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Interdisciplinarity dimension in Research Information Systems – evidence from Poland

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Abstract

Research information systems (RIS) or scientific information systems (SIS), alike enterprise information systems (EIS), should cover interdisciplinarity aspects as a dimension that influences significantly research potential and activity of particular scientists.

The aim of the work is to investigate the Polish scientific environment related to life sciences and engineering, with reference to its interdisciplinarity. It is believed that researchers having knowledge and experience in many different scientific areas are more successful and prone to make substantial scientific discoveries. Analysing Polish scientific achievements with respect to research projects granted and publications of the leading researchers, author states that scientists with multi-scientific background are more effective in granting additional funding for research. However, multidisciplinarity (interdisciplinarity), in terms of subject areas of specialization, has limitations. Author expects, that number of disciplines in which particular scientist has an experience might be extended with a success only to certain level.

Preliminary results suggest, that interdisciplinarity background of individual scientists need to be incorporated in RIS/SIS as an obligatory dimension. It is of great importance for potential research cooperation, policy advisors and authorities financing research activities, as well as for business searching for professionals in differentiated scientific fields.

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Keywords: scientific information system; interdisciplinarity; multidisciplinarity; bibliometrics

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1. Introduction

The concept of interdisciplinarity in research has recently received a lot of attention and interest from researchers, policy authorities and society. Discussion over the subject concentrates around the changing social and intellectual organization of the sciences and scientific disciplines, together with their impact on solving world's economic problems by applying innovative solutions.

Interdisciplinarity is often perceived as the core identification, weather the research is to be successful, prone to make breakthroughs and to generate more relevant outcomes. Interest in the issues related to the interdisciplinarity of research is increasing [1]. It takes place not only within scientific environment, but also among authorities, political bodies and entities responsible for research funding. Interdisciplinary scientific fields attract policymakers and business environment attention at local and global levels. It is caused by their strategic position in the development of science and technology and due to their high commercial potential [2][3][4]. As it is given in documentation of Polish authorities financing scientific research, "it is necessary to constantly verify areas of interdisciplinary scientific research and development work aimed at the acceleration of the sustainable economic development for the improvement of life quality of the Polish society. The selection of such priorities permits more rational use of results of the research in practice and the creation of preferences for them in the allocation of financing, which is intended to rationalise and prioritize the use of resources" [5].

Having in mind above statements, it is important to state a question, whether the level of scientific multidisciplinarity can be extended to the infinity? At which level of scientific disciplines involved in research one can talk about interdisciplinarity or specialized multidisciplinarity? Is it possible to overextend this number? Another problem arises consequently, if the interdisciplinarity matters in real life research? Is it really significant for successful scientists to have feedback and experience in different specialized scientific fields [6]? Taking the case of Polish scientists conducting research in engineering and life sciences, author tries to discuss above questions.

2. Databases and methodology

2.1. Data

Databases processed for the case study analyses are prepared on basis of data available from the Foundation for Polish Science (FPS) website, concerning the PARENT/BRIDGE[†] Grant Programme and from the Scopus bibliometric resources. The PARENT/BRIDGE Grant Programme, within the bio-, info- and techno- thematic areas is co-financed from the Priority Axis 1. Research and development of new technologies, Measure 1.2 Improvement of human potential of science" OP IE 2007-2013.

In literature there is present a strong statement, that research within the biotechnology, nanotechnology, information technology and engineering is overlapping and construct per se the nano-biomedical science [7]. These research disciplines are highly interdisciplinary, combining bio-, nano- , techno- and info- scientific fields. At the same time, they are described as a source of a high number of discoveries and innovation

[†] The PARENT/BRIDGE programme application addresses to women and men with a child (up to 4 or 7 years, depending if born or adopted), who have taken leave or interrupted their work in connection with having a child for an uninterrupted period of at least 6 months. There is the condition that the return to research work after such leave (or interruption) occurred prior to the application deadline but no earlier than 12 months before the application deadline.

applications in life sciences and medicine [8]. The above review was the basis for the selection of the group of research projects and scientific leaders being subject for further analyses in the case study.

They were five editions of the PARENT/BRIDGE Grant Programme, FPS, within its duration in period 2010-2012. Following edition was in progress of applications evaluation while the analyses performed. The final call for seventh programme edition has been just announced. Once the results for the first five programme were available, the presented study analyses concern the beneficiaries, that have successfully submitted applications. Thus the given research evaluates grants for 58 entrepreneurial scientists, among which occurred only one man. The submission process was performed via online application, which gave the author a possibility to analyse all projects accepted for financing.

The second on-going part of the research work performed for this paper, consist of analyses on the scientific leaders submitting successfully their research proposals for the calls of Ministry of Science and Higher Education, Poland in period 2008-2012. They were more than 10000 projects accepted by the Ministry for financing, but the analyses concentrate on projects based in engineering and life sciences, in particular in (bio-, info- and techno- areas). These projects consist of, accordingly to different types of calls, about 6000 observations.

2.2. Research methods used

Within the context of current research, interdisciplinarity is observed from two different perspective. One aspect concentrates on the multi-scientific areas covered by particular research projects, other perspective analyses experience and knowledge of individual leading researchers. Both approaches are merged here and lead to evaluation of scientific performance of leading researchers, described here as individuals applying (to FPS or MSHE) with a success for an supplementary funding for their research.

In particular, analyses concentre on data referring to bibliometrics, i.e. publications, citations, together with the *h-index* of particular leading researchers. The enumerated features are analysed with reference to thematic areas of specialization, understood as scientific disciplines, in which research is performed and its results published. The bibliometric data given are subject to statistics analyses and correlation measures, both in terms of linear and on-linear correlations between pairs of independent variables.

In case of projects submitted to the Ministry, the database used for analyses is prepared on the basis of research leaders (team leaders) experience info and data given in the Information Processing Institute databases, with reference to the bibliometric data stated in the Scopus database. Preliminary comparative analyses of both databases are in progress.

3. Research analyses and preliminary results

3.1. Case study description

Results presented here, followed by the discussion are referring to the analyses of the interdisciplinarity levels of the research leaders accepted for the financing by the FPS.

According to data provided, they were 423 proposal applications submitted for five programme editions. With 58 projects accepted it gives the total success rate at the level of 13,71%. The grants success rate within different thematic areas of bio-, info- and techno-, was however diverse. The number of proposals in particular thematic areas, compared to the number of applications accepted is presented in Table 1.

Table 1. The number of proposals in particular thematic areas

Thematic Area	No of project proposals	No of projects accepted	Success rate %
Bio	241	31	12,86
Bio-Info	17	2	11,76
Bio-Info-Techno	13	0	0,00
Bio-Techno	38	8	21,05
Info	21	5	23,81
Info-Techno	21	3	14,29
Techno	72	9	12,50
Total Number	423	58	13,71

Candidates for scientific grants were enabled, during the submission process, to select more than one thematic area to which their proposal is assigned. The area of biosciences is the most popular one, both in the number of project proposals, and the number of projects selected for financing. The number of research projects accepted in topics related to bio-techno and techno- areas are also at high level. While there were submitted projects proposals covering all three thematic areas, there has not been accepted any of these projects. Due to this fact, analyses referring to the interdisciplinarity in triple specialized fields was not possible.

It is needed to underline that 82,76% of grants within the PARENT/BRIDGE Grant Programme belong to the bio-techno related thematic areas. The subjects covered by their research are described in literature as biotechnology, bionanoscience, biomedicine or nano-biomedical sciences [8]. Multiplied thematic areas suggest greater interdisciplinarity represented by particular project proposals, in comparison to proposal applications allocated to singular thematic area.

Further analysis has been focused on projects and their coordinators performance separately for projects relating to bio and non-bio thematic areas. There has been identified 41 research projects related to the bio-thematic areas, while other projects has been defined as non-bio. Author has enumerated 17 projects not assigned to bio research.

3.2. Scientific disciplines and statistics

Projects proposals for the analysed granting programme, apart from their assignation to the appropriate thematic areas, has also indicated basic scientific discipline they belong to or rooted from. Researchers were asked to indicate this discipline on the open question base. That resulted in various specialization levels of disciplines chosen. There are answers referring to chemistry or physics as general, while very specific areas of oncology (e.g. oncological endocrinology) are indicated. The summary of the discipline origins, normalised according to the keyword selection of the research topics, is presented in Table 2.

Searching for the interdisciplinarity background of individual researchers, it has been decided to concentrate analyses on the publication performance of the individual scientists. Bibliometric data collected from the Scopus database has been used, with respect to documents, *h-index*, number of citations, publications and disciplines specialization of researchers understood as subject areas in which they publish.

The methodological approach used here was the one enhancing the proposal evaluation procedures of the FPS. Project applications for the PARENT/BRIDGE Grant Programme were assessed and scored according to the quality of the project content with respect to the significance of the publication activity of the author. The interdisciplinarity dimension (disciplines of specialization) was not assessed.

Table 2. The number of proposals in particular thematic areas with reference to scientific discipline

Scientific discipline	No of projects assigned	Bio/Non-bio
Biochemistry	9	Bio
Chemistry	8	Non-bio
Molecular biology	14	Bio
Biotechnology/Medicine/Medical engineering	13	Bio
Physics	5	Non-bio
Biology/Evolutionary Biology	3	Bio
Environmental sciences	2	Bio
Nanotechnologies/Materials engineering	3	Non-bio
Computational science	1	Non-bio
Total	58	41/17

The work presented here has covered also aspects reflecting research interdisciplinarity within areas. As disciplines of origin affiliated to project proposals were indicated on the open-question base, they were not used in further analyses. The diversity in answers was very high, and apart the overall outlook of heterogeneity, they cannot be used for measuring interdisciplinarity. For this purpose, subject areas of documents published by individual scientists, indicated in the Scopus database, has been taken into account. These subject areas are described in paper as scientific disciplines in which researchers have experience in.

Statistics for variables presenting scientists activity are given in Table 3. The average levels for number of publications and number of citations are higher for scientists performing in non-bio-related research areas. While the number of subject areas, together with the value of the *h-index* are on the similar level, non-depending on the thematic area of the project. Having in mind the last result, the correlation analyses was conducted.

Table 3. Statistics for variables

No	Publications	h-index	Citations	Disciplines
Bio average	14	6	186	4
Non-bio average	22	7	227	5
Total average	17	7	198	4
Bio St. error	13,28	3,85	202,35	1,61
Non-bio St. error	15,24	4,58	271,59	1,64

3.3. Correlations

The created database for the leading researchers successfully applying for external founding from the FPS, completed with information on the number of publication in ISI journals, citations, *h-index* given was supplemented with number of disciplines in which particular scientists publish. The basic statistics presented above give only preliminary information on the similarities and differences between scientists performing research in engineering and life sciences. In particular results concern special group of these researchers – young females (between 25-40), holding PhD. Degree. At the same time on-going preliminary analyses of data referring to research projects financed by the MSHE, Poland in period 2008-2012 are promising with respect to overall outlook on population of Polish leading scientists.

Correlations between pairs of variables representing research performance of scientists co-financed by the FPS are presented in Appendix A.

While analysing results one can see significant and relatively strong correlation between number of publications and number of disciplines in which papers are published. Pearson correlation and Spearman's rho correlation coefficients are strong, respectively at the level of 0.514 and 0.586.

At the same time linear and nonparametric correlation between disciplines of specialization and *h-index* are also relatively strong – above 0.39 level. In depth study on h-index and its correlation with disciplines of specialization, with respect to number of papers published overtime, suggest however, that there is a certain data interval for number of disciplines, that gives a greater chance for success. The success is understood here as a higher *h-index*. It is suggested by the results, that researchers having specialization in 3-6 disciplines, are these with an average higher *h-index.* The visualisation of these results is given in section A3 in Appendix A.

The correlation between number of citations and *h-index* is at very high, significant level, but these arises from the structure constituting of high dependence between these two variables. Thus this correlation is not analysed here.

4. Results discussion

Initial results for the case study of the FPS beneficiaries give an overview, that appreciated levels of interdisciplinarity in life and engineering sciences among successful researchers is suggested between 3-6 disciplines of specialization. Higher number of scientific disciplines indicated in experience may lead to fragmentation of research projects performed or lower significance of research results obtained. At the same time number of indicated scientific disciplines specialization lower than three suggests inexperience of scientists and may lower success rate of research projects performed.

It is visible that smart specialization in interdisciplinarity of research fields matters. However, not very strong correlation results obtained for the initial case study might suggest, that multidisciplinary background of researchers is taken too seriously while making decisions concerning financing research projects. Young researchers, even innovative and prone for discoveries, might not be accepted for financing if not prove greater interdisciplinary specialization enumerated in number of publications with high impact factor. They can overcome this obstacle only by publishing more in a longer time. However, as it is presented, higher number of publication in very wide range of disciplines might have no impact on *h-index* if the papers are of low quality or not significant. The number of citations is then at low level.

As expected, the current analyses performed on the FPS beneficiaries database suggest that interdisciplinarity level should be incorporated in existing scientific information systems. It is core to include number, and if possible names, of disciplines of specialization in most popular research information system databases. It will be crucial for potential science cooperation, publications and leaders, together with peer reviewing business search. It is visible, that relating only on *h-index* measure and citations is no fully appreciable.

Results of the analyses conducted, appropriately interpreted, may also be exported to the studies on Enterprise Information System. In particular it can be used in research methodology of operation management functions. As stated in modern literature, research issues in the management field are becoming increasingly interdisciplinary. Linkages and relations between the fields are becoming more important than the individual fields themselves [9]. Redefinition and reorganisation of the operation management is reflected in evaluation of its information system. Recent research and studies on operation management information system give an evidence to its evolving interdisciplinarity and raise awareness for the need of inter-organizational research [10]. Thus, the modern IT enterprise systems include in their architecture structure matrixes covering multidisciplinary aspects of business performance (i.e. related to resources, customers, together with knowledge and technologies used for production, management and marketing within enterprise) [11], [12].

Systems supported by IT infrastructure need to be based on knowledge models able to capture inherent complexity of enterprise services systems and serve as a building blocks for a more complex automated-reasoning systems [13]. Having in mind current research results it is important to understood that number of fields taken into consideration for multidisciplinary approach, should be limited. As presented in analyses, excessive interdisciplinarity might be either ineffective for the information system clarity, or not satisfactory for achieving intended results.

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References

[1] Bar-Ilan J., January 2008, Informetrics at the beginning of the 21st century—A review; Journal of Informetrics, Volume 2, Issue 1, , Pages 1–52;
[2] Heimeriks G., 2012, Interdisciplinarity in biotechnology, genomics and nanotechnology, Science and Public Policy, - spp.oxfordjournals.org;
[3] Heimeriks G., Leydesdorff L., 2012, Emerging search regimes: measuring co-evolutions among research, science, and society, - Technology Analysis & Strategic 44 p. 51-67;
[4] Tang, X., Yang, C. C. and Song, M., 2013, Understanding the evolution of multiple scientific research domains using a content and network approach. J. Am. Soc. Inf. Sci., 64: p. 1065–1075;
[5] Operational Programme Innovation Economy 2007-2013, October 2007, National Strategic Reference Framework 2007 – 2013, Ministry of Regional Development, p. 79, 81-82;
[6] Morris, S. A. and Van der Veer Martens, B., 2008, Mapping research specialties. Ann. Rev. Info. Sci. Tech., 42: p. 213–295;
[7] Pei R., Porter A.L. (2011), Profiling leading scientists in nanobiomedical science: interdisciplinarity and potential leading indicators of research directions, R&D Management 41 (3), 288-306;
[8] Meyer M., Rafols I., 2010, Diversity measures and network centralities as indicators of interdisciplinarity: case studies in bionanoscience, Scientometrics Vol. 82 No.2, p 263-87;
[9] Nambisan S., 2003, Information Systems as a Reference Discipline for New Product Development, MIS Quarterly, Vol. 27, No 1, pp. 1-18;
[10] Buhman C., Kekre S., Singhal J., 2005, Interdisciplinary and Interorganizational Research: Establishing the Science of Enterprise Network, Production and Operations Management, vol. 14, No 4., pp.493-513
[11] Brown C., Vessey I., 2003, Managing the Next Wave of enterprise Systems: Leveraging Lessons from ERP, MIS Quarterly Executive, Vol. 2, No 1, pp. 45-57;
[12] Badii A., sharif A., 2003, Information management and knowledge integration for enterprise innovation, Logistic Information Management, Vol. 16, Iss:2, pp. 145-155;
[13] Sicilia M.A., Kop C. and Sartori F.(Eds.), 2010, ONTOSE 2010, LNBIP 62, pp. 135-147.

Appendix A. Correlations and Nonparametric Correlations

A.1. Correlations

N=57		No publications	h-index	No citations	No disciplines
No publications	Pearson Correlation	1	,813**	,770**	,514**
	Sig. (2-tailed)		,000	,000	,000
h-index	Pearson Correlation	,813**	1	,926**	,391**
	Sig. (2-tailed)	,000		,000	,003
No citations	Pearson Correlation	,770**	,926**	1	,270*
	Sig. (2-tailed)	,000	,000		,042
No disciplines	Pearson Correlation	,514**	,391**	,270*	1
	Sig. (2-tailed)	,000	,003	,042	

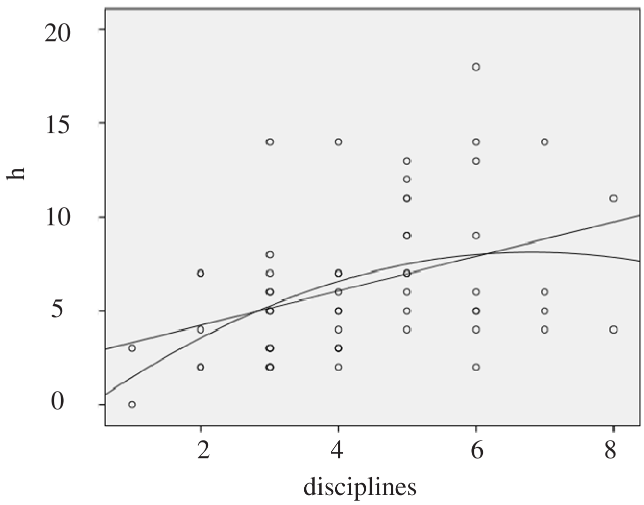
**. Correlation is significant at the 0.01 level (2-tailed).
*. Correlation is significant at the 0.05 level (2-tailed).

A.2. Nonparametric Correlations

N=57		No publications	h-index	No citations	No disciplines
No publications	Spearman's rho Correlation Coefficient	1,000	,849**	,787**	,586**
	Sig. (2-tailed)	.	,000	,000	,000
h-index	Spearman's rho Correlation Coefficient	,849**	1,000	,947**	,394**
	Sig. (2-tailed)	,000	.	,000	,002
No citations	Spearman's rho Correlation Coefficient	,787**	,947**	1,000	,341**
	Sig. (2-tailed)	,000	,000	.	,009
No disciplines	Spearman's rho Correlation Coefficient	,586**	,394**	,341**	1,000
	Sig. (2-tailed)	,000	,002	,009	.

**. Correlation is significant at the 0.01 level (2-tailed).

A.3. Correlations and Nonparametric correlations for disciplines and h-index



linear regression 0.180
R^2 0.153