SCIENCE - SOCIETY RELATIONS ENHANCEMENT: POLICY IMPLICATIONS AND SOME SCIENTOMETRIC EVIDENCES

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Abstact. The paper considers the significant transformations in the social dimensions of science in last decades. It is argued that science is no more "productive force" only, but it becomes a powerful factor for economic growth, enhancement of quality of life and social prosperity. Another tendency is the enhanced science-policy interactions, as well as the growing role of knowledge transfer and research ethics. New concepts, related to the increasing importance of the social functions of science, have occurred - "knowledge society, "knowledge-based economy, "sustainable development". The scientometric study, presented in the paper, based on counting the publications on science-society relations and issuing new scientific journals on the considered topic, supports these statements.

Keywords: science and society, societal impact of science, participatory research, science-industry relations, sustainable development, science policy, scientometric study

Introduction

According to Janez Potočnik, former European Commissioner responsible for Science and Research (2004 – 2009), and currently serving as European Commissioner for Environment, the development of modern science undergoes three major periods, associeted with concrete human values: (I) *The age of truth:* from the Renaissance to the Enlightenment, i.e. the 16th-18th centuries; (II) *The age of progress:* during the industrial revolution, i.e. the 19th century; (III) *The age of responsibility:* since the emergence of „knowledge-based society, i.e. the second half of the 20th century untill nowadays.[1)]

The founder of science studies, John Bernal, stated that science would no longer be just a protected area of intellectual inquiry, but would have as an inherent function the improvement of life for mankind everywhere, being an instrument of social transformation and always acting with consideration of the societal interests (Bernal, 1939).

Analytical framework of the study

During the last decades some significant transformations have occurred in the social dimensions of science. It raises its role in the context of world problems (shortage of natural resources, new health threats, global warming, terrorism, etc.). The science intensifies its social impacts because of emergence of new research fields with huge potential – gene engineering, nanotechnologies and information and communication technologies, cognitive

sciences, increasing in the same time the risks of research misconduct. Science is no more "productive force" only, but it becomes a powerful factor for economic growth, providing knowledge for development of new innovative products and services. It enables the social prosperity and the enhancement of quality of life of the modern societies, regarding better education, healthcare, social security, communications, entertainment, etc. The political aspect of science is related to its contribution to the development and implementation of socially relevant policies. Besides it assists the preservation of the cultural and historical heritage and of national identities, as well as the beneficial interplay between different cultural traditions.

The global intellectual dimension of modern science is also connected to its role for sustainable development, which guarantees a healthy environment and favourable life conditions for the future generations. Science shifts its focus towards prognostics; design of visions and scenarios about the future, i.e. from not directed, curiosity-driven research in the recent past the trend is to socially relevant visionary programs in science. Apparently it grows the interest to long-term developments, with relation to new kind of research products. The climate change is the typical example in this respect, and in more general sense – all activities, related to sustainable development.

As stated by Donald P. Hearth, Former Director of NASA Langley Research Center, in his forward to the book, presenting a series of public lectures on the impact of science on society: *"Science and technology have had a major impact on society, and their impact is growing. By drastically changing our means of communication, the way we work, our housing, clothes, and food, our methods of transportation, and, indeed, even the length and quality of life itself, science has generated changes in the moral values and basic philosophies of mankind"* (Burke et al., 1985).

Since 1980, interest in developing philosophical accounts of scientific knowledge that incorporate the social dimensions of scientific practice has

been on the increase.[2)] It is so, because in the middle 80s of 20th century the system of science and society changes dramatically. In this period the problems of the technology transfer become a priority of the world economic thought. It is a multiplier process, transforming the scientific knowledge in products, which are useful for the society. But only to the end of 90th years of the past century it is definitely realized that the research process had leaved the sphere of pure intellectual exercises and had become an expensive social activity, requiring the regulation by a new social contract.

Science has been rapidly changing. There is an emerging consensus that we are experiencing a *"radical, irreversible, worldwide transformation in the way that science is organized and performed"* (Ziman, 1994). The so called "Mode 2 of knowledge production" has appeared with an emphasis on contexts of application, transdisciplinarity, networking and collaboration, social accountability, involving new actors in research activities, as well as links with various publics, based on a new participatory model of communication (Gibbons et al., 1994; Ziman, 1994; Nowotny et al., 2001). Programme-oriented funding was (and is) a major expression of these new forms of knowledge production. The study of Jensen et al. (2008) has shown that, even in the institution hosting the most fundamental sciences, roughly half of the scientists are in close contact with society, i.e. they popularize or look for funding outside the academic sphere. Metaphors of "discovery," "forging frontiers," and "working at the cutting edge" are giving way to an idea of science as "wealth creating," and "life enhancing," "competitive," "market oriented," and "entrepreneurial" (Cohen et al. 2001).

All these transformations lead to "re-contextualisation of science" toward society – in sense of reducing its autonomy and enhancing of interaction between academic science, governmental sector, business and society.[3)] The quality of research and its excellence (the advancement of science as such) are considered with equal significance as its social relevance. These two compo-

nents converge in the concept of *"strategic research"* (Rip, 2002), replacing the earlier regime "Science, the Endless Frontier" after Vannevar Bush's report to the US President in 1945. In this respect, it increases the importance of the so called "anticipatoty knowledge", including research in form of prognoses, models of development, scenarios for the future, foresight exercises, strategy building, risk assessment and descriptions of possible technological or social phenomena in the future. In general, the anticipatoty research is strongly related to policy purposes, transferring the results of science progress to some socially significant initiatives and measures, making them more effective and reliable.

In the same time, the increasing social role of science during last decades results in promulgation of two new society and economy concepts: *"knowledge society"* and *"knowledge-based economy." The* term "knowledge industry" was extended to "the knowledge economy" by Peter Drucker. As stated by Drucker, almost four decades ago, *"knowledge has become the central factor of production in an advanced, developed society"* (Drucker, 1969). Although both concepts originate from the 1960s and 1970s, they became popular as a policy idea especially at the end of the twentieth century. Developed and less developed countries take the path towards the knowledge society as an effective way to achieve economic prosperity and social advancement. *"Achieving knowledge-intensive growth is no longer the sole prerogative of the highly developed nations … Nor is it the sole prerogative of national policymaking. Value creation depends increasingly on a better use of knowledge, whatever the level of development, whatever its form and whatever its origin.*"[4)]

In 2000 European Commission announced the Lisbon Strategy with its aim to make the EU the most competitive knowledge-based economy in the world, improving the social cohesion and maintaining environmental sustainability. Another important initiative of EC in this respect is the loung-

ing the programme "Science in Society" in FP7. Its objective is to reinforce the societal dimension of the European Research Area, supporting European trans-national research and policy activities, with a focus on the ethical soundness of research and the responsible conduct of science, public engagement in science, and the promotion of scientific education, scientific culture and science ommunication.[5)] The idea of knowledge-based economy and society has been spread worldwide, especially in most developed countries as USA, Japan, Canada, Israel, South Korea, India, China, etc.

In line with these considerations, the goal of scientometrics can be determined as "the improvement of knowledge regarding the development of science and technology, including the link with societal and political or policy questions".[6)]

Research methodology

In order to demonstrate the growing role of science for the modern society, a scientometric study of its research aspects is performed. It is grounded on counting the publications, where the science-society interactions appear as a subject of study, and which contain some specific key words or combinations of them in their title, using the Thomson Reuters' Web of Science database. In one case the selected key words have been searched in the topic of the publication, not only in the title, in order to display more clearly the publication dynamics over the years. The document type distributions and those of countries – origins of the publications, are shown as well.

Another scientometric indicator, used to support our research statements, is the dynamics of editing new scientific journals in the field of science and society relations. They are identified using various databases and searching tools such as Google.

Study outcomes

The first investigated key word combination is "science AND society". The total number of found documents is 3845. Most of them are book reviews (1270), followed by 1127 articles and 942 editorial materials. The proceeding papers are 146, and the reviews – 90.

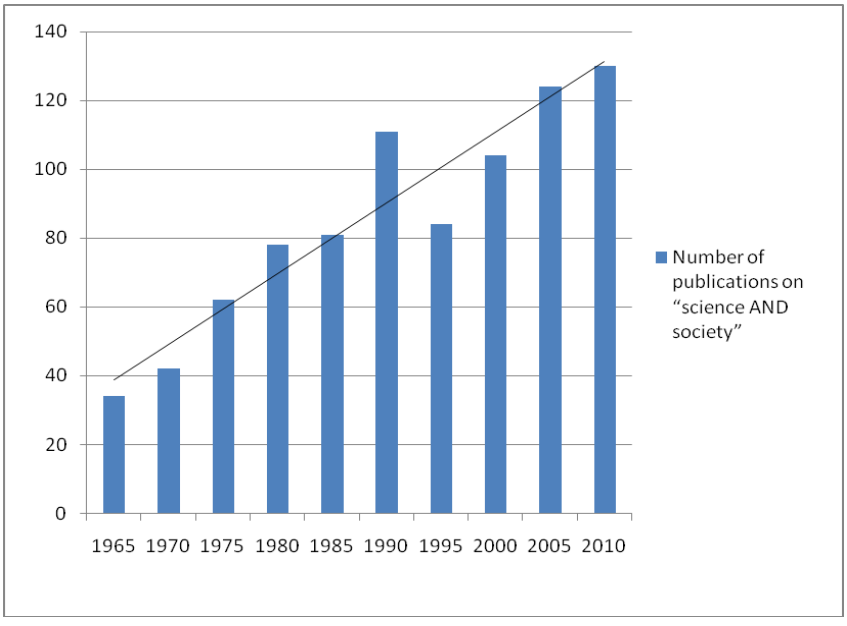


Fig. 1. Number of publications on "science AND society" according to "Web of Science"

The publication distribution over the years indicates a tendency to stable increase (Fig. 1). USA is the leading country, publishing on the considered topic, followed by England, Canada, Germany and Australia (Fig. 2).

As expected, similar results are obtained in case of combination "science AND public." The positive trend in number of publications is here even more visible (Fig. 3).

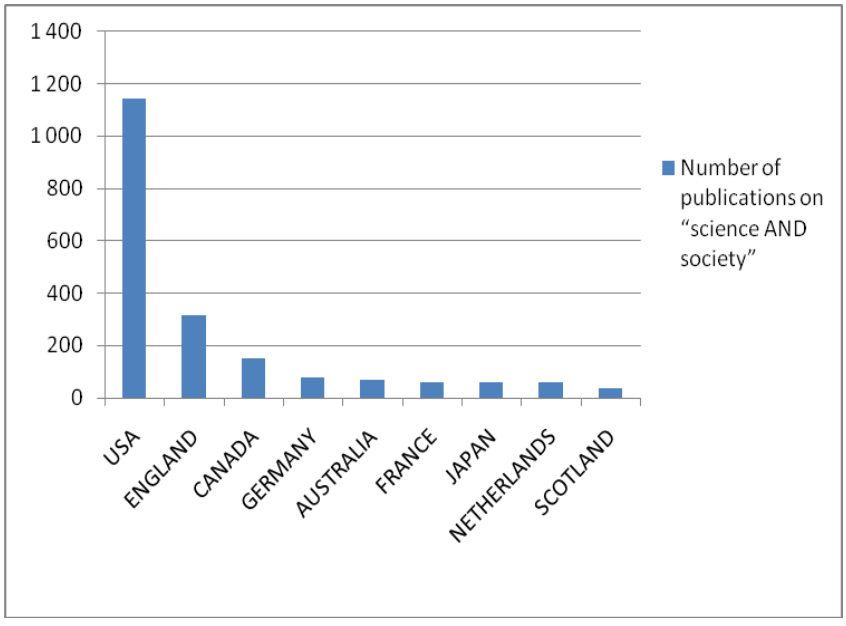


Fig. 2. Countries with biggest number of publications on "science AND society" according to "Web of Science"

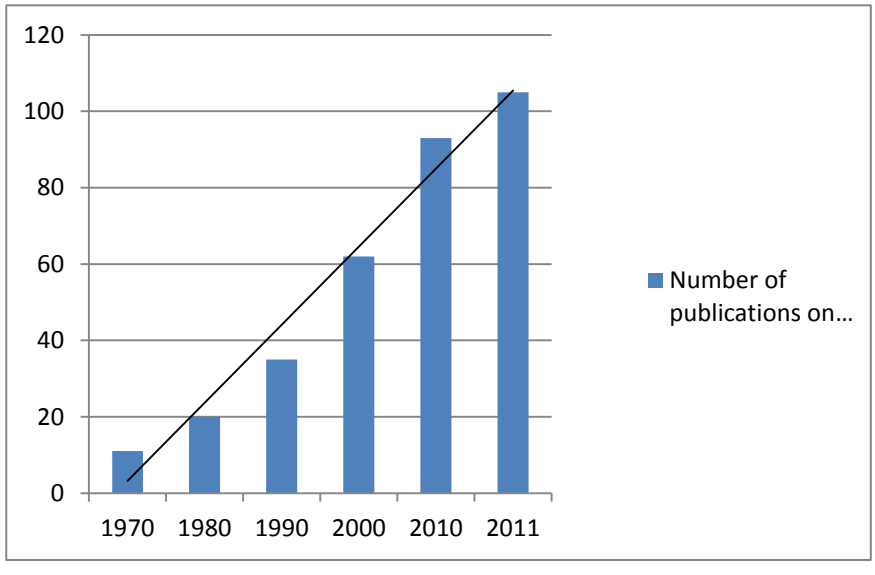
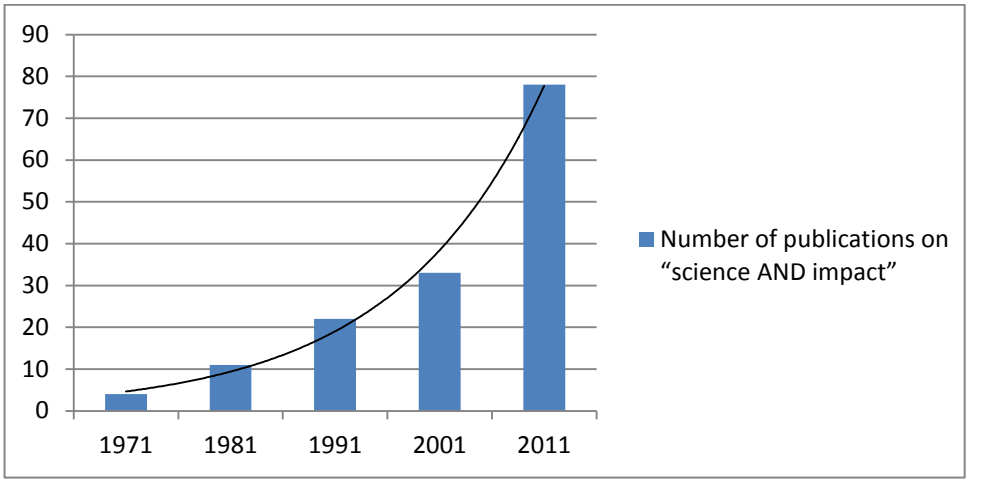
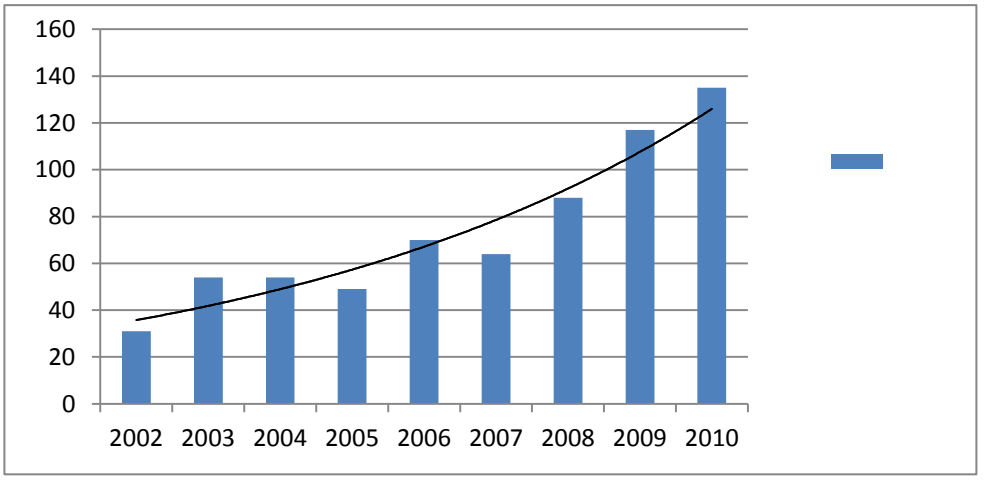


Fig. 3. Number of publications on "science AND public" according to "Web of Science"

We have examined also the publication distributions on “science AND impact”, “participatory AND research”, (science AND industry OR "knowledge transfer"), “science AND culture” and ("scien* AND ethic*" OR "research AND ethic*"). The results regarding the publication dynamics are displayed on Fig. 4. In all cases the numbers of the extracted documents from Web of Science database are growing during the selected periods of time, and this fact corroborates the thesis of the increased interest to the topic of science-society relations and interactions. Concerning the countries – origins of the found publications, USA is always much before other countries, and most active in publishing on the considered topics it turned out to be UK, Canada, Germany, Australia, Netherlands, and France. From the region of Asia among most productive countries they appear sometimes Japan, China, and India.

Another important indicator for the growing role of science for society are the enhanced policy implications of research activities, on one hand, and the growing role of research policy towards development of science, on the other hand. Therefore the key word combinations “science AND policy” and (foresight OR "anticipatory research") were used in order the publication activity in the considered field to be revealed. In case of key words “science AND policy” the amount of 4 453 documents was found, from them – 1 740 articles, 916 editorial materials, 914 book reviews and 424 proceedings papers. The combination (foresight OR "anticipatory research") has retrieved 1 082 scientific documents with similar distribution under type: 532 articles, 191 editorials, and 145 proceedings papers. The book reviews here are less – only 51. Fig. 5 shows the diachronic distribution of the papers.


90
80
70
60
50
40
30
20
10
0
1971
1981
1991
2001
2011
Number of publications on "science AND impact"


160
140
120
100
80
60
40
20
0
2002
2003
2004
2005
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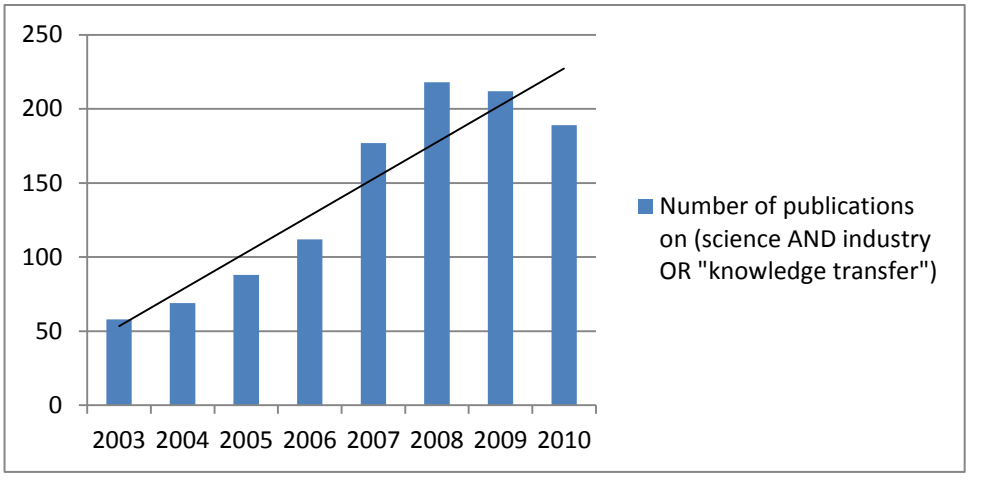
2009
2010


250
200
150
100
50
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2003
2004
2005
2006
2007
2008
2009
2010
Number of publications on (science AND industry OR "knowledge transfer")

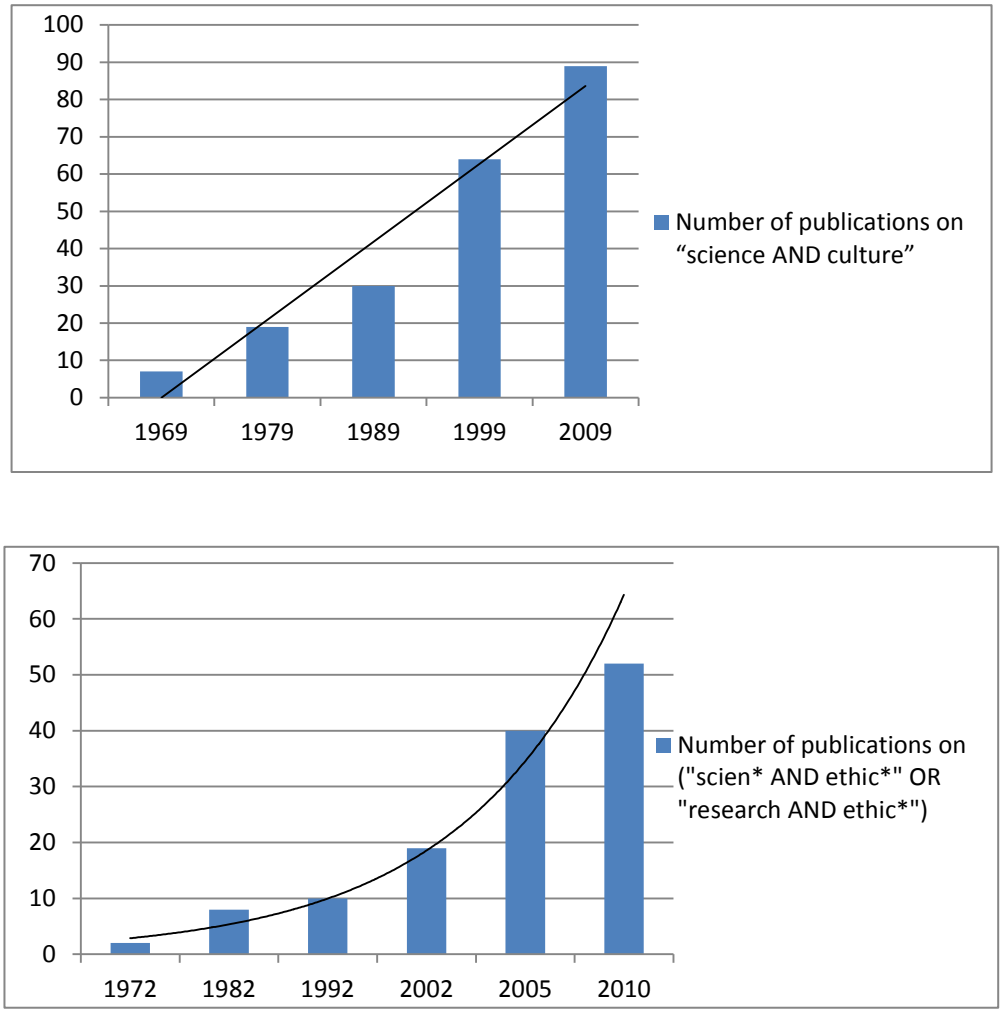

Fig. 4. Number of publications on "science AND impact", "participatory AND research", (science AND industry OR "knowledge transfer"), "science AND culture" and ("scien* AND ethic*" OR "research AND ethic*") according to "Web of Science"

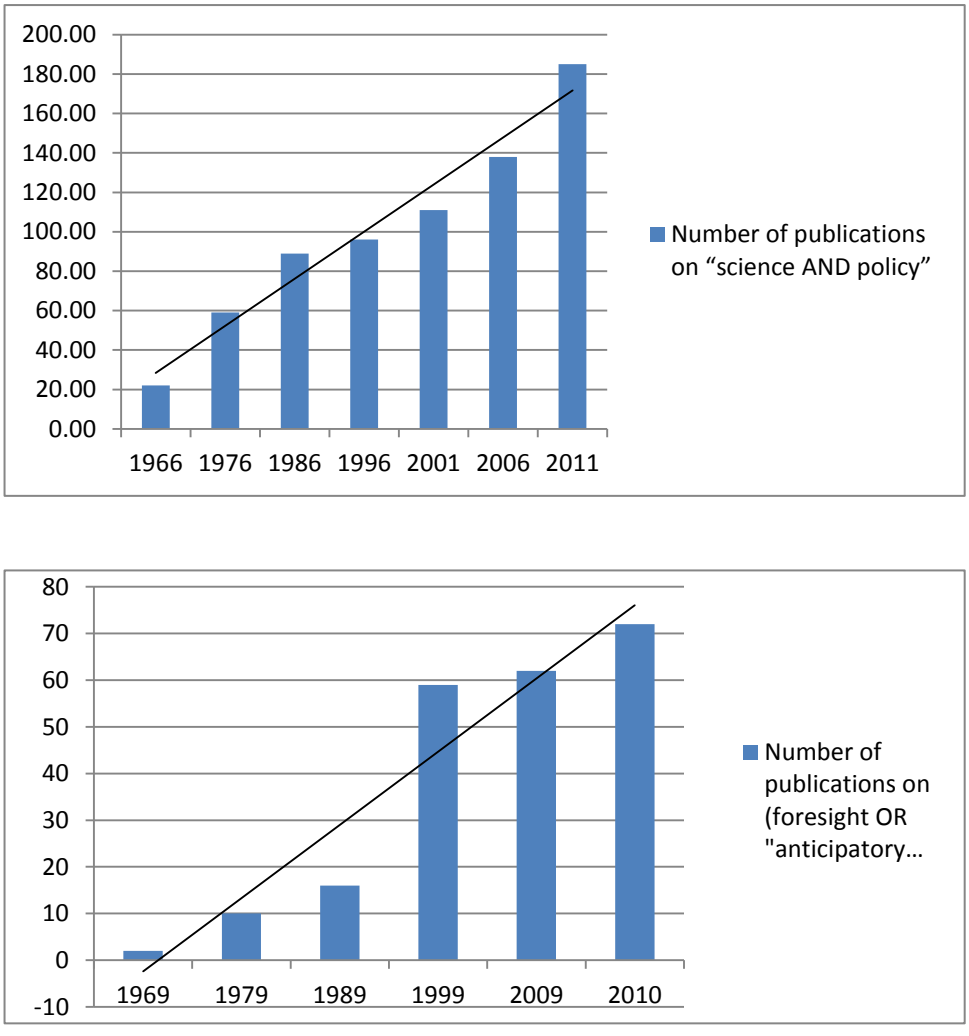

Fig. 5. Number of publications on “science AND policy” and (foresight OR "anticipatory research") according to “Web of Science”

The well performed countries in field of science and policy interactions are USA with largest number of publications, followed by England, Canada, Australia, and Netherlands (Fig. 6).

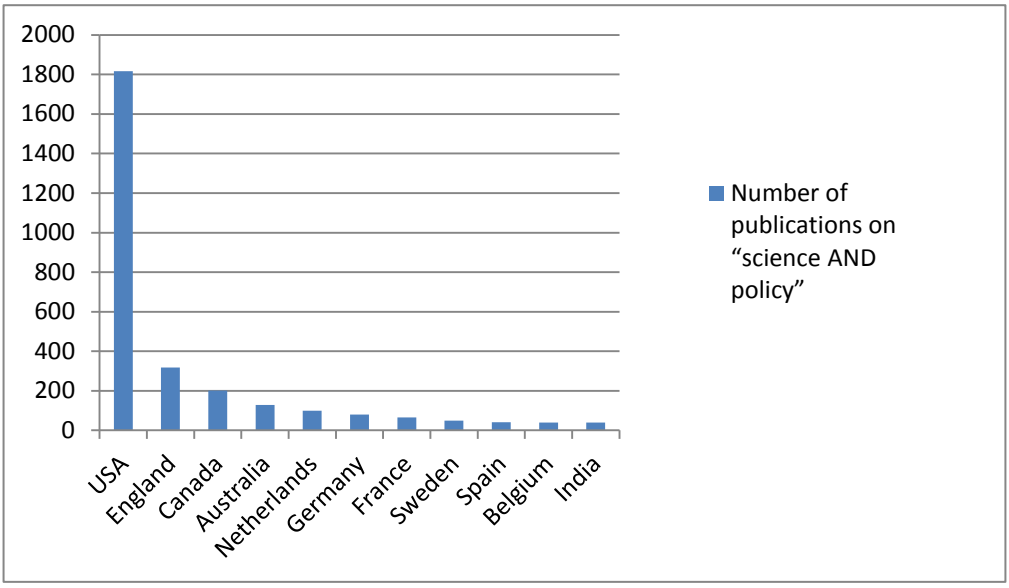

Fig. 6. Countries with biggest number of publications on "science AND policy" according to "Web of Science"

Further, the publication activity in research field, labeled with the keywords ("knowledge based society" OR "knowledge based economy") is also investigated. The amount of documents, containing one of both key word combinations in its title, is not so large in size – totally 245 publication were found, most of them (107) – proceedings papers, followed by 84 articles and 32 book reviews. But the time distribution shows again a strong trend to growing of publication number (Fig. 7).

Similar tendency we have obtained in the topic "sustainable development"**,** being another important indicator for the rising role of modern science for the society and economy (Fig. 8).

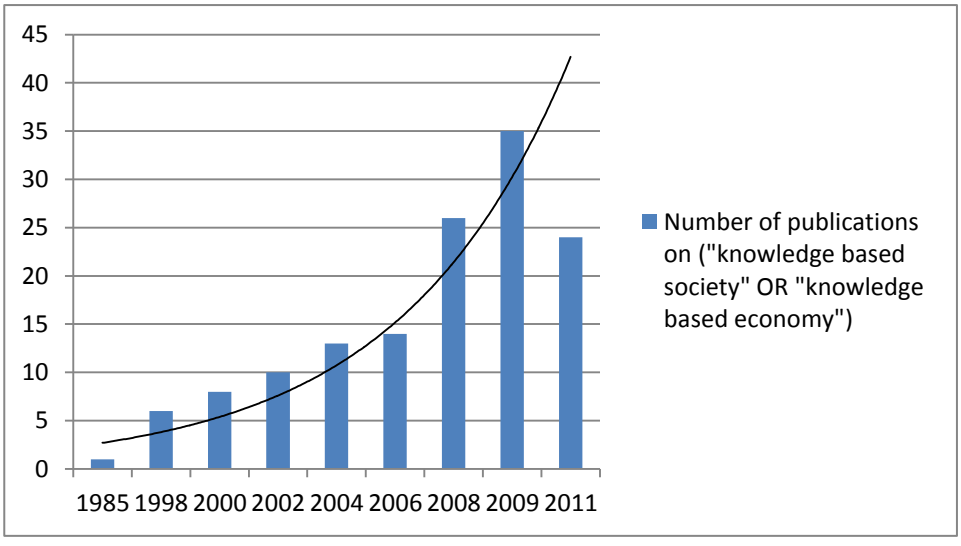

Fig. 7. Number of publications on ("knowledge based society" OR "knowledge based economy") according to “Web of Science”

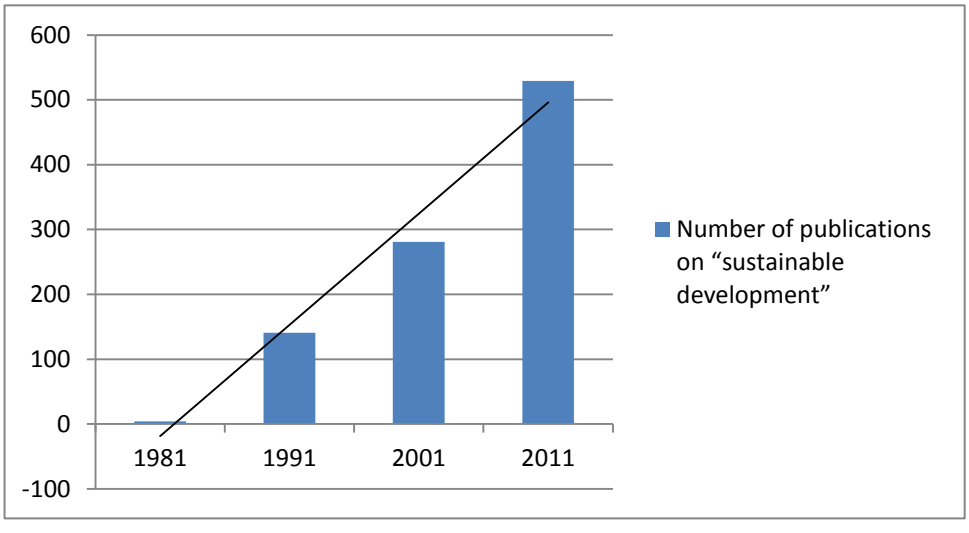

Fig. 8. Number of publications on “sustainable development” according to “Web of Science”

And now we will present the results of the second part of our study – the investigation how many journals, related to science – society links, have been appeared during last decades. The results are displayed in Table 1. They indicate an increasing research interest in the considered topic, expressed in stable growing of number of the new journals, related to science and society. For more clarity we refer to the description of the thematic scope of some brand new journals in the considered field.

"*Synesis* publishes original papers that address science, technology, ethics and policy – both singularly, and in intersection. The journal welcomes submissions that seek to form intellectual bridges within and between the disciplines, and in so doing develop insight to the important issues, questions, problems and possible solutions that engage science and technology as a social force."[7)]

"The *International Journal of Science in Society* provides an interdisciplinary forum for the discussion of the past, present and future of the sciences and their relationships to society. Conference presentations and Journal articles range from broad theoretical, philosophical and policy explorations, to detailed case studies of particular intellectual and practical activities at the intersection of science and society."[8)]

"The *Journal of Science and Technology Policy in China* (JSTPC) aims to offer a fluid debate on science and technology issues in the hope of influencing the wider community of policy makers and contributors."[9)]

Table 1. Journals related to science and society topics, classified by their date of foundation

till 1970	1971-1980	1981-1990	1991-2000	2000-2010	2011-2012
Socio-Economic Planning Sciences Technological Forecasting and Social Change Environment: Science and Policy for Sustainable Development	Evaluation Review Science Communication Social Studies of Science Science and Public Policy Research Policy Science, Technology & Human Values	Bulletin of Science, Technology & Society Review of Policy Research IEEE Technology and Society Magazine	Society and Animals: J. of Human-Animal Studies Peace Economics, Peace Science and Public Policy Sustainability: Science, Practice, & Policy Environmental Science & Policy Ecology and Society Science Technology & Society Science and Engineering Ethics	NanoEthics J. of Science Communication SYNESIS: a J. of Science, Technology, Ethics, and Policy Genomics, Society and Policy J. J. of Science and Technology Policy in China	Int. J. of Science Education Part B: Communication and Public Engagement J. of Science Policy & Governance J. of Low, Science, and Policy Int. J. of Science in Society

Conclusions

In the presented study we have identified a growing research interest in field of science and society relations, social relevance and societal impacts of science, science-policy interactions, etc., expressed by increasing publication activity and process of setting up new journals on the considered topic. The growing numbers of scientific documents in subjects as "knowledge transfer", "anticipatory research and foresight", "research ethics" also support this finding.

The rising role of science for the modern society is indicated as well by the wide spread of new concepts as "knowledge society", "knowledge-based economy" or "sustainable development".

Another important result of our study is related to the assumption that the strong commitment of science with societal problems and values is a phenomenon, characteristic for most regions of the world. We have found out that countries in North America, Europe, Asia, and Australia carry out increasing research in this sphere.

These outcomes require more active concern of science policy makers in order to address adequately the growing role of science-society interactions.

NOTES

1. http://ec.europa.eu/archives/commission_2004 2009/potocnik/news/docs/20051110_speech_budapest.pdf
2. http://plato.stanford.edu/entries/scientific-knowledge-social/
3. ftp://ftp.cordis.europa.eu/pub/fp7/sis/docs/sis_masis_report_en.pdf
4. http://unesdoc.unesco.org/images/0018/001899/189958e.pdf
5. http://unesdoc.unesco.org/images/0014/001418/141843e.pdf
6. http://sciencescitoyennes.org/wpcontent/uploads/2011/09/STACS_Scientometrics.pdf
7. http://www.synesisjournal.com/
8. http://science-society.com/journal/

9. http://www.emeraldinsight.com/products/journals/journals.htm?id=jstpc

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Gibbons, M., Limoqes, C., Nowotny, H., Schwartzman, S. & Scott, P. (1994). *The new production of knowledge: the dynamics of science and re-search in contemporary society.* New York: SAGE Publications.

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Nowotny, H., Scott, P. & Gibbons, M. (2001). *Re-thinking science: knowledge and the public in an age of uncertainty*. Cambridge: Polity Press.

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