Novelty and academic impact

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Motivation of the paper

- The old times of science: the "renaissance man" (Jones, 2009), the "gentlemanly specialist" (Rudwick, 1985), the English "amateur scientist" (Shapin, 2008) or the French "savant".

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- In this context, **does the science system maintain its standards of creativity and innovation?**

- Most empirical evidence of a negative bias against groundbreaking and innovative research comes from peer review (Braben, 2004; Chubin and Hackett, 1990; Wesseley, 1998; Heinze et al., 2009); Alberts,

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- Economists of innovation: Innovation = original recombination of existing elements (Nelson and Winter 1982, Schumpeter 1942). Example: Edison invention of the "electric candle" as the Cross-pollination of two distant ideas: "candle" + "electricity", and the test of more than 6.000 different materials to find the filament for the bulb.

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- Weitzman (1998) proposes a mechanism for the growth of ideas in the economy that result from binary random combinations of existing ideas (pairwise cross-pollination).

Measuring novelty in science: pairwise journal citation frequencies

- Uzzi et al. (2013) build on this idea to study novelty in science. They employ pairwise journal co-citations in articles' reference lists (Small, 1973) to identify recombinations of previous knowledge. The "atypicality" or the conventionality of those re-combinations are computed through their frequencies of occurrence over the whole period.

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- Wang, Veugelers and Stephan (2017) use the sum of (completely) new pairwise reference combinations weighted negatively by the cosine similarity of the two journals.

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- The originality of keyword combinations are intended to capture the "thematic novelty" of the scientific papers (their propensity to raise questions that are new to their corresponding scientific field).
- Novelty /disruption results more from intentional specific investigations rather than from random combinations of already existing pieces of knowledge.

Main questions

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- Is novelty a good leverage for excellence? Is it risky?
- Does it pay to be novel in science? Provided you get results, and get published, do you have higher impact?

The data

- Our dataset includes all research articles published from 1999 to 2013 and indexed in Thomson Reuters Web of Science (WOS): 10 million articles (7.8 million before 2011) having more than two keywords.

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- These papers are classified in three major research areas: humanities and social sciences (7.18%), life sciences (46.68%) and hard sciences and engineering (46.14%).
- A number of associated data for each paper which will be used to build our list of independent and control variables.

The indicator

Novelty: atypicality of a papers' keywords combinations in year t and scientific domain c.

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- Step 3: attribute an indicator of commonness for each pair of keywords, year and subject category.

$$Com_{ijct} = \frac{N_{ijct}/N_{ct}}{\frac{N_{ict}}{N_{ct}} \times \frac{N_{jct}}{N_{ct}}} = \frac{N_{ijct} \times N_{ct}}{N_{ict} \times N_{jct}}, \quad (1)$$

with N_{ct} the number of (non-distinct) keyword combinations in papers published in c and year t. The terms N_{ict}, N_{jct} and N_{ijct} give the number of such (non-distinct) keyword combinations in which respectively keyword i, keyword j, and both keywords i and j appear.

The indicator (II)

- Step 2: attribute a unique *novelty of keyword combinations* indicator for each paper in our sample (most articles have more than 2 keywords).

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- Step 4: Take the max novelty over the subject categories c.

$$nov = max_{c \in C}(nov_c). \tag{4}$$

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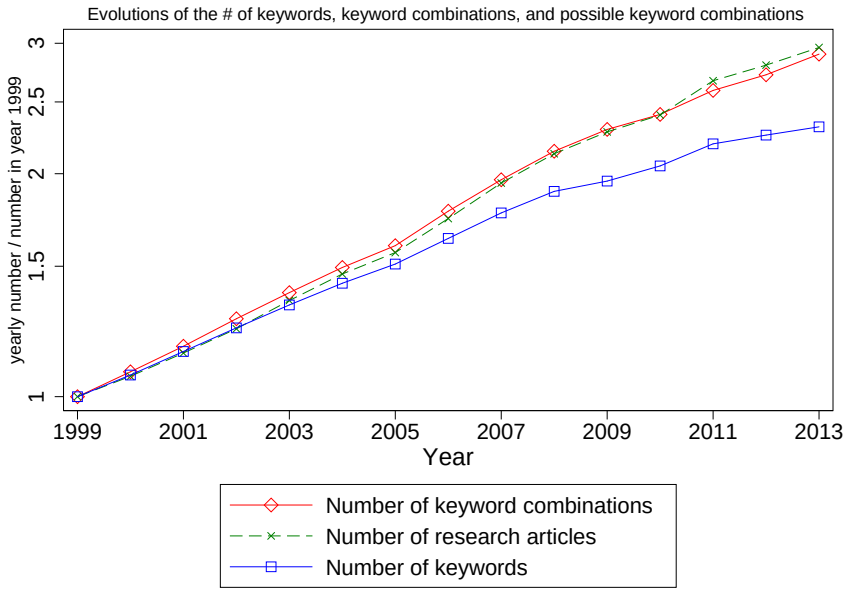
- Using ISI keywords.

The evolution of scientific knowledge

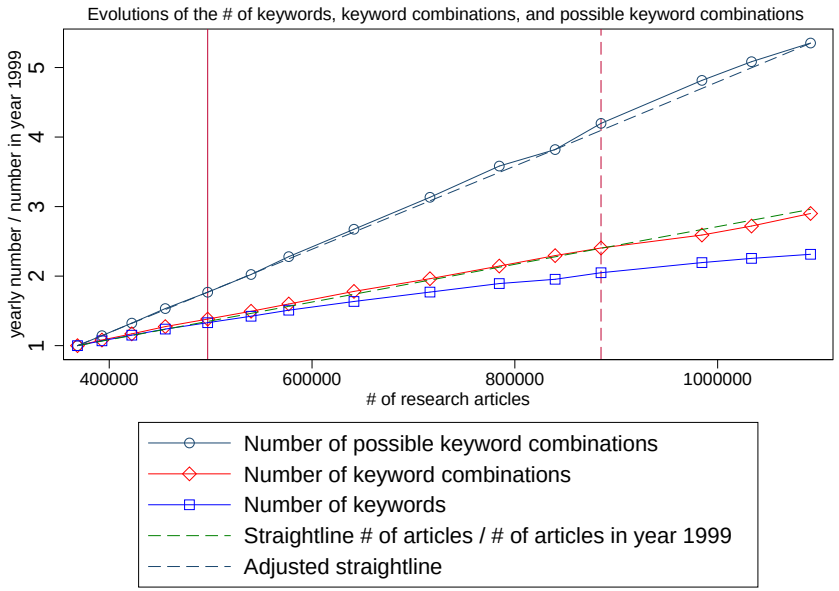
Figure: The evolution of the number of distinct keyword combinations, number of distinct keywords, and number of research articles



- Evolution of the number of distinct keyword combinations follows a very similar growth pattern as the number of research articles (about 290% growth from 1999-2012).

The evolution of scientific knowledge

Figure: The evolution of the number of possible keyword combinations, the "explored" keyword combinations and keywords with respect to the number of research articles.



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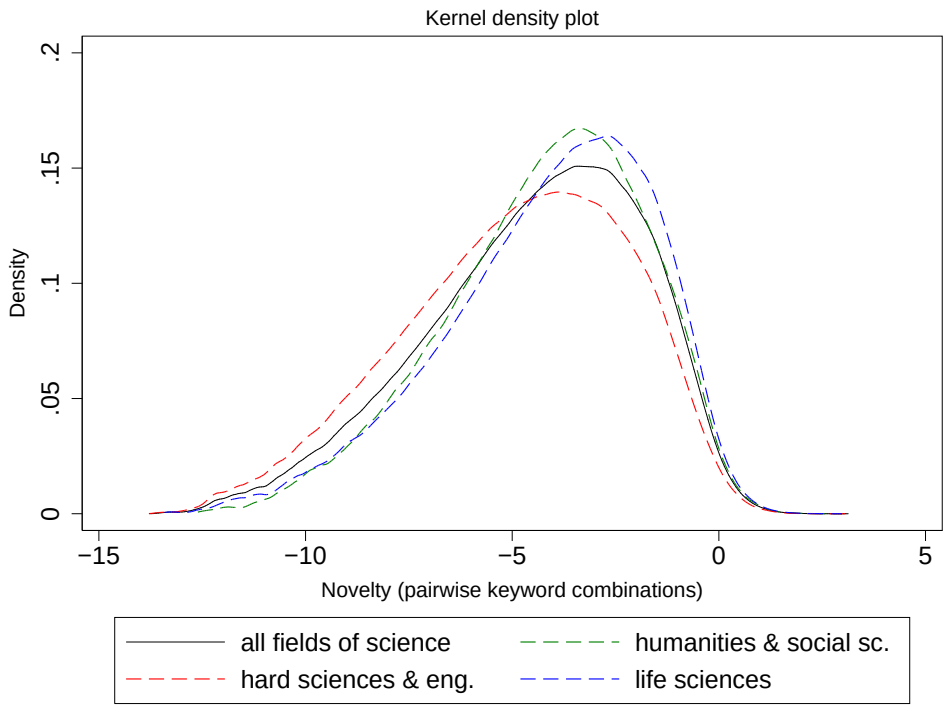
The distribution

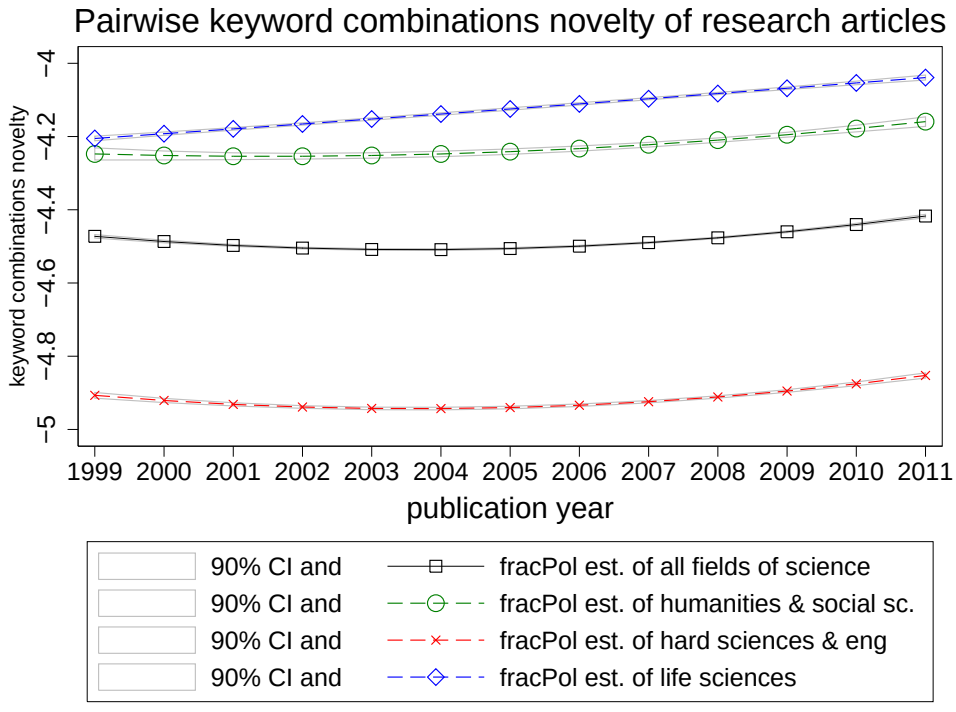
Figure: The distribution of keyword combinations novelty (3-year). For all articles and for the three domains of science



- Most articles have intermediate levels of novelty.
- Similar across all three fields of science.

Novelty in science: Time evolution

Figure: Evolution of keyword combinations novelty for the three large fields of science



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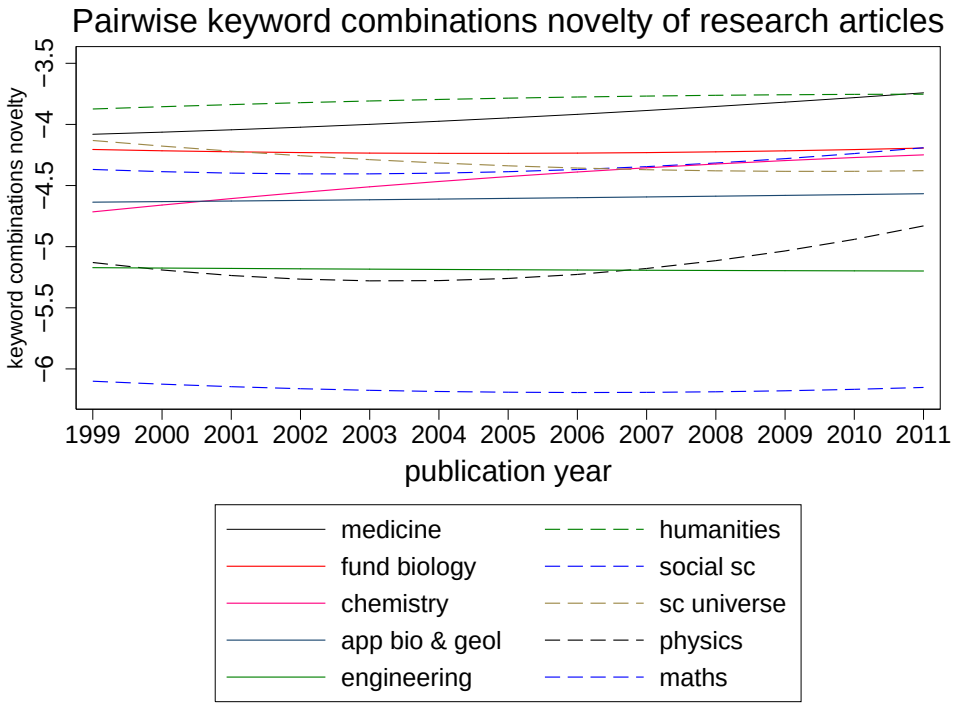

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A pairwise journal reference benchmark: the distribution

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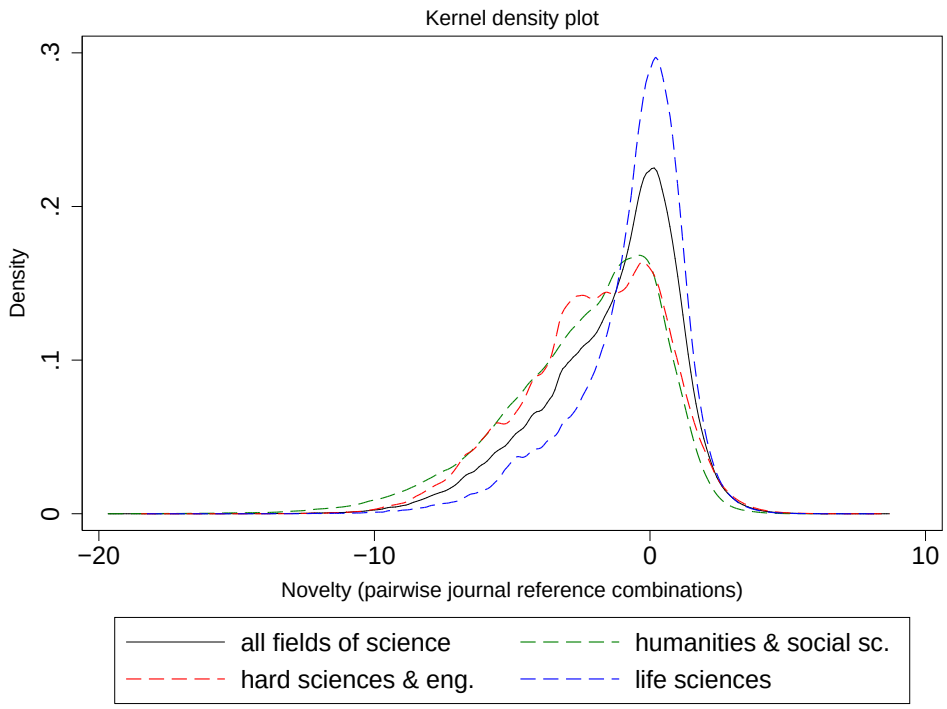

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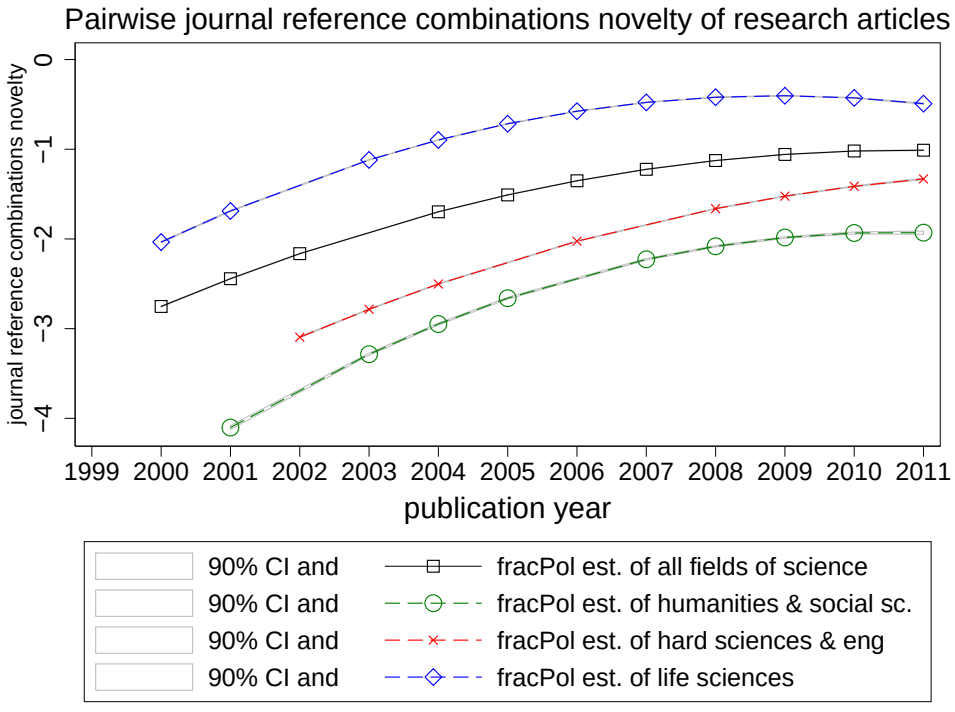

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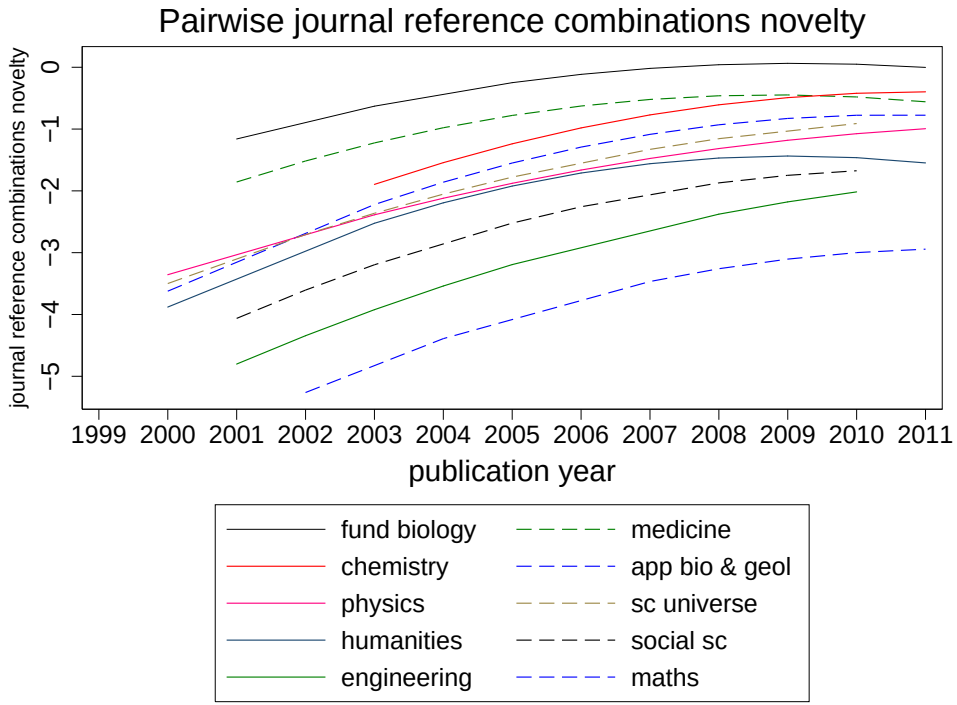

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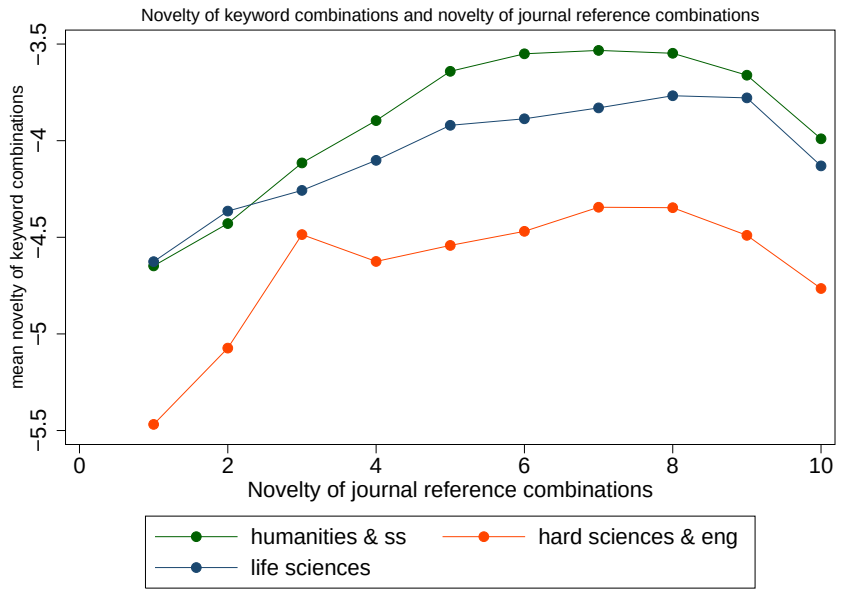
Correlation between keyword combinations novelty and pairwise journal reference combination novelty



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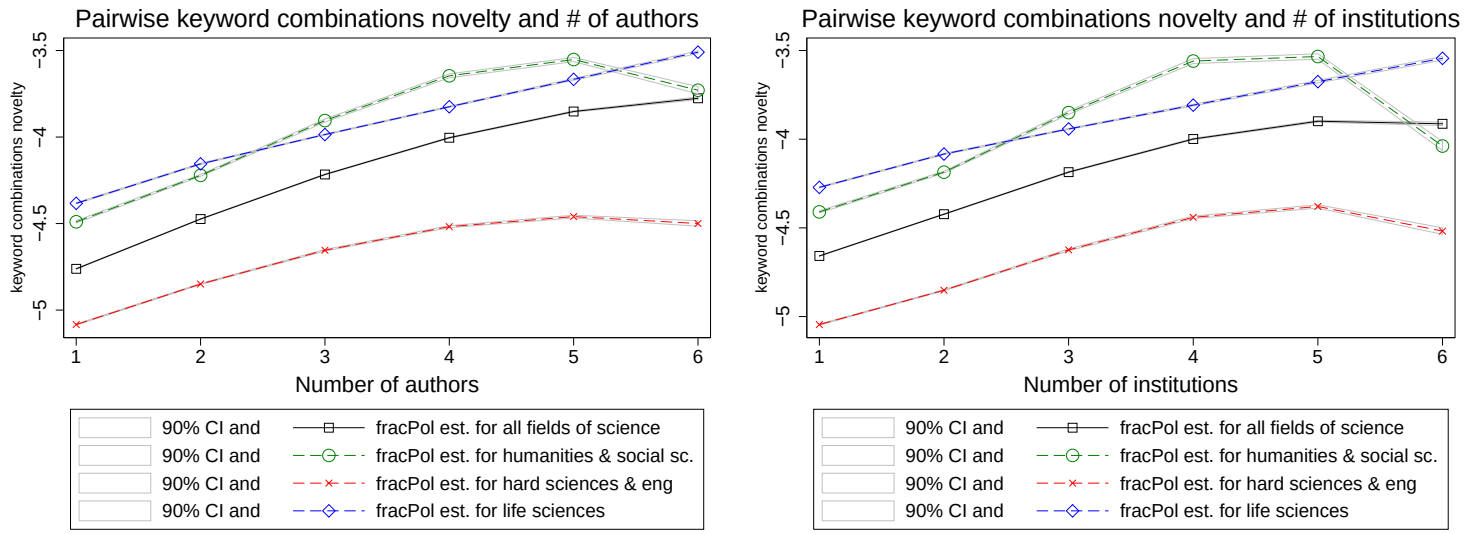
Which teams produce more novel papers?

Figure: Novelty of keyword combinations and number of authors by fields (3-year window).



- Novelty increases with the number of authors across all fields of science.
- Novelty is higher with US authors, lower for Asian authors.

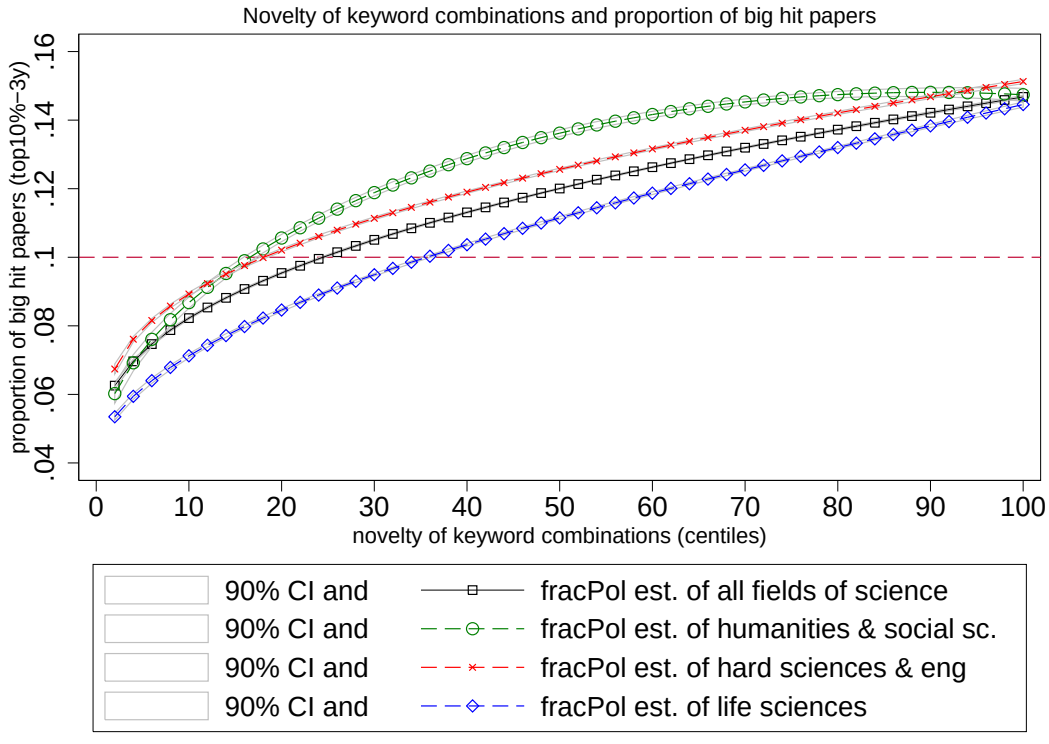
Is novelty "popular" in science?

Do highly novel papers attract outstanding attention from peers?

- Dependent variable: *"big hit paper"*
- Dummy taking the value 1 if the paper belongs to the top-10% most cited in its scientific field and publication year.
- Robustness checks with top5% and top1% most cited.
- Logistic regressions

Empirical evidence (I)

Figure: Novelty and big hits



- Papers ranked according to their novelty score.
- The average paper in top centiles of novelty has 2 to 3 times more chances to be in the top-10% most cited in its field.

Empirical evidence (II)

Table: Predicting citations and big hit probabilities (Pairwise keyword novelty)

	big hit (10%)		big hit (5%)		neg.bin (coeff.)		neg.bin (disp.)	
	3y	5y	3y	5y	3y	5y	3y	5y
Full sample	42%	45%	41%	44%	38%	37%	-15%	-4%
Human and social sciences	25%	28%	25%	29%	30%	32%	-21%	-10%
Hard science and engin	45%	48%	42%	46%	44%	39%	-15%	-4%
Life sciences	45%	48%	46%	48%	33%	33%	-15%	-4%

Notes: Obtained from exponentiated coefficients in generalized negative binomial estimations and logistic regressions. Dependent variable for negative binomial regressions: number of forward citations (3y and 5y). Dependent variable for logistic regressions: dummy taking the value 1 if the paper is a "big hit" in its field ("top-10%" or "top-5%"). Control variables: number of keywords, publication year and disciplines dummies.

take away

- Keyword combination frequency is a way to measure article novelty
- Novelty is performed in larger and boundary spanning teams
- Novel papers attract significantly more citations.

THANK YOU!!!

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