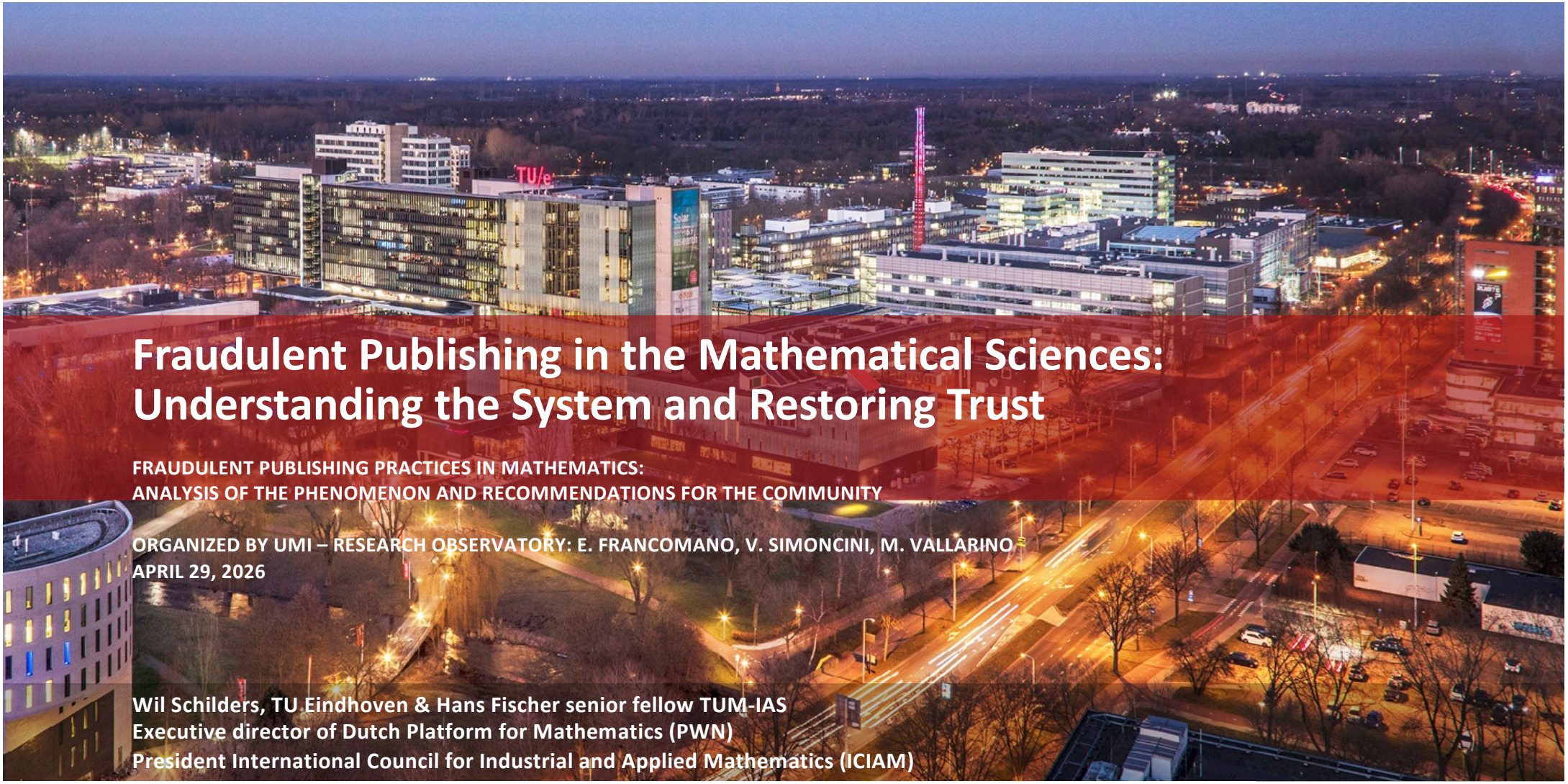


Fraudulent Publishing in the Mathematical Sciences: Understanding the System and Restoring Trust

FRAUDULENT PUBLISHING PRACTICES IN MATHEMATICS:
ANALYSIS OF THE PHENOMENON AND RECOMMENDATIONS FOR THE COMMUNITY

ORGANIZED BY UMI – RESEARCH OBSERVATORY: E. FRANCOMANO, V. SIMONCINI, M. VALLARINO
APRIL 29, 2026

Wil Schilders, TU Eindhoven & Hans Fischer senior fellow TUM-IAS
Executive director of Dutch Platform for Mathematics (PWN)
President International Council for Industrial and Applied Mathematics (ICIAM)

Department of Mathematics and Computer Science

TU/e EINDHOVEN UNIVERSITY OF TECHNOLOGY

Based on two joint IMU-ICIAM publications

Fraudulent Publishing in the Mathematical Sciences

Ilka Agricola, Lynn Heller, Wil Schilders, Moritz Schubotz, Peter Taylor, Luis Vega

September 2025

1 Introduction

This report is the first of two publications of a joint Working Group of the International Mathematical Union (IMU) and the International Council of Industrial and Applied Mathematics (ICIAM). In it, we shall analyze the current state of publishing in the mathematical sciences and explain the resulting problems. Our second publication will offer concrete recommendations, guidelines, and best practices for researchers, policymakers, and evaluators of mathematical research [71]. It will explain how to detect and counteract attempts to game bibliometric measures, empowering the community to reclaim control over research evaluation and drive necessary change.

As students, teachers, authors, reviewers, editors and committee members, we contribute to the creation, publication, consumption and evaluation of research outputs. In the current academic environment, the assessment of research quality is heavily influenced by bibliometric analysis. As a result, there is a strong incentive for researchers to optimize their bibliometric data. Unfortunately there is a growing number who are using fraudulent methods to do this. New (and to many unknown) threats such as *paper mills*, *predatory journals* and *citation cartels* have been invading the 'ecosystem' of scientific publishing and putting the integrity of our profession at risk. A detailed glossary is provided in Appendix A, with an extensive list of references pointing to further reading that supports the claims made in this article. As a main source, we recommend the excellent book [8]. It is worth noting that most of the articles in the reference list have appeared in the last five years, reflecting the urgency of the problem. It will become clear that two driving forces behind the problems we address are the advent of Article Processing Charges (APCs) for Open Access as a business model for scientific publishing and the pervasive demand for quantitative research output assessment. Also intricately involved are the companies that collect citation data and use it to produce measures such as the journal impact factor, the h-index, and the lists of highly-cited researchers (HCRs) that are derived from this data. We will argue that products such as these are having detrimental effects on the publication enterprise.

This is the digital arXiv version of this article with complete clickable references. The print version with a selection of the most important references appeared in the October 2025 issue of the Notices of the AMS [2].

How to Fight Fraudulent Publishing in the Mathematical Sciences: Joint Recommendations of the IMU and the ICIAM

Ilka Agricola, Lynn Heller, Wil Schilders, Moritz Schubotz, Peter Taylor, Luis Vega

September 5, 2025

1 Introduction

Predatory journals and citation cartels are reactions to the effort to exactly quantify and rank the quality of research through scientific 'performance indicators', in the form of bibliometric measures. While evaluations are needed for the effective allocation of resources, a complete ranking of research quality cannot exist. Bibliometrics, on the contrary, suggest that everything can be ordered by simple numbers computed in some way or another from citations. In a field like mathematics, where the number of research papers and general citations are quite low, these citation numbers are prone to severe manipulation. The pressure to publish and the competitive job market provide an incentive for even serious scientists to artificially improve their own numbers. Predatory journals and citation cartels are at the extreme end of this enterprise, turning the desire to quantify into a money-making scheme. A fringe phenomenon in the past, this problem has by now reached even well-established research institutions and can no longer be ignored. Such manipulation results in a massive waste of limited resources being invested in low-quality research, while higher-quality work may be discontinued due to lack of funding. The opportunity cost of misaligned incentives is immense.

For a detailed description of fraudulent publishing in mathematical sciences, an explanation of technical terms, and an extensive list of references, we refer to our article [1]. This note builds on that work to make explicit recommendations for policy makers and institutions on how to encourage good scientific practice and simultaneously detect and combat fraudulent behavior. For individuals, we provide a set of possible actions to safeguard our research communities from being corrupted by fraud and pure business interests.

These recommendations were formulated by the authors in close collaboration with the IMU Committee on Publishing (chaired by Ilka Agricola) and have been endorsed by the Executive Committee of the IMU and the Board of the ICIAM in May/June 2025.

TU/e

Why this topic now?

- Increasing concerns about research integrity
  - In recent years, there has been a noticeable rise in retractions, questionable practices, and discussions about scientific misconduct across many disciplines, including mathematics.
- Growing reliance on bibliometric indicators
  - Research evaluation is increasingly based on metrics such as citation counts, h-index, and journal impact factors, which are often used as proxies for quality despite their limitations.
- Rapid expansion of scientific publishing
  - The number of journals and publications has grown dramatically, driven in part by open access models and financial incentives, making quality control more challenging.
- Emergence of new forms of manipulation
  - New phenomena such as citation cartels, paper mills, and AI-assisted text generation have created systematic ways to artificially inflate research output and impact.

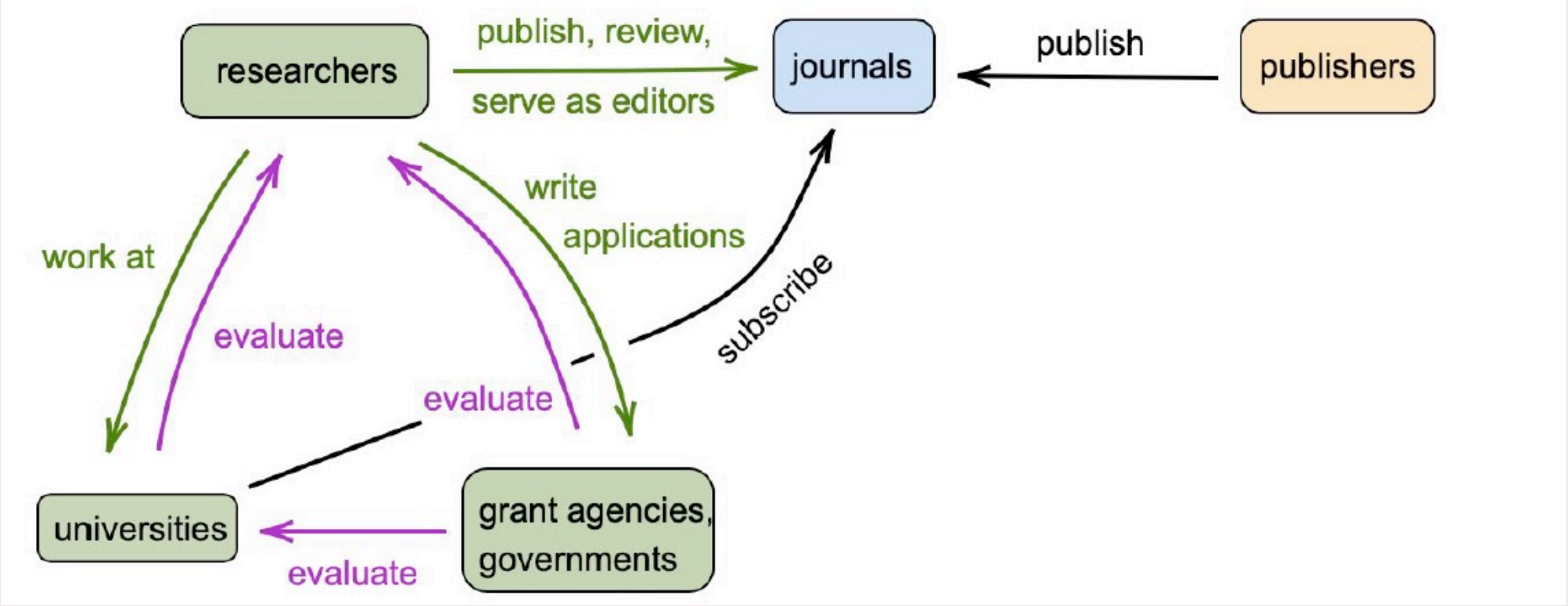
This is not about isolated cases,
but about systemic developments

TU/e

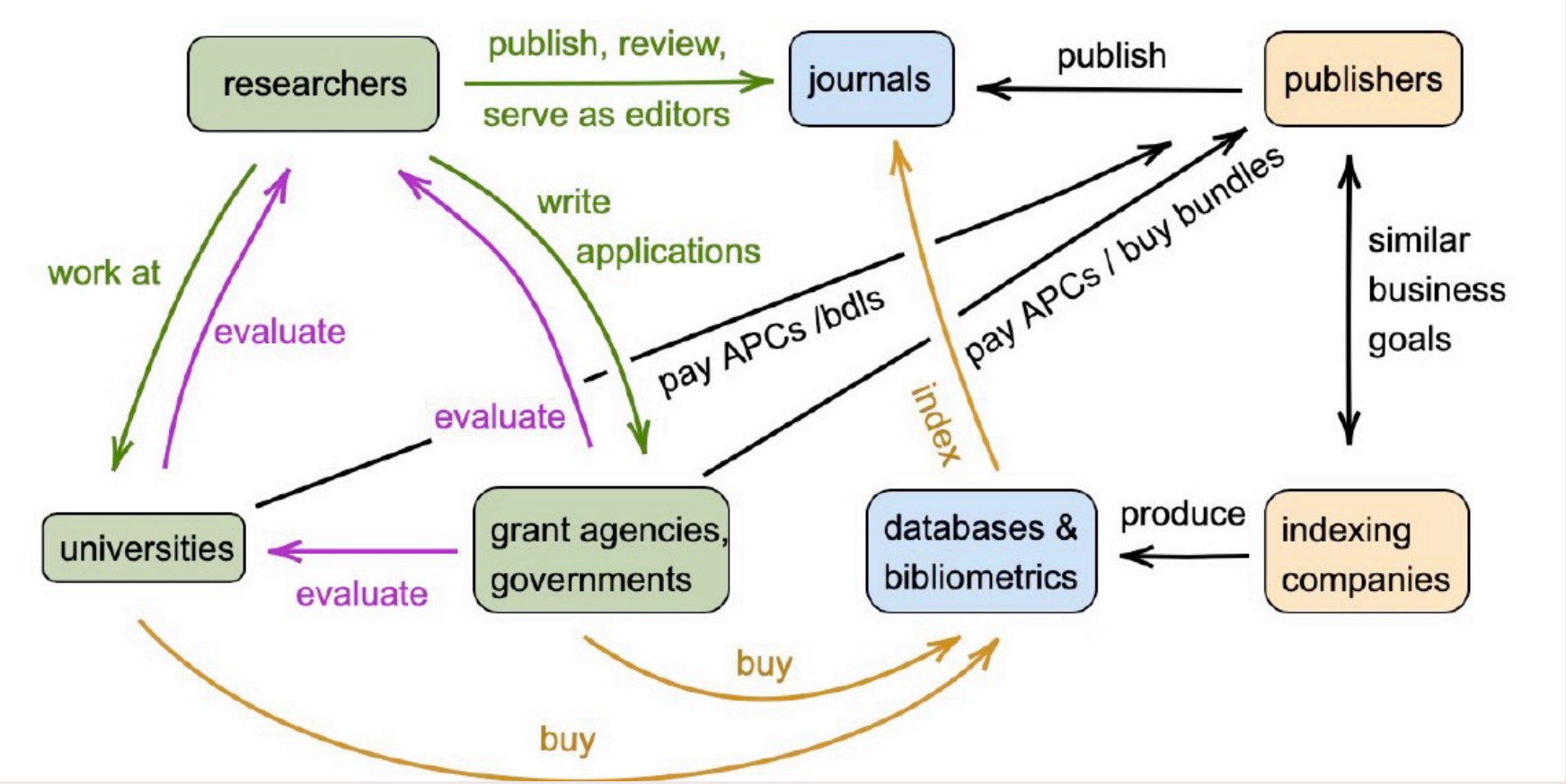
Why should we care?

- Undermines trust in science
  - If unreliable or manipulated results enter the literature, confidence in scientific findings is weakened—both within academia and in society.
- Distorts research evaluation and funding
  - Decisions on hiring, promotion, and funding may be based on inflated or misleading indicators rather than genuine scientific quality.
- Rewards quantity over quality
  - Incentive systems may encourage producing many papers instead of focusing on fewer, more substantial contributions.
- Harms early-career researchers
  - Young researchers face pressure to conform to these practices, putting them at a disadvantage if they adhere to high standards.
- Blurs the line between good and poor science
  - The increasing volume of low-quality or manipulated publications makes it harder to identify truly valuable research.

The academic publishing ecosystem



The academic publishing ecosystem



The core problem: incentives

- Evaluation of research is necessary
  - Universities and funding agencies must assess research quality to make decisions on hiring, promotion, and allocation of resources.
- Increasing reliance on quantitative indicators
  - Metrics such as citation counts, h-index, and journal impact factors are increasingly used as convenient and seemingly objective measures of performance.
- Easy-to-measure replaces hard-to-measure
  - Because true scientific quality is difficult to assess, there is a tendency to rely on simple numerical indicators, even when they do not capture real impact.

When a measure becomes a target,
it ceases to be a good measure

Key mechanisms of manipulation

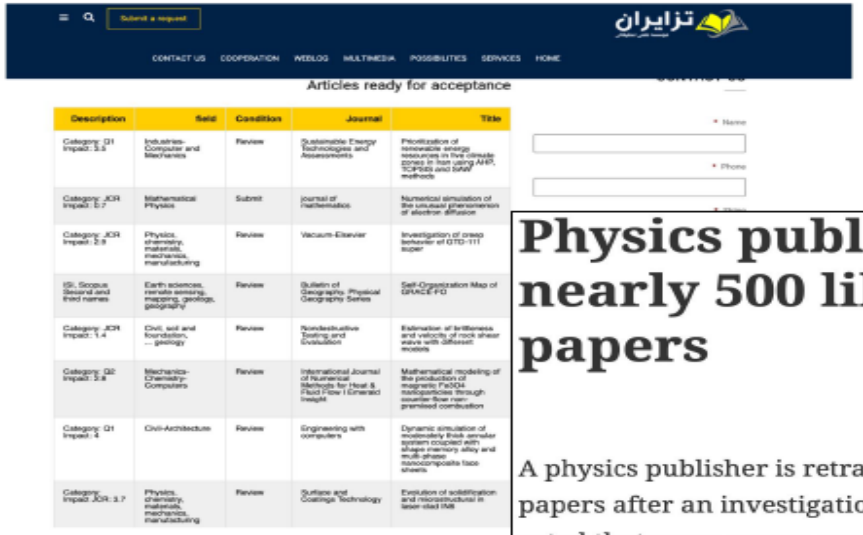
- **Citation cartel -** Group of researchers that systematically cite each other to artificially inflate citation counts.
- **Paper mill -** Commercial organizations producing and selling scientific papers, often with fabricated or low-quality content.

Exclusive: Russian site says it has brokered authorships for more than 10,000 researchers

A company in Russia hawks its wares

Paper mills, predatory journals and conferences, Mega-journals publishing anything for APCs…

Introducing two sites that claim to sell authorships on scientific papers



Blackmailing, citation brokers, hijacked journals…

Physics publisher retracting nearly 500 likely paper mill papers

A physics publisher is retracting 494 papers after an investigation "indicated that some papers may have been created, manipulated, and/or sold by a commercial entity" – aka a paper mill.

IOP Institute of Physics

Students `term papers' published to boost an institution…

Retraction Watch

TU/e

Key mechanisms of manipulation

- **Citation cartel -** Group of researchers that systematically cite each other to artificially inflate citation counts.
- **Paper mill -** Commercial organizations producing and selling scientific papers, often with fabricated or low-quality content.
- **Predatory journal -** Journals that charge publication fees without proper peer review, often misrepresenting their quality.
- **Predatory conference -** Events with little or no scientific review, primarily organized to generate revenue and publications.
- **Mega-journal** - Very large journals publishing thousands of papers annually, often with minimal selectivity.

These are not isolated phenomena,
they are systematic responses to incentive structures

Why mathematics is vulnerable

- Low publication and citation rates
  - Compared to many other disciplines, mathematicians typically publish fewer papers and receive fewer citations, making statistical indicators less robust.
- Large variation across subfields
  - Different areas of mathematics have very different publication and citation cultures, so comparisons based on metrics are often misleading.
- Small changes → large metric effects
  - Because absolute numbers are small, even modest increases in citations or publications can significantly affect rankings and indicators.
- Weak signal-to-noise ratio
  - The limited amount of data makes it difficult to distinguish genuine scientific quality from random fluctuations or artificial inflation.

Bibliometric indicators are particularly fragile and easily distorted in mathematics

The Clarivate case (I)

- In November 2023, Clarivate excluded roughly 1,000 researchers from the Highly Cited Researchers list for integrity concerns.
  - Trend over the years: ~300 excluded in 2021, ~500 in 2022, ~1,000 in 2023, ~2,000 in 2024
- In addition, the entire field of mathematics (~90 HCRs) was removed from the list, because the level of distortion was considered too high.

> *„(Mathematics) is a highly fractionated research domain, with few individuals working on a number of specialty topics. The average rate of publication and citation in Mathematics is relatively low, so small increases in publication and citation tend to distort the representation and analysis of the overall field. Because of this, the field of Mathematics is more vulnerable to strategies to optimize status and rewards through publication and citation manipulation.“*
>
> 6

The Clarivate case (II)

- End of 2025, mathematicians are back in the Clarivate list
- Some 65 mathematicians are listed
  - Mainly in applied areas
  - Often, HCRs have many co-authors and strong overlap with engineering / AI
  - Pure mathematicians (e.g. algebra, geometry, number theory) are largely absent
  - HCR lists are not representative of the full mathematical spectrum
  - Terence Tao, despite being one of the most influential mathematicians, does not consistently appear on the Highly Cited Researchers lists, illustrating that citation-based metrics do not reliably capture true scientific excellence.

The issue is not only fraud or manipulation;
it is that the underlying comparison is fundamentally uneven across fields

What do we observe?

- Weak correlation between citations and quality
  - Highly cited papers or authors are not necessarily those with the most significant or influential mathematical contributions.
- Discrepancy with major prizes and peer recognition
  - Prestigious awards and expert evaluations often highlight different researchers than those ranked highly by citation-based metrics.
- Strong self-citation patterns in some cases
  - A relatively high proportion of citations may come from an author's own work or from closely connected groups, inflating apparent impact.
- Concentration in certain research areas
  - Some fields with higher publication and citation activity are overrepresented in metrics, while others are underrepresented.

Some observations

Where are highly cited mathematicians located – and what does this tell us

University	# of HCRs
China Medical University Taiwan	11
King Abdulaziz University, Saudi Arabia	5
Queensland University of Technology (QUT), Australia	3
Stanford University, US	3
University of California Los Angeles, US	3
Beijing Normal University, China	2
Shandong Univ. of Science and Technology, China	2
University of Electronic Science and Technology of China	2
Amirkabir University of Technology, Iran	2
University of Milano-Bicocca, Italy	2
University of Urbino, Italy	2
University of Michigan, US	2
University of Minnesota – Twin Cities, US	2

Institutions having more than one primarily affiliated HCR in mathematics (from a total of 89 HCRs in math in 2019)

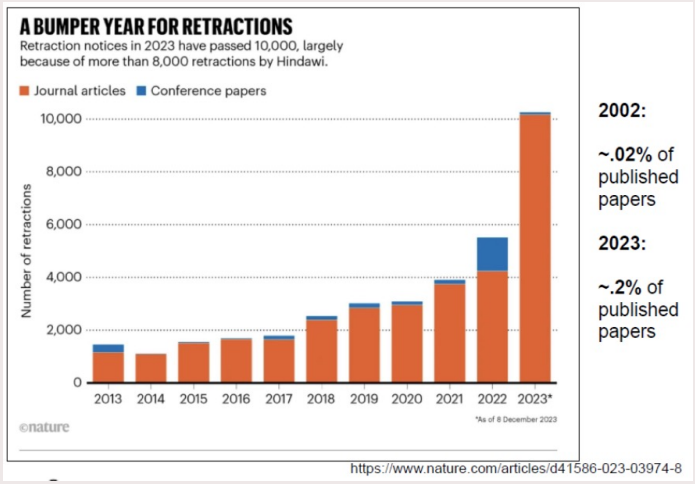
- The institution with the highest number of highly cited researchers in mathematics is a specialised medical university without a mathematics department.
- This suggests that citation-based indicators may reflect structural features of the publication system rather than the actual organisation of mathematical research.

We should be stricter about secondary affiliations

TU/e

Retractions: a growing signal

- Retractions in mathematics remain relatively rare, but are increasing in recent years:
  - ~1000 retracted papers in mathematics (primary field)
  - ~3000 papers with mathematics as secondary topic
  - ~150 for Springer and Elsevier, 0 for SIAM
  - 7 out of 89 HCRs appear in retraction database (2019)
- Strong growth across all sciences
  - ~0.02% (2002)
  - ~0.2% (2023)
- Retractions are often linked to paper mills, plagiarism, duplication
  - While retractions can also result from honest errors, their concentration in certain contexts points to structural vulnerabilities in the publication system.



https://www.nature.com/articles/d41586-023-03974-8

Citation behaviour differs across groups

Cohort	median SCS	median SRS
HCRs	15.63	12.91
Top 1000 cited	6.96	6.87
Prizewinners	7.91	0.22

Self-citing score (SCS) and self-referencing score (SRS) for different cohorts of mathematicians

SCS: % of citations to own work
SRS: % of references to own work

- Highly cited researchers exhibit significantly higher levels of self-citation and self-referencing compared to other groups.
- These differences reflect distinct citation behaviours across communities, not necessarily differences in scientific quality.

Bibliometric indicators are sensitive to how researchers cite, not only to what they contribute

TU/e

HCRs and University Rankings

- University rankings rely heavily on bibliometric indicators
  - Citations, highly cited researchers, indexed publications
- Highly cited researchers are a key component
  - Influence institutional reputation and ranking position
  - In some documented cases, citation manipulation at the individual level has translated into measurable effects on university rankings
- Rankings affect:
  - funding decisions
  - student choices
  - institutional strategies

Rankings amplify incentives to optimise bibliometric indicators

A few further vulnerabilities

- The reliability of bibliometrics depends strongly on the underlying database; curated mathematical databases such as zbMATH Open and MathSciNet play a different role from commercial citation databases.
- The problem ranges from poor publication practices to systematic manipulation and, in some cases, outright fraud.
- AI is likely to amplify existing problems by lowering the cost of producing plausible-looking but unreliable papers.

Conclusion and actionable perspective

What have we learned?

- Bibliometric indicators are not neutral
  - Once used for evaluation, they influence how researchers publish and cite.
- Different fields and communities exhibit different citation patterns
  - Publication and citation behaviour varies widely across subfields of mathematics.
- Metrics can produce results that are difficult to reconcile with the structure of mathematics
  - Observations such as the institutional distribution of HCRs do not reflect the traditional organisation of the discipline.
- Incentives created by rankings reinforce these effects
  - When rankings depend on metrics, there is strong pressure to optimise them.

The observed distortions are systemic, not incidental, and will persist without intervention

What can be done?

For policymakers

- Reduce reliance on bibliometric indicators
  → Quantitative metrics should not replace expert judgement in evaluation.
- Use expert-based evaluation
  → Peer review remains essential for assessing quality in mathematics.

For institutions

- Focus on quality, not quantity
  → Evaluation should prioritise significant contributions over publication counts.
- Avoid rigid metric-based criteria
  → Overly strict numerical targets can distort research behaviour.

For individuals

- Cite responsibly
  → Citations should reflect relevance, not strategic considerations.
- Be aware of publication practices
  → Researchers should recognise how incentives influence behaviour.

Improving evaluation systems requires action at all levels

TU/e

Final message

- Evaluation is necessary
  - Decisions on funding, hiring, and promotion require some form of assessment.
- But metrics are only proxies
  - Quantitative indicators cannot fully capture scientific quality.
- Over-reliance creates distortions
  - When metrics dominate, they influence behaviour in unintended ways.
- When a measure becomes a target, it ceases to be a good measure
  - What we measure shapes what we value and ultimately what we produce

The challenge is not to abandon evaluation,
but to ensure that it reflects what we truly value in mathematics

TU/e