The Miracle of Peer Review and Cooperation in Science

An Agent-Based Model

Simone Righi [2] **Karoly Takacs** [1]

[1]Lendulet RECENS and ERC-N.648693, Hungarian Academy of Sciences

[2]University of Bologna

Peer review

- Peer review is the fundamental process used by the scientific community to select and to ensure the quality of academic publications
- Scientists regularly **contribute high-quality reviews**, while only **authorship** is credited for academic career.
- Why do researchers provide impartial reviews and constructive advice voluntarily?

Peer review and Social dilemmas

- We build an Agent-Based Model to study researchers decisions to choose the level of effort in reviews and in manuscript production.
- The puzzle concerned is described as a double social dilemma game.
- Evolutionary approach, where self interested researcher/reviewers decide upon the quality of their contributions. Successful strategies tend to diffuse in the population

The model: authors/reviewers

N scientists writing single-author papers. Scientists as both reviewers and authors.

- Low / high **effort for review** (high effort is costly)
- Low / high **effort for manuscript** = quality (high effort is costly)
- Publication yield a **payoff** that out-weight even the high effort cost
- A high-effort review can properly judge the value of the submission
- Scientists accumulate public and editorial **reputations**
- **Single** or **double** blind review
  - With single blind →Reviewers can condition effort on reputation of author

Scientist strategies:

- **Manuscripts**: d / c = low / high effort
- **Reviews**: D / C / Rep = low / high effort / Depending on reputation of Author.

The model: Journal editor

- A **single journal** with a single editor, who is not an author or a reviewer in the journal.
- **Selects** $\mu = 2$ **reviewers** for each paper chosen uniformly at random (results similar with reviewer selection based on reputation)
- with an upper limit of reviews for each reviewer $k = 4$. Reviewers always accept.
- Information setup:
  - Editor cannot assess quality of reviews and of manuscript.
  - Quality of published papers is revealed, quality of un-published papers remains unknown.

The model: Reputation

Individual agent editorial reputation:

$$REP_i^E = \#GP - \#Rej - \alpha \cdot \#BP + \gamma \cdot (\#GR - \#BR) \quad (1)$$

- $\#GP$: # of published high quality (good) papers
- $\#BP$ # of published low quality (bad) papers.
- $\#Rej = \#BN + \#GN$: # of rejected papers (good or bad).
- $\#GR$: # of high quality (good) reviews.
- $\#GR$ # of high quality (bad) reviews.
- $\alpha > 1$: **relative detrimental effect** for the journal reputation **of accepting a low quality paper** (set to 2).
- $\gamma << 1$: **relative weight** of the agent's behaviour **as referee** compared to the one as author (set to to 0.10)

Given that high effort is costly authors preference are:
$BP > GP > BN > GN$

Editorial Policy

- Fixed (does not evolve) $\rightarrow$ Comparative analysis.
- If reviewers agree the editor follow their advice.
- In case of *disagreement*:
  - **AP**: Reject the paper
  - **1P**: Accept the paper
  - **ER**: Follow the advice of one of the referees chosen at random probability proportional to the relative Editorial Reputations of the referees;
  - **MR**: Follow the advice of the Most Reputed referee.

Limit to the number of publications

- The number of publications is limited to a fixed proportion $\epsilon < 1$ of submissions.
- If the editorial process produces too many accepted papers:
  - all accepted contributions are ranked according to editorial reputation REP_i^E
  - the first ϵN papers are published.

Timing of the model

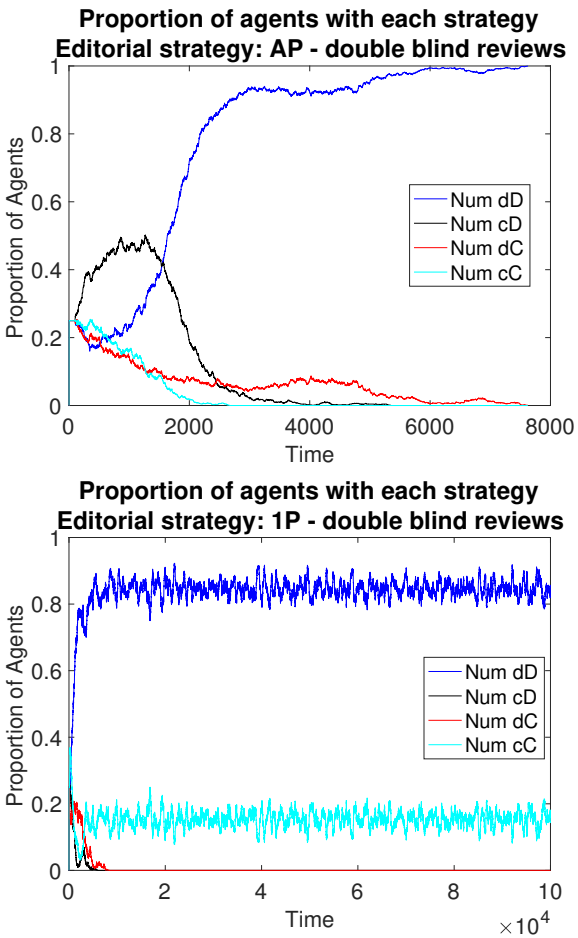
Intra step timing:

1. All authors produce a paper;
2. Editor assigns papers to reviewers;
3. Reviewers produce reviews;
4. Editor decides about publications;
5. Authors reputation is updated;
6. Their cross-sectional payoff computed according to: $V_{acc} - e(GP^t + GN^t) - E \cdot \#GR$
7. Strategies with higher returns tend to diffuse in the population (replicator dynamics).

Simulations end with convergence on a single strategy or after a (very) long period of time.

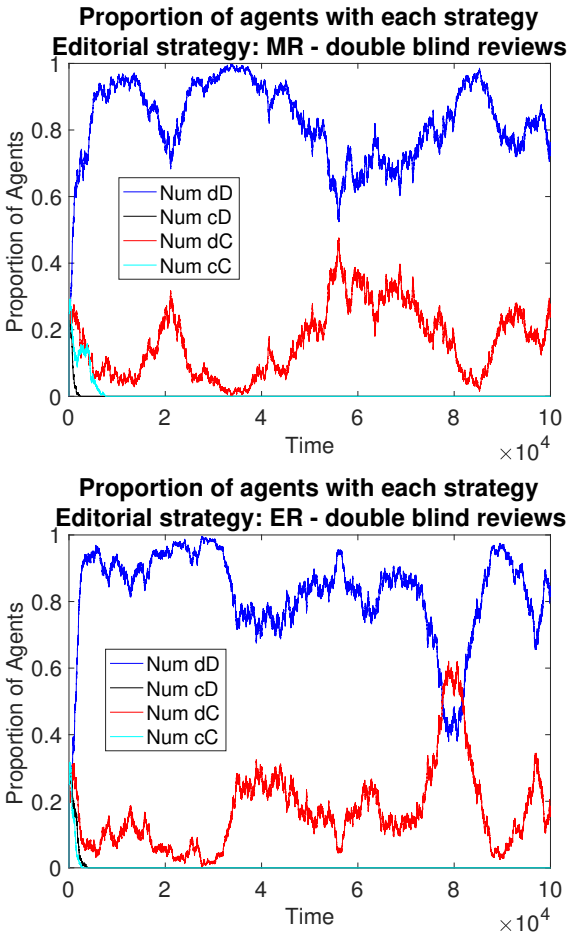
Results

Baseline: No cooperation - Double blind



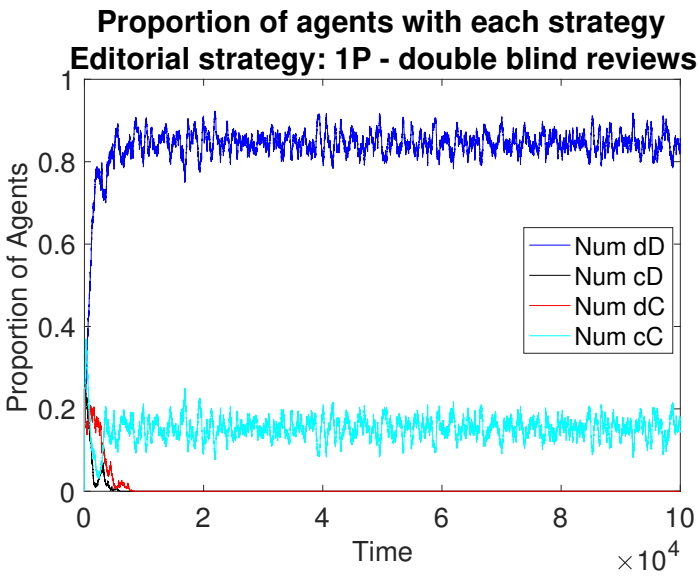
- high-quality reviews have no benefits → every reviewer is better off by choosing low effort.
- if reviews are random → 50% chance of publishing (regardless of quality) → no meaning of doing (costly) high quality papers.
- No feedback loop → science ends up as an empty exercise.

Baseline: Reputation and Editorial Strategies



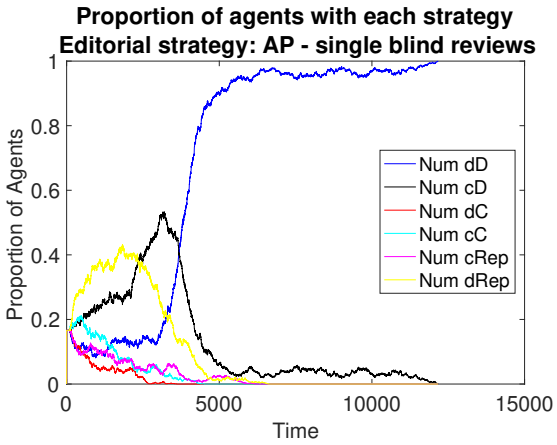
- Low effort in review is still dominant
- $\rightarrow$ a relatively bad reputation does not matter as the chances of publishing a paper become equivalent for good and bad papers over time.

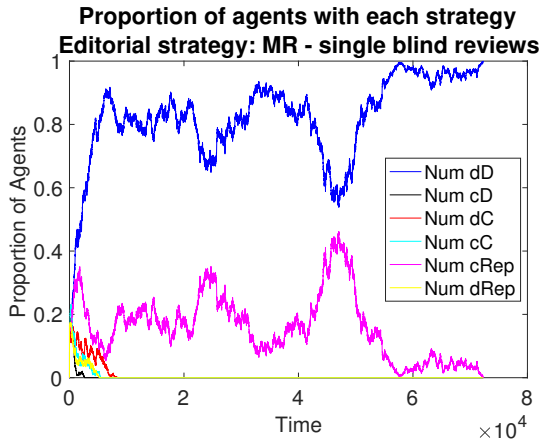
Baseline: No cooperation - Double blind

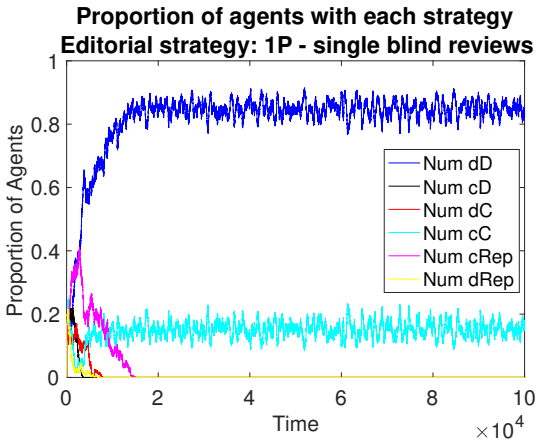


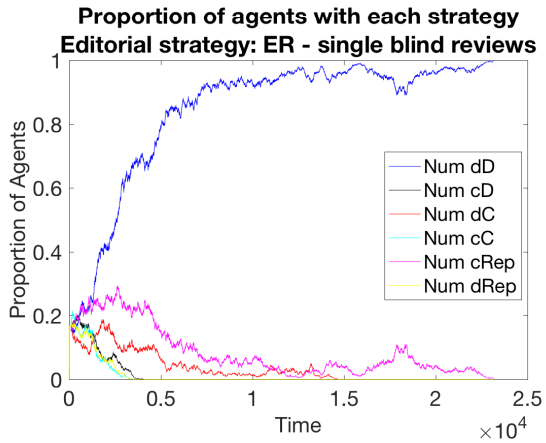
- Due to lack of cooperation of reviewers.
- with random reviews: # positive reviews $\not\Rightarrow$ higher quality.
- Under 1P **good papers** are more likely to get published.

Baseline: No cooperation - Single blind

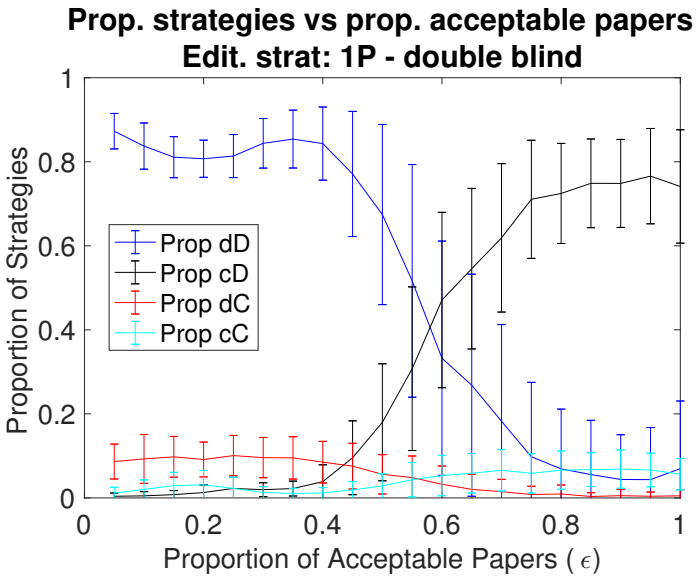








Effect of Publication rate



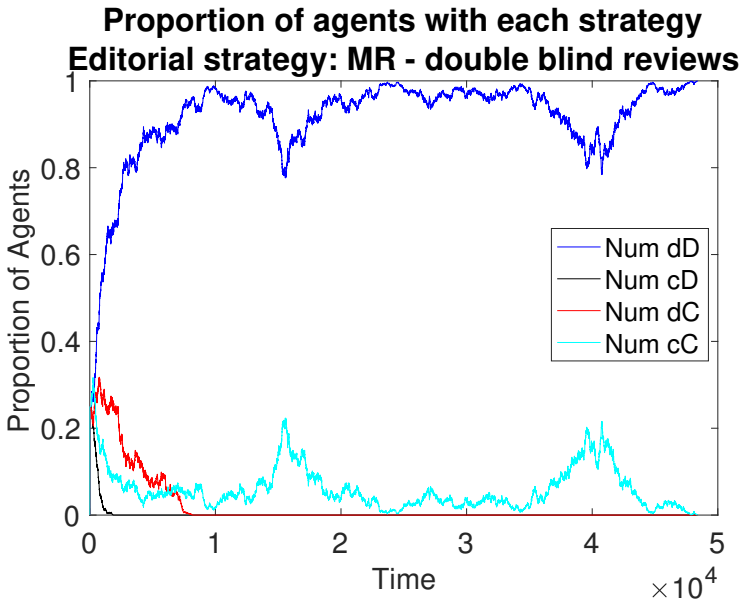
- Increasing the journal space allows for more cooperation (in 1P)
- When nearly all papers are published, the true qualities of nearly all papers are revealed.
- Bad papers written with low effort result in a loss of editorial reputation, which weighs largely for scientists' publication chances.
- "PLOS One" style of publication could lead to high quality papers.

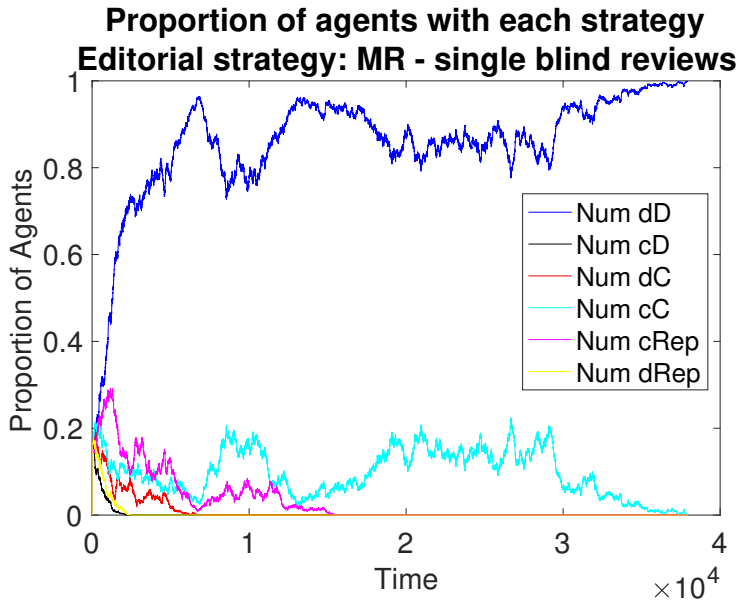
Introducing reputation bias

Editors may have bias in favour of authors with high REP_i^E and against authors with low one.
We assume that:

- authors with an editorial reputation lower than the median has a chance of **desk rejection** that is in negative linear association with their reputation.
- authors with an editorial reputation **higher than the median** has a chance of **desk acceptance** that increases linearly with their reputation
- concentrates peer review in the middle range, where no clear reputational judgment can be expected from the editor.

Introducing reputation bias: still no cooperation





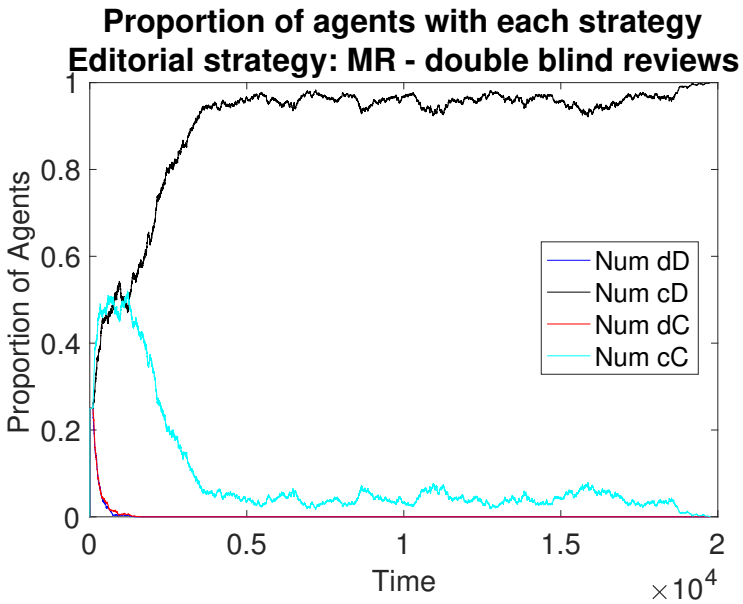
Journal Impact Factor

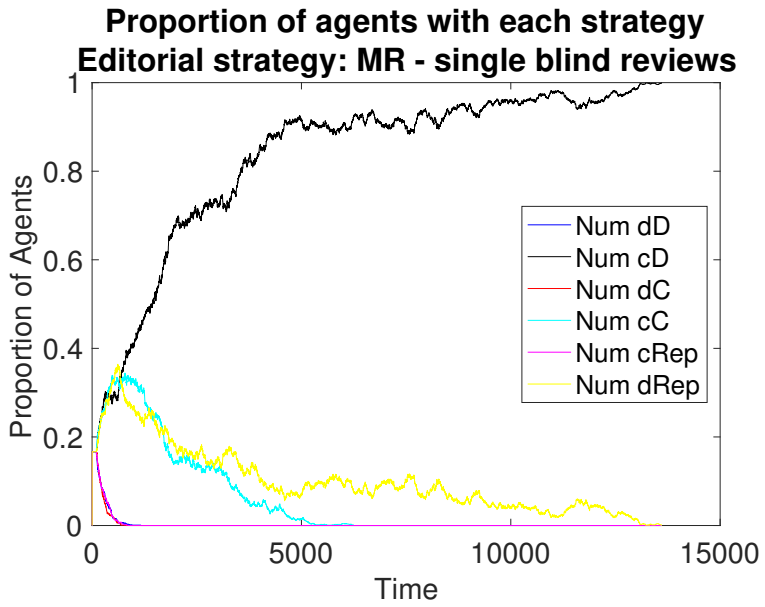
- Publishing in a reputed journal produces a payoff that depends also on the quality of past published papers (a public good).
- All agents who publish receive a bonus (added to their payoff):

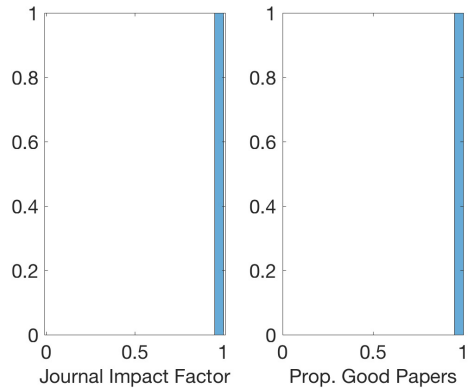
$$JIF_t = \kappa \cdot \frac{\sum_{\tau=1}^{t} \sum_{i=1}^{N} GP_i^{\tau}}{\sum_{\tau=1}^{t} \sum_{i=1}^{N} GP_i^{\tau} + \sum_{\tau=1}^{t} \sum_{i=1}^{N} BP_i^{\tau}} \qquad (2)$$

- $\kappa > 1$ defines the "technology of public good": how much reward JIF gives to published authors.
- Considering the Journal Impact Factor and $\kappa > 1$,$\rightarrow$ linear Public Good Game

JIF and cooperation







Conclusions

- Why scientists devote considerable time and effort for writing reviews that decreases their time spent on their own research?
- **baseline equilibrium**: low effort in writing papers as well as in writing reviews spread $\rightarrow$ scientific practice becomes an empty exercise.
- **More relaxed editorial policies** $\rightarrow$ better performances.
- **Pure Reputational bias** ensure some quality of manuscripts... but low quality still dominant.
- **Journal impact factor**, when enhances the individual payoff (e.g. easier to get a work, a promotion) ensures high manuscript quality.
- Current work (with Elena Vallino, Torino) extends our simple model towards studying multiple journals that compete for success with each other.

Thanks

- Righi S., Takacs K. (2017), **The Miracle of Peer Review and Development in Science: An Agent Based Model**, *Scientometrics* (10.1007/s11192-017-2244-y)
- Righi S., Takacs K., Vallino E., **Journal competition and the miracle of peer review**, *in development*.

Personal webpages:
Simone Righi:
`http://digilander.libero.it//righi_simone/`
Karoly Takacs:
`http://web.uni-corvinus.hu/~tkaroly/`