# The Social Dependence of Cognition: An Agent-Based Simulation of the Perception of Scientific Value as a Function of Impact Factor

**Davide Secchi**[1]

**Abstract.**

## 0.1 Introduction

The work on metrics for academic publishing has been growing significantly in the last decades, among enthusiasts and critics. One such measures has topped the others for use and institutionalization. This is ISI Thomson's Impact Factor (IF) and it has been widely used as a proxy to determine the quality of a selected number of journal publications.

It is not until very recently that academics started to point out the limits of this index [14]. In fact, IF falls short of what some—mostly administrators at universities and research institutions—claim are its most important advantages. IF should be able to discriminate between high and low quality journals using a formula that counts the number of citations each article in a given journal attracts in one (or five) year(s). This assumption on journal quality faces two major issues. One is that academics have repeatedly pointed out that there is no direct connection between the distribution of citations of articles published in a journal and the IF [10]. This gave rise to strong counter-actions, such as banning the use of IF among certain academic circles [2]. The problem seems to be that highly cited papers skew the distribution, hence the mean—roughly represented by the IF—does not fairly represent the average quality of papers. The second major issue relates to the logical fallacy of attributing the (alleged) characteristics of a system—i.e. a journal—to its individual components—i.e. the articles. This is the so-called *composition and division* fallacy [16]. Another fallacy that a logician might evoke is the *appeal to authority* fallacy, otherwise called *ad verecundiam*. This happens when one uses IF to point at the value of a given article due to the prestige of the journal where it has been published [16]. In another work, I connected these fallacies to point at the limits of rational decision making [5] and the argument fits the case here too.

Whether one criticizes the IF for the first or the second reason, it is undeniable that there are institutional aspects of the measure that play a role in the way academics approach it. What is the relation between the use of IF and the perception of scientific value of an article? Does it vary depending on the influences from the academic community one is part of?

This article is an attempt to assess whether cognitive processes around *perceived scientific value* (PSV) vary depending on the institutional understanding of IF that their reference group has. This is a study of how social dynamics are key to understand cognitive processing. The theoretical background to frame these questions is that of distributed [4], systemic [3], or E cognition [7] and tied to a model developed in [8, 7].

[1] University of Southern Denmark, Denmark, email: secchi.davi@sdu.dk

## 0.2 The Model

To simplify, two categories of academics can be hypothesized. Some scholars are less critical and embrace the logic behind those who propose IF and want to use it as a measurement of research quality. Hence, they push for those in their 'circle' to publish in high IF journals as much as possible. For these individuals, IF is a reflection of the inner scientific value (PSV) of an article. Instead, there are other academics that discard IF completely, hence they have a publication strategy that is not at all related to the measure. For these scientists, PSV is independent from IF and subjectively evaluated through an assessment of the article. In order to highlight the combined social impact of group membership, these two groups are defined *intelligence units* (IU), in line with a tradition started with Herbert Simon [13].

I modeled two categories of academics as agents in an agent-based simulation model (ABM) that features an organization—i.e. a research institution or a university—where the two groups share similar environmental conditions but differ in the way they regard IF and understand PSV of articles. In the real world, these two groups can be departments, research centers, or else. The choice of ABM is in line with finding a method that effectively tackles emergent properties of a system where a number of agents are diversely defined. The conditions for agents' interaction, behavior, and change are set and their adaptive dynamics shape the properties of the system [6]. The simulation was coded and implemented using NetLogo 5.2 [15].

All parameters for this simulation are specified in Table 1 and further details are in the article. In the following, we summarize some of the most relevant parameters to provide sufficient details to explain how the simulation works.

Besides being randomly allocated to these two groups—one of IF enthusiasts, IU2, and the other of IF skeptics, IU1—research of each agent's publications are evaluated 24 times in the simulation. This is a process that mimics the yearly review or appraisal processes that most institutions run their staff through. When the evaluation period comes, each agent is randomly allocated a number of up to four publications (*pub*) that are considered for assessment. Each publication is assigned an IF and this also happens randomly, so that high or low IF are allocated to articles independent of the group the agent belongs to. In this way, the wish to publish in high IF journals is not necessarily what actually happens. In addition to a value representing IF, each publication has a 'value' assigned to it that may or may not be in line with the IF—i.e. the actual quality of the article may (or may not) differ from the relative IF.

At the beginning of the procedure, each agent is assigned an attitude towards IF $a_{if}$ on a random normal distribution with mean $= 0$ and standard deviation $= 0.5$. Its affiliation to IU1 or IU2 depends on the strong or weak value of $a_{if}$. In addition to that, each agent is attributed a value that signifies the tendency towards accepting and using recommendations, information, and advice coming from other agents. Using a more technical jargon, we call this element 'human *docility*' [12, 5, 1]. As seen in Table 1, there are three distributions in which the mean assumes different values, to test how much this social orientation of agents affects PSV. This latter is distributed differently depending on agent's affiliation to IU1 or IU2. IF enthusiasts from IU2 have a higher mean for PSV because they believe that IF truly discerns higher value of a publication in relation to lower values. Hence, they perceive those low (or no) IF publications as particularly weak.

The simulation also allows for members of the same IU to be close to each other. Here 'closeness' is to be intended as a mental/cognitive state more than physical closeness. Switching 'on' or 'off' the parameter *group* enables this outcome. Agents can also change IU depending on whether their PSV becomes more aligned to the average of PSV agents of other group have. This is the parameter *change*. Also, in a way to mimic real life situations, agents can leave or join the organization however, the number with which they do is a value that, at every year/period, may take any number between 0 and the upper bound of the selected parameter (see Table 1 for details).

Finally, every agent can reach other agents using a proximity or *range* parameter, hence limit or extend its reach but never having a clear perspective of the entire organization.

## 0.3 Procedures

The procedure uses three steps. First, agents select one paper to evaluate from other agents next to them (using the value of the parameter *range*) and they conduct an assessment according to the rules of their own intelligence unit. This is based on IF for those belonging to IU2 and to perceived value for the others from IU1.

The second step of the procedure sees agents selecting another paper to assess. This would—depending on vicinity—very likely be another from their own IU. The rules for the assessment are the same as in step one, however the paper is "handed in" to the agent by another agent in something that may mimic the suggestion of a good read.

The third step introduces a socialization mechanism in that every agent passes through a process of additional assessment. At first, the agent updates its own assessment of the papers using a function of their *docility* so that those with higher $d$ values are more prone to think carefully and adjust their first evaluation towards something they believe is more congruous. The second update compares one agent's assessment with those of other agents around it. While highly docile individuals compare their assessment and update it independent on the affiliation of the other agents they are comparing it with [1]. Low docility agents would only consider updating their judgement if the recommendations come from agents affiliated with the same IU as their own.

**Table 1. Parameter Notations and Values**

| Parameter | Values | Description |
|---|---|---|
| steps | 500 | The maximum number of opportunities that agents have to interact with each other when dealing with problems. The simulation may stop earlier, if `pub_waves` reaches 24 sooner than when `steps`$= 500$. |
| runs | 25 | Number of times a simulation is performed with each given configuration of parameters. |
| publications, $pub$ | $\sim [0, 4]$ | This is a number of publications, between 0 and 4, that each agent presents every time there is an evaluation (*publication wave*, see below). It is randomly assigned. |
| publication IF, $pub_{IF}$ | $\sim [0, 5]$ | This is the IF associated with the journal where the publication is accepted, hence it is attributed to the publication. It is randomly assigned and varies between 0 and 5. |
| publication value, $pub_v$ | $\sim [0, 1]$ | The value of a scientific contribution assigned to each publication on a random basis. |
| IF attitudes, $a_{if}$ | $\sim \mathcal{N}(0, 0.5)$ | This is the attitude each agent has towards the impact factor (IF) of a journal publication. |
| docility, $d$ | $\sim \mathcal{N}(0.6, 0.2)$, $\sim \mathcal{N}(0.9, 0.2)$, $\sim \mathcal{N}(1.2, 0.2)$ | This is the docility level associated randomly to each agent in the simulation — higher values indicate higher probability to adapt to the respective IU as well as less autonomy from the respective IU. |
| perceived scientific value, $PSV$ | $\sim \mathcal{N}(1, 0.25)$ | This is the value attributed to a scientific output by an agent that is not affiliated with any IU. |
| | $\sim \mathcal{N}(1, 0.15)$ | This is the value attributed to a scientific output by an agent that is affiliated with IU1 — smaller st.dev means that values are more grouped around the mean. |
| | $\sim \mathcal{N}(1 + \alpha, 0.15)$ | This is the value attributed to a scientific output by an agent that is affiliated with IU2 — the higher mean signifies stricter criteria to assess $PSV$. |
| $PSV$ difference between IU1 and IU2, $\alpha$ | $0.25, 0.50$ | The average difference in the perceived scientific value that members of IU2 have in relation to those from IU1 — this value affects directly the mean of the random-normal distribution for IU2; st.dev. is unaffected. |
| group | [true, false] | The tendency to be socio-cognitively closer to the other members of the IU the agent is affiliated with. |
| change | [true, false] | The possibility to change IU depending on the distance of one's $PSV$ to the mean $PSV$ of either IU1 or IU2. |
| leaving, $l$ | $[0, 3, 5]$ | A random number of agents between 0 and $l$ exits the system. |
| joining, $j$ | $[0, 5, 15]$ | A random number of agents between 0 and $j$ enters the system. |
| range | $4, 8$ | This is the value used to explore the environment that surrounds each agent. |

## 0.4 Findings and Conclusions

The simulation is equivalent to a factorial design of $2^7 \times 3^3$ and, given its size, data was collected using Abacus 2.0, a supercomputer available through the Danish e-infrastructure cooperation (DeIC) to the University of Southern Denmark. Following a procedure involving power analysis [9, 11], the simulation was performed 21 times per configuration of parameter, each covering at least 24 evaluation periods (i.e. up to 500 steps).

Results show that *range* has a small impact on PSV of agents from both IU1 and IU2. The effect of the *group* is mostly visible for members of IU2—i.e. the IF enthusiasts—especially when the unit can tie relations among its members more strongly because affiliation numbers remain stable over time. In that case, there is an increase in PSV, independent of the IF of the evaluated papers. This happens when the parameter *leaving* takes the value 5, and PSV increases as the simulation runs.

When agent are left free to switch IU—i.e. *change* is 'on'—, most agents switch to IU1. Especially when there is a high turnover and relatively high *docility* levels there is a vast majority of agents affiliated with IU1 and PSV tends to decline. Instead, opposite conditions lead to radicalization and polarization of PSV, with IU1 maintaining a stable view and IU2 increasing their perceptions over time.

The simulation is an attempt to show that cognitive processes around a simple number do not depend solely on individual characteristics but are vastly dependent on institutionalization and socialization mechanisms.


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