МЕТОДОЛОГИЧЕСКИЕ ВОПРОСЫ СОЦИАЛЬНОГО ПОЗНАНИЯ

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The Concept of "Socially Robust Science" — Reasons for Introducing, Basic Characteritics, and a Method of Measurement

The paper considers the intense dynamics in the role and social functions of modern science. Multiple concepts, models and policy theses are identified, enphasising specific aspects of this process, however, it was found out that they do not articulate and explane well the whole range of transformations in the exo-systemic social context of science during the formation of knowledge societies. By that reason a new conceptual framework based on the so-called "Socially-Robust Science" is introduced, which reflects the encreased role of science for the social and economic development, considering in the same time the reverse impact of society on the research sector. Some fundamental principles of partnership between science and society are presented, as well as the fundamental objectives of science in a knowledge-based society, related to its social context (labeled as "Target Package 7s"). A corresponding metric is suggested — Index of Social Robustness of Science (ISRS), based on reliable, easily accessible and annually updated data. It enables the establishement of ratings and the making of longitudinal comparative international analyses concerning social relevance, degree of social impact of the national research systems and intensity of their collaboration with the public.
Keywords: science and society, conceptualization, socially-robust science, indeces, comparative analysis.

Introduction

In recent years, along the formation of so-called "knowledge societies", some noticeable transformations in the social functions of science occur. Three societal forces are responsible for the change: (i) globalisation; (ii) industrial and post-industrial society; and

(iii) climate change (Krishna 2014). The social responsibility of research is growing, as well as the role of knowledge transfer. In the same time the period from the generation of new knowledge to its application gets shorter. The boundaries between science and technology are increasingly blurring. What before was considered a fundamental knowledge without direct practical benefit, later has proved to have a huge potential for various applications with real economic value — such as nanomaterials, computer tomography or research in the field of artificial intelligence. Research outcomes are to greater extend focused on their beneficiaries, while the interaction of science with different social structures and general society increases significantly. Modern science is problem-oriented, with extended ethos, deeply pervading into the public system. Basic transformation occurs in the social impact — it happens by new channels of connection between various stakeholders, building network structures (Ziman, 1996). There is a change in the purpose context of social functions of science — from aspiration to obtain a scientific result that is possible and true, to scientific result that is potentially useful and / or appropriate[1]. "*Value addition, profit and creation of wealth have become a primary goal, whilst the advancement of knowledge has taken a back seat*" (Krishna, 2014, p. 144).

An important point is that science is always required to maintain high ethical principles and standards in the process of production of new knowledge, as well as in regard to its dissemination and application. It is associated with the problem of trust in science, of its public image. Science itself becomes more dependent on the way it is accepted by the public because it affects political decisions related to its development, and the opportunities for its funding.

In recent decades, politicians demonstrate a growing willingness to abandon the model of autonomous, deterministic science, giving preference (at least in some specific circumstances) of the model, which involves active collaboration between the academic sphere and society and stronger integration of the social context in science (Rodríguez, Fisher & Schuurbiers, 2013). Modern science actively opens up to the public with commitment to a new "social contract", engaging on a network basis in the research process new actors, taking its research programs to the public interest. There is an implicitl recognition that "*the main responsibility of scientists is to develop knowledge that is aligned with society's norms and values*" *(*Glerup & Horst, 2014, p. 42).

At the same time, the growing public participation in production of scientific knowledge, and the stronger social commitment to the issues of science policy are an important indicator of the increased role of science in the modern knowledge society. This, on the other hand, is a serious challenge for science itself — it becomes more dependent on the public support and public participation in all phases of the research process, as well as in the application of research products. The public begins to interact actively with science on a macro-level (by organised participation in science policy and research evaluation, mainly discussing ethical aspects of research), as well as on a micro-level (e.g. in the form of individual participation in projects under the so-called "citizen science"). Members of the public, being only users of scientific knowledge by now, are gradually becoming its co-producers.

Transformed social functions of science provoke further changes in the production, validation and dissemination of knowledge in the knowledge society. According to Nowotny,

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[1] E.g. discovery of a method for human cloning would not be appropriate research result, although it is in principle possible to achieve.

Scott and Gibbons "*... a new language has been invented — a language of application, relevance, contextualization, reach-out, technology transfer, and knowledge management*" (2003, p. 185). At the same time, it increases the importance of the commercialization of scientific knowledge, which is a relatively new phenomenon. It is associated with the intellectual property of research products, creating in turn new ethical problems, because knowledge in general is considered as a "public good" and should become available to the entire society. Apparently, the necessary balance in this area is to be found.

Social functions of science for the first time in the "knowledge society" are settled at regulatory level and have been imposed as a mandatory attribute on the research system. According to the vision of OECD, "*the government ... has a role in ensuring and subsidising the creation of science to improve social welfare*" (OECD 1996, p. 21). At EU level a consensus is achieved on the idea that the treatment of risk and uncertainty regarding research in the process of decision-making requires profound analysis and attention from the political authorities (European Commission, 2000; 2005). The fostering of science — society interaction is realized in concrete policies, programs and organizational structures.

But some authors rightly point out that these new trends should not impinge in an excessive degree the autonomy of science as a cognitive activity, since "*the dynamics of scientific knowledge is dictated primarily by creativity and criticism of theories, models and methodologies, and such highly specialized intellectual activities are not subjected to the imperatives of the market logic*" (Stefanov, 2016, p. 10).

About the need of reconceptualization

The above arguments indicate intense dynamics in the role, status and social functions of science in the period of formation of knowledge-based societies. On the other hand, they were identified multiple concepts, models and political theses that focus on one or another important aspect of the considered processes, but without a clear articulation and explaination of the whole range of changes in the exo-systemic social context of modern science. This proliferation of theoretical visions, and the diversity in their main focus calls for a ***reconceptualization***, outlining the new ideas concerning science as a factor for social development and the novel elements in the science — society relationship.

The concept of Modus 2 (Gibbons et al., 1994; Nowotny, Scott & Gibbons, 2003) focuses on the way of production of scientific knowledge. All the associated consequences for the social dimensions of science are discussed in the context of the primacy of the application, the transdistsiplinarity, and the network organization of the research process. That is, the basic subject of Modus 2 are not the social functions of science in the modern society, and their changes are regarded only as a side phenomenon.

Moreover, Gibbons et al. (1994) emphasize a new kind of research process in the framework of the so-called "heterogeneous consortia", involving mainly experts and professionals from different social spheres. The concept for post-normal science, in turn, speaks of "extended expert communities" in the discussion of certain policies (Funtowicz & Ravetz, 1993). In Modus 2 and in "post-normal science" is launched in principle the idea of public participation, but primarily in setting scientific priorities, in the evaluation and control of safety and of social effectiveness of the research outcomes, as well as in the innovation activities.

However, the so-called *"engagement at early stages"*, where the opinion of the public is taken at an early stage of the research process, is not profoundly considered, as well as the co-production of scientific knowledge through direct involvement of people without specialized scientific knowledge and expertise by participation in "*Citizen science*" projects where they contribute in important and large-scale research endeavors, or through so-called "*Knowledge Coalitions*" within which the capacity of people with specific expertise and tacit knowledge is used (e.g. patients suffering from a disease, environmentalists, or residents of territories affected by certain natural processes, etc.). It should be noted that the utilization of tacit knowledge is among the main highlights in the concepts of "knowledge society" and "knowledge management", which has to be taken into account in a reconceptualization.

Moreover, Modus 2 implies a strong commercial commitment of research, speaking of "*Market of knowledge*". This is also in the focus of the so-called "post-academic science" (Ziman, 1996). But the development of science in recent years contradicts to Modus 2 by ***rehabilitation of basic research*** and rise of the awareness of its importance regarding possible future applications with great impact on our society. Furthermore, lately spreads the idea that science must keep perimeter of relative independence in relation to its internal standards, norms and values that guarantees the generation of objective knowledge, having the capacity to affect positively the social development.

The concept of technoscience focuses its subject on the growing cohesion of science and technology, and on their transformation into socially useful products and services. The concept of "Big Science" (Galison, 1992) reflects mainly the scale of modern research, although it considers some implications as the need for more cooperation and involvement of various stakeholders. Similarly, the model of "Network Society" (Castells, 2005) characterizes changes in the organization of social partnerships and new positioning of the actors in the process of utilization of new information and communication technologies.

The thesis of finalization (Böhme, van den Daele, Holfield, 1976) discusses mostly the cognitive dimension of the relation basic — applied science, but the corresponding social consequences are of minor consideration. The concept of "used-inspired basic research" (Stokes, 1997) and of "directed basic research" (Crow & Bozeman, 1998) are oriented towards a more adequate typology of research, without examining the nature and forms of science-society relationship. The term "strategic research" (Rip 2002) reflects the changes in science policy toward prioritizing of program — and project-oriented funding for socially relevant research. On the other hand, a variety of models of science-society relations — e.g. "Interactive Science" (Scott et al., 1999), "Social dialog and participation" and "Co-production of science" (Felt, 2002), and "Upstream engagement" (Wilsdon & Willis, 2004; EC, 2007) conceptualize well the changes in the forms and mechanisms of interaction, but they do not problematize the social functions of science and its role for the social development on a global scale.

"Socially Robust Science" as a new conceptual framework

Nowotny (1999) introduced the concept of "Socially Robust Knowledge" in contradiction with the concept of "*knowledge, free of context, undistorted by biases and interests*" (p. 13). Taking into acount the substantial transformations of the research systems as a result of the changed social climate in which they operate, and their stronger commitment to cultural, political and economic social contexts, the author detects orientation towards "*socially robust or contextually sensitive knowledge*" (ibid). It means, knowledge should prove its usefulness in the particular context again and again to be considered as acceptable (Nowotny, 2003). That's why science begins to create socially robust knowledge, i.e. knowledge that is reliable not only in the laboratory but also beyond; knowledge obtained not in complete autonomy and ambition only to reaching the truth, but generated in conditions of dependence on the public interests and consistent with them. This reduces the possibility that it could be contested.

Therefore, the transformation of social functions, role and status of science can be conceptualized by the term "***Socially Robust Science***" — similar to the above-mentioned term "Socially Robust Knowledge" of Helga Nowotny. This term more adequately reflects and emphasizes the exo-systemic social context of modern science in the knowledge society, explicating its role as a factor for social and economic advancement and the changes in its social functions. At the same time, it reflects the impact of society, politics, culture, and economic conditions on the development of science and on its status nowadays. These reversible processes affect all social spheres and transform them to become more democratic and useful to society. In general, science in the "knowledge society" is transcending the academic domain, with growing social impact.

The development of science and its changing environment require further transformation in the science — society relations. These, in order to be more productive, effective and beneficial for both domains, should be in compliance with the following fundamental **principles of partnership**:

- "***Supportive reflexivity***" — a principle of mutual respect, open-mindedness and well-intentioned desire to achieve maximum benefit for the research system, as well as for the whole society; that means, science has to take into account the expectations, interests, needs, values and attitudes of the society, and to admit a "non-invasive» public control, because the advancement of science brings not only progress for mankind, but is also associated with potential risks and threats; the public should respect the autonomy of science in terms of its endogenous mechanisms and standards for acquiring knowledge, and at the same time — to have an awareness of the social importance of research and willingness to support it.
- ***Moderate application of the market principles*** — adjustment of the regulatory framework at European and national level to achieve a reasonable balance in: intellectual property — public interest; paid knowledge — knowledge of open access; funding applied research — support for fundamental research, and so on.
- ***Mutual information, training and coevolution*** — enhancing science communication, including by science journalism and strengthened dialogue with the public in various forms in order to achieve a better understanding of science and more efficient synchronization of the research process with the problems, aspirations and moral imperatives of society.
- ***Mutual trust building***; by side of the public: reducing doubts and suspicions about the usefulness and safety of research products; by side of science: removing the bias that the public is not sufficiently competent and its intervention in the planning, implementation and evaluation of research would have only negative consequences for science.

Observing these principles, modern science would have the potential to gain more clearly outlined profile of being relevant, reliable and useful for people. This will facilitate the implementation of its integrative function — in the best and most efficient way to "fit" in public system without loosing its specific image of "truth seeking" and its relative independence within the cognitive process.

Science can be considered as socially robust regarding the public relevance of research (by strengthening social functions, responsibility and role of science) and in relation to the broader public foundation in the generation and application of scientific knowledge (or presence of a strong social factor, external to the research system, which supports and pilots the development of science). Science in a knowledge-based society should be oriented towards achieving some fundamental objectives related to its social context (labeled as "**Target Package 7s**"):

- ***Social relevance, acceptability and reflexivity*** (conformity with public needs, attitudes, expectations and values, and rapid response to emerging societal issues);
- ***Social responsibility*** (avoidance of research with potentially negative consequences for society, as well as prevention of possible threats and risks);
- ***Social suitability and pertinence*** (research results have the capacity to bring real social benefits; problem-oriented research);
- ***Social effectiveness*** (achieving greater social impact);
- ***Social interaction and coherence*** (dialogue and public participation in all stages of the research process, without violating the internal criteria and standards for "good research practice"; synchronization of visions and values of science and the public).
- ***Synergy and integrity*** (increasing the effects of the interaction; greater integration to achieve more positive results for science and society);
- ***Strong science, strong potential for social impact*** (only objective, obeying high internal standards and values science is able to produce high quality research outcomes with capacity for strong and beneficial social impact).

These indicators are interrelated. For example, the increased potential for social impact inspires the need for greater social responsibility of science.

The proposed here a new conceptual framework in a peculiar way "reconcile" the two extreme views regarding science: considering science as an entirely autonomous "ivory tower"; and treating science as a tool of producing only commodities for the market, called to carry surplus material value (in the utilization-instrumental interpretation of science and technology). Furthermore, the relationship science — society should be viewed and interpreted as a multi-dimensional problem requiring the establishment of appropriate metrics.

In general, the conceptual framework based on the thesis of "Socially Robust Science" combines some elements of models and concepts regarding the knowledge production, the relationship between basic and applied science, the science-society relations, specific theses of the research policy, as well as some characteristics of the concept of "knowledge society". At the same time, it contains some new ideas and concepts, attaching innovative features to the theory of social dimentions of modern science.

Design of quantitatively measurable index

In order to quantify the degree of the social relevance and impact of science in a single country, as well as to create an opportunity for making international comparative analyses, I propose the so-called ***Index of Social Robustness of Science — ISRS*** as a synthetic complex indicator with composit character[2], which is formulated in such way that:

- to be based on easily accessible, annually updated and sufficiently reliable statistical data, enabling country ratings;
- to contain information about the degree of development of the research system and its interaction with the industry and economics of the country, as well as about some important direct and indirect impacts on the social life; to reflect also the opposite impact — this of science policy and of the society on science, e. g. by rating of the research funding and of the public participation in the policy regulations;
- to be easily calculated, and to bring to numeric results, which afford an easy and clear comparison under countries.

The proposed Index of Social Robustness of Science is based on rank values (taking into account the position of the country in the ranking on the corresponding sub-indicator), which further facilitates its calculation and provides greater objectivity and comparability of the data. The sub-indicators are the following:

A. Citable documents H index. It indicates well the quality and visibility of the research output, expressing the potential of a national research system to exert social impact.
B. QS University ranking, average score Top 3. This sub-indicator reflects the degree of successful fulfilment of the educational function of science.
C. ICT use. These technologies are related to the modern concept of technoscience, having great impact on the national economy, as well as on the everyday life of people.
D. Knowledge intensive employment. This is an indirect sub-indicator of the social impact of R&D.
E. University — industry research collaboration. It is a significant precondition for the realization of the social functions of science.
F. Capacity for innovation. It reflects the potential of the national R&D system for efficient absorbtion of research outputs.
G. Gross expenditure on R&D (% of GDP). It indicates well the degree of social support for the development of science.
H. Stakeholder engagement for developing regulations. This sub-indicator reflects indirectly the strength of public involvement in research policy.

The Index of Social Robustness of Science is calculated by the formula:

$$\mathbf{ISRS = [1 / (A+B+C+D+E+F+G)] \cdot 10^4}$$

The resulting values are rounded to integer.

In order to demonstrate how the ISRS works, an example rating of seven countries with developed economies (according to International Monetary Fund) is provided. Five of them are from the European region, and two others are from Asia.

Table 1 presents the country data for the year 2017 with the obtained values of ISRS. The results indicate that the proposed index is with a good “resolution”, enabaling clusterization in three well established groups: countries with high social robustness of science (ISRS>100); countries with moderate rate of the index (ISRS Є [50, 100]), and countries with low level of social robustness of science (ISRS<50).

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[2] “Syntetic” means that the indicator concentrates a large amount of information; the complexity reflects the property “multi-aspect”; the composite character refers to the design of the index and means that it is composed by mathematical combination of several different sub-indicators.

Table 1. Index of Social Robustness of Science (2017)

Country Sub-indicators	UK	Finnland	Dennmark	Japan	Korea	Russia	Slovakia
A. Citable documents H index*	1	18	15	6	19	22	42
B. QS University ranking, average score Top 3*	2	17	15	8	9	25	68
C. ICT use*	9	7	1	8	3	40	30
D. Employment in knowledge intensive services*	8	10	12	55	68	15	44
E. University — industry research collaboration*	6	2	14	17	28	44	78
F. Capacity for innovation**	12	1	11	4	17	66	89
G. Gross expenditure on R&D (% of GDP)*	21	8	6	3	2	34	31
H. Stakeholder engagement for developing regulations***	5	15	17	30	13	36	4
Index of Social Robustness of Science	**156**	**128**	**110**	**76**	**63**	**35**	**26**

Sources:

* https://www.globalinnovationindex.org/gii-2017-report

** http://reports.weforum.org/global-competitiveness-report-2014–2015/rankings/

*** http://stats.oecd.org — Better Life Index — Edition 2017

Analysis of the results for the leading countries

United Kingdom. The country is at leading positions in Citable documents H index and in QS University ranking, average score Top 3. It is well presented (among first 10) in sub-indicators such as Stakeholder engagement for developing regulations, University — industry research collaboration, Employment in knowledge intensive services, and ICT use.

One of the main reasons for the high score of UK in Social Robustness of Science is apparently the support of national research policy. The consultancy document of UK government ***"A Vision for Science and Society"*** (DIUS 2008) argues that *"we now need a more mature relationship between science, policy and society, with each group working to better understand the needs, concerns, aspirations and ways of working of the others*" (p. 4). The 2016–2018 Strategy for Public Engagement with Environmental Science[3] appeals for effective science communication, as well as for intensive dialog with the public about the issues in environmental science. In December 2014 a National science and innovation strategy was launged, named "Our plan for growth: science and innovation"[4], where the science — society interaction takes an important place. The government is developing a network of so-called Catapult Centres, which provide business with access to new cutting-edge technologies and to academic expertise, building innovative bridges between research sector and industry (OECD, 2014b).

[3] http://www.nerc.ac.uk/about/whatwedo/engage/public/nerc-per-strategy.pdf

[4] https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/387780/PU 1719_HMT_Science_.pdf

UK is also well known with the quality and prestige of its higher education, particularly regarding the leading research universities. Four of them are among the top 20 in the world and other 12 — in the top 100, according to QS Top Universities 2017 ranking[5]. Moreover, many British universities have developed research units and programs related to science-society interaction. The country has also well-established traditions in communicating science to the public — by popular TV programs, supporting the public understanding of science, by science festivals, numerous science museums and visiting centers, the annually FameLab competition, café scientific initiatives, etc.

Finland. Finland takes the first position in Capacity for innovation and is on second place in University — industry research collaboration, that guarantees an effective realization of the research products. The country is on the prestigious 7th place in ICT use, and demonstrates good achievements in Gross expenditure on R&D as % of GDP and in Employment in knowledge intensive services.

In 2008, shortly after the national innovation strategy was launched in Finland, the Ministry of Employment and the Economy began, in cooperation with a number of stakeholders, to draw up a demand and user driven innovation policy[6]. In 2013, a Resolution on Comprehensive Reform of State Research Institutes and Research Funding was adopted, fostering the high-level research with a strong societal focus, which enables the adequate addressing the problems of Finnish society. Another initiative, launched to support financially the process of commercialization of research outputs, is the New Knowledge and Business from Research Ideas of the Finnish funding agency for innovation — Tekes. Some strategies were adopted also last years to stimulate the advancement of clean technologies and bioeconomy in the country (OECD, 2014a).

Finland widely applies the model of "Living labs" — *"user-centred, open innovation ecosystems based on a systematic user co-creation approach integrating research and innovation processes in real life communities and settings, placing the citizen at the centre of innovation, and having thus shown the ability to better mould the opportunities offered by new ICT concepts and solutions to the specific needs and aspirations of local contexts, cultures, and creativity potentials"*[7].

Denmark. The country holds the first position in ICT use, and it is among the countries with high capacity for innovation. Dennmark is on 6th place in R&D funding and has a strong research system, with well established science base (OECD, 2014). The new innovation strategy, called "Denmark a Nation of Solutions. Enhanced cooperation and improved frameworks for innovation in enterprises"[8], adopted in December 2012, emphasizes the role of the knowledge exchange between research institutions and companies, as well as the need of more demand-driven innovations, making the research outputs more competitive and socially relevant.

The literature speaks of "Danish model" of institutionalized public participation in decision-making on science and technology issues, based on reaching an agreement through discussions, which originated in the 80s of the twentieth century and has received widespread international recognition (Horst, 2012). It is implemented by the so-called consensus conferences "Danish style" (Andersen & Jæger, 1999; Seifert 2006). An important

[5] https://www.topuniversities.com/university-rankings/world-university-rankings/2018

[6] http://julkaisut.valtioneuvosto.fi/bitstream/handle/10024/74963/TEM_oppaat_19_2015_Inspiring_innovation_30112015.pdf?sequence=1

[7] http://s3platform.jrc.ec.europa.eu/documents/20182/138085/Living+labs+for+regional+innovation+ecosystems_update.pdf/7197a890-a0c2–4db6–9e7a-58fd7f63e20d

[8] https://ufm.dk/en/publications/2012/files-2012/innovation-strategy.pdf

feature of the Danish model is that public understanding of science is not seen as diffusion of knowledge only, but as assimilation of different culture of debate, enlightenment, responsibility and participation (Horst, 2012).

Conclusion

The analysis shows that the economically and socially developed countries, meeting the criteria for "knowledge society», have well-functioning and effective R&D systems. However, to achieve high social robustness of science they should be provided with better financial resources, and significant measures and initiatives in science policy should be taken in support of dialogue and interaction between the research sector and various segments of society. Only by intensive knowledge transfer to industry and business, by adopting high educational standards and by intensive involvement of the public, modern science can raise its potential in favor of social progress and prosperity.

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