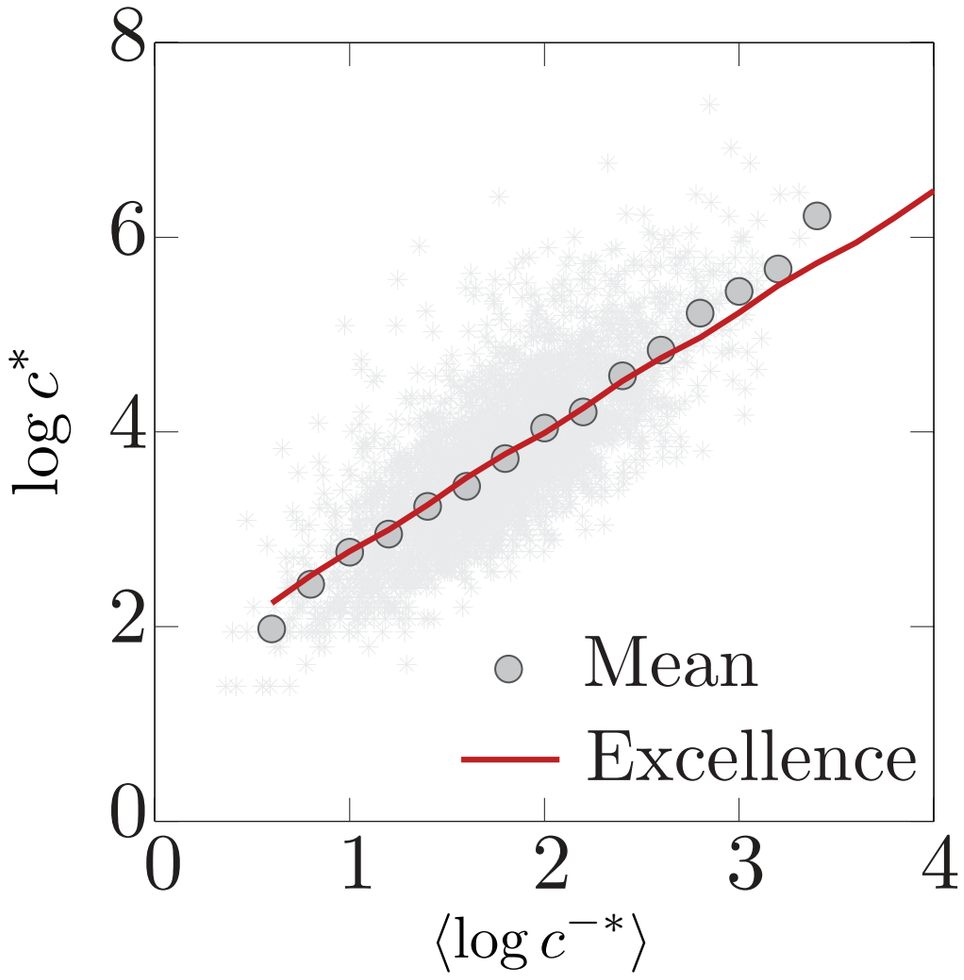


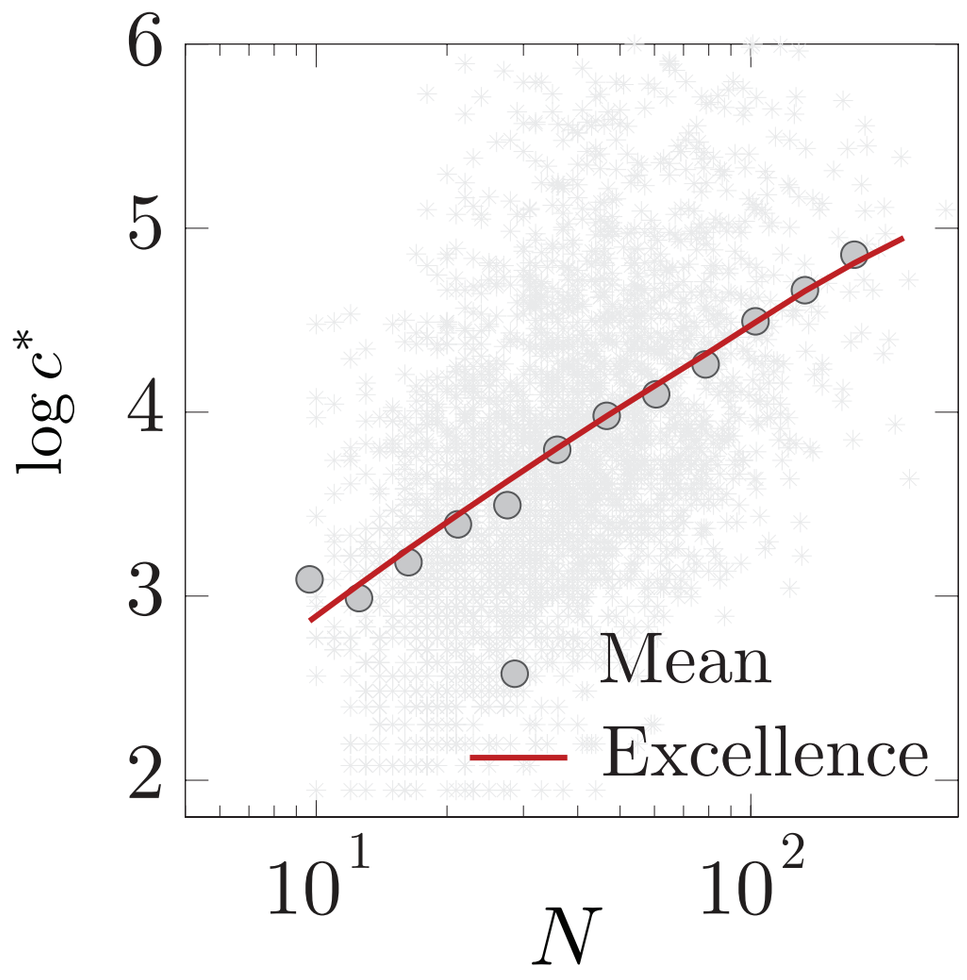
Rescaled Data



Sinatra, Wang, Deville, Song, Barabási, *in review* (2015)

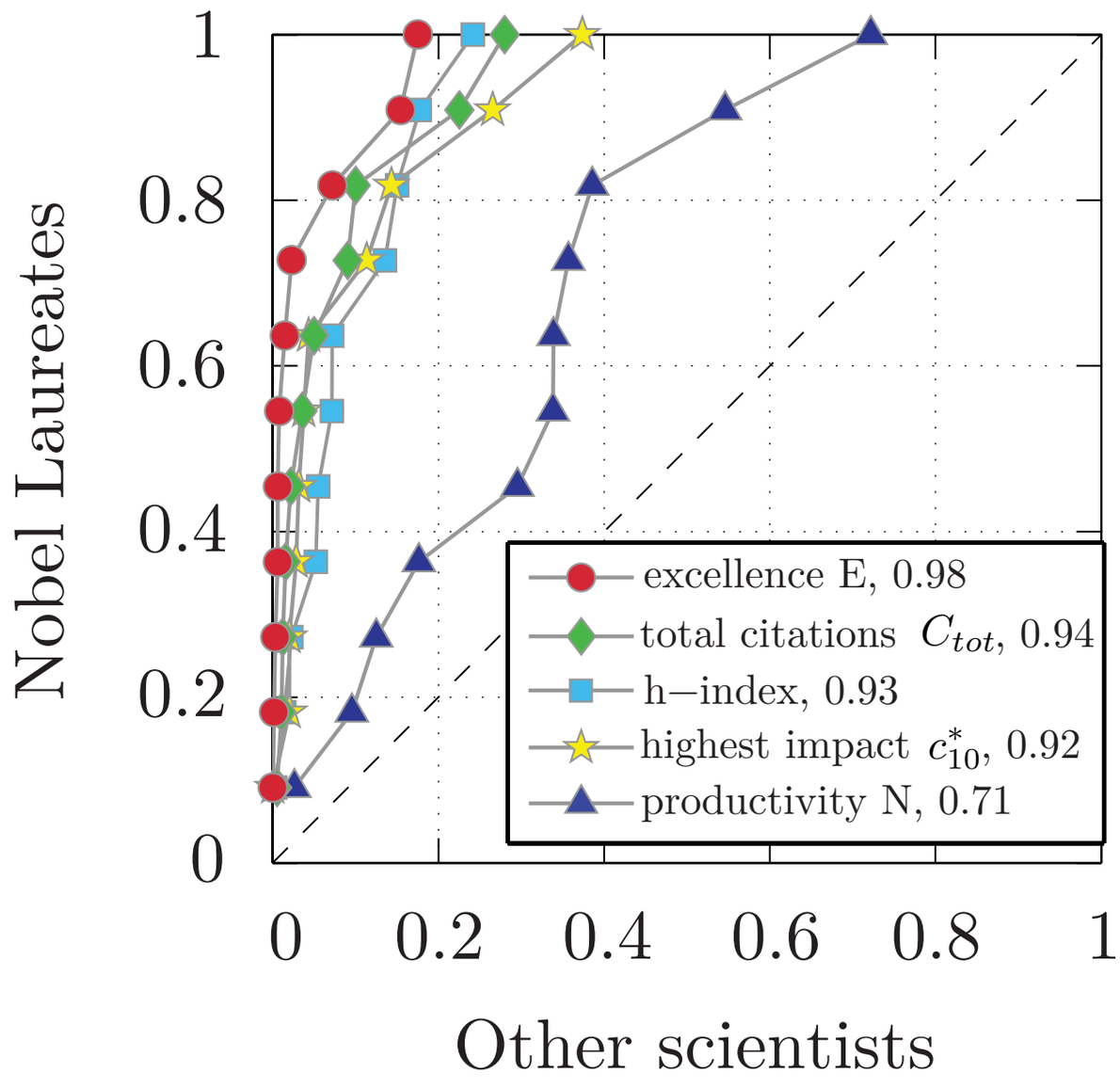
The excellence model predicts the highest impact work of scientists





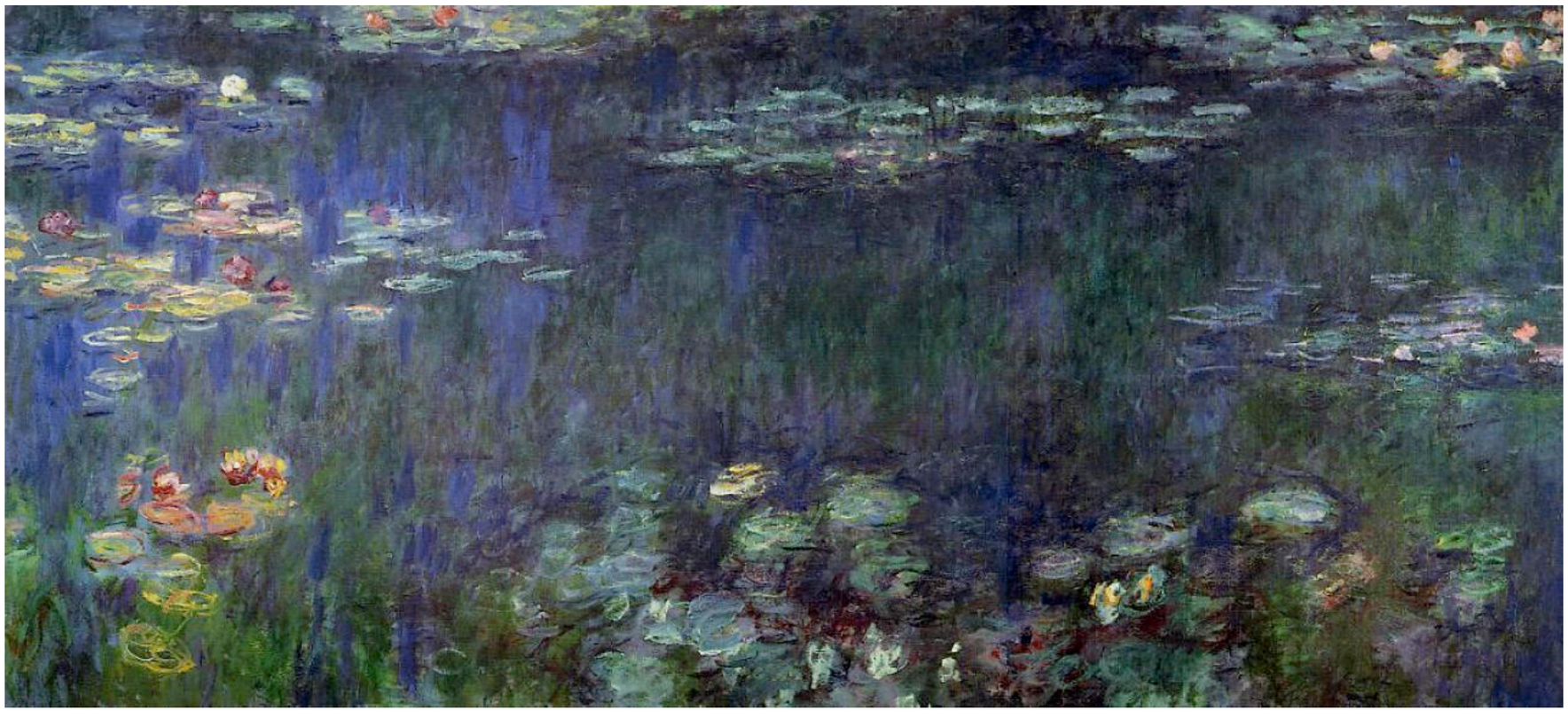
Sinatra, Wang, Deville, Song, Barabási, *in review* (2015)

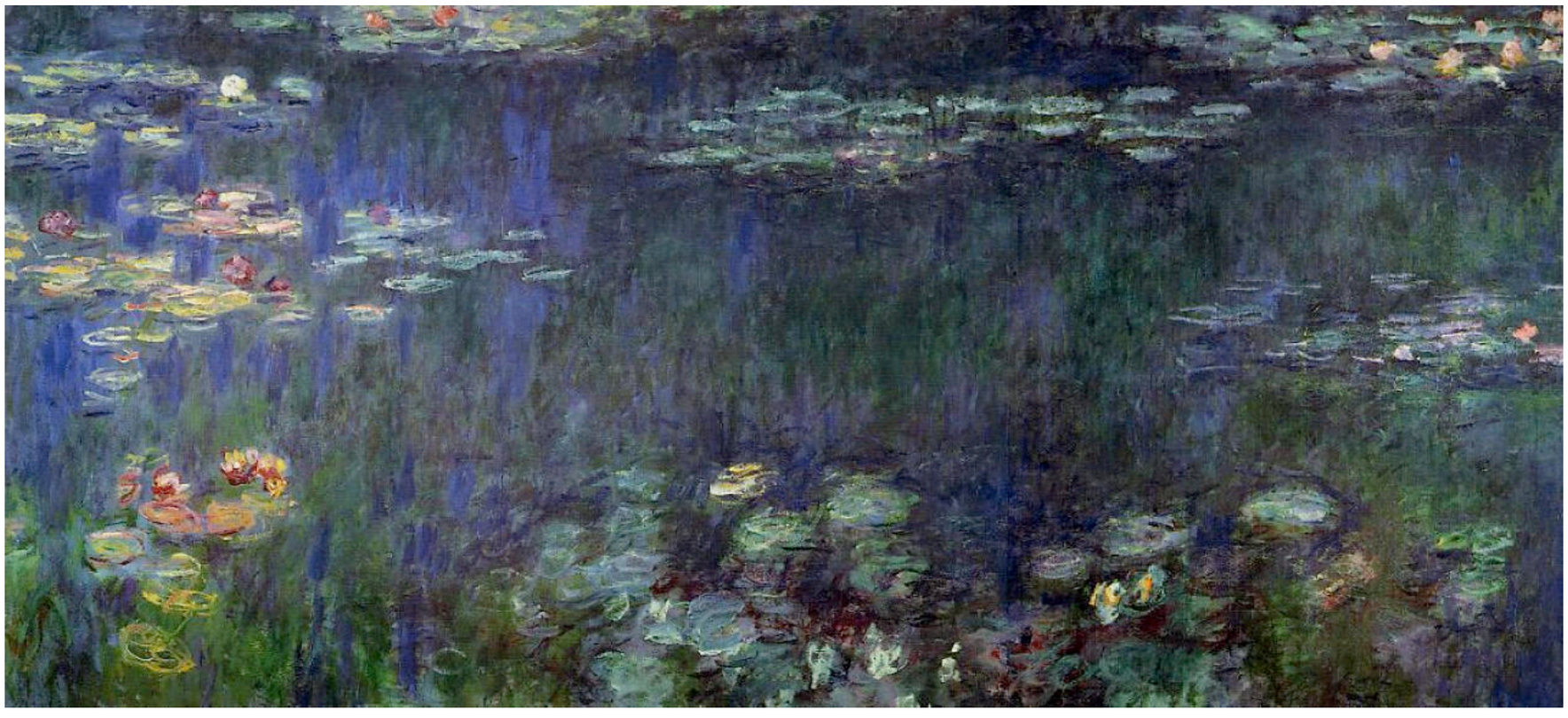
Excellence detects best Nobel Laureates



Sinatra, Wang, Deville, Song, Barabási, *in review* (2015)

What breeds excellence?

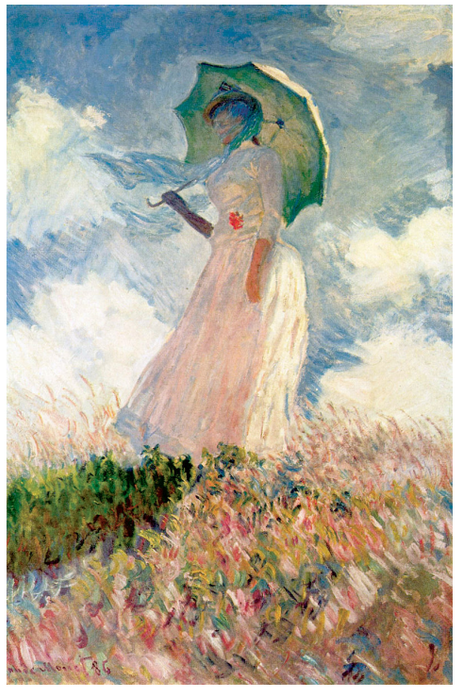


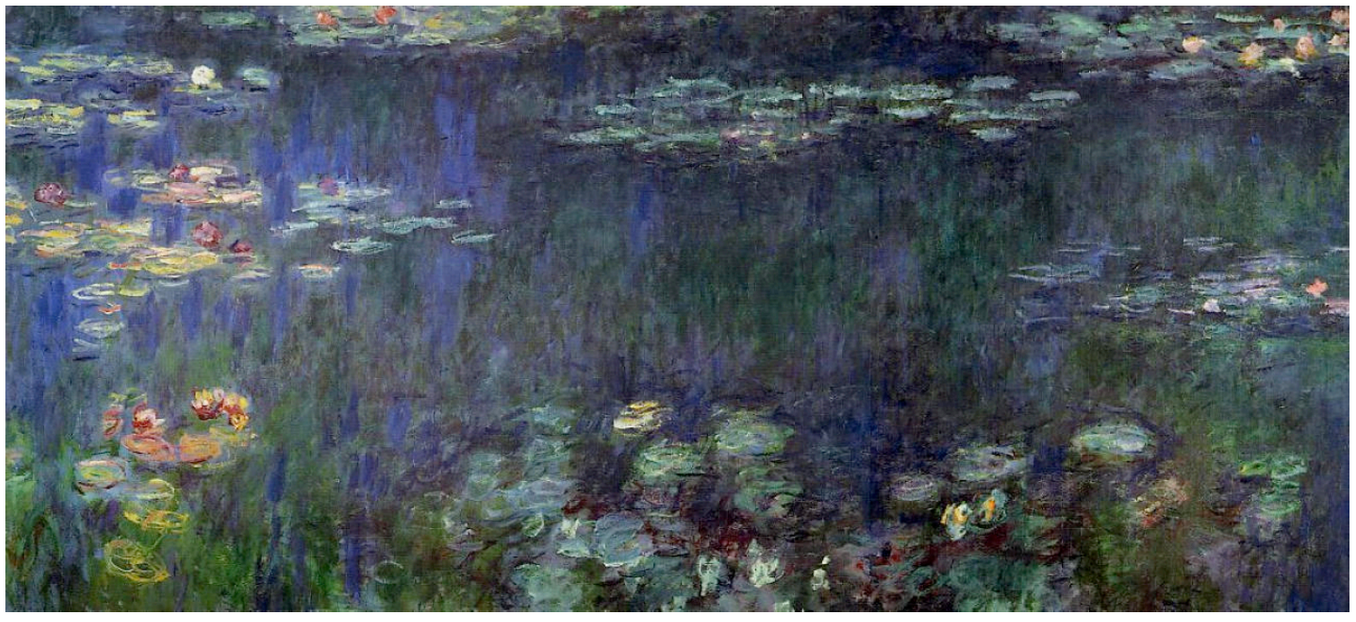


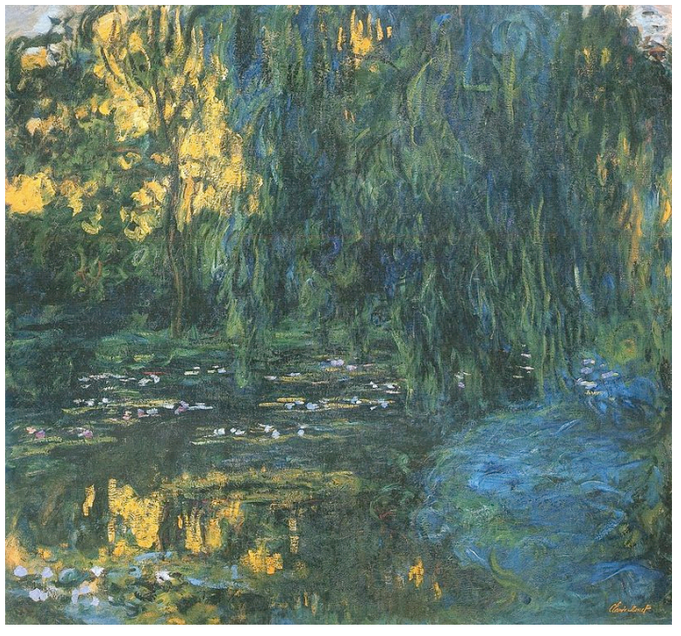
Water lilies, 1915

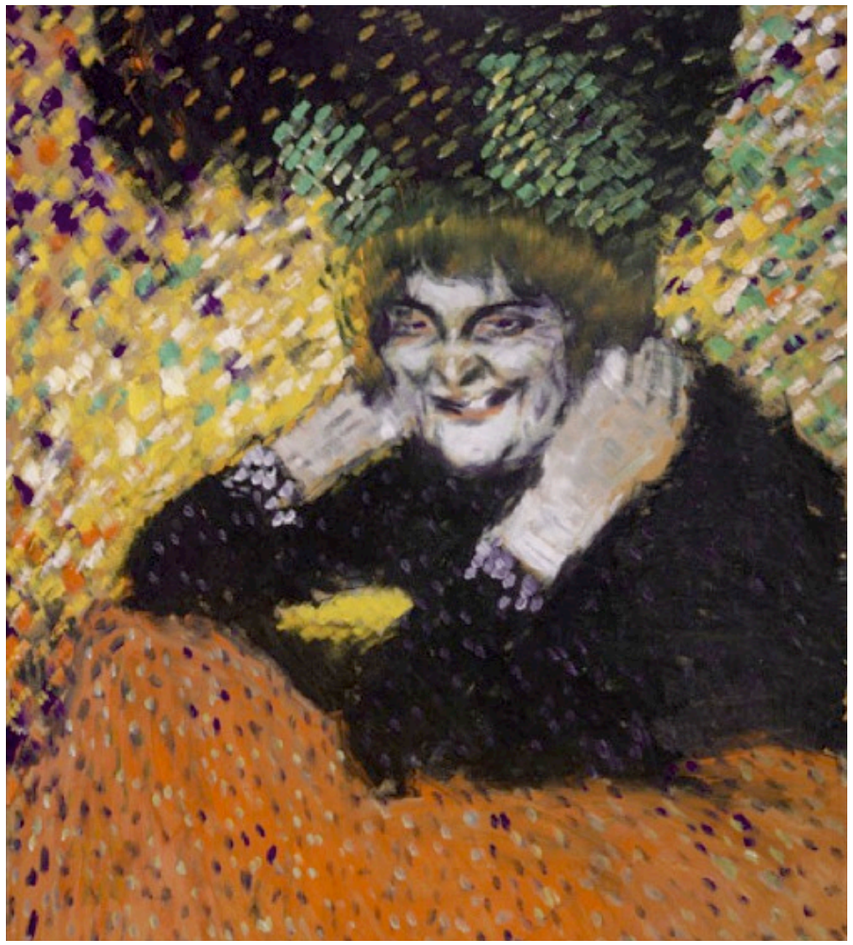
Le déjeuner sur l'herbe, 1865–1866

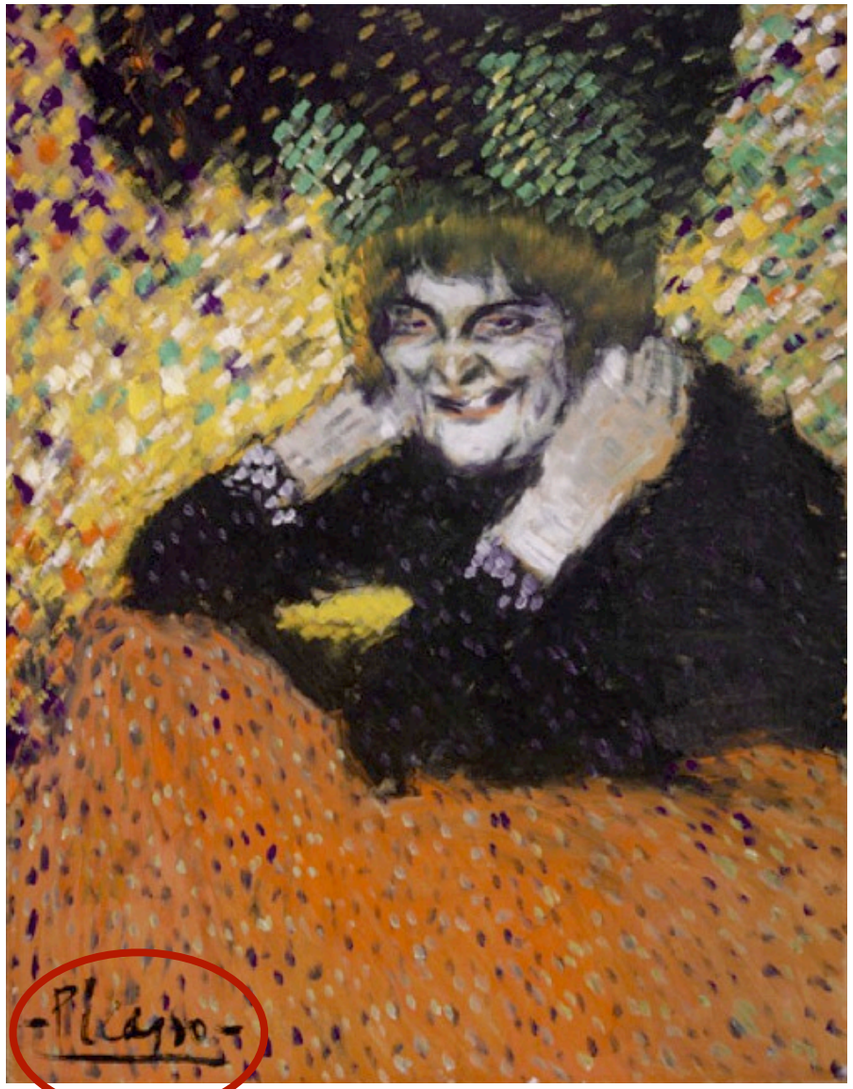
Claude Monet







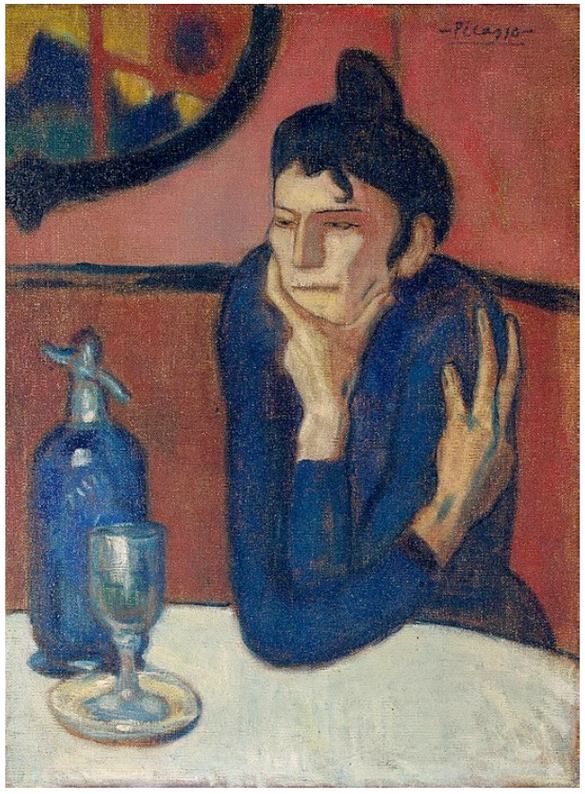


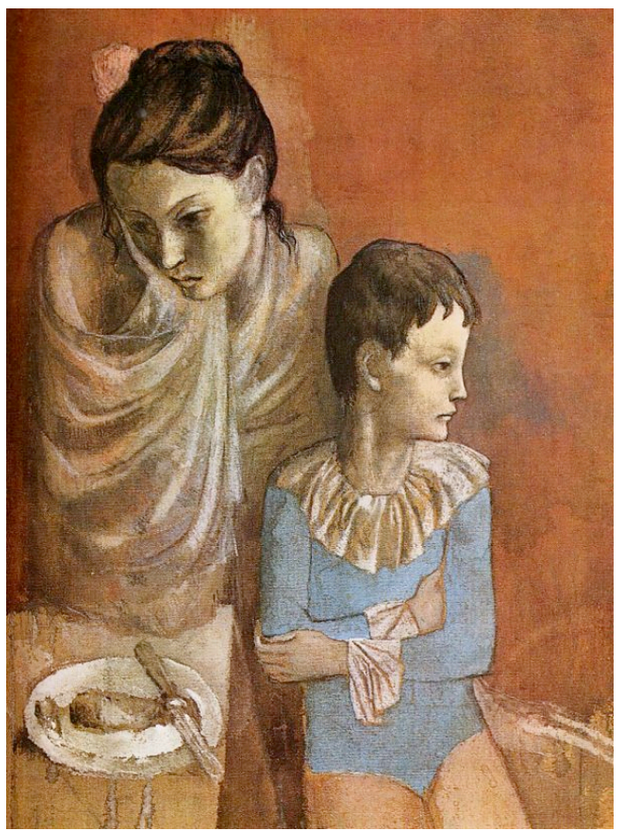


Old Woman (Woman with Gloves, Woman With Jewelery) 1901

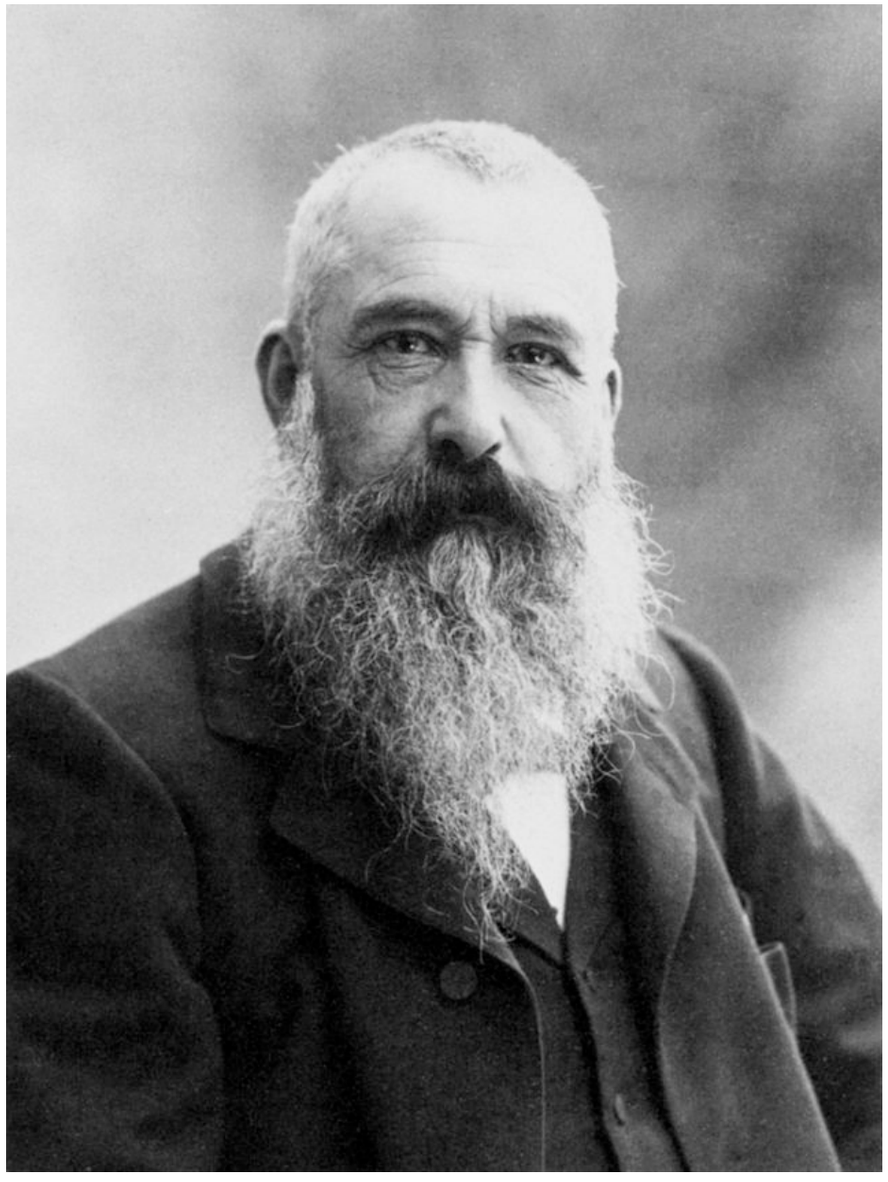
Portrait of gertrude stein (1906)

Pablo Ruíz y Picasso





Monet vs Picasso

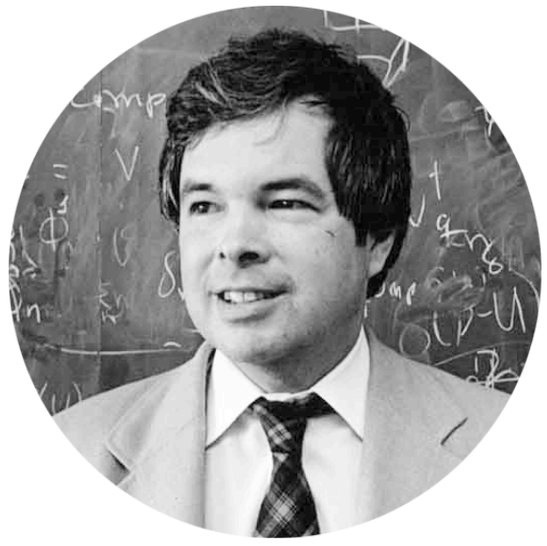


VS

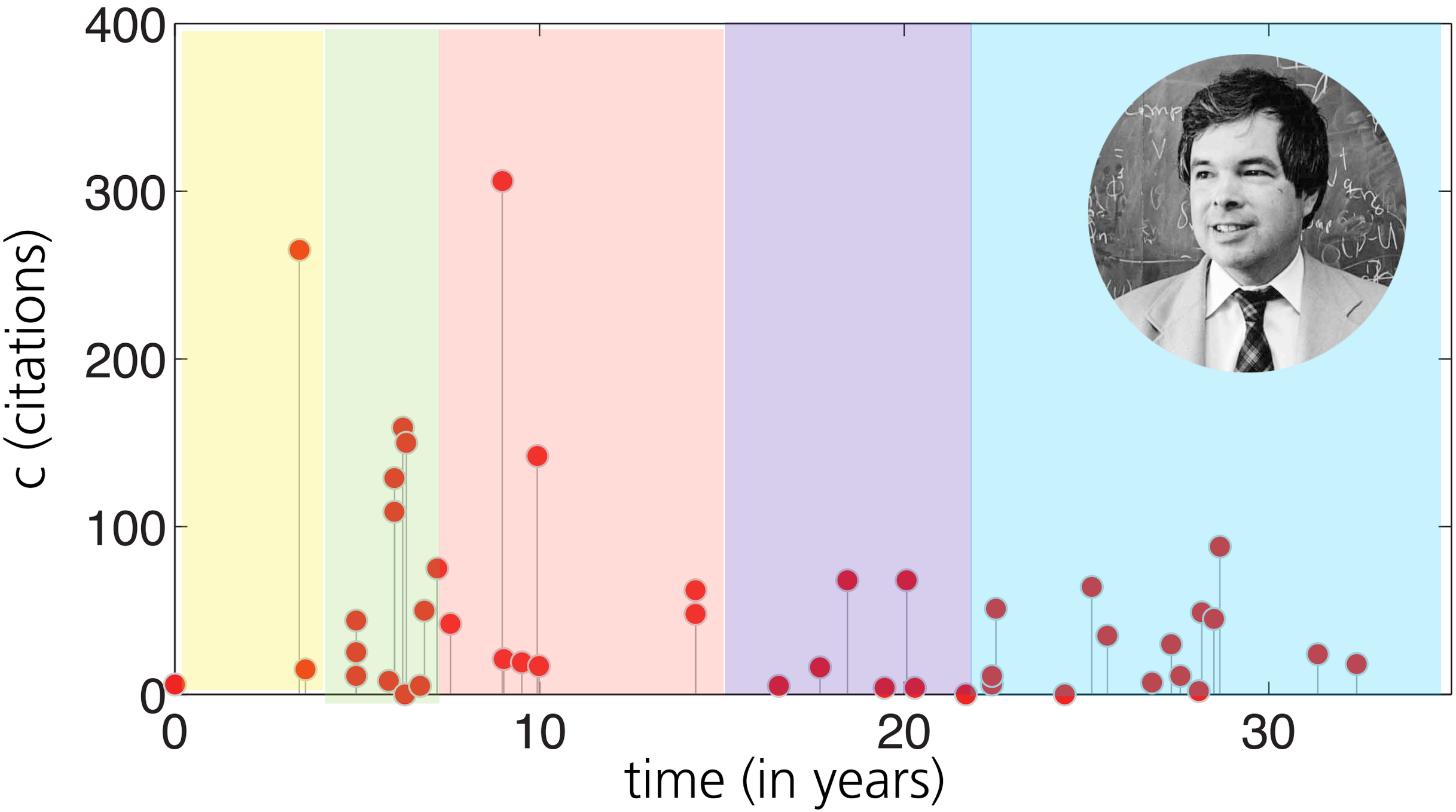
…and in

?

We characterize topics in scientific careers



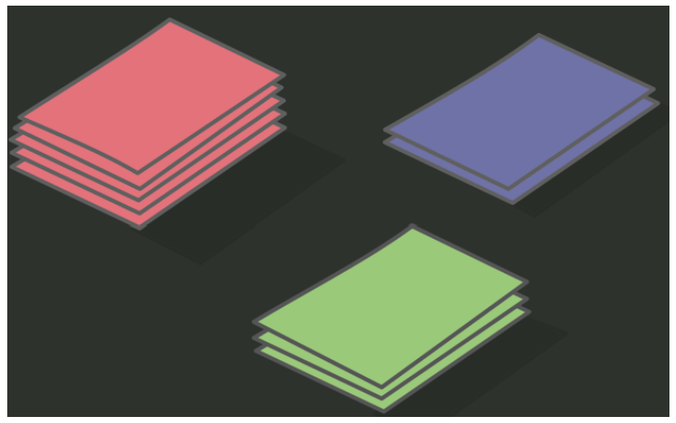
We characterize topics in scientific careers



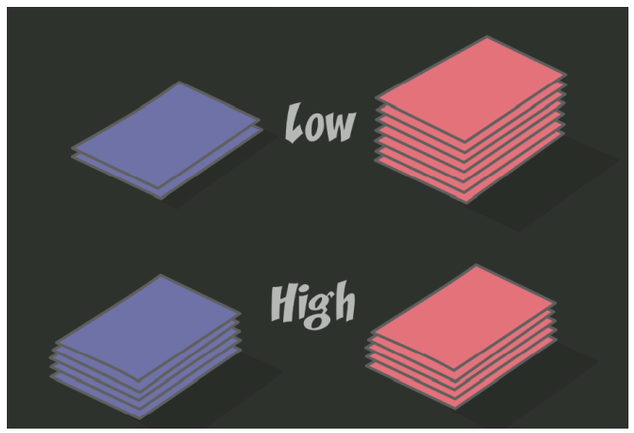
Deville, Sinatra, Barabási, *in preparation* (2015)

We compare topic heterogeneity between careers

of topics



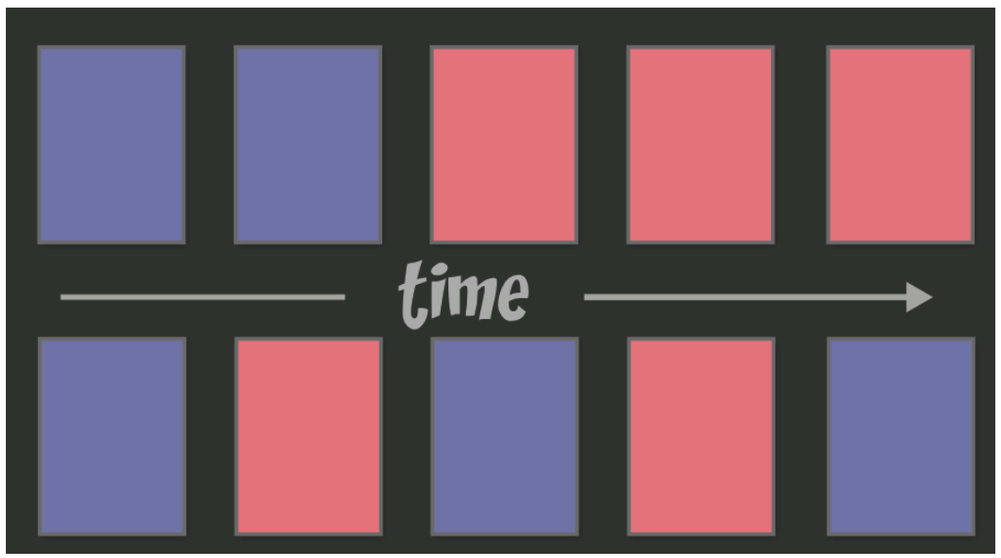
topic heterogeneity
Entropy H^1



$\longrightarrow 0$

$\longrightarrow 1$

topic focus
conditional entropy H^2



$\longrightarrow 0$

$\longrightarrow 1$

Deville, Sinatra, Barabási, *in preparation* (2015)

Kimmo Kaski

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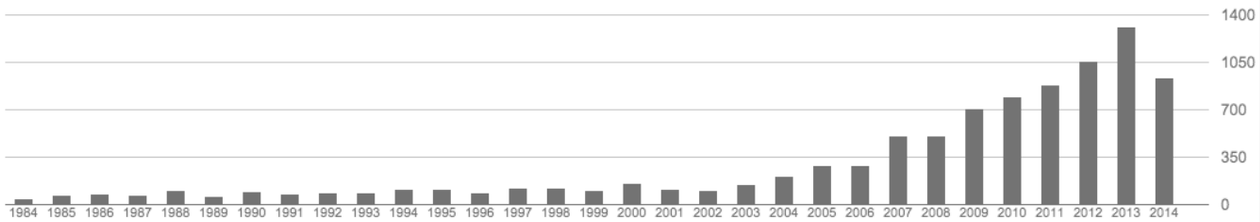
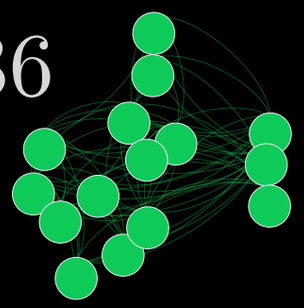


$$N^T = 18$$
$$H^1 = 0.86$$
$$H^2 = 0.57$$

$$N^T = 5$$

$$H^1 = 0.38$$

$$H^2 = 0.36$$



Pradip Dutta

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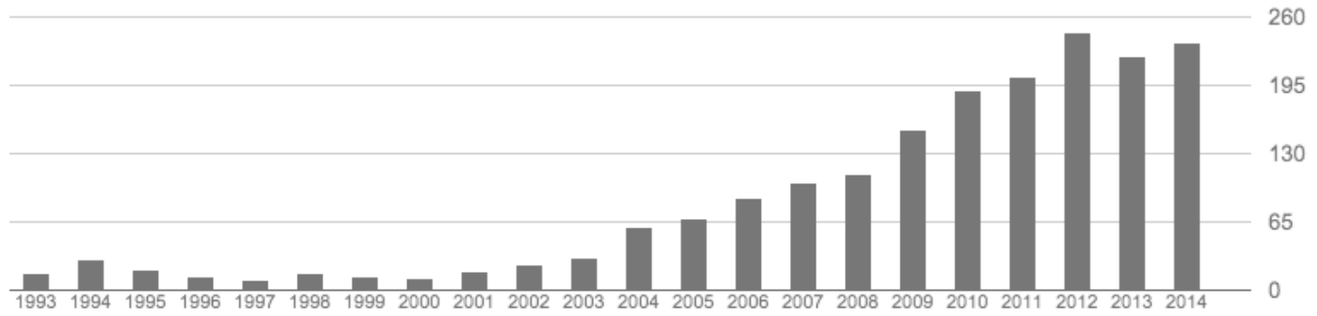
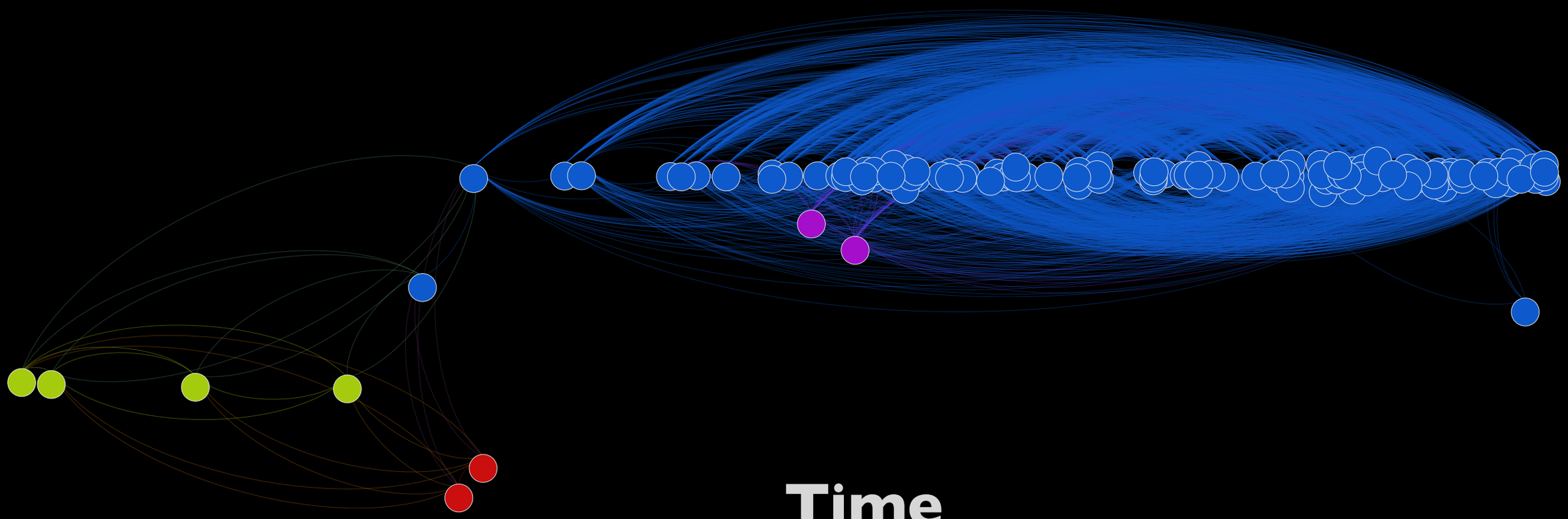
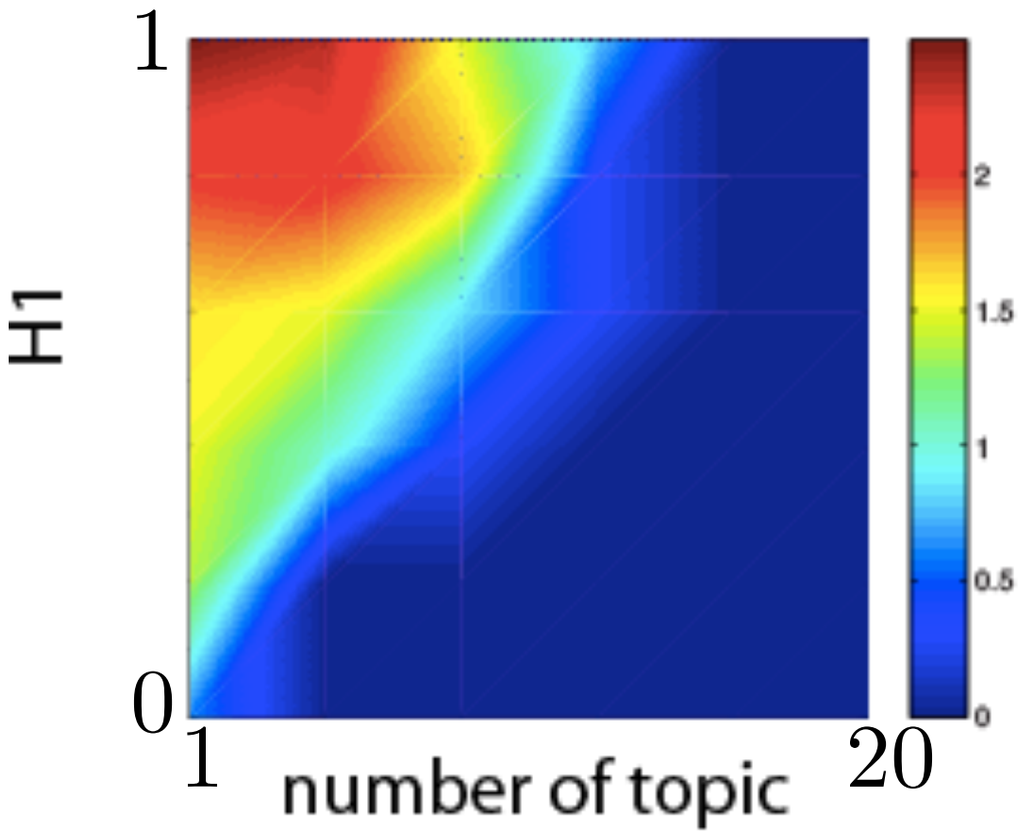
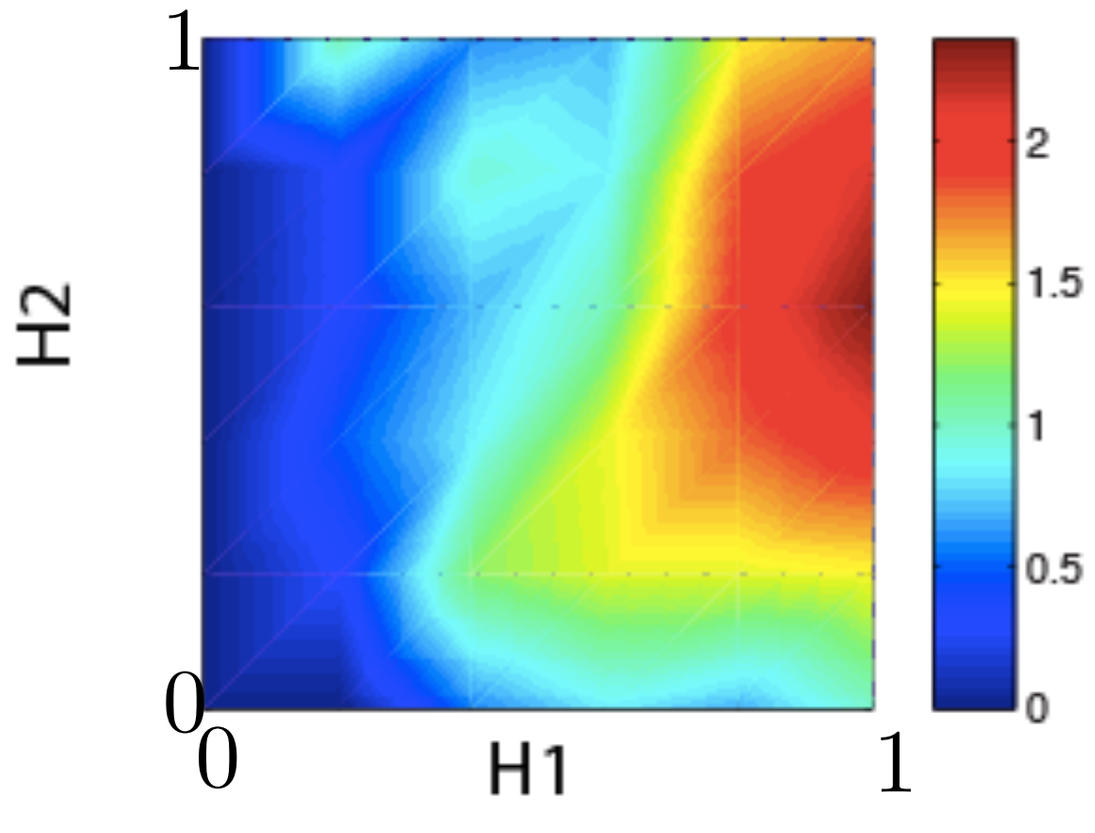




Most scientists are “MONET”

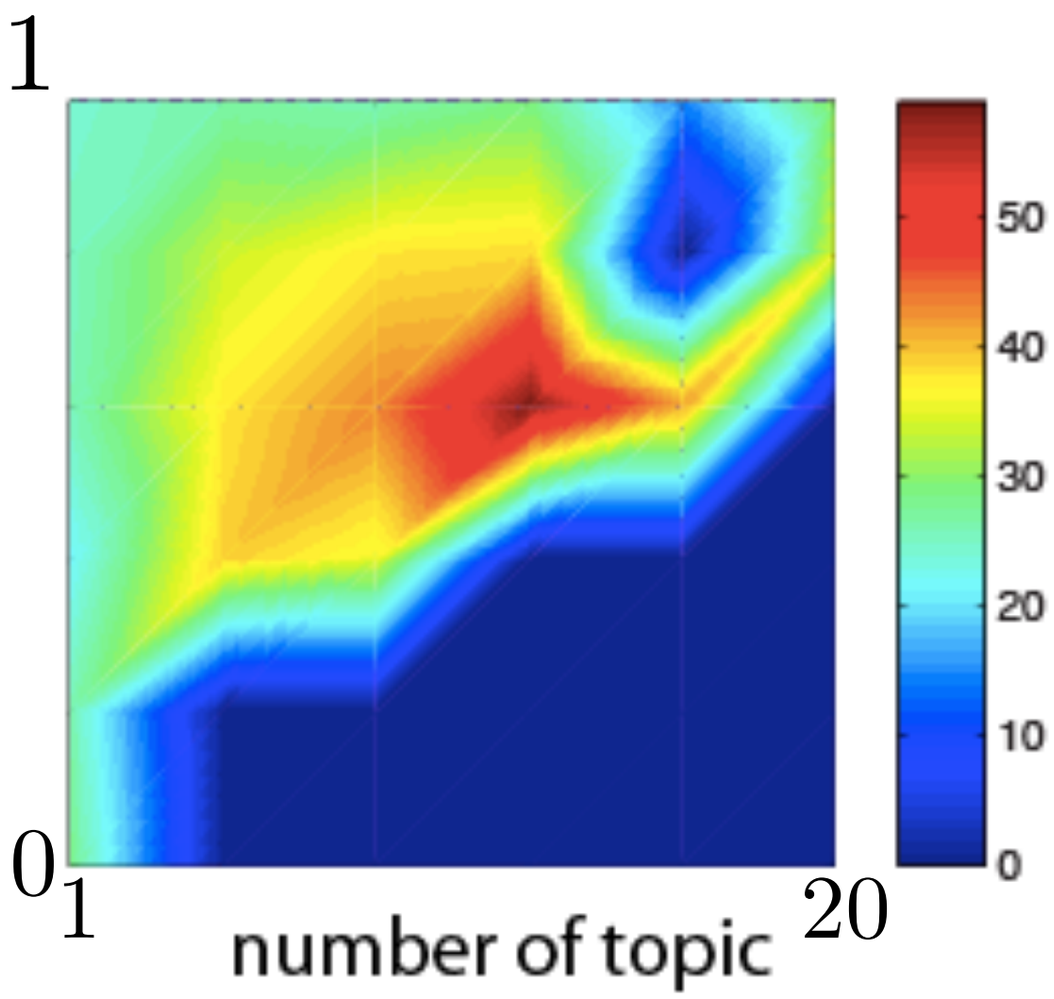




Colorcode: # of scientists

Deville, Sinatra, Barabási, *in preparation* (2015)

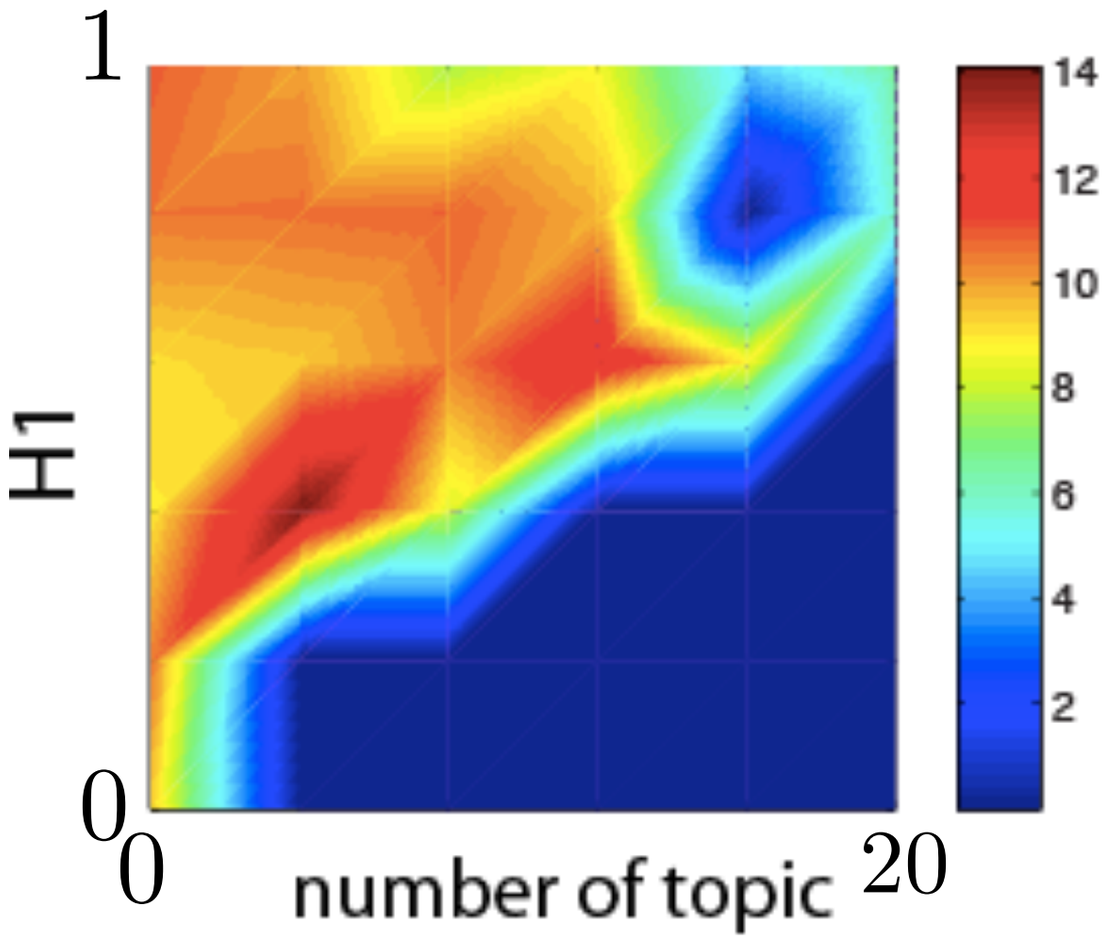
h-index successful scientists are “Picasso”



Colorcode: average h-index

Deville, Sinatra, Barabási, *in preparation* (2015)

Excellence-successful scientists are both “monet” and “picasso”



Colorcode: excellence

Deville, Sinatra, Barabási, *in preparation* (2015)

It is not (just) a new indicator, rather it explains all other indicators

Some challenges and open questions

→ What determines excellence?

- → Team
- → Affiliation
- → Gender, likability,…

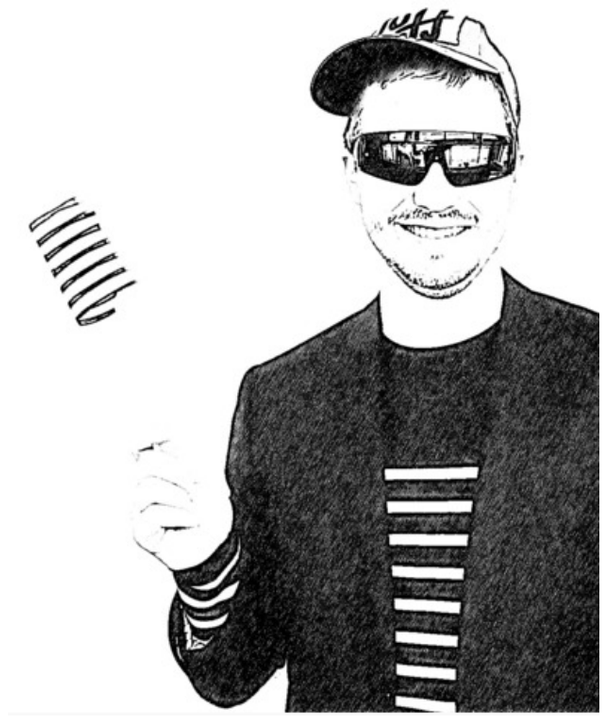
→ Uncovering <u>laws</u> (unbiased) that drive impact

→ We need to understand what impact indicators really mean

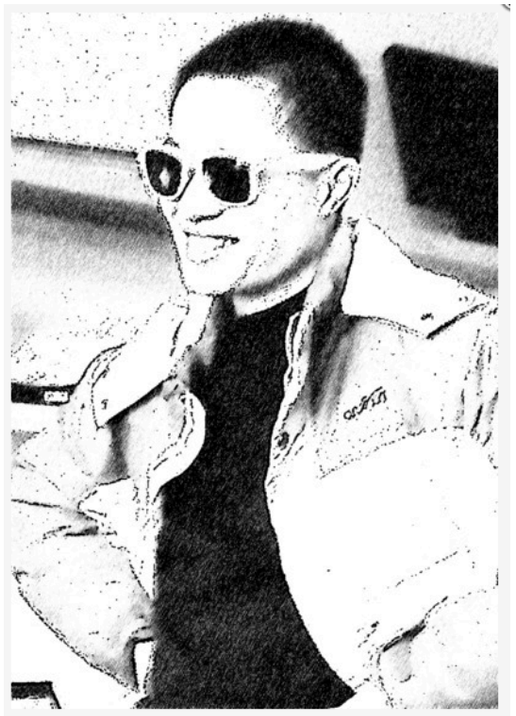
→ Beyond citations: other proxies for impact (altmetrics)?

Team

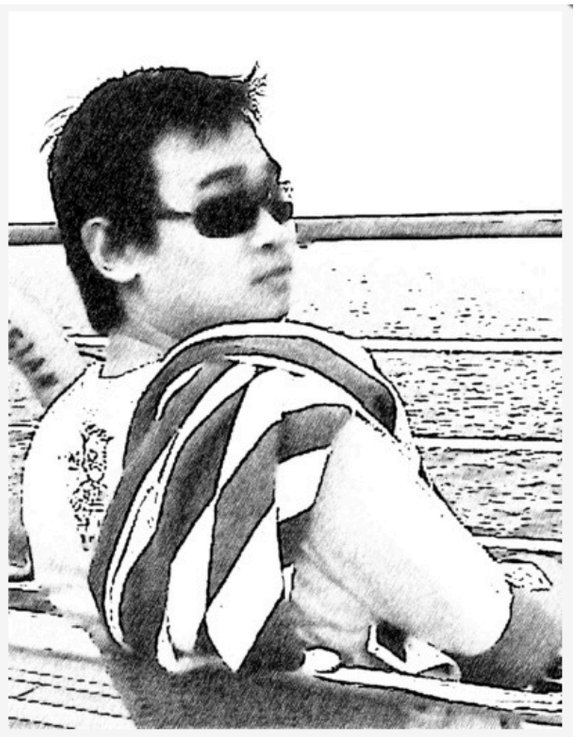
LÁSZLÓ BARABÁSI



PIERRE DEVILLE



CHAOMING SONG



DASHUN WANG

Thank you

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