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What model of science? Towards a sociologically oriented science policy

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Abstract

In the contemporary global world the various models of making and distributing science are cultivated. The particular model of institutionalized science can significantly determine the quality of working both as a scientist and as a student. Research upon science environment in the meaning of investigation the framework of science influences for example the system of communication between different actors engaged in science, good practices, possibilities offered by particular context of science and facilities of acquiring the scientific knowledge etc. It this view the presented paper finds its justification directing analysis towards the quality of making science. Hence the paradigm of sociological science policy is strongly needed.

The paper is going to reconstruct the key models which recognize contexts of making science and its numerous dimensions. The research is based on the set of literature founded through the digital key words searching process. The chosen literature recalls the most significant research based on science policy. Consequently the described models tend towards the most globalized and open models of making science to show the path of required changes into still founded coercive science structures mostly institutionalized by long-lasting tradition. The final conclusion states that more concrete steps in reformulating the science policy are required to obtain the desirable model of open science and at the same time to develop the high standing scientific priorities.

Key words: models of science, science policy, network, open science, sociology of science, good practices

Introduction

The intention of the paper is to shed light on the area of science policy discussed from the sociological point of view. It is worth mentioning that the field of sociological science policy is not hugely developed when we look at the map of sociological research especially in Poland. Hence the aim of this paper is to gather the most significant perspectives into one place to systematize knowledge and precise core problems. The presented selectively overview is based on the most relevant publications which encompass a wide range research upon science and its forms of policies. The literature research was done digitally through key words searching process. Generally the research upon science includes variety of topics discussed from different paradigms and streams of knowledge. The conception of science is mostly directed towards philosophical debate related to science and its problems. Digital search indicates that the main areas connected with science investigation are scrutinized within the philosophy of science and sociology of science. To recall the examples within mentioned fields the emphasis is put on problems like authority in science (Rybicki, Goćkowski 1980), philosophical development of scientific methodologies (Goćkowski, Sikora 1993), kinds of pathologies in scientific and academic life (Goćkowski, Kisiel 1994), tradition and identity of science (Goćkowski, Marmuszewski 1995), roles of scientists (Znaniecki 1994, Znaniecki 1984, Goćkowski 1996, Mucha, Keen 2006), position of university in relation to its values and tradition (Goćkowski 1999, Kostkiewicz 2007, Sztompka 2007), notion of rationality in science (Halfpenny 1991, Garfinkel 1984, Turner 1991), science management and intersectionality in science (Sytek1994, Funtowicz, Ravetz, 1993, Gallopin, Funtowicz, O'Connor, Ravitz 2001, Turnpenny, Jones, Lorenzoni 2011).

Specifically science policy regarded from the sociological point of view which is affected by social environment and its dimensions orients analysis towards the background of making and sharing science. This scope of view is rather rarely met and developed. Hence the mission of the following pages is to recall the significant literature reference to offer an overview and also state as introduction to research science policy at regional/local level as well. The paper is going to reinvestigate the main models of science throughout history and specify its trends and dominant goals. This problem touches especially on two sociological disciplines: the sociology of science (considering specificity of organization, major forms of interactions) and the sociology of law (concerning the fact of institutionalization of legal processes in science and its practices). The formally distinguished official forms of science and the power of informal structures can make a difference. Below the emphasis will be put primarily on the legal solutions related to science. The forms of mentalities are treated marginally here but are worth highlighting as a great challenge for future research.

The model of science is understood as network based. It means that the networks between key actors and their hierarchies, dependencies and the processes within networks will be revealed. The perception of science as networks is an added value into public policy in general because it indicates a strong need towards good practices in making law upon science. Especially this attitude can recognize weak points within bureaucratized science and make suggestions to provide more flexible law within science

The key question of the paper is oriented towards pointing out the most preferable model of science. The main assumption of this paper is the statement that the form of science policy shapes concrete models of science which emerge from general processes of formalization responsible for building the system of hierarchies, strategic actors, their institutional interactions, paths of decision making etc. The general perspective refers to the forms of science management and considering the present tendencies towards democracy and transparency, the globalization of good practices.

Science policy. The sociological perspective

The general sociological theoretical frame problematizing science is called the sociology of science. To start with a definition: "Sociology of science deals with the social conditions and effects of science and with the social structures and processes of scientific activity. Science is a cultural tradition, preserved and transmitted from generation to generation partly because it is valued in its own right and partly because of its wide technological applications. Its most distinguishing characteristic is that the primary purpose of its cultivators, the scientists, is to change the tradition through discoveries (…) The relatively objective, consensual evaluation of discoveries makes science an extreme case of institutionally regulated cultural change. Sociologists of science have concentrated on this characteristic of science as a tradition and as an institution" (Ben-David, & Sullivan, 1975, p. 203). The core issue related to the discipline of the sociology of science refers to its decision making processes, ways of management science, becoming controlled and proceeded, organized and institutionalized. The concerns upon science and its problems connected with values, functions, perceptions, legitimization have been broadly described in recent decades. The sociology of science, the sociology of scientific knowledge and more widely the sociology of knowledge have had a rich tradition spread in various paradigms. The most recognized one probably belongs to Robert Merton's sociology of science where the problem of institutionalization and normative structures is revealed. However the analysis is elaborated from the theory of functionalism (Merton, 1973).

The notion of science is discussed in the context of rationality more commonly. Only to recall the most renowned perspectives, science can be perceived through the prism of technological determinism where the positivist, utilitarian and strictly (narrowly) scientific character is highlighted. The main representatives are for instance Thorstein Veblen, Wesley Clair Mitchell (also known as the followers of technocracy), Willian Fielding Ogburn who formulated the hypothesis of the lack of simultaneous development of social changes which are retarded in comparison to technological changes which are always ahead), Daniel Bell (conception of the post-industrial society), Neil Postman (the notion of „glorification of technology") and Leslie White.

Another stream developed in understanding the roots of science from a sociological overview is proposed by representatives of the communication determinism. Here, the changes in the ways of making communication between people are key meanings to experiencing the social world. The most important authors are especially Harold Innis (the conception of communication bias), Marshall McLuhan (medium is the message), Jürgen Habermas (forms of rationalities and rationality of communication). The more liberal, in-deterministic view is located within the theory of culturalism developed by Florian Znaniecki (the humanistic coefficient is prominent to constitute social practices like scientific ones). The greater tendency for integration and synthesis is represented by Science and Technology Studies (STS) where the research attention drives towards intersectionality through different disciplines and cross-boundaries problems (Nowotny, 2007).

The sociology of science is an integral part of science policy. Science, being and/or becoming institutionalized is taken under consideration in many debates and normalised by the current state and/or globe trends observable in the approach to science policy. As Adriana Valente, Tommaso Castellani and others notice that: "The relationships between scientific research and policy-making have been deeply investigated in recent decades by a number of scholars from many disciplines, producing many different models of science-policy interactions. Basically, the evolution of the studies on the topic moved towards a greater complexity, including more actors and variables, considering the non-linearity of the knowledge production and translation processes, and stressing the dependence on the context" (Valente, Castellani, Larsen, & Aro, 2014, p. 1). The same introductory idea is met in Aletha C. Huston's paper: "The major role of science policy is to guide and generate scientific inquiry; the major role of science in social policy is to inform solutions. Potential usefulness affects both types of policy by directing the solution of scientific questions and the adoption of information in planning social programs and policies (…) The culture of science values inquiry, questioning and skepticism; scientists are comfortable with ambiguity, complexity and uncertainty (…) science policy is driven partly by political values, ideology and current social issues (…) policymakers' beliefs about the important social problems of the day have a direct influence on the scientific activities of scholars in the field because those beliefs affect government initiatives in research and decisions about priorities for funding (Huston, 2008, p. 2, compare with Graffy, 2008).

The idea of science policy has been problematized through various models exposing different forms of relations and interactions between actors, systems of knowledge, practices and its utilization, organization of scientific traditions and institution of rationalities and paradigmatic mentalities. Donald Gray, Laura Colucci-Gray and Elena Camino highlight the multilevel and multidimensional need for reorganization of science. As we can read about the aspects and issues concerning a contemporary debate upon both science and education which among them are: "the growing awareness of complexity and uncertainty in the realms of science, society and environment interactions; the greatly accelerated and unsustainable pace of change as a result of the power of science and technology to transform and manipulate the resources of a planet that is bounded and finite; the nature of current knowledge production and use and its social implications (including the rise of conflict); and finally, the need to expand participation and decision-making processes with respect to complex socio-environmental issues (…) In the face of these concerns, there is a need to address the type of thinking that is offered and spread at all levels of education: thinking that is predominantly shaped by a positivistic epistemology, a mechanistic linear model of cause and effect and a methodological approach based on reductionism. In order to embrace complexity and uncertainty a more holistic, systematic approach to science and science education is required. This approach implies an appreciation and understanding of the limits of disciplinary knowledge as a particular and bounded perspective; an understanding of the importance of the relationships amongst parts of a system, which are not captured by analytical and quantitative methodologies and a more inclusive approach to different types of knowledge, of which scientific knowledge is only one. A more fluid and inclusive way of thinking asks for putting together reflection and action: different patterns of thinking, mindsets and mental schemes can be reframed within practices that do not separate and divide but which seek to relate and put into dialog. This is change at multiple levels, from the wider social context to the more personal interactions of educational encounters" (Gray, Colucci-Gray & Camino, 2009, pp. 4-5).

The models of science treatment have been exposed by many authors specifying the changes of relations and character in approach to science. Below the scheme of different ways of perceiving science is presented. This overview is distinguished based on four indicators: strategy, decision-making processes, possibility of participating in the area of science and finally, the form of evaluation. Nathaniel Logar is an author of this division (see Table 1).

The first proposed model was designed by Vannevar Bush (Bush 1945). The main idea was to establish the institution of science as completely independent from any other influence or ideological wave for instance politics. In this model a top priority has been placed over politics and facts recognized by scientists are always reliable. Another name for this model is: the"linear model" by Nathaniel Logar, or "elitist view" by George Mazuzan, "technocratic vision" and "modern model" by Silvio Funtowicz (Valente, Castellani, Larsen, & Aro, 2014, p. 3). The essence of the Bush's model was to provide a linear relation between scientific knowledge to improve significantly a range of social convenience, technological growth and implement a better politics (Logar, 2011, compare with Wagle, 2000; Pielke, 2004; Madison, 2000).

The second model, defined as Mode 2, is a response to increasing complexity of factors which can be groundbreaking in science (Gibbons, 1994). The Mode 2 model assumes orientation towards applicability of science, its social impact, opportunity for diffusion and effect on other scientific disciplines. It means that trans-disciplinarity is postulated in this model. The Mode 2 model is contrasted with the Mode 1 model which separates academic systems of knowledge in the forms of their distinguished spaces like universities, special laboratories and develops decision making processes captured in hierarchies.

The third model made by Silvio Funtowicz (Funtowicz, 1993; Funtowicz 2006, compare with Guimaraes Pereira 2009, Benessia 2009) elaborates the perspective of post-normal science what emphasizes strong uncertain conditions and situations of science production. Hence the notion of "extended peer community" appears to make inclusive evaluation by various groups of people not only the experts in a strict sense. The conceptions of "public engagement" and "democratic accountability" are strongly highlighted. The reason is that science and its results affect more and more people so a wider audience wants to participate in the decision making processes on a larger scale.

Funtowicz's model is divided into five sub-models to express the variety of approach to science (see Table 2). The first model, mentioned above, is identified with conviction that science is certain hence the scientific results should be followed by policy makers. The names of this model are: "modern or technocratic

Table 1. Characteristics of different science policy models.

Model	Linear model (Bush 1945)	Mode 2 (Giddons et al. 1994)	Post-normal science (Funtowicz, Ravetz 1993)	Pasteur's quadrant (Stokes 1997)	Well-ordered science (Kitcher 2001)
Strategy	Basic research put into a reservoir of knowledge	Application-oriented	Democratic	Use-inspired basic research	Well-ordered science
Participants in decision making	Scientists	Heterarchical	Extended peer network	-	Occurs as if there was participation of a tutored public
Participants in science	Scientists	Socially distributed	Different sources of knowledge across the lay-expert divide	Basic and applied researchers	Science implementation occurs as if there was participation of a tutored public
Evaluation, quality control	Peer review, evaluation by experts	New modes of quality control, more social accountability, reflexivity	Expanded peer networks	-	Occurs as if there was participation of a tutored public

Source: Logar, 2011, p. 251.

Table 2. Scheme with some features of Funtowicz's model of science-policy interactions (Funtowicz, 2006).

Technocratic (modern) model	Precautionary model	Model of framing	Model of science/policy demarcation	Model of extended participation
Science is certain, science drives policy	Science drives policy but science is uncertain	Science is one of the inputs for policy, different stakeholders are involved	Science and policy have strictly different roles, each one has own interests and agenda	Open public dialogue replaces rigorous scientific demonstration

Source: Valente, Castellani, Larsen, & Aro, 2014, p. 4.

model" to express the power and reliability of science. The second model called "precautionary model" still insures the primacy of science but also stresses the elements of uncertainty. The process of science production is involved in situations of uncertainty and risk. The third model known as "the model of framing" embraces the awareness of many stakeholders. The knowledge of specific needs and roles which stakeholders have can be taken under consideration by those who are to shape the science policy. Science's interests cannot be considered as the most important ones by policy makers. The forth vision of science is defined as "the model of science/policy demarcation". In this model the specific and unique science and policy-making goals and agenda are differentiated. The result is that the line of demarcation between science and policy is becoming complicated and more complex. The consequence of such a model can initiate the potential situations of conflicts when interests and goals can contrast with each other. The fifth model, "the model of extended participation" expresses an open dialogue and voice of wider public to formulate scientific purposes and shape the scientific scenarios of daily life and future benefits.

To continue the description from the previous division of science, the fourth model, known as Pasteur's quadrant, was described by Donald Stokes (Stokes, 1997). The key idea of this model stresses an understanding upon science: either making leading research for instance by providing new solutions, new paradigms with rejection of previous conceptions and ways of thinking or making use-oriented science which means that science can be inspired by for instance some urgent problems by increasing its usefulness for society, environment and technology. The combination of these two categories, which create the matrix (development of understanding and focus on use), can result in the "use-inspired basic research".

Finally, the fifth model called "well-ordered science", was elaborated by Philip Kitcher (Kitcher, 2001). This model forces active and well-educated, tutored citizens' participation towards science evaluation on every step of the decision making process. The most significant idea is the conception of deliberation (from prioritizing goals, scientific aims, through their implementation and up to examination). Citizens play a major role in identifying purposes and assessment of needs. Government in responsible for providing accurate agencies to facilitate goal achievement.

The above reflections upon science can bring the statement of formulating and shaping science in the category of an "agora" in the contemporary world. More and more people are becoming interested in science as a public good. Scientists cannot perceive themselves exclusively as experts. Living in the "risky society" (Beck, 1992) and experiencing the complexity and differentiation of institutionalized science which is under the influence of the "open public dialogue", it is necessary to make realistic a "bridge building" perspective (Kinser, 2014) to effectively interconnect stakeholders and provide the idea of public and global engagement. The popular notion is the "Science 2" conception to formulate a strong social need towards science – society – technology cooperation by enhancing a creative and open dialogue in the society of cognitive capitalism (Bendyk, 2010).

New science challenges. What next?

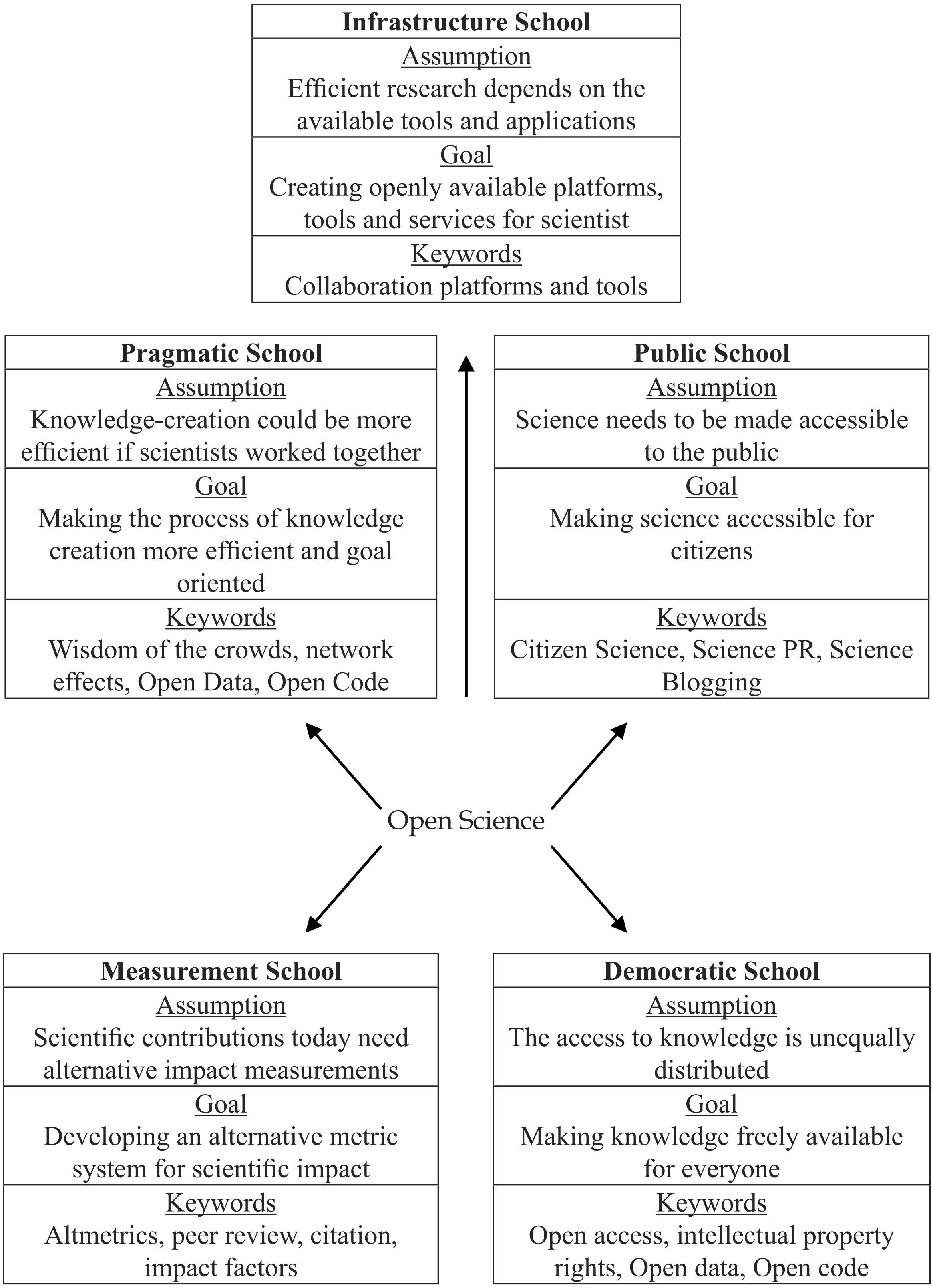
Continuing the socially engaged science tendencies more and more core ideas upon science refer to an increasing openness and improvement of access to science. "Recent decades have seen an increased demand from citizens, civic groups and non-governmental organizations for greater scrutiny of the evidence that underpins scientific conclusions (…) there is growing participation by members of the public in research programmes, as so-called citizen scientists: blurring the divide between professional and amateur in new ways (…) Much of the remarkable growth of scientific understanding in recent centuries is due to open practices; open communication and deliberation sit at the heart of scientific practice (…) Open science is defined (…) as open data (available, intelligible, assessable and useable data) combined with open access to scientific publications and effective communication of their contents" (The Royal Society Science Policy Centre Report, 2012, pp. 8 -16).

As it is presented below (Diagram 1) the formula of open science can be found in several ways. Benedikt Fecher and Sascha Friesike (Fecher, & Friesike, 2014) postulate five visions of open science project.

The first proposition is called the public school of open science which means in this model that accessibility and comprehensibility are strongly emphasized. The relationships with a wider audience constitute a key to provide scientific results in a clear way and adjust sources of scientific knowledge to increase the public sphere of scientific discoveries.

The second is recognized as the democratic school of open science. Here the unequal distribution of knowledge is stressed to undertake actions towards a variety of improvements including many disabilities which make a difference in being able to explore for instance scientific journals. Data is treated as a commodity to which everyone should have access without any restrictions embracing format, infrastructure, multi-functionality, law (licenses), diseases etc.

Diagram 1. Open Science: One Term, Five Schools of Thought



Source: Fecher, & Friesike, 2014, p. 19.

The third vision is known as the pragmatic school of open science. The most important here is sharing information worldwide to receive broader feedback, working collectively to build up knowledge, create new solutions and shape a better future. Complexity in today's world requires finding more appropriate and satisfactory tools and services. In the way the collective capital and intelligence are constructed. Consequently networked science is directed, powered and reconstructed by people through discussions on many accessible platforms.

The forth model named as the infrastructure school of open science assumes that *material* fundamentals of science should be serviceable. It means that, from this particular perspective, science runs towards better designed and prepared tools and platforms for sharing knowledge, scientific results, papers etc. In other words science is becoming more service-oriented: without technological support the effective scientific communication would not be possible.

The fifth proposition is constituted by the measurement school of open science. This model suggests alternative means for scientific impact assessment. It shows what kinds of channels can be used to make comments, improvements, new ideas etc. Mostly web/digitally oriented platforms are attached with special service to measure citations, readings, views, the levels of public exploration etc. Hence science is becoming more measurable and controllable, digitally open and accessible. The character of science is changing towards more visibility.

Summary

The literature set tends to the conclusion that science is globally governed. "Governance means rules, processes and behavior that affect the way in which powers are exercised" (European Commission, 2009, p. 8). The most distinctive principles of new science governance are as following: a) "openness" in the sense of providing worldwide communications systems with society, b) "participation" which refers to all citizens and their increasing role in formulation at every stage of policy systems, c) "accountability" spread among all institutions, d) "effectiveness" in the meaning of obtaining objectives and also building systems of evaluation methods and results to have a control and make measurements correctly, e) "coherence" between all policy bodies to grow a system of good and most desirable practices. These major principles are supported by two other principles which are: "proportionality" (in the sense of sustainable development) and "subsidiarity" which means a range of helpful practices to cultivate lifelong learning processes among institutions and providing advisory platforms for a variety of consultancies. All these major principles are going to normalize good practices based on democratic rules and transparency.

It is worth mentioning that the project of "global governance of science" is challenging especially from the point of different science traditions developed in every country. There are two distinguishable senses of global governance. "Governance can be *global* in two senses. First, *global* can mean comprehensive, applying to all of science. Second, *global* can indicate a crossing of national boundaries (…) So global governance is about more than relationships between states. It also focuses on the growing complexity of trans-state relationships (…) it is recognized that in order for governance to be truly global in the transnational sense it must in addition be global in the sense of being comprehensive" (European Commission, 2009, pp. 9-10).

The policy of global science includes both internally and externally based relationships and research. Science is changing its horizons to be more publicly and globally welcomed. Undoubtedly the global science governance seems to be promising but not undoable. The widely spread discourse upon the science quality and its models brings the vision of problematized, competitive and creative science models to make both making and absorbing knowledge more open and accessible to everyone. Hence the more research upon science management is needed to recognize and reveal more unique and grounded contextually factors at regional and local levels of analysis to confront theory and conceptualized goals of improving the quality of science models with the empirical specificity.

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