JASSS

Marc Mölders, Robin D. Fink and Johannes Weyer (2011)

Modeling Scientists as Agents. How Scientists Cope with the Challenges of the New Public Management of Science

Journal of Artificial Societies and Social Simulation **14** (4) 6
<http://jasss.soc.surrey.ac.uk/14/4/6.html>

Received: 27-Jun-2011 Accepted: 19-Jul-2011 Published: 31-Oct-2011

Abstract

The paper at hand applies agent-based modeling and simulations (ABMS) as a tool to reconstruct and to analyze how the science system works. A Luhmannian systems perspective is combined with a model of decision making of individual actors. Additionally, changes in the socio-political context of science, such as the introduction of "new public management", are considered as factors affecting the functionality of the system as well as the decisions of individual scientists (e.g. where to publish their papers). Computer simulation helps to understand the complex interplay of developments at the macro (system) and the micro (actor) level.

Keywords:
Systems Theory, Theory of Action and Decision Making, Academic Publication System, Science System, New Public Management, Agent-Based Modeling and Simulation

Science as a societal system

1.1 Considering the production of new and reliable knowledge as the societal function of science (Luhmann 1981, 1990), many scholars dealt with the question how to assess what can be regarded as "new" or as "reliable". Not denying that these questions are fundamental for social studies of science, we will focus our attention on the production process. Accordingly we will take one step back. Before judgment can be made about how new or how reliable a manifest piece of knowledge might be, it has to enter the scientific courtroom: It has to be published.

The publication system

1.2 Publications serve as science's memory. If we do not follow a metaphorical understanding of memory as a container, but a more operational one, it is easy to see that although paper does not blush, the insights of a paper may be forgotten and fade away. They do so when they are no longer cited, when there is no one referring to them anymore—when the process of science works without them (Stichweh 2007; Mölders 2011). Publications combine past and future events for the scientific community. They document what is worth being documented and they show what might be worth to proceed in the light of what is already known. So we may say that whoever is convinced to have produced some sort of new and relevant knowledge is obliged to publish his or her findings in order to let the "organized scepticism", as Robert K. Merton put it, deliberate and decide about whether these findings enrich scientific knowledge with new insights (Merton 1942; Weingart 1976, 2001).

1.3 This obligation is justified by the norms of science as an institution. It derived from the assumption that science is the social place where new and reliable knowledge has to be produced. But the need to publish (and not to perish) can have other social reasons. Junior researchers and other scientifically trained personnel need to come up with a list of publications in order to climb the next step of an academic's job ladder. So, the meaning of publications can be explained by institutional as well as actor-centered arguments.

Institutional rules and self-governance of science

1.4 When we ask more specific for the criteria where to publish what, the situation might change. An institutional explanation would leave no doubt that an address will be chosen that promises to have the deepest scientific impact. In order to address a chosen scientific public, an author will offer his new paper (or book) to a certain range of publishers or journals, i.e. for *scientific reasons*.

A publisher or a journal editor on the other hand, is likewise expected to follow the scientific imperative to only publish works that have proven to be worth being presented to the scientific peers—the function of the inner-scientific instrument of peer review is exactly this.

1.5 Peer review is said to be the best example for the self-governance of science. Scientists apply scientific criteria for deciding which knowledge is relevant with regard to the scientific progress. And as the relevance of publications for individual careers is unquestionable, the thesis of science governed by itself seems to be a plausible one (Gläser & Lange 2007; Schimank 1995).

Science policy

1.6 But of course the production of science needs external resources, which means in the first place: money. That the production of science needs money, offers an opportunity to challenge its self-governance. The state, in its function of funding science, cannot decide upon the scientific quality of a research proposal. Since there is something like a science policy, whose birth is usually connected to the implementation of the so-called Bush Report of 1946, the scientific institutions themselves (resp. the researcher him- or herself) decided about what topic to pursue next—of course for mere scientific reasons. Whether these were good reasons, was again examined by other researchers.

New public management

1.7 With the introduction of instruments of New Public Management (NPM) this practice is challenged (Huber 2009). Recent publications suggest that NPM-instruments—such as an evaluation-based granting of funds, benchmarks, agreements on objectives or other instruments to measure (quantitatively) the research performance of scientists, institutes, departments or entire universities—become relevant factors for the production of scientific knowledge. Several authors suggest that the impact of NPM on the research process becomes visible in changes of the behavioral patterns of researchers. There is some empirical evidence that they adapt to these new opportunity structures in a way, that changes the phenomenon we call science, e.g.: a limited freedom of choice with regard to topics pursued, the elimination of "unorthodox" perspectives and new criteria to answer the question, where to publish what (Boer, Enders, & Schimank 2008; Gläser, Lange, Laudel, & Schimank 2008).

Scientists as decision makers

1.8 At this point we want to leave the institutional dimension and focus on the perspective of actors. The basic assumption would be that there is NPM and that this enhances the decision making of the individual researcher by extra-scientific criteria. For some this might lead to decisions only to publish in journals with a high impact factor (in order to get better results in evaluations that determine their share of public funding). Others might refuse these criteria and orientate themselves only towards scientific impact. Tentatively one can think of at least three distinct types, differentiated by specific motivations that explain their decisions concerning their publications:

1. The "careerist", who carefully selects each place of publication with a specific view on rankings etc.
2. The "orthodox scientist", whose selection criteria only follow scientific explanations, not caring about what this might mean for evaluations etc.
3. The "mass producer", who wants to publish as much as possible, maybe with a preference for high-rated places, but not following a dominant strategy.

1.9 In the following we want to raise the question whether the decision making of scientists might be a good case to use computer simulation. We assume that there are different types of researchers, whose decision rules differs concerning the crucial question, where to publish which paper. The model, we are going to construct, should be able to demonstrate the emergent effects at the system's level of the publication system, that derive from a shift in the balance of the three types, triggered e.g. by NPM. Computer simulation allows us to develop different scenarios (with different contextual factors, different mixes of types etc.). Furthermore, it facilitates the observation of feedback mechanisms between the (changing) structure at the system's level and the (changing) strategies and behavior at the actor's level.

Scientists in action

The publication system as ABMS

2.1 We assume that individual scientists decide rationally where to publish (more precisely: where to submit a paper with a specific topic). The paradigm of agent based modeling and simulation (ABMS) opens the possibility to simulate individual decisions. Epstein and Axtell introduced agent based models to social sciences with their ground-breaking book *Growing Artificial Societies* (1996). A central idea of this book was the emergence of complex and emergent structures at the macro-level, based on actions at the micro-level that are guided by very simple rules. However, in order to generate reliable results, we propose - in contrast to Epstein and Axtell - that even at the micro-level we need complex decision rules grounded on a sociological theory of action.[1] A sociologically grounded model at the micro-level additionally provides the opportunity to calibrate the model by empirical surveys of real actors, in order to make the model more valid.

Sociological models

2.2 Formalized sociological models of social action already exist, e.g. the model of sociological explanation by Hartmut Esser (1993), who refers to subjective patterns of decision making at the micro-level, namely the SEU theory (Subjective Expected Utility). Fink and Weyer (2011) and earlier Nils Lepperhoff (2000) have shown that models of social actions, based on SEU theory, can be implemented within the ABMS paradigm. Enhancements of Esser's SEU-theory were developed by Clemens Kroneberg (2005; Kroneberg et al. 2010). His model of frame selection (MFS) points to frames and scripts, which are selected, before the actual action is performed, and which shape the final decision making process. As recent studies have shown (Kroniger & Lücke 2010), even the complex MFS can be integrated into an agent-based simulation, which analyses the interplay of governance structures and decision making of different types of actors. To sum it up: Operationalized sociological theories of action are suitable for the implementation of an ABMS that sketches the complex interplay of processes at the micro and at the macro level.

Our approach

2.3 In order to generate insights about the publication system by means of computer simulation we suggest the following stepwise approach:

1. Start with a hypothetical "Strategic publication model" (SPM) formalized by variables of the SEU theory.
2. Calibrate and/or modify the model by an empirical study of "real" (human) scientists.
3. Implement the model by using ABMS.
4. Perform ABMS with different experimental settings.

A hypothetical "Strategic publication model" (step 1)

2.4 For the sake of clarity, we simplify the publication system and only focus on publications in journals. In our model a journal is classified by the following items:

- Impact factor—IF [0,1];
- Acceptance rate—AR [0,1] (dynamic variable with feedback loops, not explicitly modeled here);
- Topically fitting factor—TFF(T) [0,1] (where T is the topic of the submitted proposal).

The scientists have to decide which papers with which topics shall be submitted to which journals. Consequently the set of actions A can be modeled as

- A = {submit paper with topic T in journal X}

Types of actors

2.5 The agents of the simulation consist of the different types of scientists, as introduced earlier . The journals on their part can be characterized by different criteria such as impact factor, acceptance rate or topic. Hence the different types of scientists have specific orders of preference:

The careerist

- IF > AR > TFF

For the careerist it is most important to publish in a journal with a high impact factor (IF), less important to submit a proposal to a journal with a high acceptance rate and least important to make a topically fitting submission.

The orthodox scientist

- TFF > AR > IF

Of course most important for him or her is to make a topically fitting submission (in the sense of scientific standards), less important to reach a high acceptance rate and least important to publish in journals with a high impact factor.

The mass producer

- AR > IF > TFF

For her or him the most important factor is quantity—publish as much articles as possible. Submissions for journals with a high AR guarantee a lot of publications. Less important is to publish in journals with high impact factors and irrelevant for the mass producer is to make topically fitting publications.

2.6 Furthermore we need a $p_{i,j}$ which contains the probability (p) that the selection of journal (i) for the submission of a proposal meets the scientist's objectives (j), where j is one factor of the journal criteria {AR, IF, TFF}. The values can be derived from the journal vectors (AR, IF, TFF) and are not modeled in detail here.

Calibration and implementation (steps 2 and 3)

2.7 The model presented here is a hypothetical one and has to be calibrated and probably refined in case of discrepancies. Calibration contains especially the validation of the assumed types of scientist and the specific assignment of preference orders and values. This can be done via a conventional questionnaire adapted to the variables of the SEU theory.

2.8 Step 3 is the implementation of the model with standard ABMS software (e.g. NetLogo, Repast).

Perform ABMS with different experimental settings (step 4)

2.9 The details of the experimental setting still have to be figured out. They heavily depend on the theoretical issues that have to be solved. In our case of the academic publication system we are interested in the following questions:

- To which extent do decisions of individual (science) actors affect the structure of the academic publication system?
- And vice versa: To which extent does the structure of the academic publication system affect the decisions of individual (science) actors?
- To which extent does NPM change the preferences of individual (science) actors? Does the balance of the three types shift remarkably?
- Can significant effects of that shift be observed at the system's level?

2.10 By constructing different scenarios we will investigate how different types of scientists (as well as different mixes of types) affect the publication system. One criterion to measure the performance of the system (as well as of actors) might be the quantity and the topic of accepted papers.

2.11 The experimental setting thus could be varied the following way:

- varying the ratio of types of scientists;
- varying the ratio of types of journals.

Our main focus is on the emergent effects on the system's level and on the feedback between macro and micro level.

Outlook

3.1 Our "strategic publication model" is based on a systems theoretical concept of science as societal system which is supplemented by an actor oriented approach of decision making of individual scientists. The academic publication system is taken as a "test bed" to experiment with ABMS in order to reconstruct actors' decisions as well as system's dynamics, but —above all—to understand the complex interplay of micro and macro level.

3.2 The hypotheses that we want to investigate in future studies, are as follows:

(H1) There is a significant link between the (changing) structure of the publication system, induced by NPM, and the preferences of the (science) actors. Preferences of actors adopt very quickly, if the systemic constraints change.

(H2) There is a significant feedback effect, since changing preferences of actors in turn affect and change the structure of the system. Journals with a high impact factor will have a better chance to survive than journals with a high topically fitting factor.

(H3) The general "load factor" of the system depends on the strength of systemic constraints. Only those actors will survive who fit to the systemic demands.

Notes

[1]We believe that the KISS-principle (keep it simple stupid) is not sufficient to understand social processes. Thus we need more complex agent models (e.g. RREEMM). For a more elaborate discussion see Weyer, Fink & Liboschik (2011).

References

BOER, H. F., Enders, J., & Schimank, U. (2008). Comparing Higher Education Governance Systems in Four European Countries. In N. C. Soguel & P. Jaccard (Eds.), *Governance and Performance of Education Systems* (pp. 35-54). Dordrecht:

Springer.

EPSTEIN, J. M., & Axtell, R. (1996). *Growing Artificial Societies. Social Science from the Bottom Up*. Washington, D.C.: Brookings Inst. Press.

ESSER, H. (1993). *Soziologie. Allgemeine Grundlagen*. Frankfurt/M.: Campus.

FINK, R. D., & Weyer, J. (2011). Autonome Technik als Herausforderung der soziologischen Handlungstheorie. *Zeitschrift für Soziologie, 40*(2), 91-111.

GLÄSER, J., & Lange, S. (2007). Wissenschaft. In A. Benz, S. Lütz, U. Schimank & G. Simonis (Eds.), *Handbuch Governance. Theoretische Grundlagen und empirische Anwendungsfelder* (pp. 437-451). Wiesbaden: VS Verlag.

GLÄSER, J., Lange, S., Laudel, G., & Schimank, U. (2008). Evaluationsbasierte Forschungsfinanzierung und ihre Folgen. In R. Mayntz, F. Neidhardt, P. Weingart & U. Wengenroth (Eds.), *Wissensproduktion und Wissenstransfer* (pp. 145-170). Bielefeld: transcript.

HUBER, M. (2009). Von loser zu enger Kopplung. Die Entstehung risikofreudiger Universitäten und neuer Planungshorizonte. In J. Weyer & I. Schulz-Schaeffer (Eds.), *Management komplexer Systeme. Konzepte für die Bewältigung von Intransparenz, Unsicherheit und Chaos* (pp. 169-184). München: Oldenbourg. [doi:10.1524/9783486592634.169]

KRONEBERG, C. (2005). Die Definition der Situation und die variable Rationalität der Akteure. Ein allgemeines Modell des Handelns. *Zeitschrift für Soziologie, 34*, 344-363.

KRONEBERG, C., Yaish, M., & Stocké, V. (2010). Norms and Rationality in Electoral Participation and in the Rescue of Jews in WWII: An Application of the Model of Frame Selection. *Rationality and Society, 22*, 3-36. [doi:10.1177/1043463109355494]

KRONIGER, J., & Lücke, F. (2010). Analyse und Evaluation von Steuerungsmodellen am Beispiel von Verkehrstelematiksystemen (Diplomarbeit, TU Dortmund).

LEPPERHOFF, N. (2000). Dreamscape: Simulation der Entstehung von Normen im Naturzustand mittels eines computerbasierten Modells des Rational-Choice-Ansatzes. *Zeitschrift für Soziologie, 29*, 463-484.

LUHMANN, N. (1981) Die Ausdifferenzierung von Erkenntnisgewinn: Zur Genese von Wissenschaft. In: Nico Stehr/Volker Meja (Hg.), *Wissenssoziologie. Sonderheft 22 der Kölner Zeitschrift für Soziologie und Sozialpsychologie*. Opladen: Westdeutscher Verlag, 102-139.

LUHMANN, N. (1990) *Die Wissenschaft der Gesellschaft*. Frankfurt/M.: Suhrkamp.

MERTON, R. K. (1942). Science and technology in a democratic order. *Journal of Legal and Political Sociology, 1*(1/2), 115-126.

MÖLDERS, M. (2011). *Die Äquilibration der kommunikativen Strukturen: Theoretische und empirische Studien zu einem soziologischen Lernbegriff*. Weilerswist: Velbrück.

SCHIMANK, U. (1995). Politische Steuerung und Selbstregulation des Systems organisierter Forschung. In R. Mayntz & F. W. Scharpf (Eds.), *Gesellschaftliche Selbstregelung und politische Steuerung* (pp. 101-139). Frankfurt/M.: Campus.

STICHWEH, R. (2007). Einheit und Differenz im Wissenschaftssystem der Moderne. In J. Halfmann & J. Rohbeck (Eds.), *Zwei Kulturen der Wissenschaft—revisited* (pp. 213-228). Weilerswist: Velbrück.

WEINGART, P. (1976). *Wissensproduktion und soziale Struktur*. Frankfurt/M.: Suhrkamp.

WEINGART, P. (2001). *Die Stunde der Wahrheit. Zum Verhältnis der Wissenschaft zu Politik, Wirtschaft und Medien in der Wissensgesellschaft*. Weilerswist: Velbrück.

WEYER, J., Fink, R. D., & Liboschik, T. (2011). Softwarebasierte Methoden der Netzwerk-Analyse. In J. Weyer (Ed.), *Soziale Netzwerke. Konzepte und Methoden der sozialwissenschaftlichen Netzwerkforschung (2. Aufl.)* (pp. 109-131). München: Oldenbourg.