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Peer Review at the Crossroads

Dmitry Kochetkov[1,2]

[1]Centre for Science and Technology Studies, Leiden University, Leiden, the Netherlands | [2]Department of Probability Theory and Cybersecurity, RUDN University, Moscow, Russian Federation

Correspondence: Dmitry Kochetkov (d.kochetkov@cwts.leidenuniv.nl)

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ABSTRACT

Peer review has long been regarded as a cornerstone of scholarly communication, ensuring high quality and credibility of published research. Although academic journals trace their origins back three centuries, the procedures for evaluating submissions, particularly peer review, have undergone continuous evolution. Peer review's formal institutionalisation in the mid-20th century represents a significant, yet natural, phase in this ongoing transformation of scholarly communication. By the early 21st century, there emerged an opinion that the conventional model of peer review faces systematic challenges, including inefficiency, bias and institutional inertia. The study aims to synthesise the evolution, practices and outcomes of both conventional and innovative peer review models in scholarly publishing. Through a mixed-methods approach combining interpretative literature review and process modelling (Business Process Model and Notation–BPMN), it identifies four frameworks: pre-publication peer review, registered reports, modular publishing and the Publish-Review-Curate (PRC) model. While the PRC model, which integrates preprints with post-publication review, demonstrates advantages in transparency and accessibility, no single approach emerges as universally ideal. The choice of model depends on disciplinary context, resource availability and institutional priorities. The analysis underscores the need for adaptable platforms that enable hybrid workflows, balancing rigour with inclusivity. Future research must address empirical gaps in evaluating these innovations, particularly their long-term impact on equity and epistemic norms.

1 | Introduction

Peer review in scholarly communication refers to feedback provided by researchers (peers) on a specific study. It is a defining feature of academic journals, distinguishing them from popular or professional publications. Traditionally, peer review is meant to ensure the quality of scientific research, increasing the level of trust within the academic community and among funders (G. D. Smith and Jackson 2022). Peer review helps to identify and correct errors in scientific studies that may lead to flawed conclusions and misguided decisions (Kelly et al. 2014). While authors benefit from constructive feedback, the process of accepting feedback can be challenging due to several interrelated factors, highlighted by (Watling et al. 2023):

- Emotional challenges,
- Structural and process-related issues,
- Cultural and professional pressures,
- Experience and power dynamics,
- Systemic inequities.

Some scholars further highlight that peer review can enhance an article's readability and broader scholarly appeal, irrespective of its initial quality.[1] Additionally, it is critical to acknowledge that not all researchers have access to collegial discussions about their work, rendering peer review an indispensable channel for academic dialogue and feedback.

Key Points

- No 'ideal' peer review model exists.
- Conventional pre-publication peer review faces systematic challenges.
- Registered reports and modular publishing focus on methodological rigour and iterative publication workflows.
- The PRC model demonstrates advantages in transparency and accessibility.
- Empirical evidence for innovations remains limited.
- Future platforms require adaptable hybrid workflows.

Reviewers typically evaluate a wide range of criteria such as those outlined in a UK House of Commons report (Peer Review in Scientific Publications: Eighth Report of Session 2010-12. Vol. 1 2011):

1. Study design and methodological rigour,
2. Soundness of results,
3. Transparency of data used in the study,
4. Interpretation of results,
5. Whether study objectives are met,
6. Completeness of the study (preliminary vs. final),
7. Scientific novelty and significance,
8. Ethical compliance.

International journals often require evaluation of language proficiency. However, criteria vary across disciplines and journals.

By the early 21st century, peer review was labelled as 'broken' by some critics (McCook 2006). The main problem noted by McCook is the increasing number of manuscripts and the burden on reviewers. This, however, only scratches the surface.

Allen et al. (2022) highlighted the issue of the 'black box': while anonymity of traditional peer review aims to uphold integrity, it may also suppress discussion, perpetuate biases, and entrench dominant paradigms, stifling innovative ideas. As Academician L.I. Abalkin noted, 'no one has the right to usurp the truth' (Sukharev 2020, 44). Without reform, science risks stagnation or a shift towards alternative communication channels.

R. Smith (2006) linked peer review to democracy: 'a system full of problems but the least worst we have' (178). Yet can we consider peer review as a uniform concept, given the variety of existing models? Which model of peer review best fulfils the functions of scholarly communication?

The aim of the study is critical evaluation of the effectiveness, challenges, and implications of conventional and emerging peer review models, such as the Publish-Review-Curate framework and deconstructed publication approaches (registered reports and modular publishing), in fostering transparent, efficient and equitable scholarly communication. The analysis covers historical background and contemporary innovations to identify trends shaping peer review practices. The study employs interpretative literature review, as well as BPMN (Business Process Model and Notation) for modelling and describing the processes that constitute various peer review models.

While this study employs an evidence-based methodology to analyse peer review models, I should note upfront that the conclusions reflect certain normative commitments. Specifically, this manuscript argues for greater emphasis on transparency, community-driven evaluation and distributed responsibility, which are reflected in the Publish-Review-Curate (PRC) model. This normative orientation does not undermine the comparative analysis of all four models but rather contextualises it. Each model serves legitimate purposes depending on the context; however, the broader academic ecosystem would benefit from expanding PRC-aligned alternatives to the traditional publication channels. This position is revisited substantively in the Conclusion.

The rest of the paper is structured as follows. Section 2 briefly outlines the evolving functions of scholarly communication and peer review's role in this framework. Section 3 describes the methodology of the study, followed by an analysis of peer review development and its current crisis. Subsequent sections explore solutions to the crisis and peer review's adaptation to global publishing changes. While focused on scientific articles, the findings of the study can be extended to books and conference proceedings.[2] At the same time, review for other purposes, for example, evaluation of grant applications, is a topic for a separate discussion.

2 | Functions of Scholarly Communication

Kling and McKim (1999) outlined three building blocks of scholarly publishing as a form of communication: publicity, accessibility and trustworthiness. While publicity and accessibility relate to the dissemination of research outputs, trustworthiness ensures credibility through peer review, journal reputation and sponsorship. Thus, scholarly communication is traditionally believed to serve multiple functions summarised in Table 1.

While traditional models emphasise peer review as indispensable for certification (Kling and McKim 1999), Bohlin (2004) highlighted fields like physics where preprint servers (e.g., arXiv) reduced reliance on journals for quality control. Tensions arise as rapid dissemination via preprint servers, whereas enhancing accessibility, also may undermine the traditional quality control function.

Björk (2007) proposed the Scientific Communication Life Cycle Model (SCLC) to map the entire scholarly communication ecosystem. The model connects phases like funding, research, publication and practical application. Using the structured IDEF0 methodology, Björk detailed this complex system through over 33 diagrams and 113 distinct activities. While the model's scope is comprehensive, it puts special emphasis on peer review as a multi-faceted process essential for quality assurance.

TABLE 1 | Functions of scholarly communication.

Function	Brief description	References
Registration	Establishes priority and ownership of ideas	(Bohlin 2004; Roosendaal et al. 2001)
Archiving	Ensures long-term preservation and accessibility of knowledge	(Bohlin 2004; Roosendaal et al. 2001)
Awareness/ distribution	Disseminates research to relevant audiences	(Kling and McKim 1999; Roosendaal et al. 2001)
Certification/ quality control	Validates research outputs mainly through peer review	(Bohlin 2004; Roosendaal et al. 2001)

In the current stage, the link between scientific communication and peer review becomes more complex, as peer review adopts both pre- and post-publication validation roles (Chtena et al. 2025). Preprint servers disrupt academic publishing by separating dissemination (via preprints) from certification, which may now occur post-publication through overlay journals, third-party review platforms, or journals integrating preprints into their workflows. Initiatives such as Publish-Review-Curate, discussed in subsection 5.2, challenge the traditional gatekeeping function of academic journals.

The open access movement further redistributed functions of scholarly communication, putting an emphasis on free access over traditional subscription-based trust. Finally, the traditional roles of scholarly communication are no longer seen as static functions but as interdependent processes that evolve with digital innovation (Baffy et al. 2020).

3 | Data and Methods

The first task of this study is to trace the evolution of peer review over time. While our analysis of the evolution of peer review incorporates elements of historical analysis, it does not fully qualify as such because primary sources were not directly utilised. Instead, it functions as a background of the study, and one that is intentionally concise, as a comprehensive history of peer review falls outside the scope of this research.

Literature review deliberately employs an interpretative, rather than systematic, methodology. The core objective necessitates synthesising conceptual developments and illustrative models of peer review, not exhaustive cataloguing of every publication. Consequently, sources were identified through targeted searches across major academic platforms and repositories, including Semantic Scholar, Google Scholar and pertinent grey literature channels. The selection process was guided by inclusion criteria: works were considered only if they primarily described, analysed, or proposed typologies of peer review models. Studies where peer review was merely tangential or incidental were excluded.

For modelling and describing the processes that constitute various peer review models, the BPMN (Business Process Model and Notation) was employed, a notation traditionally used for business process modelling. BPMN is a widely adopted standard for business process modelling, offering a graphical notation that is easy to use (Völzer 2010). BPMN excels at representing behavioural aspects of processes, enabling its application across diverse domains (Perry 2006). However, modelling other dimensions of processes may require supplementary methods (e.g., narrative modelling within this study). The graphical process notation was developed using the open-source software Draw.io.[3]

The review of innovations in peer review is based on recent work by Waltman, Kaltenbrunner, et al. (2023), whereas incorporating specific modifications and an interpretive literature analysis. This approach refines the categorisation of innovations while aligning with existing scholarly discourse. This method synthesises research while maintaining an interpretive epistemology (Weed 2005). Interpretive reviews aim to balance the contributions of research literature and practitioner perspectives by incorporating both extracted data and commentary into the analysis (Kahn et al. 2008). This methodology allows for the development of practical understanding within a field and bridges the gap between research and practice (Russell 2005). I aim to bridge the gap between research, policy, and practice by analysing and interpreting both academic and grey literature. For sourcing academic literature, Semantic Scholar was primarily utilised, whereas standard web search engines (such as Google) were employed to identify grey literature and partially supplement academic sources.

4 | Crisis of Peer Review

This section traces how peer review evolved into a formalised institutional system and then analyses why that system now faces crisis.

The 19th century marked a shift towards formalised peer review. The Royal Society introduced written referee reports in 1832, initially emulating the French Académie's expert evaluations (Moxham and Fyfe 2018). However, this practice remained inconsistent, with referees often providing stylistic feedback rather than rigorous validation (Burnham 1990). By the late 19th century, learned societies like the Royal Society used refereeing to allocate prestige and manage publication costs, whereas independent journals relied on editors' judgements (Burnham 1990; Moxham and Fyfe 2018). Thus, learned societies emphasised collective decision-making and expert evaluation to safeguard finances and prestige, whereas editorial peer review initially prioritised rapid publication over formal evaluation (Burnham 1990; Hooper 2019). In the late 1890s, printed peer review report form (checklist) began supplementing invitation letter (Fyfe 2019).

Standardised pre-publication peer review by referees became widespread only after World War II (Chapelle 2014). For example, *The Lancet* adopted mandatory peer review in 1976. The post-war surge in manuscript submissions drove journals to institutionalise *'entry filtration'* systems, solidifying

pre-publication peer review as a dominant model by the late 21st century (Figure 1).

The institutionalisation of peer review is manifested in the development of ethical principles which have been adopted by the majority of the academic community. One of the most well-known documents (COPE 2013) was developed by the Committee on Publication Ethics (COPE). This document contains basic principles for reviewers, which have become common practice in the workflow of academic publishers worldwide. Furthermore, most academic journals have a section on their website that describes the peer review policy applied by the journal.

By the late 20th century, the mechanisms meant to ensure quality began to show signs of systemic failure. Concerns emerged about efficiency, bias, equity and incentives misalignment. These problems reflected structural contradictions in the peer review system itself. The following paragraphs outline four interconnected dimensions of this crisis.

The rapidly growing volume of manuscripts has created a critical *shortage of reviewers*. The primary reason for declining review invitations is time constraints (Tite and Schroter 2007; Willis 2016). This shortage has cascading effects: extended review timelines frustrating authors, as well as expansion of reviewer search criteria, leading to less qualified evaluation.

Simultaneously, current peer review practices perpetuate *inequities* towards specific groups in academia. Anonymity, often intended to mitigate bias, can instead obscure discriminatory tendencies creating a *'black box'* problem. Despite institutional commitments to equity and inclusivity in scientific publishing (COPE 2021), a few groups still dominate scientific periodicals, such as male authors from the United States and the United Kingdom (O. M. Smith et al. 2023).

Peer review is also often seen to prioritise consensus over scientific novelty, inadvertently reinforcing mainstream paradigms at the expense of novel ideas. This conservatism can suppress disruptive findings (Steinhauser et al. 2012), favouring incremental advances while marginalising unconventional approaches (Hess 1975). As a result, it may limit opportunities for game-changing scientific discoveries (Braben and Dowler 2017).[4]

Finally, the inefficiency of the current peer review process manifests in two ways: protracted timelines delaying knowledge dissemination (see point 1) and redundant evaluations due to serial submissions. Aczel et al. (2021) found that in 2021, reviewers worldwide spent over 100 million hours (equivalent to more than 15,000 person-years) with associated costs exceeding $1.5 billion (USA), $600 million (China) and $400 million (UK). These figures raise urgent questions about the cost-effectiveness of current practices.

The crisis has generated a surge in innovations described in Section 5.

5 | Innovations in Peer Review

In the previous section, the crisis facing the traditional peer review model has been outlined. This raises the question of how the crisis can be overcome. Recent scholarship has increasingly focused on innovations in peer review practices (see reviews by Kaltenbrunner et al. 2022; Woods et al. 2022). This section explores emerging innovations organised around four schools of thought: Quality and Reproducibility, Democracy and Transparency, Equity and Inclusion, and Efficiency and Incentives (Waltman, Kaltenbrunner, et al. 2023). For each school, I examine specific innovations and their empirical evidence, ultimately identifying patterns that inform the four overarching peer review models. At the same time, I have updated the typology and introduced a third tier of the hierarchy, where it is applicable (Figure 2).

The taxonomy explicitly extends the framework proposed by Waltman, Mulati, et al. (2023). My contribution lies in augmenting this structure through the introduction of the third, more granular level of classification. This novel tier functions to specify particular operational models and practices that are conceptually situated within a particular school of thought. For instance, deconstructed publication is categorised under the Quality and Reproducibility school, principally because its core justification emphasises strengthening methodological rigour and reproducibility, achieved via mechanisms like preregistration and modular dissemination. At the same time, transparency elements intrinsic to deconstructed publication also arguably resonate with the Democracy and Transparency school, illustrating a common situation where innovations cross strict categorical boundaries. Hence, placement decisions tend to reflect the dominant underlying intent of each model, whereas consciously acknowledging the frequent cross-cutting nature of peer review innovations. The essential function of this third tier, therefore, is to operationalise the schools of thought by mapping them onto specific, recognisable peer review methodologies.

I should also acknowledge that the list of innovations in peer review presented in this paper is not comprehensive. For instance, I could mention ranking papers instead of reviewing them or bidding for papers (Birukou et al. 2011). However, these initiatives mainly did not go beyond the pilot phase; so they have not significantly affected the publishing landscape.

5.1 | Quality and Reproducibility

Training reviewers through workshops, face-to-face sessions and self-taught courses is a strategy employed by many publishers.[5] However, empirical studies indicate that such interventions have only limited impact on improving the quality of peer review. In a randomised controlled trial (RCT) by (Schroter et al. 2008), reviewers detected only ~3/9 major errors on average, with training interventions (face-to-face or self-taught) yielding minor, short-term improvements. These gains diminished by the third review (Paper 3), suggesting no sustained benefit. Similarly, a trial by BMJ found self-taught training marginally improved review quality scores (2.85 vs. 2.56 control) and error detection, but effects were not editorially significant and faded over time (Schroter et al. 2004). A meta-analysis of five RCTs evaluating peer review training interventions found no significant improvement in review quality (Bruce et al. 2016). Another systematic review of various training programs reported only marginal

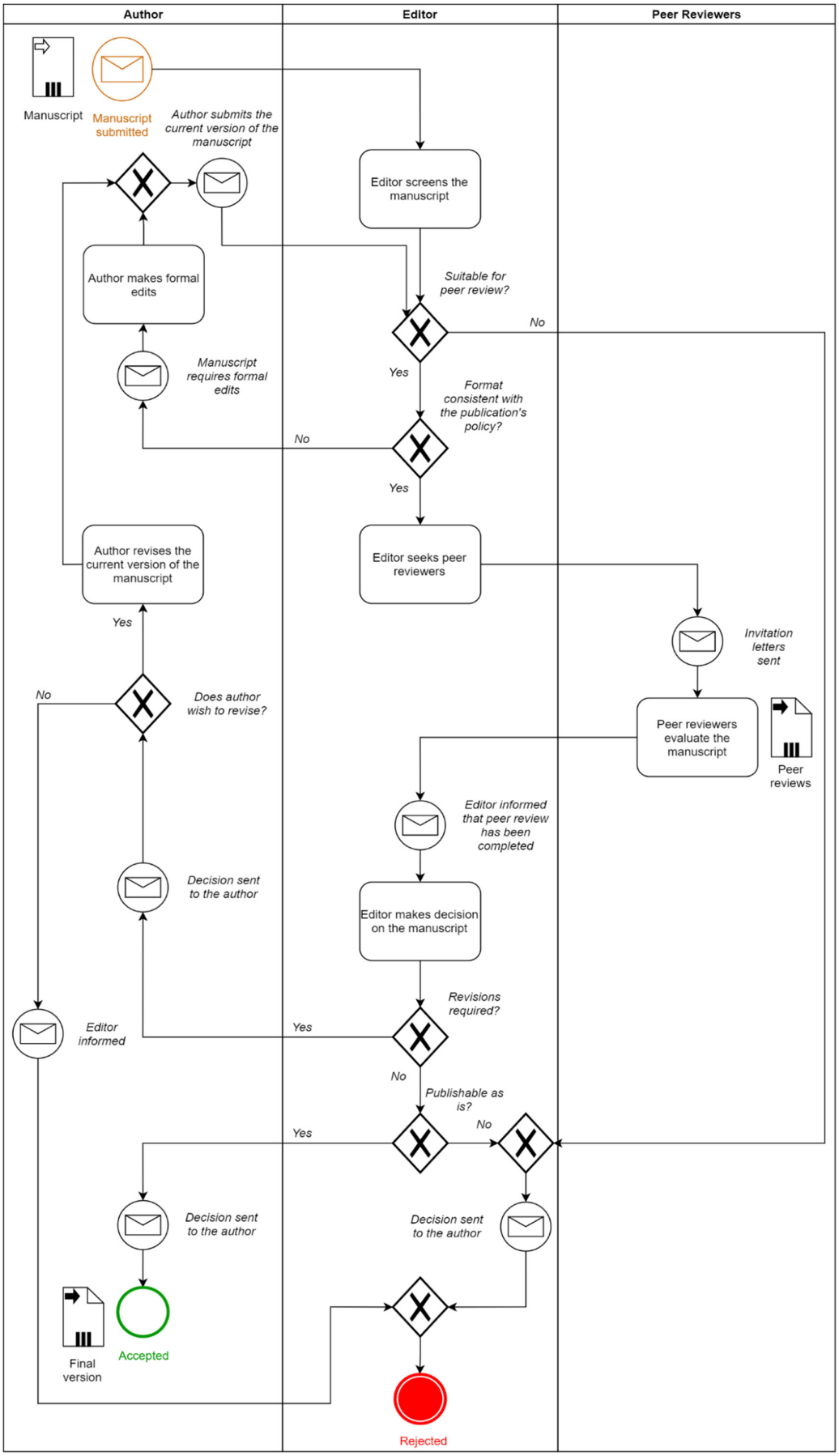

FIGURE 1 | Model 1—conventional editorial workflow.

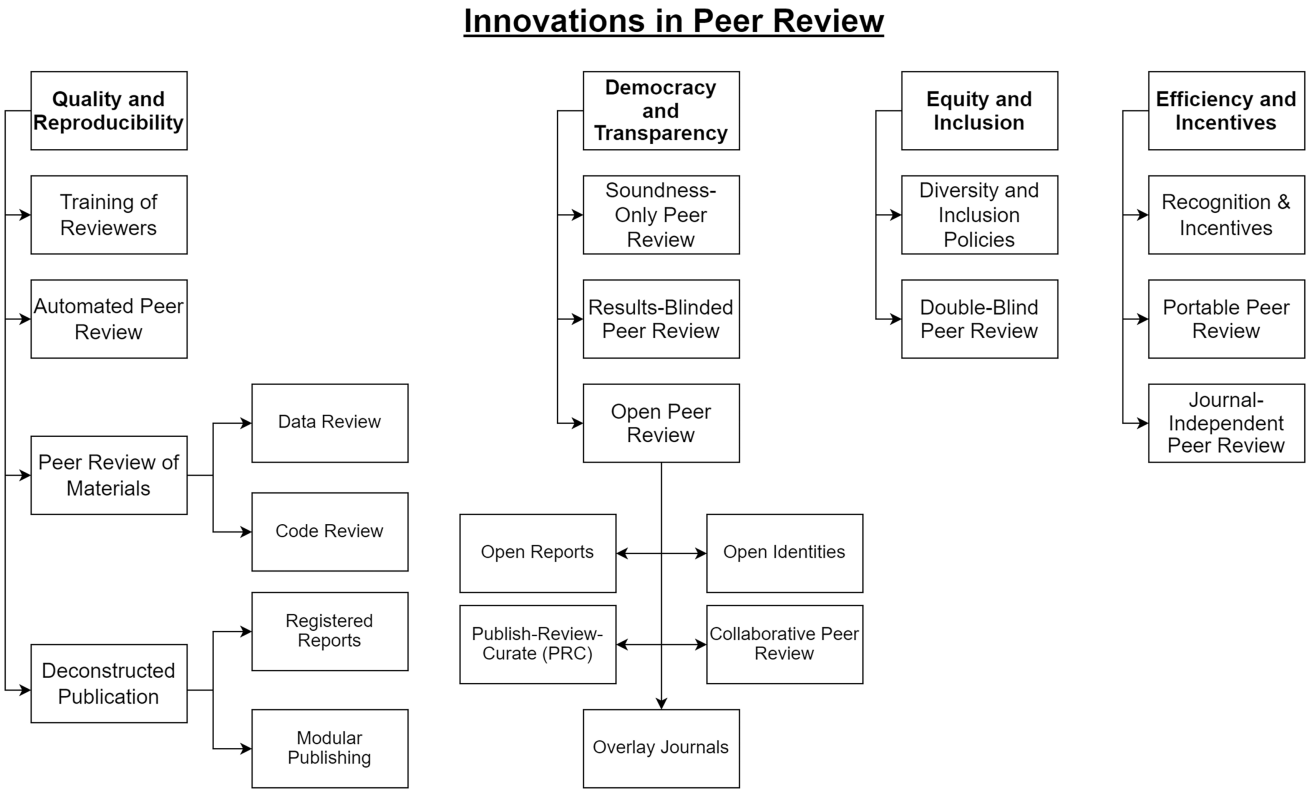

FIGURE 2 | Taxonomy of innovations in peer review.

and statistically inconclusive effects on reviewers' performance (Galipeau et al. 2015).

Software leveraging artificial intelligence (AI) for *automated evaluation of scientific papers* emerged in the 2010s,[6] exemplified by tools such as StatReviewer[7] and UNSILO.[8] This category also includes *statcheck*,[9] designed to verify statistical analysis. At that time, such tools were treated as supplementary aids incapable of replacing human expertise (Baker 2015; Heaven 2018).

The emergence of Large Language Models (LLMs) in the 2020s has partially reshaped scholarly practices. LLMs are most effective in augmentation roles, such as drafting reviews, summarising sections, or identifying methodological inconsistencies, but require human validation for accuracy and context (Díaz et al. 2024; Khraisha et al. 2024).

However, LLMs present significant risks if used beyond augmentation. Díaz et al. (2024) argue that LLMs lack critical analysis and struggle with high-level reasoning, making them unsuitable for standalone evaluations. LLMs risk amplifying biases, breaching confidentiality and producing non-reproducible feedback due to opaque training data and evolving outputs (Hosseini and Horbach 2023). Over-reliance on LLMs may undermine epistemic norms, such as universalism, by perpetuating status-quo biases in scholarly evaluation (Hosseini and Horbach 2023), whereas also posing a significant risk of manipulation bias (Ye et al. 2024).

Despite ethical and methodological challenges, the integration of LLMs into peer review processes is likely to expand significantly in the coming years. However, transparency is critical: reviewers and editors must disclose LLM use and assume responsibility for outputs' accuracy and tone (Hosseini and Horbach 2023). Thus, academic consensus is that LLMs cannot replicate human judgement in critical analysis, bias mitigation, or epistemic community-building. Current evidence advocates for cautious, transparent integration of LLMs as assistive tools, with human oversight remaining indispensable.

The growing reliance on data in scientific research has prompted publishers to formalise the review of datasets (e.g., PLOS (A Reviewer's Quick Guide to Assessing Open Datasets n.d.)). Similar scrutiny is increasingly applied to code used in research[10] to ensure transparency and reproducibility. While emerging initiatives in peer review promote quality control through explicit reviews of source code and datasets (Kaltenbrunner et al. 2022) empirical studies assessing the effectiveness of such initiatives are nearly absent.

Within the Quality and Reproducibility School, *deconstructed publication*, which is a type of scholarly publishing where the research is communicated in separate stages, rather than as a single, traditional journal article (Johnson 2024), represents a distinct group of models. This approach is sometimes termed fragmented publishing that involves disseminating a single study in multiple publications (Frandsen et al. 2019), enabling uniformity, reliability, and integrity in scholarly output when a single study is disseminated across multiple formats or iteratively updated over time (Challenger et al. 2000). Originally conceived to mitigate ethical concerns such as data manipulation, deconstructed publication encompasses two specific forms relevant to this discussion, registered reports and modular publishing. While deconstructed publication innovates general publishing

workflows rather than peer review itself, deconstructed publication models may substantially influence peer review practices.

Registered reports (RRs) exemplify a hypothesis-driven empirical publication format (Registered Reports: Peer Review Before Results are Known to Align Scientific Values and Practices n.d.) (Figure 3). Researchers submit study protocols (Stage 1 manuscript) during early stages of investigation, undergoing initial peer review focused on the research question and methodology. Approval at this stage leads to provisional acceptance, after which data collection and analysis proceed. A final review stage (Stage 2 manuscript) then evaluates adherence to the preregistered protocol, ensuring methodological rigour in alignment with the approved design.

RRs have empirically proved their efficiency in mitigating publication bias. Scheel et al. (2021) compared 71 RRs with 152 standard psychology studies, finding that only 44% of RRs reported positive results for their first hypothesis, compared to 96% in standard reports. This stark difference suggests RRs reduce selective reporting and Type-I error inflation, supporting their role in enhancing research credibility. Thus, the authors argue that RRs counteract publication bias by decoupling study acceptance from results (Scheel et al. 2021). Soderberg et al. (2021) found that RRs significantly outperform traditional publications in psychology and neuroscience across multiple quality metrics, including methodology, analysis, and overall paper quality while maintaining comparable levels of novelty and creativity despite preregistration requirements.

An important advantage of RRs over other peer review models lies in their capacity to enhance research efficiency. By conducting peer review at Stage 1, researchers gain the opportunity to refine their study design or data collection protocols *before* empirical work begins. Other models of review can offer critiques such as 'the study should have been conducted differently' without actionable opportunity for improvement.[11]

However, a survey by Sarafoglou et al. (2022) revealed that while researchers acknowledge preregistration improves hypothesis formulation, experimental design and data management, they also report significant drawbacks. Among 299 researchers with preregistration experience, 73% noted increased work-related stress and 78% observed longer project durations. These practical burdens stem from the need for rigorous planning, peer review delays and adherence to predefined protocols. Additionally, researchers without preregistration experience ($n = 56$) were less likely to recommend the practice, with only 45% endorsing it, citing concerns about inefficiency and compatibility with exploratory research (Sarafoglou et al. 2022).

Critiques of RRs include their limited impact on theoretical rigour and potential stigmatisation of non-preregistered studies. Scheel et al. (2021) caution that RRs do not address weak theoretical foundations, which remain a critical issue in psychology. Sarafoglou et al. (2022) further highlight disparities in adoption across disciplines, with fields like animal research or industry collaborations perceiving preregistration as less feasible. Some respondents also noted that journals occasionally penalise deviations from preregistered plans, undermining flexibility in data analysis.

Syed (2023) examined how editors and peer reviewers engage with preregistration protocols during manuscript evaluation. Analysing 201 articles from PLOS journals with open peer review histories, results reveal minimal engagement. 43% of articles had at least one editor/reviewer mention preregistration, dropping to 14% for accessing preregistrations and 10% for comparing plans to manuscripts. At the individual editor/reviewer level ($n = 689$), engagement plummeted further: 18% mentioned preregistration, 5% accessed plans and 3% evaluated alignment with manuscripts. When reviewers assessed preregistrations, most (73%) identified undisclosed deviations (e.g., unregistered analyses, unreported preregistered methods). These findings suggest peer review rarely verifies preregistration adherence, undermining its credibility. The author argues reviewers must prioritise evaluating preregistrations, whereas authors should transparently report deviations. Without systematic scrutiny during review, preregistration risks becoming a superficial marker of transparency rather than rigour. A recent innovation, *RegCheck*,[12] aims to address this issue, employing LLMs to systematically compare preregistered research plans with published scientific papers. This tool enables researchers to efficiently assess whether completed studies align with their original protocols and identify any deviations.

A related initiative called *Lifecycle Journal*[13] has been recently launched by the Center for Open Science. This endeavour combines the benefits of deconstructed publication with the post-publication or publish-then-review model, which will be discussed in the next subsection.

A distinct form of deconstructed publication is *modular publishing* (Figure 4). Unlike preprint servers, which disseminate complete manuscripts, modular platforms publish individual research components such as hypotheses, methodologies, datasets and code. These components correspond to discrete stages of the research lifecycle, enabling iterative feedback at each stage.

Two prominent examples of this model are *ResearchEquals*[14] and *Octopus*.[15] ResearchEquals permits authors to upload 37 research modules, including 'Review' and 'Other' items. The research modules can be uploaded in any sequence. In contrast, Octopus requires seven research elements to be published in a predefined order, aligning more closely with the structure of empirical research. Thus, both platforms support open post-publication review, though they differ functionally: Octopus allows revisions to published modules, while ResearchEquals lacks versioning capabilities.

5.2 | Democracy and Transparency

While quality and reproducibility innovations address methodological rigour, another category of innovations prioritises a different concern, which is the opacity of traditional peer review. By embracing transparency mechanisms, the Democracy and Transparency school seeks to transform peer review from a private gatekeeping process into a public dialogue.

Peer review models focusing exclusively on the rigour and soundness of the research rather than its significance and relevance, as implemented by journals such as PLOS ONE and Scientific

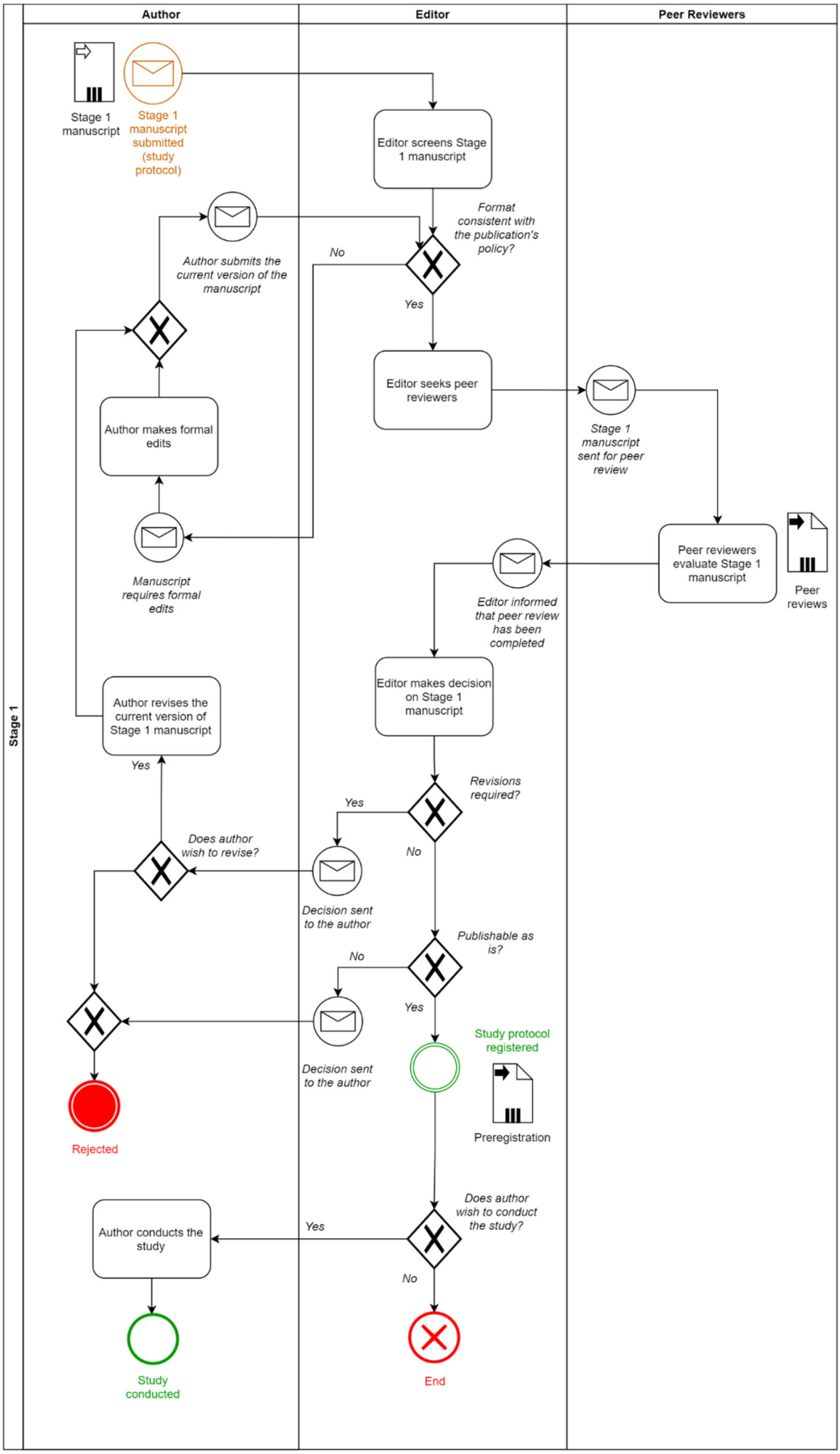

FIGURE 3 | Registered reports publication workflow (model 2).

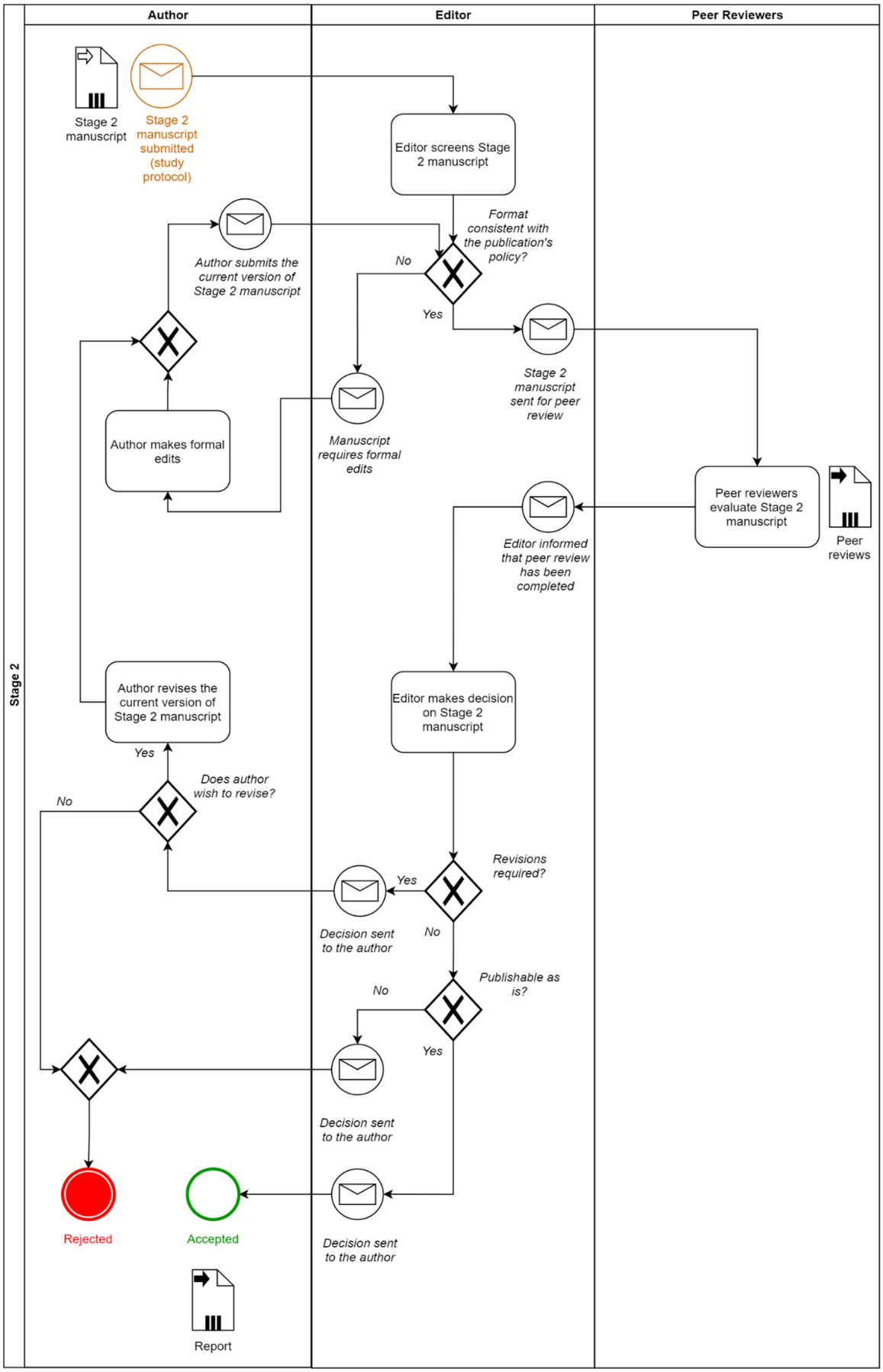

FIGURE 3 | (Continued)

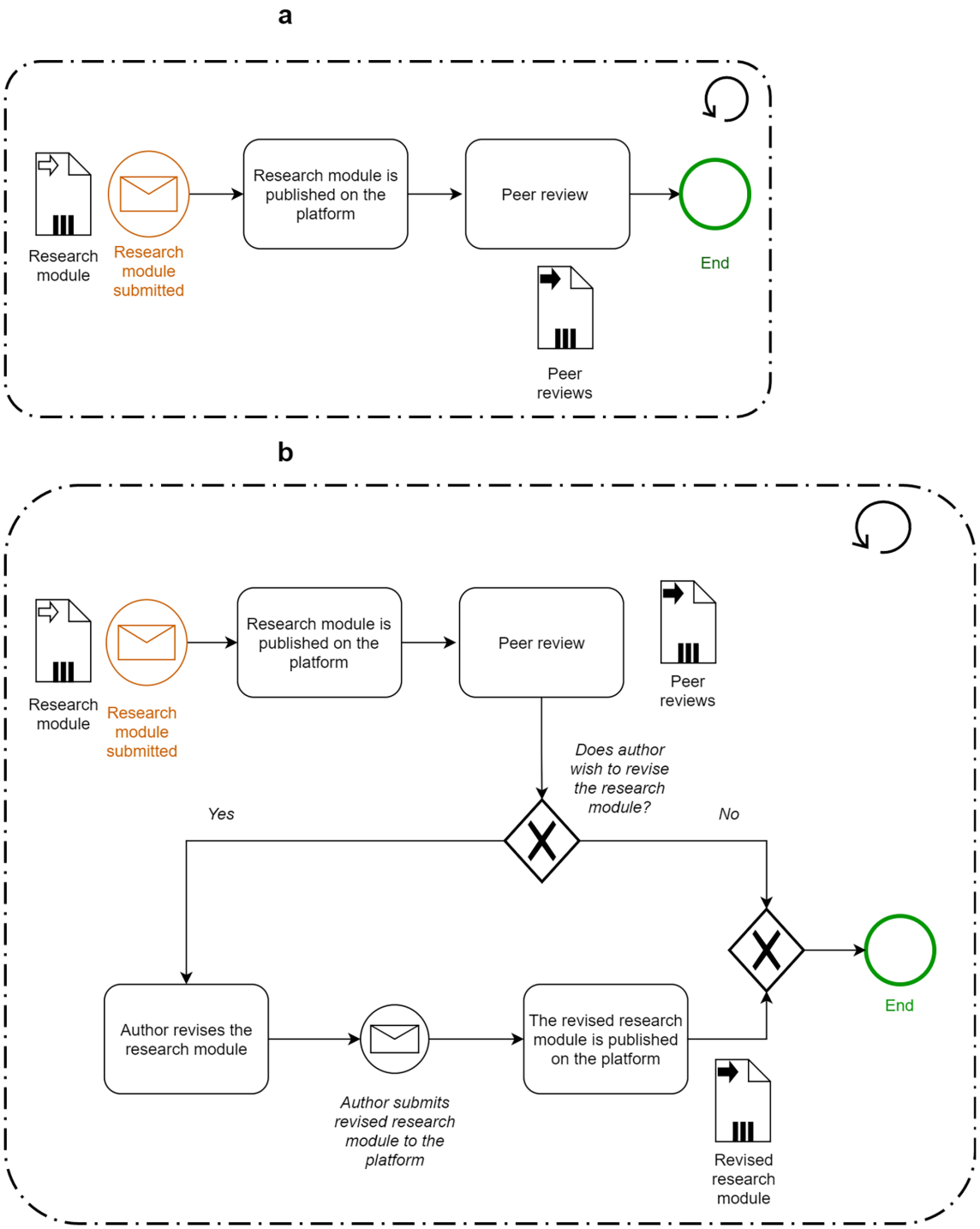

FIGURE 4 | Model 3—modular publishing. (3a) No versioning of published modules (ResearchEquals). (3b) Modules can be revised (Octopus).

Reports, share similarities with registered reports. However, it is distinguished by the single-stage evaluation process. While this model maintains the traditional editorial workflow, it shifts the focus from broader interpretative claims to the technical soundness of research. The rationale for this paradigm is the assumption that the academic community at large is better positioned to evaluate the significance and contribution of the study, rather than editors and peer reviewers alone (Spezi et al. 2017).

Results-blinded peer review is an innovative approach to manuscript evaluation that aims to reduce biases associated with traditional peer review processes. By masking the results during the initial review stages, this method encourages a focus on the quality of the research design and methodology rather than the outcomes (Grand et al. 2018; Järvinen et al. 2014; Locascio 2017; Woznyj et al. 2018). Reviewers are less likely to favour positive outcomes, leading to a more balanced representation of research findings (Grand et al. 2018; Woznyj et al. 2018). Researchers may focus more on methodological soundness and theoretical contributions, enhancing the overall quality of research (Locascio 2017; Woznyj et al. 2018).

Open Peer Review represents a broad conceptual category encompassing several distinct models of evaluation. Open Reports and Open Identities are characterised by their expansion of conventional peer review practices. While these approaches retain the core framework of pre-publication evaluation, they modify its operational parameters by introducing transparency mechanisms absent in conventional systems. Wolfram et al. (2020) identified 617 journals that published at least one article with open identities or open peer review reports as of 2019.

Open Reports facilitate the publication of review reports alongside articles, providing readers with insights into the review process. They add a layer of scrutiny, potentially improving the quality of reviews as they are subject to public examination (Fox 2021; Ross-Hellauer 2017). *Open Identities* are thought to increase accountability, motivating reviewers to provide thorough evaluations. Open Reports and Open Identities can enhance transparency in the peer review process, potentially improving the quality of research outputs by allowing for more constructive feedback and accountability among reviewers (Ross-Hellauer and Horbach 2024). At the same time, evidence suggests that female reviewers are less likely to sign their reviews, which may discourage their participation in the review (Fox 2021). Some researchers express concerns that open identities could lead to biased reviews and discourage honest feedback, particularly for junior researchers (Ross-Hellauer and Horbach 2024). A further limitation arises when manuscripts are rejected: in this case, peer review reports remain accessible solely to authors.

The *Publish-Review-Curate (PRC)* model, often referred to as preprint-based peer review,[16] is the next step towards full transparency in scholarly communication. This framework radically redefines the role of peer review. It is no longer a gatekeeping tool, but rather a platform for discussion. Publication is no longer the final stage of work; it becomes a foundation for iterative updates. Platforms such as eLife,[17] Peer Community in,[18] F1000Research[19] and MetaROR[20] exemplify the PRC model as shown in Figure 5. It is important to note that PRC's implementation varies upon the context, for example, in the case of MetaROR (eLife, Peer Community in, etc.), the manuscript is initially posted by the author on preprint servers such as arXiv, MetaArXiv, SocArXiv, bioRxiv, or OSF Preprints, whereas F1000Research operates a repository of its own.

Among the key players in PRC implementation is Copernicus Publishing, a publisher specialising in geoscience journals. For instance, journals like Atmospheric Chemistry and Physics[21] employ a two-stage publication model: manuscripts are initially released as non-peer-reviewed 'discussion papers' to solicit community input, after which revised versions undergo formal peer review.

Model 4b is sometimes referred to as *overlay journals* which are academic journals that operate by overlaying peer review and editorial processes onto preprints hosted in open access (OA) repositories (Corker et al. 2024; Rousi and Laakso 2024). Butler and Boisgontier (2025) introduced the term *'peer print'* to denote a peer-reviewed preprint, which is the output of Model 4.

Collaborative peer review is a model where multiple reviewers evaluate a manuscript together, rather than independently. Each reviewer reads the manuscript and prepares a written evaluation, similar to traditional peer review. However, the key difference is that reviewers share their evaluations and engage in discussions to reach a consensus on the review (An et al. 2023). It is a decentralised process that enhances the quality of manuscript evaluations through independent assessments, group discussions, and consensus building, ultimately benefiting both the reviewers and the scientific community. PREreview[22] exemplifies collaborative decentralised peer review through its Live Reviews, enabling open real-time discussion of preprints.

5.3 | Equity and Inclusion

The previous two schools focus on improving rigour and transparency within peer review itself. However, innovations in Equity and Inclusion attend to broader societal concerns.

The principles of equity and inclusion, as well as the *inappropriateness of biases* of different origins (geographic, gender, ethnicity), are reflected in numerous recommendations (COPE 2021; Royal Society of Chemistry 2020) and policies of most major academic publishers. Unfortunately, the results of implementing these policies are still far from successful, and perhaps these processes require more time.

Some studies suggest gender bias exists in the peer review process. Analysing reviewer feedback from the American Political Science Review between 2007 and 2020, König and Ropers (2022) found that male reviewers were more likely to give favourable evaluations to male-authored manuscripts, whereas female reviewers showed similar bias towards female-authored submissions. Manuscripts reviewed by both male and female reviewers exhibited less gender bias, with similar evaluation standards across author genders. Murray et al. (2018) found that manuscripts with male last authors had a 7% higher acceptance rate compared to those with female last authors when reviewed by all-male teams, whereas mixed-gender reviewer teams showed smaller, non-significant differences. Logistic regression analyses confirmed these disparities persisted even after controlling for institutional prestige, submission year, and other variables.

Meanwhile, empirical studies reveal controversial outcomes. Based on a large-scale analysis of 145 scholarly journals involving approximately 1.7 million authors and 740,000 referees, Squazzoni et al. (2020) found no systematic evidence of gender bias against women in peer review processes. Manuscripts authored or co-authored by women were generally treated as favourably or slightly more favourably than those by men, particularly in biomedicine and health sciences. However, social sciences and humanities journals showed relatively less favourable outcomes for women. Editors exhibited gender homophily by matching authors and referees by gender, but this did not translate into systemic disadvantages for women.

Many journals have predominantly white editorial boards, which can perpetuate biases against marginalised authors (Bancroft et al. 2022). O. M. Smith et al. (2023) found that authors from Asia, non-English-speaking countries, and low-Human Development Index countries faced worse review outcomes. The authors partially attributed these disparities to

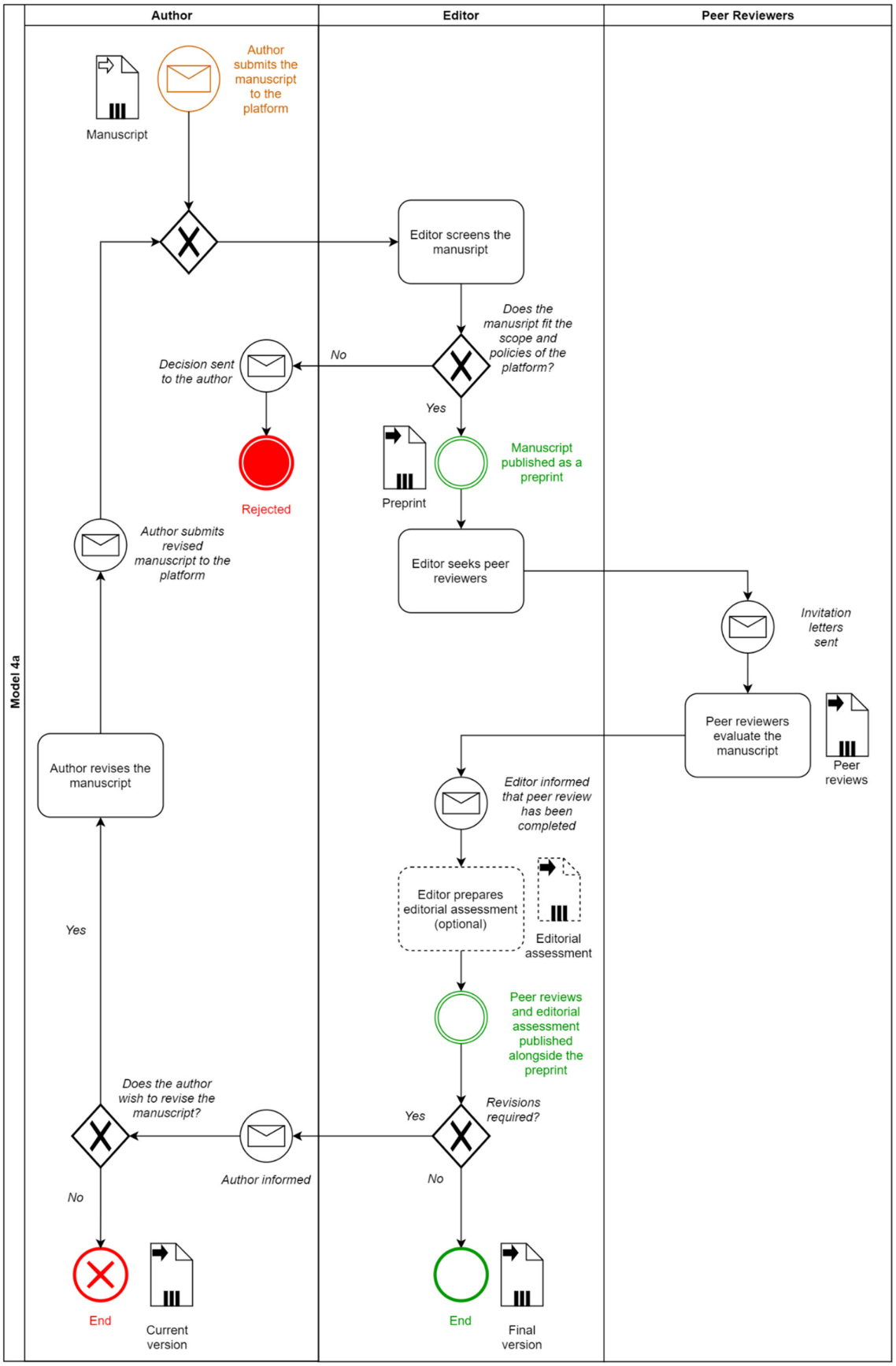

FIGURE 5 | Model 4—publish-review-curate model. Model 4a involves uploading the manuscript directly to a platform (e.g., F1000Research). Model 4b, on the other hand, involves initially posting a preprint on a preprint server followed by peer review on a peer review platform (e.g., eLife, MetaROR, or Peer Community in).

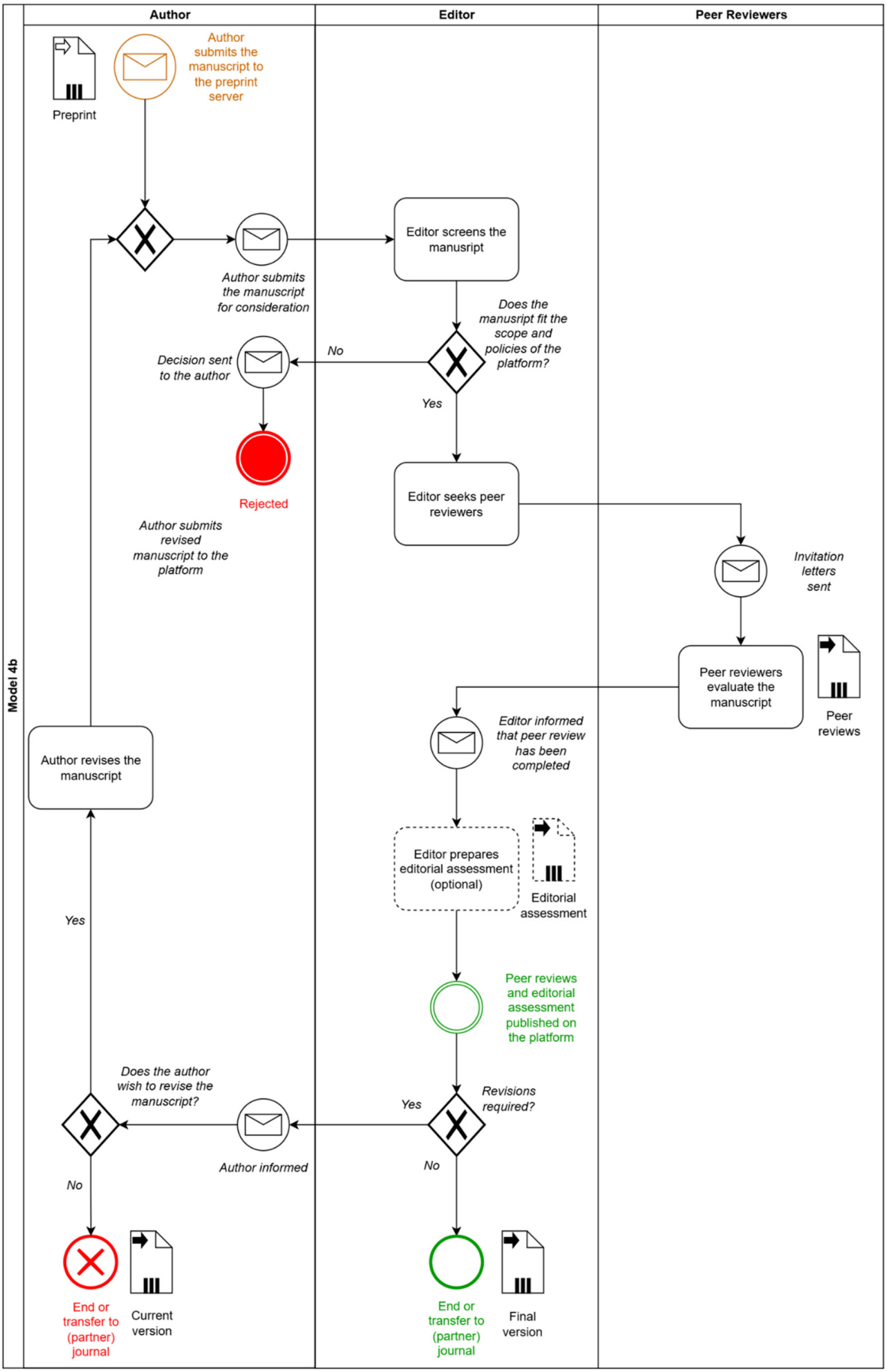

FIGURE 5 | (Continued)

the lack of diversity among editors and reviewers, who were predominantly from North America and Europe. Zumel Dumlao and Teplitskiy (2023) argued that authors from wealthier countries were more likely to be assigned same-country reviewers, who were more likely to give positive reviews.

Diverse editorial boards are often viewed as tools for mitigating biases in academic publishing. For example, a field experiment showed that racially diverse editorial boards reduced disparities in perceptions of journal fairness and willingness to submit research between race scholars and non–race scholars (Auelua-Toomey and Roberts 2022). Fox et al. (2019) found that female editors were more likely to invite female reviewers, which could encourage more submissions from female authors. Another study showed that female editors increased the share of published articles authored by women (Bransch and Kvasnicka 2022). However, there remains a notable lack of empirical evidence on the effectiveness of such policies.

Double-blind peer review is intended to protect the identity of the author and thereby prevent bias in the review. This practice has been used for quite a time in the social sciences and humanities (Horbach and Halffman 2020; Karhulahti and Backe 2021). In the Global South, this practice is quite common for natural sciences and medicine as well (Fontenelle and Sarti 2021). A study on the International Conference on Learning Representations (ICLR) found that after implementing double-blind review, scores for prestigious authors decreased, suggesting a reduction in prestige bias (Sun et al. 2022). O'Connor et al. (2017) argued that the double-blind peer review process is largely effective in minimising bias; however, perceived unblinding of authors or institutions is associated with higher manuscript acceptance rates even in double-blind peer review systems.

However, anonymity is very conditional—there are still many 'keys' left in the manuscript, by which one can determine, if not the identities of the authors, then their countries, research groups, or affiliated organisations. On the other hand, the reviewer's identity is much more securely protected. This issue is especially evident in localised communities: in Russia we often encounter deliberately positive or deliberately negative reviews (Sukharev 2020). The same is true in specialised fields where reviewers may have conflicts of interest (Rühli et al. 2009).

5.4 | Efficiency and Incentives

Finally, the fourth school of thought addresses more practical problems: the current system wastes enormous resources while peer review lacks proper recognition.

Current academic publishing disproportionately benefits publishers, as reviewers mainly work unpaid—a form of 'academic exploitation' funded largely from public funds. This is the viewpoint I adhere to; however, I must acknowledge that it is debatable. An idealistic view on peer review is an integral part of academic service, fostering a sense of community and collaboration among researchers. Peer reviewers typically hold positions at academic or research institutions, where they receive a salary for their primary responsibilities, which may include research, teaching and administrative duties. The salary from these institutions does not specifically compensate them for peer reviewing, as this task is often considered part of their professional duties (Bellini 2007). Some journals and publishers have begun to explore direct compensation models for peer reviewers, recognising the time and expertise required for thorough reviews. At the same time, financial incentives may encourage hasty reviews, resulting in lower quality assessments, as reviewers might prioritise speed over thoroughness to maximise earnings (Garg 2015).

However, any work requires not only internal motives, but also *external incentives*. Peer review, a cornerstone of scientific publishing, *requires appropriate recognition*. Current recognition mechanisms include certificates of recognition from academic publishers, as well as records integrated into researchers' profiles on platforms such as Web of Science, ORCID, etc. However, peer review activities remain largely unaccounted for in institutional and national systems of research evaluation, reward and recognition. I should note that open review increases the visibility of reviewers' work, facilitating recognition through the disclosure of their identities and published comments (da Silveira and Abadal 2024).

As mentioned above, traditional peer review faces inefficiencies. This issue arises when an article rejected in one journal is resubmitted to another, where peer review restarts from scratch. One way to solve this problem would be to transfer reviews between journals, also known as 'portable peer review.' At the moment, this model is mainly used by large publishing houses (manuscript transfer to another journal of the same publishing house). There are also consortia of journals, such as the Neuroscience Peer Review Consortium (Saper et al. 2009), as well as the Manuscript Exchange Common Approach (MECA), an initiative that supports the exchange of manuscripts and reviews between journals and platforms, including preprint servers (NISO RP-30-2023, Manuscript Exchange Common Approach (MECA) (Version 2.0.1) 2023). Although review exchange reduces peer review costs, it does not significantly change the editorial workflow; thus, it is simply an add-on to Model 1 (conventional model).

The idea of exchanging reviews has evolved into *journal-independent peer review*. Review Commons,[23] a consortium of 23 life sciences journals, brought this idea into practice. A manuscript is first published on a preprint server and undergoes independent review, after which the author can revise the paper and submit it to one of the consortium members. In my opinion, improving the quality of peer review is achieved by ensuring that reviewers focus on the manuscript itself, rather than the question of whether it fits a particular journal. Focus on a journal's scope, prestige, or specific thresholds can lead to biases, such as undervaluing methodologically sound but niche studies or overemphasising flashy but superficial results. Journal-independent peer review fits into the workflow of Model 3 (Publish-Review-Curate), where manuscripts are first published and then reviewed. The two models share conceptual similarities, including a focus on transparency, community-driven curation and flexibility.

6 | Comparative Analysis of Peer Review Models

In the previous sections, I briefly examined the evolution of the peer review and its current crisis in relation to scholarly

TABLE 2 | Comparative analysis of the four review models in terms of editorial workflow.

Comparison options	Model 1	Model 2	Model 3	Model 4
Content available to the reader	– Final version – Peer reviews (optional) – Preprint (optional)	– Preregistration (study design) – Final version of the manuscript on the platform – Peer reviews (optional) – Preprint (optional)	– Research modules – Peer reviews	– Preprint (multiple versions) – Peer reviews – Editorial assessment (optional) – Final version in traditional journal (optional)
Editor's role	– Organisation and oversight of peer review process – Making publication decisions	– Organisation and oversight of peer review process – Making publication decisions (limited)	None	Curation: evaluation of scientific work, organisation and oversight of peer review process (without making publication decisions)
What does peer review entail?	Manuscript evaluation in order to identify its strengths and weaknesses, help authors improve their work, and finally make an acceptance decision (1 stage)	Stage 1: evaluation of the strengths and weaknesses of the study design, its rigour, and making final acceptance decision Stage 2: evaluation of the conducted study in accordance with the preregistered design and making final acceptance decision (2 stages)	Option 1: peer review with an opportunity to revise the research module. Option 2: peer review with an opportunity to update within the next stage of research process (manuscript preparation).	Manuscript evaluation aimed at identifying its strengths and weaknesses. Some PRC initiatives also make decisions on inclusion into curated collections (Peer Community In, F1000 Research).
Object of review	Manuscript as a whole (methodology, relevance, novelty, soundness, etc.), sometimes only the soundness	Manuscript in terms of study design and execution	Research module	Manuscript as a whole (methodology, relevance, novelty, results, etc.)
Types of research	Any	Empirical studies, systematic reviews.	Better fits empirical studies	Any

TABLE 3 | Comparative analysis of the four models of review in terms of functions of scholarly communication.

Functions of scholarly communication	Model 1	Model 2	Model 3	Model 4
Registration	Journals register contributions through publication, but delays in peer review can delay the registration.	Preregistration ensures early registration of methodology but not results.	Research modules are published stage-by stage, registering contributions at each stage	Preprints are published instantly, ensuring early registration of contributions[a]
Awareness/dissemination	Relies on journal reputation and access.	Preregistration provide early access to study design. However, dissemination in other aspects follows Model 1 and Model 4.	Modules are distributed independently, increasing accessibility of research components, but the overall message may be lost.	Preprint servers and open peer review platforms (eLife, F1000Research, MetaROR) provide instant access to a wide audience.
Certification/quality control	Editors and peer reviewers ensure quality. At the same time, traditional peer review is often non-transparent, which can mask bias and poor quality of review.	Two-stage peer review mitigates publication bias but is more time-consuming.	Modular publishing focuses on details.	PRC model increases transparency.
Archiving	Journals, publishers' websites, and electronic libraries normally guarantee long-term storage, but access depends on the publisher's policy.	Similar to Model 1, but with two stages of publishing (preregistration and report).	Modules are stored on specialised platforms (ResearchEqual, Octopus).	Preprints are archived in open repositories (arXiv, bioRxiv, etc.).

[a]Preprint is optional for Models 1 and 2.

communication. Next, I explored the main innovations in peer review, which can be classified according to the course of proposed changes (e.g., towards greater transparency, reproducibility, or efficiency). Synthesising these developments, it becomes possible to distinguish four overarching models of peer review based on their reconfiguration of scholarly communication workflows:

- Model 1: conventional model (pre-publication peer review—gatekeeping),
- Model 2: registered reports (two-stage evaluation),
- Model 3: modular publishing (granular, iterative review),
- Model 4: Publish-review-curate (PRC model—post-publication curation).

Table 2 illustrates how Models 1–4 constitute the scholarly communication process.

Model 1 emphasises editorial control but lacks transparency, whereas Model 4 prioritises open, community-driven curation over gatekeeping. Models 2 and 3 offer structured, iterative evaluation but vary in flexibility, with Model 2[24] focusing on methodological rigour and Model 3 enabling iterative, module-based dissemination. Now, I can compare the four models across the main functions of scholarly communication (Table 3).

These comparative analyses remain deliberately neutral across models; however, subsequent conclusions assess their implications for the future of scholarly communication in light of transparency and inclusivity concerns outlined in Section 4.

Conventional Model 1 provides content filtering but lags behind in the speed of dissemination and transparency. Model 2 (Registered Reports) overcomes some of the shortcomings of Model 1 by focusing on methodology but is not suitable for all types of studies. Model 3 (Modular Publishing) is promising for open science, but very new.[25] Thus, the number of adoption cases is still very limited, and therefore we don't know much yet about its strengths and weaknesses. So far, it seems that the potential of Model 3 has not been fully realised yet.

Model 4 (PRC) generally corresponds to the vision of the International Science Council (ISC) on 'more efficient and effective modes of peer review that are inspired by open norms' (International Science Council 2023, 12). However, quality control through open preprint peer review is the most transparent peer review model, but it is more time-consuming for the reader than traditional pre-publication peer review. I would argue that AI is already transforming the reading workflow by changing the very essence of the 'reading' function (see Bergstrom and Ruediger 2024). I believe that AI could similarly be used to summarise the strengths and weaknesses of the papers based on open reviews, thereby not only supporting open reports, but also making Model 4 more reader-friendly. Many PRC advocates are motivated by their frustration with the conventional publishing system, and this frustration often outweighs a clear vision of the future (Hyde 2025). This partly explains the diversity of PRC models used and the divergence in assessments of future trajectories.

Models 3 and 4, partly Model 2, raise concerns for the financial sustainability of such initiatives, because most of them are NPOs and exist at the expense of grants (subject to future research). Long-term preservation, as well as versioning and peer review of preprints, require infrastructure. However, the notion that the conventional model has superior financial sustainability metrics is misguided, as evidenced by journals that have disappeared in the past and continue to disappear now. In fact, financial instability threatens all scholarly communication models and functions—see, for instance, Jamali et al. (2022). While many online-only open-access journals lack robust preservation plans, journals affiliated with large commercial publishers or utilising dedicated preservation services, such as the Public Knowledge Project, offer stronger guarantees against vanishing (Brainard 2020).

It should be also noted that peer review innovations pull in opposing directions, with some aiming to increase efficiency and reduce costs, whereas others aim to promote rigour and increase costs (Kaltenbrunner et al. 2022). Ultimately, I must acknowledge that no 'ideal' peer review model exists. The selection of a model, as well as the prioritisation of specific scholarly communication functions, depends on the context. For this reason, a forward-looking publication platform should enable flexibility in choosing between diverse models and frameworks, which is a topic requiring further research. I must also emphasise that many innovations in peer review have existed for too short a period to allow empirical assessment of their effectiveness. To date, such evaluations have been conducted only for training of peer reviewers, RRs, open reports and open identities, as discussed in Section 5. Another interesting point of discussion is the relationship between the genre of an article and the peer-review model used. This topic is also worthy of future research.

7 | Conclusion

The comparative analysis of four peer review models reveals that no single approach universally addresses the multi-faceted challenges of scholarly communication. Instead, the optimal model depends on disciplinary priorities, institutional resources and epistemic goals. For instance:

- If methodological rigour and reproducibility are at stake, choose Model 2 (registered reports).
- If rapid dissemination and community-driven evaluation are critical, choose Model 4 (PRC).
- If incremental, iterative research workflows dominate prevail, choose Model 3 (modular publishing).

Innovations in peer review can be easily combined. For example, portable peer review can be easily integrated with open reports/identities. Registered reports/modular publishing are interoperable with the PRC model. However, I expect *future research* to provide empirical evidence on peer review innovations' long-term impact on equity, reproducibility and epistemic diversity.

My *personal perspective* is that the conventional publication model with a 'black box' peer review inside is increasingly proving its inadequacy. I *personally support* Model 4

(Publish-Review-Curate) as a peer review innovation that fits the majority of the disciplines and types of studies. At the same time, I must recognise the complexity of change in academic publishing. Academic traditions are deeply entrenched, and transforming these practices will require sustained effort over time.

PRC model is a return to the roots of scholarly communication. This model will allow all actors involved to take greater responsibility for their work: authors for their articles, reviewers for their assessments, and editors for supporting the process of scholarly communication. This is the atmosphere of scientific discussion that we need very much.

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Dmitry Kochetkov: investigation, visualization, writing – original draft.

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Conflicts of Interest

The author is affiliated with the Centre for Science and Technology Studies at Leiden University, which is involved in the development of the MetaROR platform.

Data Availability Statement

Data sharing is not applicable to this article as no new data was created in this study.

Endnotes

[1] Peer feedback received during discussions of this research's preprint (for further details, please, refer to (Kochetkov 2024)).

[2] For example, an open science experiment during the recent Science, Technology and Innovation Indicators (STI2023) conference (Waltman, Mulati, et al. 2023).

[3] Draw.io. URL: https://www.drawio.com/ (date of access: 18.03.2025).

[4] It is important to acknowledge that this phenomenon exhibits significant disciplinary variation. In some disciplines, critical observers on the contrary raised concerns that journals tend to give incentives for inflated claims prioritising the publication of novel positive results (Nosek et al. 2012). This pressure forces authors to emphasise scientific novelty at the expense of reproducibility. For instance, this tendency is exemplified by the long-standing debates in psychology (Open Science Collaboration 2015).

[5] For example, Certified Peer Reviewer Course by Elsevier. URL: https://researcheracademy.elsevier.com/navigating-peer-review/certified-peer-reviewer-course (date of access: 22.01.2024).

[6] At the same time, plagiarism detection systems have existed much longer, for example, 'Antiplagiat,' a well-known system in Russia, originated in 2005.

[7] StatReviewer. URL: http://statreviewer.com/ (date of access: 22.01.2024).

[8] UNSILO. URL: https://site.unsilo.com/site/ (date of access: 22.01.2024).

[9] Statcheck. URL: https://michelenuijten.shinyapps.io/statcheck-web/ (date of access: 22.01.2024), also R package.

[10] Among recent initiatives, I can mention CODECHECK. URL: https://codecheck.org.uk/process/ (date of access: 22.01.2024).

[11] The author gratefully acknowledges reviewer Balazs Aczel for this valuable addition to the study.

[12] RegCheck. URL: https://regcheck.app/ (date of access: 02.04.2025).

[13] Lifecycle Journal. URL: https://lifecyclejournal.org/ (date of access: 02.04.2025).

[14] ResearchEquals. URL: https://www.researchequals.com/ (date of access: 28.02.2024).

[15] Octopus. URL: https://www.octopus.ac/ (date of access: 28.02.2024).

[16] The Publish-Review-Curate (PRC) model is occasionally referred to as post-publication peer review or open peer review. However, this terminological ambiguity risks conceptual misalignment: the former term overlaps semantically with processes like publication commentary or book reviews, while the latter conflates PRC with Open Reports and Open Identities addressed earlier.

[17] eLife. URL: https://elifesciences.org/ (date of access: 22.01.2024).

[18] Peer Community in. URL: https://peercommunityin.org/ (date of access: 22.01.2024).

[19] F1000Research. URL: https://f1000research.com/ (date of access: 22.01.2024).

[20] MetaROR. URL: https://cms.metaror.org/ (date of access: 14.04.2025).

[21] Atmospheric Chemistry and Physics. URL: https://www.atmospheric-chemistry-and-physics.net/peer_review/interactive_review_process.html (date of access: 06.05.2025).

[22] PREreview. https://prereview.org/ (date of access: 22.01.2024).

[23] Review Commons. URL: https://www.reviewcommons.org/ (date of access: 22.01.2024).

[24] There is a point of view that registered reports work best for empirical studies that are of a confirmatory nature and work less well for exploratory studies. Researchers cannot necessarily anticipate all of the aspects of the data collection and analysis in the latter type of study (Arpinon and Espinosa 2023).

[25] My concern is that insufficient consideration of broader system interactions could lead to undetected systematic errors. Current evidence remains limited, however, and this model requires further empirical investigation.

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