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Lessons from the p-value debate and the replication crisis for "open Q science" – the editor's perspective or: will the revolution devour its children?

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Lessons from the p-value debate and the replication crisis for “open Q science” – the editor’s perspective *or: will the revolution devour its children?*

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Abstract

The scientific production system is of ultimate importance for the way how humans address global challenges. Recently, scholars have begun to voice concerns about structural inefficiencies within this system, as e.g. the replication crisis, the p-value debate or the identification of various forms of publication bias have brought up. Most suggested remedies tend to address only partial aspects of the system’s inefficiencies, while no unifying agenda towards an overall transformation of the system has yet emerged. We argue that a unifying agenda is even more urgently needed in light of Artificial intelligence (AI) that is arising as a tool for scientific writing services. Without appropriate reactions from the Q science community, this trend may even exponentiate present credibility problems due to limited replicability and ritual-based statistical practice, while amplifying all forms of already existing biases. Our review of these developments suggests that naïve openness in the science system alone will unlikely lead to major efficiency gains. We contribute by identifying key elements for the definition of transformation pathways towards open, democratic and conscious learning, teaching, reviewing and publishing that will be supported by openly maintained AI tools. As part of this transition, roles and incentives for reviewers will have to gain in relation to authors: Future Q scientists will have to write less, learn differently and review more.

1 Introduction

In our roles as researchers, editors, authors and referees we perhaps agree that most concerns in applied/empirical agricultural and food economics are related to adequacy of research methods and writing for answering the research questions while ensuring replicability. For these long-standing and overarching challenges in the academic way of working, learning and teaching, remedies include for instance calls for more rigor in writing and review to achieve full transparency in methods, data collection and processing (e.g., Di Fan *et al.*, 2022; Christensen and Miguel, 2018), or for better teaching “methods of writing” (e.g., Olson, 2015; Bellemare, 2022; McCloskey and Ziliak, 2019).

In this context, some scholars see the transition to an open science system with full transparency as key to address these challenges (e.g. Christensen, Freese and Miguel, 2019). In fact, the idea may be inflated by biases such as overstating positive results (Nuzzo, 2015), ritual based application of empirical methods (Gigerenzer, 2004, 2018), or the well-known cult of statistical significance (Ziliak and McCloskey, 2008) along with a non-transparent use of empirical methods (Christensen and Miguel, 2018) have led, among others, to publication bias (Brodeur *et al.*, 2016; Brodeur, Cook and Heyes, 2020). This was partly incinerated by the “replication crisis” and the “p value debate” in many fields, including agricultural and food economics (hereafter Q) domain (Ferraro and Shukla, 2022, 2020; Heckeley *et al.*, 2023; Hirschauer *et al.*, 2016).

Butler *et al.* (2017) mention the following reasons for these developments: “... *inadequate training of researchers, the pressures and incentives to publish in certain outlets, and the demands and expectations of journal editors and reviewers*”. What we have learnt so far from the crisis is that more effort is needed to reduce ritual-based working towards “mindful” empirical research. In this regard, a cultural change for empirical research in an open science framework with pre-registration of research and replication as central elements has been proposed (Heckeley *et al.*, 2023; Finger, Grebitus and Henningsen, 2023; Arpinon and Espinosa, 2022).

However, from our perspective as editors, it seems that the (open) Q profession is one the one increasingly concerned about these developments, yet on the other hand lacks behind to defining and acting along transition pathways towards open science at equal opportunities. While few colleagues would question that the current scientific production system in the Q profession may suffer from inefficient incentives and questionable developments, we argue that this debate still remains fragmented and largely irrelevant with respect to actual change, while “ritual-based” (Gigerenzer) practices continue to dominate the academic mainstream. For instance, in the open science discussion, it appears that the final editor-only decision making in the current publication system is not subject to debate. Also, efforts for more adequate teaching with open resources seem limited, while the replication crisis and the p-value debate demonstrate the necessity of a major revision of teaching empirical methods, and their potential alignment to the training of research design and scientific writing.

While spelling this out, artificial intelligence (AI) based technologies became ready for teaching, research and paper work¹ (Sabel *et al.*, 2023). AI-based technologies were set to be the most disruptive technologies ever developed (Russell and Norvig, 2021), and availability is expected to considerably speed up by quantum computing. This makes it necessary to integrate AI literacy in the curriculum to train future researchers who must work in an AI environment (Casal-Otero *et al.*, 2023). Yet, this also re-triggers the debate on quality assurance.² For instance, will the new technology even foster ritual-based scientific working and use of

¹ Examples: <https://openai.com/blog/chatgpt> or <https://www.perplexity.ai/>

² <https://www.forschung-und-lehre.de/forschung/fake-science-und-moeglichkeiten-sie-zu-erkennen-5623>
(in German)

statistical methods despite (future) open AI? Will even more efforts be needed in the future need to demonstrate the originality and the contribution, will this become more essential since ever?

How to counteract AI-based paper-waves? The current pressure of (early career) researchers to advance their careers in the current journal system seems not be prepared yet. Still, academic careers are strongly incentivized by quantitative measures of publication work (e.g., number of publications, impact factors of journals, authorship contributions, citation index of authors). A recent study identified a notable share of AI-supported fake publications in the field of biomedical science (Sabel *et al.*, 2023). This gives a first taste of upcoming challenges.

In this paper, reflect the current research and publishing system with final editor-only decisions will suffice for a cultural change towards mindful method use in an open science framework. Our aim is to discuss the question how the demanded cultural change in data-based research with statistical inference can be effectively supported by an open science framework in a world with AI. In contrast to other discussions, we aim to highlight implications for the teaching system, also because the expected AI transformation of Q publishing will likely shift the focus from qualified authors to qualified reviewers. We therefore base our discussion on critical reflections on the publication system with final editor-only decisions based on (open) reviews, the non-open teaching system keeping economic theory, statistics and scientific writing as independent parts of the curriculum in the Q domain, and the debated implications from the p-value debate in light of newly available AI.

This paper is organized as follows: In the next section, various deficiencies in the current scientific production process are summarized and reviewed. For this, we distinguish three layers: Section 2.1 will focus on deficiencies in the peer review system, 2.2 on deficiencies in the publication system yet outside actual peer review, and 2.3 on known deficiencies in the overall scientific incentive system not necessarily tied to the publication process. In Section 2.4, we analyse how an assumed wave of AI-supported manuscripts may amplify some already existing efficiencies. In Section 3, we review the state of open teaching and AI teaching in the Q domain, and in Section 4 we conclude with a discussion of possible transition pathways towards a more efficient and less biased scientific system in our field.

2 Why the peer review process needs a major revision

2.1 Potential deficiencies in the peer review system

Peer-review is at the core of the scientific production system and aims to ensure novelty, originality and correctness of scientific findings. The system typically involves *four* actor groups: (i) authors, (ii) reviewers, (iii) readers, and (iv) editors.

- i. *Authors* seek to pass the peer review process successfully as peer-reviewed publications serve as credits for researchers' contributions to the advancement of knowledge. Besides written publications, these are increasingly accompanied by graphical abstracts and video presentations in order to make core findings more accessible, but also to garner attention that could yield e.g. more citations.
- ii. *Reviewer(s)*, selected by editors, assess, scrutinize and comment the work of authors submitted to journals. Under single blind review, the authors do not know who their reviewers are and receive comments anonymously, yet referees know the authors' names. Under double-blind review, reviewers and authors remain anonymous to each other. Some journals offer open review on agreement with the referees (and authors for their response letters). Open peer review may in this context adopt any or all of the

following elements: Non-anonymous reviews, open review reports, response letters etc, free self-selection of inclined reviewers into the review process.

- iii. *Readers* as researchers use publications that have passed peer review as the most important reference for their own scientific work. Policy makers or management use publications or respectively extracted policy/management briefs as a base for scientifically informed decision-making in management or for the design of policies.
- iv. *Editors* coordinate the review process by matching the work of authors with potential reviewers. Also, editors act as judges during the review process because they own the decision over which manuscripts enter peer review, who's opinion to follow in case of controversial reviewer judgements, and when to determine that a submitted work has ultimately passed the review process through the official acceptance decision (Tennant and Ross-Hellauer, 2020).

In fact, the actor groups are complemented by *publishers* and *scientific communities* of peers with their respective associations:

- v. *Publishers* with a profit oriented management facilitate the scientific production process through provision of the required infrastructure: A publisher's business model consists of selling publications that have passed peer review, either as printed journals or books, or increasingly in electronic format to subscribing libraries. Costs include website, databases, licenses etc. (Da Teixeira Silva and Nazarovets, 2022). The market for commercial scientific publishing services is often described as oligopolistic with respect to *readers* and oligopsonistic with respect to *authors*.
- vi. *Scientific community* or the communities of peers comprise the population from which peer reviewers are typically selected from. The rankings established within scientific communities offer decision support to editors for what is considered as relevant for assessing the quality and novelty of a manuscript.

Any form of blind review has the advantage that reviewers can act independently; double-blind review even aims to protect authors and their work from reviewers' prejudgments. However, anonymous reviews are also increasingly criticized for being in-transparent, undemocratic and therefore potentially biased (Da Teixeira Silva and Nazarovets, 2022). Some journals offer open review, which may lend credit to more constructive reviewing and decision-making (Goeva, Stoudt and Trisovic, 2020; Wolfram *et al.*, 2020); yet mixed results regarding the effectiveness in the current system based on peer review and editor-only decisions exist (Da Teixeira Silva and Nazarovets, 2022). Also in open review, decision biases, e.g. by gender (Fox and Paine, 2019; Bornmann, Mutz and Daniel, 2007) can inflate the idea.

For instance, Donald and Hamermesh (2006) found e.g. that during elections for officers of the American Economic Association, not only scholarly impact had an effect, but women had a statistically higher chance to get elected than men. The authors conclude that "... *The apparent demand for more female candidates than have generally been provided may also mean that the Association's leaders have discriminated against women by failing to nominate them in numbers sufficient to satisfy the preferences of the electorate for female officers.*" (Donald and Hamermesh, 2006: 1291).

Clearly, it would be more desirable to have a higher authority judging scientific quality, especially in light of different scientific communities. However, since no such higher authority exists, the peer review selection process can only partly be objective, and can never lead to better results than the best possible selection of the most qualified reviewers who were available, i.e., willing to review (Tennant and Ross-Hellauer, 2020). This will in principle also hold for all

forms of open peer review: Final editor-only decisions clearly limit addressing such potential biases, yet the peer review system is also a social networking process and potentially subject to other prejudicial effects that can occur within any social group.

2.2. Potential deficiencies in the scientific publication system

A broad literature has emerged over the past decades that has assessed structural shortcomings of the scientific publication system. The overall system is known to carry at least the following biases, that are not necessarily inherent in the peer review system alone:

Gender/minority bias: single blind peer review may disadvantage female authors or authors from minority groups within the scientific community. However, in addition more subtle biases can occur. Based on a systematic review and meta-analysis, Schmaling and Gallo (2023) concluded that women were less likely to apply for grants and would receive smaller award amounts after reapplying, even though no gender difference was found for initial application rates. In contrast, Bornmann, Mutz and Daniel (2007) in their meta-analysis of gender differences in grant peer review had found men to receive a grant about 7% more likely than women. For National Science Foundation grant reviews, Broder (1993) reported that female reviewers were notably stricter on female proposals than on male proposals, and they rated female proposals on average lower than their male colleagues did. This result holds even after controlling for institution and reviewer experience. In contrast, Fox and Paine (2019) found that manuscripts submitted to journals by female authors were more likely to be rejected after peer review, and female authors were on average cited less often after publication than male authors.

Language and/or location bias: innovative ideas and original findings may not receive proportionate attention if they are not published in a language that is widely accessible to authors, e.g. English (e.g., Herrera, 1999), or if they are published in journals that are difficult to access (electronically). In addition, language bias may amplify the general publication bias, as the Cochrane handbook for systematic reviews acknowledges: When non-native English authors are more likely to publish in an international journal (in English), it has been found that they tend to submit rather statistically significant results to these journals, while seeking publication of insignificant result in local journals (Higgins *et al.*, 2019). In other words: the language bias may also represent a variation of the file drawer problem, according to which insignificant results tend to be neglected by authors and editors and may end up unpublished or published in journals of low visibility.

Publication bias comprises overstating positive results (Nuzzo, 2015), ritual based (Gigerenzer, 2004, 2018), or the well-known cult of statistical significance (Ziliak and McCloskey, 2008) along with a non-transparent use of empirical methods (Christensen and Miguel, 2018). Stanley (2005: 309) defines publication bias as “... *editors, reviewers or researchers have a preference for statistically significant results*”.

As a consequence, studies that do not identify a statistically significant effect will less likely see publication, and their potential contribution to the knowledge frontier will consequently been missing (Brodeur *et al.*, 2016; Brodeur, Cook and Heyes, 2020). Stanley (2005: 313) further reports that “... *nearly all economic applications of meta-analytic methods that detect publication bias have found evidence of it.*” Publication bias is especially prevalent in economics and other social sciences also because reviewers and editors (and authors) tend to stick to established paradigms, and this may imply a tendency to discard or ignore novel findings that may challenge these views (Doucouliagos, 2005).

This publication bias was partly incinerated by the “replication crisis” and the “p value debate” in many fields, including agricultural and food economics (Ferraro and Shukla, 2022, 2020; Heckeley *et al.*, 2023; Hirschauer *et al.*, 2016). The contribution of replications has received little attention so far as the question if and under which conditions previously published findings

could be replicated has been judged as an inadequate (because not novel) research question. For research in applied economics, however, many studies that have analysed the replicability of other studies find that replication is typically limited, if not impossible (Finger, Grebitus and Henningsen, 2023). Such important insights on external validity of empirical findings often remain undisclosed, despite their relevance for moving the scientific frontier and maintaining trust in research in general.

The availability of software packages further facilitated the rapid (statistical) testing of alternative model specifications and/or simulation runs without in-depth knowledge of the process and coding behind. To some extent comparable to AI, such technological innovations have lowered the (time) cost of doing economic research. Based on try and error approaches, new and unexpected insights from “data mining” can be expected, yet an imbalance in method diversity against sound use of empirical methods is increasingly recognized as a reason why research findings turn out to be difficult to replicate with larger data or minor changes in the corresponding modelling approach (Butler, Delaney and Spoelstra, 2017).

2.3 Potential inefficiencies in the scientific production system

Some debated issues thus far seem less driven by biased decisions of reviewers, editors and authors. Instead, these problems would to some extent still persist in the scientific publication system even in absence of any decision bias, because they are due to underlying incentives in the academic career system with focus on the frequency of publications and the number of citations. Such indicators offer some neutral and unbiased measure of scientific productivity and a researcher’s achievements; however, they also impose some problems. Butler, Delaney and Spoelstra (2017) bring it down to the point that e.g. inadequate results in replication studies could be due to “... *inadequate training of researchers, the pressures and incentives to publish in certain outlets, and the demands and expectations of journal editors and reviewers*”. In addition, attention to publications is often traced in terms of citations and editors are credited by publishers for managing publications that receive a lot of attention from within a certain scientific community, e.g. in terms of citations.

Thus, one may argue that the scientific production system is not in the first place directed towards solving problems around a sustainable future, implying that researchers are not necessarily rewarded in proportion to their long-term service for humanity. Instead, in the absence of suitable measures, the scientific production system is driven by an incentive system that rewards authors and editors for their ability to garner attention within a scientific peer group (Frey, 2003).

Why is this potentially problematic? The basic peer review system could in principle function based on no other incentive than researchers’ and reviewers’ intrinsic motivation to achieve the best possible result for any particular research question at hand. However, in reality this would function only i) in the absence of competition between individual researchers under asymmetric information and ii) in the absence of commercial publishing companies that possess at least some market power within the market for peer-reviewed publications (Butler, Delaney and Spoelstra, 2017). In fact, both of these drivers interact and form important components of the scientific incentive system that tends to reward “attention” as a measurable yet incomplete proxy for “scientific achievements”. The question remains, whether this goes in the “right” direction if reviewer work in this system continues receiving the lowest remuneration. From basic economics, we understand that some market regulation may be warranted.

In absence of such market failure, the scientific production system would counteract undesirable developments by itself, since the group of reviewers may not be subject to the same incentives as editors, and could therefore act as a corrective. Under AI, corrective competencies may become even more important as AI is suspected to take over more parts of the

research process, with an increasing number of papers to be reviewed. With an increasing number of requests for reviews and at the same time a great incentive to spend one's time as an author rather than as a reviewer—ultimately because reviewer work in this system receives the lowest remuneration—a decisive weakening of the system should be anticipated (Waltman *et al.*, 2023; Da Teixeira Silva and Nazarovets, 2022).

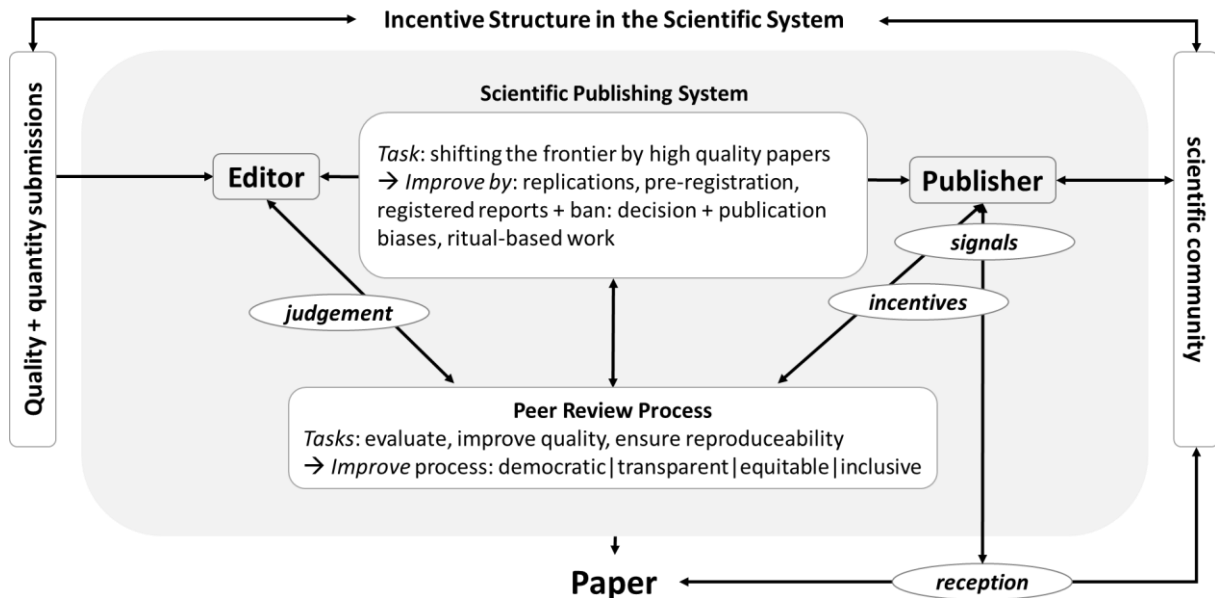


Figure 1: Major strands within the current literature on deficiencies of the scientific publication system.
Source: Own based on four schools of thought to improve peer review by Waltman *et al.* (2023).

By Figure 1 our attempt is to illustrate the different layers within the process: peer review is subject to a growing literature, and this highlights the importance of the editorial judgment that could potentially act as a guard of norms within the system. Figure 1 also demonstrates that the incentives introduced by commercial publishers may discourage editors and consequently all other actors within the system to guard such norms that thrive towards an equal, fair, transparent and unbiased scientific publication process. For instance, the introduction of incentives that serve authors' personal vanity may complement commercial publishers' business model but could have detrimental effects for the overall system³ (Da Teixeira Silva and Nazarovets, 2022).

2.4 Emerging challenges to the scientific publication process

AI-based technologies are readily available for supporting paper work, to a far larger extent than software and computing could have been expected, i.e. AI is set to be the most disruptive technologies ever developed (Russell and Norvig, 2021). This suggests that in the nearer future, the system will need to handle considerably larger amounts of paper work. But will this also lead to a "knowledge explosion"?

AI algorithms will lower the transaction cost especially for those authors who previously had difficulties to identify relevant literature and to describe the state-of-the-art regarding their specific research question. It seems plausible that a new inflationary wave of AI-supported manuscripts could challenge the scientific publication process through an adverse selection process. In this regard, Williams (2023) shows that these presently widely available AI algorithms are in no way free from prejudice, discrimination and other weaknesses that occur in social networks.

³ Teixeira da Silva claims in the conflict of interest section in Da Teixeira Silva and Yamada (2022), that they were banned in 2015 from submitting to any Taylor & Francis journals after having criticized several of the publisher's editorial and publishing processes.

Also, Williams (2023) stresses the problem that AI as an aide to scientific writing will primarily “...associate, exacerbate, and iterate on perceived patterns...” which will inevitably also “...continue to increase the bias within them...” (Williams 2023: 207). In fact, besides amplification of existing biases, further deficiencies in the peer review process may arise: less efficient reviews, reviewer fatigue and declining average quality of reviews (Waltman *et al.*, 2023). All this will likely inflate the research production systems’ efficiency in generating knowledge, while favouring an ever more “ritual based” academic culture.

To illustrate challenges whether such an increase in manuscripts would really trigger a “knowledge explosion”, we rely on the concept of the “law of important articles” (Holub, Tappeiner and Eberharter, 1991). These authors refer to a belief among researchers according to which “... *the number of important articles in a field in economics would increase by the square root of the total number of articles in this field*” (Holub, Tappeiner and Eberharter, 1991: 317). Using modern growth theory as a case study of such a “field”, the authors suggest to model number of important articles in this field, approximated by the number of at least n citations $X_{n,t}$ cumulated over all articles that can be attributed to a certain field in year t (not just the ones newly published in that year $X_{0,t}$). This gives:

$$X_{n,t} = bX_{0,t}^{\alpha} \quad (1)$$

Holub et al. (1991) chose $n=30$ citations to an article at time t as a minimum criterion for an article to be rated as “important” in the field of economic growth theory. The authors also corrected for the fact that the number of citations tends to accumulate over time, such that younger articles may c.p. have a smaller number of citations than articles that were published several years before year t .

In a linearized form, the assumed relationship between important articles and all articles in a field sets a base for regression-based estimation of the parameter α :

$$\log(X_{n,t}) = \log(b) + \alpha \log(X_{0,t})$$

This way, Holub et al. (1991) tested the hypothesis that this parameter would be approximately equal to 0.5 in the economic growth theory, suggesting that the “...*number of important articles would be the square root of all articles*” (Holub et al. 1991).

In their study, the authors find that the law of important articles seems to hold for general topics such as foundations of growth theory and optimal growth theory, while in more specific subsections of the literature on economic growth theory the estimated coefficient alpha could deviate statistically from 0.5 when applying a 95% confidence interval. Interestingly, these deviations were found primarily for parameter values below 0.5, which suggests that in several subtopics of economic growth theory, the number of important articles was even less than the square root of all articles.

The analysis by Holub et al. (1991) was conducted even before debates around the appropriate use of p-values, HARKing and the replication crisis came to economists’ attention. Linking the idea of Holub et al. (1991) and the sum of biased and inappropriate research practices emphasized by Butler et al. (2017) to the replication crisis in economics, one can assume an over-proportional increase in the number of “unimportant” articles in the past 30 years. One should therefore assume that the parameters estimated by Holub et al. (1991) for alpha in equation 1 would constitute upper boundaries of the share of important articles within all articles e.g. in the field of agricultural economics.

Furthermore, one can assume that the availability of AI technologies will lead to a further increase in the number of scientific manuscripts. To illustrate consequences of AI-pushed

increases in the number of manuscripts that will enter the publishing system, we use a stylized example based on two hypothetical journals:

The High Quality Journal of Agricultural Economics (HQJAE): we assume that this journal is a quality leader in its field and therefore the number of important articles in this journal is roughly equal to the square root of all articles that this journal has published so far. In other words, this journal has a coefficient $\alpha=0.5$ according to equation 1 and we assume $b = 1$. We furthermore assume that this journal publishes an unbiased sample of all submitted articles. This assumption implies that we abstract away from Holub et al. (1991) who refer to important articles as the square root of published articles: We assume instead, that the number of important articles is the square root of the number of submitted manuscripts.

The Applied Field Journal of Agricultural Economics (AFJAE): we assume that this journal attracts more applied manuscripts based on already established methods and/or data from specific studies that may interest only few experts in the field. Nevertheless, some of these studies could still be “important”, even though the share of these important manuscripts in all submissions to this journal is lower. Due to the lower share of important manuscripts in the submissions, this journal has a coefficient $\alpha < 0.5$ according to equation 1, and we assume also $b = 1$ for simplicity.

Table 1 shows that the HQJAE can under these conditions achieve a share of 4.5 % of important articles in all articles published (22.36 / 500). The more applied field journal could still achieve 3.5 % important articles among all articles published (5,31 / 150) if it's coefficient of important articles in all articles were $\alpha = 0.33$. Alternatively, if this coefficient were $\alpha = 0.2$, Table 1 shows that this journal could at best present a share of important articles in all published articles around 1.8 %.

Table 1: Stylized scenario on the potential effect of an inflation of AI-supported manuscripts on the share of important articles in two journals.

	Assumed submissions	Assumed alpha in eq. 1	No. of 'important' articles according to eq.1	Share of 'important' articles in published articles
HQJAE	500	0.50	22.36	4.5 %
AFJAE	150	0.33	5.31	3.5 %
AFJAE	150	0.20	2.72	1.8 %
HQJAE with AI inflation	1000	0.33	10.00	1.0 %
AFJAE with AI inflation	300	0.25	4.16	1.4 %
AFJAE with AI inflation	300	0.20	3.13	1.0 %

Source: Own calculations.

Presuming that the original number of submissions doubles for each of the two journals, while the initial coefficient of important articles in all articles declines due to the larger share of shallow, weak and therefore unimportant articles has the following implications: For the high quality Journal (HQJAE), we assume that the coefficient deteriorates from $\alpha = 0.5$ to $\alpha = 0.33$, which means a decline from the reported parameter values in the general economic growth literature (Holub et al. 1991) to the reported values in some subfields of this literature (Holub et al. 1991); for the applied field journal (AFJAE) we arbitrarily assume lower coefficients (note that e.g. $\alpha = 0.2$ is $X_{n,t} = \sqrt[5]{X_{0,t}}$ in equation 1, again $b = 1$).

Table 1 illustrates that a doubling of submissions may drastically decrease the share of important manuscripts within the high-quality Journal HQJAE, namely from 4.5 % to 1 %, even for a relatively mild decline of $\alpha = 0.5$ to $\alpha = 0.33$. At the same time, this would go along with a doubling of the effort for editors and reviewers. In contrast, the table shows that the relative decline in the share of important articles in the applied field journal AFJAE would be smaller, assuming that an already relatively low share of ‘important’ submissions in all submissions does not decline substantially further, e.g. either from 1.8 % to 1.4 %, or it might even remain around 1 % for initially low values of α .

In other words, especially the high-quality journal would in our stylized example get severely affected by an inflation of rather AI supported manuscripts, as long as these would primarily be “unimportant”: as the cost of the review process doubles along with the number of submissions, the share of important articles in all published articles would decrease from 4.5% to 1%, a potentially severe decline in perceived average quality. In contrast, the applied field journal with an already assumed low share of important articles would rather see an expansion of volume while perceived average quality of this journal would remain rather constant.

In summary, an inflationary stream of shallow and/or “unimportant” (Holub et al. 1991) papers may lead to symptoms that are currently being debated as the replication crisis, p-value debate, or various aspects of publication biases. The rise of artificial intelligence (AI) as an emerging aide for scientific writing might amplify these problems and could add a new dimension to the already looming overall credibility-crisis in science.

3 State of (open) teaching and teaching AI in Q Science

One of the sources of publication biases, the p-value debate and the replication crisis was inadequate training of students and researchers (Butler, Delaney and Spoelstra, 2017; Gigerenzer, 2004). But what means adequate? Noted teaching implications (e.g., Heckeley et al., 2023)⁴ include: (i) a curriculum that rests on teaching empirical/statistical methods at Bachelor- and Master studies such that students get sustainable knowledge, are able to apply and critically reflect existing methods; (ii) implementation of experiential learning and interactive teaching methods for Master- and PhD level such that students strengthen their ability to critically reflect method choice not only for their research as authors, also as future reviewers and editors; (iii) campaigns supported by scholarly associations, journals and publishers to foster a social norm change. Ideas of how to support such a change include incentivizing investments in method learning and teaching, and transparency in an open science framework. How to include AI literacy, how to strengthen and prepare for the urgent need of reviewer competencies, and ideas for transition pathways however, remain vague.

Ultimately, we are interested how an open science framework can support such a cultural change in a world with AI, we critically reflect current teaching of writing and empirical/statistical methods, and AI literacy. We selected and reviewed 3 *curricula* of higher education from German universities in the Q-domain exemplarily. The narrow regional focus and the small number can be interpreted as a qualitative in-depth assessment. This shall offer a starting point in form a narrative pilot for a systematic review across Europe. We structure the assessment around the following questions:

⁴ We would like to thank the organizers of the ICAE 2021 Organized Symposium: *Towards Open Science: Transparency in International Agricultural Economics* for the discussion of open teaching ideas.

1. At what stages (Bachelor, Master, PhD, which year) are the subjects
 - a. *scientific writing and presenting methods*
 - b. *methods for empirical research*
 covered?
2. What content is covered in the courses under 1?
3. At what stage is AI literacy covered?
4. How are the courses linked to each other?
5. How is the exchange with other places of higher education organized?

Bundling questions 1 and 2, we find several courses that include “scientific writing” and/or “scientific presenting” and/or “research” in their titles and descriptions. These courses cover typically formulating a research question, the paper structure, sometimes the research process itself with some philosophy of science, and the related writing parts. These courses were found to be covered in the curriculum close to the graduation theses, mostly in the last year, yet this appeared not standardized. Incentives to take these courses seem also to vary. In the Master we found writing and presenting courses sometimes linked to seminars or specific thesis preparation seminars. Such seminars cover the research process, writing, presenting but also how to give and deal with feedback. In the Master we found also research ethics covered. Respective incentives for participating in such courses vary. For instance, we found places where it can be mandatory for specific majors. At the PhD level, all reviewed places offer courses in this regard, and in addition the graduate school in agricultural economics among universities in Germany, Austria and Switzerland “*Promotionskolleg Agrarökonomik*” offers such courses; yet it appears that the publishing and review process seem not covered systematically in these offers at the PhD level.

Nearly all language centres at the respective universities offer writing and presenting classes that are accepted elective modules. However, these classes mainly focus on correct use of language, less on the alignment conducted research and storytelling in a specific discipline. Yet in our perception, also here specific offers for reviewing and feedbacking seem missing. Specific trainings for unconscious bias in language but also in decision making seem not mandatory at all.

Empirical methods for research are covered throughout the reviewed curricula. We found differences how the courses are linked to the agricultural and food economics domain: some offer rather focused applied econometrics classes, while other emphasize more the link to empirical research in the agricultural and food economics domain. Also, how qualitative research methods and data acquisition are covered, varied.

Concerning AI literacy (question 3), we found specific courses that cover methods of machine learning in specific Master and/or PhD courses. We also observe that some traditional statistics and applied econometrics classes introduce such methods, up to 50% of the course. Pure AI courses including ethical implications and impacts on society appeared not specifically covered. We however found recommendations on how to declare the use of AI for graduation theses. Yet plagiarism detection software cannot distinguish whether it was used to polish the writing as English is typically not the mother tongue (language barriers) or used for generating the content. The final decision on what can be graded as own contribution is currently left to the examiners.

A major implication of the replication crisis was that teaching of research methods must be aligned to the research process, i.e., ranging from the research question, pre-registration to methods, writing and publishing (see Heckeley et al. 2023). This motivated question 4. We identified some attempts to link the research process to empirical methods at all levels (Bachelor, Master, PhD) by offering specific lectures in the method courses but also linking the presentation of the results to appropriate use of data work, particularly the null hypothesis significance testing, in courses for writing and presenting research.

Among German-speaking places, exchange between teachers seems active, also because of the joint PhD programme. For instance, materials on courses on methods are shared among teachers from different places more based on personal relations rather than on an open teaching culture. For courses of writing, presenting and reviewing, exchange and collaboration seemed less active. None of the courses we investigated offered free and open materials.

4 Discussion: implications for the transition towards Open Q Science

The aim of this paper was to discuss the question how the demanded cultural change in data-based research with statistical inference can be effectively supported by an open science framework in a world with AI. Based on critical reflections on the publication system with final editor-only decisions based on (open) reviews, we argue yet not all deficiencies in the scientific publication process can be directly linked to peer review alone, nor can a naïve call for openness alone be expected to induce a profound efficiency gain for the scientific production system in Q science.

Overall, a removal of misleading incentives in the system has to be accompanied by adequate training and more equal and transparent structures. The transition pathway development should therefore go “*beyond make it open with wait and see*” with the following elements for the **open research system** as documented processes with responsibilities for:

Establishing and maintaining an open **infrastructure** for reviews, data, coding and publications.

Introducing **rewards** for **data** and **code** sharing following **FAIR** principles (Findable, Accessible, Interoperable, and Re-usable).

Broadening the **output** portfolio by clear incentivization or standardization of **pre-registration**, **pre-registered studies** and **replication studies**.

Strengthening the **role** of the **reviewer** relative to the role of the *author* with review rewarding in the academic career system.

Transparent and reliable definition of the **editor role** with code of conducts, and mandatory (regular) training for any sources of bias in language and decision-making for editors. This should be accompanied by independent complaints officers and rewarding of taking responsibility as complaint officer in the academic career system.

Rewards for all kinds of **training against unconscious biases** in language and decision making in the academic career system, rewards to taking responsibility for achieving balanced and transparent decision making.

Developing **new publication formats** with open decision processes beyond commercial publishers’ journals and their success metrics in accordance with the San Francisco Declaration on Research Assessment⁵.

⁵ <https://sfورا.org/>

Mindful AI use for reviewer match, AI for technical and formal paper screening for detection and elimination of “Questionable Research Practices” (Butler, Delaney and Spoelstra, 2017) but only based on **open AI**. Mandatory declaration of AI use, clear disincentives for research done by AI. This must be accompanied by AI training and the nurturing of norms that favour open AI for the facilitation of an equitable and non-discriminatory peer review process (Williams, 2023).

Concerning the teaching system, based on the narrative review of current teaching in Germany, we find a non-open teaching system, where economic theory, statistics and scientific working (writing, reviewing, presenting) appear still in many cases as independent parts of the curriculum in the Q domain. Newly available calls to include AI literacy in the curriculum, seem not in place yet; we however found specific methods to be covered. We re-enforce the call by Heckeley et al. (2023) for a cultural change and a transition towards open science, including open teaching and open AI, at equal opportunities. We expand the implications by proposing to define transition pathways **towards open teaching with AI not by AI**.

The transition pathways should include documented processes with responsibilities for:

Revising **learning objectives** that include evaluation of the research process, statistical thinking and AI literacy, decision making under risk and uncertainty, and sources of decision biases. The coordination is necessary to share the same objectives in our domain. These shall be defined as templates with open access and ensure a flexible use for specific adjustments in the respective curricula.

Finding consensus about open recommendations for **compulsory content** in AI literacy, intertwined with empirical methods, the research process but also writing, reviewing and presenting skills with AI support, and research ethics. These recommendations may serve as standards. Standards, however, would imply to anticipate regular revision of them.

Finding consensus about **recommendations** for **teaching-methods** related to experiential learning and training of competencies for reviewing, commenting as future reviewers and editors. This includes more hands-on for problem solving, demonstration of good and bad practice examples and in-class reviewing, for instance of talks/videos, papers or wikis. This also suggests to consider **replication studies** as graduation theses, and a higher share of grading for the oral presentation/defence.

Finding consensus about **guidelines** for seminar **papers** and **presentations**, and graduation theses with clear guides for formulating research questions, literature analysis, use and documentation of AI for paper work.

Creating a **teaching infrastructure** for efficient exchange and further development of materials. This may include common pools with quality checks, specific tracks at conferences and teaching forums to foster exchange.

Defining **rewards** for **teaching** and sharing teaching materials in the academic system.

All recommendation shall appear in non-discriminating language. We acknowledge that our survey was small and should be interpreted as a starting point only. Nonetheless, we argue that this paper offers a base for defining transition pathways. We recommend further to base the transition pathway development on scientific evidence from systematic review of the teaching and publication system, potentially enriched by expert interviews to base the target definition and identifying mechanisms for change.

Our discussion has the following implications. Summarizing, more rigorous efforts are needed to reach an open science framework with minimal bias and efficient use of AI. Making reviews open and ask to declare AI use will not suffice. In our perspective, potentials of coordinated

but open teaching methods for research, writing and AI literacy are currently not used. We emphasize the benefits from open but coordinated teaching resources, including AI literacy, at equal opportunities that require some investments from our community. Most promising steps include open access journals, open data, code and review enriched by transparent editor decisions. However, more efforts are needed for AI literacy and open AI for research purposes. We suggest a coordinated discussion of transformation pathways towards an open, efficient and reliable science system in the Q domain. This is necessary as the Q domain needs itself to contribute with other disciplines to ensure the transition towards sustainable food systems. It is in our hands whether AI gets the power to devour its children.

The famous quote “You get what you measure” (Hamming, 1995) suggests that the outcome of any production process would be determined by the way its measurable outcome indicators are being defined. The scientific production process is of ultimate importance for the way how humans identify, address and solve global challenges, for instance sustainable production of food, renewable energy and biomass against the backdrop of a rising world population. It is therefore no overstatement that the efficient functioning of the scientific production process in all scientific disciplines related to agricultural systems is crucial for a sustainable future.

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Die Wurzeln der **Fakultät für Agrarwissenschaften** reichen in das 19. Jahrhundert zurück. Mit Ausgang des Wintersemesters 1951/52 wurde sie als siebente Fakultät an der Georgia-Augusta-Universität durch Ausgliederung bereits existierender landwirtschaftlicher Disziplinen aus der Mathematisch-Naturwissenschaftlichen Fakultät etabliert.

1969/70 wurde durch Zusammenschluss mehrerer bis dahin selbständiger Institute das **Institut für Agrarökonomie** gegründet. Im Jahr 2006 wurden das Institut für Agrarökonomie und das Institut für Rurale Entwicklung zum heutigen **Department für Agrarökonomie und Rurale Entwicklung** zusammengeführt.

Das Department für Agrarökonomie und Rurale Entwicklung besteht aus insgesamt neun Lehrstühlen zu den folgenden Themenschwerpunkten:

- Agrarpolitik
- Betriebswirtschaftslehre des Agribusiness
- Internationale Agrarökonomie
- Landwirtschaftliche Betriebslehre
- Landwirtschaftliche Marktlehre
- Marketing für Lebensmittel und Agrarprodukte
- Soziologie Ländlicher Räume
- Umwelt- und Ressourcenökonomik
- Welternährung und rurale Entwicklung

In der Lehre ist das Department für Agrarökonomie und Rurale Entwicklung führend für die Studienrichtung Wirtschafts- und Sozialwissenschaften des Landbaus sowie maßgeblich eingebunden in die Studienrichtungen Agribusiness und Ressourcenmanagement. Das Forschungsspektrum des Departments ist breit gefächert. Schwerpunkte liegen sowohl in der Grundlagenforschung als auch in angewandten Forschungsbereichen. Das Department bildet heute eine schlagkräftige Einheit mit international beachteten Forschungsleistungen.

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