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Citation analysis as a practical tool for managers and entrepreneurs: selected scientometric concepts relevant for business model improvement

Abstract. *Entrepreneurs often face the challenge of hiring academic researchers who could provide know-how or serve as potential business partners, collaborators or expert consultants. Since hiring experts may be costly, it is essential that only the best specialists be used. I this article I describe some quantitative scientometric tools (such as h-index and g-index) aimed at evaluating the academic quality of institutions or of individual researchers. Such tools provide information that is easily accessible, comprehensible and merit-based, although they must be used with caution, since disciplines differ in the absolute values of indexes. I show how to use scientometrics in a comparative manner in order to document low output and poor quality of the publications of Polish academic authors in the area of business and management. I also argue that some governmental procedures for rewarding academic excellence are not effective because they reduce incentives for publishing academic papers in English.*

Keywords: *bibliometrics, citation analysis, consulting, entrepreneurship, h-index, management, scientometrics*

Introduction

In general, any field of human professional activity can (and, I believe, should) become analysis-driven and data-dependent. This kind of philosophy and attitude generate vast amounts of information, about partners, customers, suppliers, competitors etc., current fad is to refer to them as Big Data and there is a good reason for it[1]. In a modern knowledge-based economy, relying on intuitive decisionmaking is no longer sufficient for entrepreneurs or managers who do not have the luxury of allowing "truly significant attainments become lost in the mass of the inconsequential."[2]

Currently, most business ideas are somehow related to scientific results and entrepreneurial genius must locate such "significant attainments" (i.e. signal) among the "inconsequential" data (i.e. noise) and turn them into innovative and commercial products or services faster than competitors. However, how to know which results are truly significant before they become common knowledge (because by then, it is too late)? How are business-educated entrepreneurs to know where the actual merit-based developments happen in such fields as bio- or nanotechnology, or even telecommunications, as well as, which players are the ones who should be approached either for advice or with potential collaboration offers?[3]

To maintain a competitive advantage, one must extrapolate from current insights and that requires expert knowledge and a mosaic of skills[4] (also metaphorically called "innovator's DNA"[5]). The pace of change in industry and the staggering complexity of the contemporary business environment force business people to rely on expert consulting.[6] Since hiring experts may be a costly part of a firm's operating budget, it is essential that only the best specialists, i.e. those whose advice is state-of-the-art, be utilized. However how does one find them?

To succeed, managers and entrepreneurs must cross the divide between business and academia, to face the challenge of assessing the quality of academic researchers who could provide know-how or serve as potential business partners, collaborators or expert consultants. In this process, innovative entrepreneurs are becoming intellectuals. In addition, enterprises are forced to undergo the process of rapid „intellectualization."[7]

Innovative managers face pressures to introduce the latest developments in fields related to production management, logistics or robotics. Similarly, they need ways of identifying experts of the best possible quality.

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[1] A. McAfee, E. Brynjolfsson, *Big Data: The management revolution*, "Harvard Business Review" October 2012, no. 90, pp. 60-68; T.H. Davenport, D.J. Patil, *Data scientist: The sexiest job of the 21st century*, "Harvard Business Review" 2012, no. 90, pp. 70-76.

[2] V. Bush, *As we may think*, "Atlantic Monthly" 1945, no. 176, pp. 101-108.

[3] M. Jasieński, *It's incredible how often we're surprised by findings*, "Nature" 2006, no. 440, p. 1112; M. Jasieński, *Garfield's Demon and "surprising" or "unexpected" results in science*, "Scientometrics" 2009, no. 78, pp. 347-353.

[4] M. Jasieński, M. Rzeźnik M, *Innovatics – a new toolbox of skills for innovative production managers*, in: *Innovations in Management and Production Engineering*, ed. R. Knosala, Wyd. Polskiego Towarzystwa Zarządzania Produkcją, Opole 2012, pp. 63-71.

[5] J. Dyer, H. Gregersen, C.M. Christensen, *Innovator's DNA: Mastering the Five Skills of Disruptive Innovators*, Harvard Business Review Press, Boston 2011.

[6] K. Pawłowski, *Społeczeństwo wiedzy – szansa dla Polski*, Znak, Kraków 2004.

[7] S. Kwiatkowski, *Przedsiębiorczość intelektualna*, Wyd. Naukowe PWN, Warszawa 2000.

1. Citation analysis: how is it relevant for business models?

I argue that only citation analysis, or more broadly – scientometrics or bibliometrics,[8] can tell outsiders (i.e. managers, journalists) what is worth paying attention to in the world of research. Citation analysis is based on the idea that the number of citations for a given paper, when counted in other papers, is a good measure of its scientific value. It may sound simplistic or even cruel, but there are no better ways.[9] There are quantitative tools aimed at evaluating the academic quality of institutions or of individual researchers, and for discovering new research fronts and industrial trends (from the patterns of co-citations of papers and patents). Such tools provide quality information that is easily accessible, comprehensible, and at the same time, is completely merit-based, i.e. it is independent of such confounding data as the title, academic rank, and the age or gender of a person considered as a potential expert.

I intend to show how citation analysis can be put to use by business practitioners, but the goal of this paper is not to categorize scientometrics and citation analysis within the framework of knowledge management and the structure of intellectual capital.[10] I will also not delve into the topic of patents and patent citations,[11] although this area of knowledge is of immense practical application for entrepreneurs.

When looking for potential applications of citation analysis in business one should think in terms of business models.[12] The business model is a conceptualiza-

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[8] E. Garfield, *Citation indexing for studying science*, "Nature" 1970, no. 227, pp. 669-671; M. Jasieński, *Demon Garfielda, czyli o roli analizy cytacji w rozwoju nauki (głównie ekologii) w Polsce*, "Wiadomości Ekologiczne" 1991, no. 37, pp. 247-263; K. Klincewicz, *Polska innowacyjność. Analiza bibliometryczna*, Wyd. Naukowe Wydziału Zarządzania UW, Warszawa 2008; I. Marszakowa-Szajkiewicz, *Badania ilościowe nauki: podejście bibliometryczne i webometryczne*, Wyd. Naukowe UAM, Poznań 2008.

[9] A. Łomnicki, *Impact factors reward and promote excellence*, "Nature" 2003, no. 424, p. 487.

[10] M. Golińska-Pieszyńska, *Polityka wiedzy a współczesne procesy innowacyjne*, Scholar, Warszawa 2009; A. Ujwary-Gil, *Kapitał intelektualny a wartość rynkowa przedsiębiorstwa*, C.H. Beck, Warszawa 2009.

[11] A.B. Jaffe, M. Trajtenberg, *Patents, Citations & Innovations. A window on the Knowledge Economy*, MIT Press, Cambridge, Mass. 2002.

[12] M.W. Johnson, C.M. Christensen, H. Kagermann, *Reinventing your business model*, "Harvard Business Review" 2008, no. 86, pp. 50-59; M. Jasieński, M. Rzeźnik, M. Candi, *Understanding and innovating business models: Some basic methodological issues*, in: *Innovations in Management and Production Engineering*, ed. R. Knosala, Wyd. Polskiego Towarzystwa Zarządzania Produkcją, Opole 2013, pp. 51-58; C. Zott, R. Amit, *Business model design and the performance of entrepreneurial firms*, "Organization Science" 2007, no. 18, pp. 181-199.

tion of the total current, or future, business activities of the firm.[13] Irrespective of the particular structure of a business model, the components comprising it usually are: costs and revenues, business partners, competitors, resources available and processes applied to them, ways of building relationships with various consumer segments, and, most importantly, the value proposition, i.e. the essence of what the firm is offering to the customer.

An extremely useful list of all possible applications of bibliometrics in rethinking business models, phrased in the form of, what the authors call, „analytic questions," is provided by Krzysztof Klincewicz et al.[14] Within the framework of bibliometric analyses the authors explore practically all buildings blocks of business models. For example, one may ask about strategically important issues, such as who the potential and actual competitors are, where to find the potential suppliers or partners for collaboration in academia or what the potential customer segments are etc. Constructing the value proposition involves implementing the latest scientific results, so the connection with scientometrics is evident.

2. Citation analysis: Tools for entrepreneurs and managers

Articles which contain citations to the previously published research, are themselves published in a relatively small and selected pool of „elite" journals (the composition of which varies across different databases). The Science Citation Index Expanded covers 8,500 journals, the Social Sciences Citation Index – covers more than 3,000 journals, and the Arts & Humanities Citation Index – contains more than 1,700 titles. In addition, the database of Elsevier's Scopus includes 19,500 peer-reviewed journals.

Bradford's statistical law of aggregation[15] makes the job of citation analysis easier, since it is sufficient to limit the analyses to a relatively small subset of all scientific journals to account for most of the significant progress in science. Of course, we must know which journals to focus on. An extensive review of the entire field of bibliometrics as applied to the development of technology and basic research by Klincewicz et al.[16] is particularly valuable and available online (at www.nauka.gov.pl).

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[13] C. Zott, R. Amit, L. Massa, *The business model: Recent developments and future research*, "Journal of Management" 2011, no. 37, pp. 1019-1042.

[14] K. Klincewicz, M. Żemigała, M. Mijal, *Bibliometria w zarządzaniu technologiami i badaniami naukowymi*, Ministerstwo Nauki i Szkolnictwa Wyższego, Warszawa 2012, pp. 61-67.

[15] E. Garfield, *Bradford's Law and related statistical patterns*, "Essays of an Information Scientist" 1979-1980, no. 4, pp. 476-483.

[16] K. Klincewicz, M. Żemigała, M. Mijal, op. cit.

2.1. The *h*-index

This index has taken the world of citation analysis by storm. Since its introduction, in a paper by Hirsch,[17] it has been adopted by various online services, such as Web of Science or Google Scholar, and has become a standard measure with which to assess the academic quality of individual authors.[18] Hirsch's paper itself received an incredible number of over 1500 citations (until mid-April 2014), as recorded in the Web of Science Core Collection.

Its interpretation is extremely intuitive: the Hirsch's *h*-index shows the number *h* of publications of a given author, ranked from the most cited to the least cited, which received not fewer than *h* citations each. The same measure can be applied to evaluate scientific output of institutions, countries, or journals. An $h = 10$ means that among all the papers published in the journal X, only 10 received at least 10 citations each in a certain database (e.g. Google Scholar or Web of Science, although it is important to remember that values of *h* provided by different databases may differ substantially[19]). Little is also known about the statistical properties of the Hirsch index, but first analyses[20] suggest that confidence intervals for *h*-indexes are (unfortunately) quite broad.

The simplicity of the *h*-index means that anybody interested in evaluation of the quality of research, can apply it for one's own purposes. I argue that it should become a standard measure used by executives and managers when searching the academic world for experts or external advisers.[21] After all, academic titles or honors are less reliable as measures of a person's actual and current scientific worth, since they reflect either achievements from the past or non-merit based influences, such as the extent of being professionally „connected." The Hirsch index reflects such worth directly, although one should remember that different disciplines (or even subdisciplines) are characterized by different customs and levels of „citability" of the publications.[22] Robust benchmarks, in the form of databases compiled

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[17] J.E. Hirsch, *An index to quantify an individual's scientic research output*, "Proceedings of the National Academy of Sciences USA" 2005, no. 102, pp. 16569-16572.

[18] L. Egghe, *The Hirsch index and related impact measures*, "Annual Review of Information Science and Technology" 2010, no. 44, pp. 65-114.

[19] L.I. Meho, Y. Rogers, *Citation counting, citation ranking, and h-index of human-computer interaction researchers: A comparison of Scopus and Web of Science*, "Journal of the American Society for Information Science and Technology" 2008, no. 59, pp. 1711-1726.

[20] L. Pratelli, A. Baccini, L. Barabesi, M. Marcheselli, *Statistical analysis of the Hirsch index*, "Scandinavian Journal of Statistics" 2012, no. 39, pp. 681-694.

[21] M. Jasieński, *Innovaria – It's time for academics to replace garage-based inventors*, "Warsaw Business Journal Observer" April 2004, p. 16.

[22] E. Lillquist, S. Green, *The discipline dependence of citation statistics*, "Scientometrics" 2010, no. 84, pp. 749-762.

specifically for that purpose, are also needed to allow comparisons of *h*-indexes of experts from different fields and institutions.[23]

Hirsch himself estimates[24] that, after a 20-year publishing career, a "successful scientist" will have an *h*-index of 20, an "outstanding scientist": an $h=40$, and a "truly unique" scientist would have – an *h*-index of 60. One would also be interested in obtaining a publication index which would not increase with the author's age, thus allowing the comparison of older and younger researchers. Helmut A. Abt[25] suggested that dividing the *h*-index by the number of decades that passed since the author's first publication (i.e. measuring that person's duration of academic career) creates an age-independent index of research quality.

From the perspective of managers looking for academic experts providing specialized advice, these *h* values may serve as guideposts when deciding on the level of financial compensation for their experts' services, for example. Of course, mindless computation of *h* should not replace careful scrutiny of the potential expert's credentials. I should also emphasize that this is a measure appropriate for scientifically active experts, and would not apply to non-academic business consultants who usually do not write academic papers (so their $h=0$) and who provide expert advice strictly on management-related components of the business model.

2.2. The *g*-index

This index, proposed in 2006 by Leo Egghe,[26] is meant to address some weaknesses of the *h*-index, for example, its insensitivity to the presence of very highly cited papers in the ranking list of publications. Once such papers are counted towards the value of the *h*-index, the fact that they continue to be cited very frequently (receiving even hundreds of citations) does not influence the value of the *h*-index at all! Critics of the *h*-index felt that a good index should reflect such forms of academic achievement.[27]

The value of *g* is the smallest number which fulfills the condition that the cumulative number of citations received by the *g* most cited papers is greater than or equal to g^2. One could also say that the mean number of citations received by each of the *g* most cited papers must be greater than *g*. The *g*-index is much more

[23] G. Abramo, C.A. D'Angelo, F. Viel, *A robust benchmark for the h- and g-indexes*, "Journal of the American Society for Information Science and Technology" 2010, no. 61, pp. 1275-1280.

[24] B. Cronin, L. Meho, *Using the h-index to rank influential information scientists*, "Journal of the American Society for Information Science and Technology" 2006, no. 57, pp. 1275-1278.

[25] H.A. Abt, *A publication index that is independent of age*, "Scientometrics" 2012, no. 91, pp. 863-868.

[26] L. Egghe, *Theory and practise of the g-index*, "Scientometrics" 2006, no. 69, pp. 131-152.

[27] R. Costas, M. Bordons, *Is g-index better than h-index? An exploratory study at the individual level*, "Scientometrics" 2008, no. 77, pp. 267-288.

cumbersome to calculate than the *h*-index, but it does capture new aspects of the citation data that intuitively make sense. For example (see Table 1), let us compare two young researchers in the same field, each with only 10 publications, one of whom (publication list B) already had three well-cited papers. They have the same *h*-index value of 5, but it is clear that the second researcher deserves recognition for her better output. Her *g*-index has the value of 12, taking into account this fact, compared to the first researcher's *g*-index of 5. We notice here one somewhat counterintuitive feature of the *g*-index: in some situations its value may be greater than the number of publications that the analyzed author had!

Table 1. Comparison of academic quality indexes for two fictitious publication lists. Grey cells indicate the *h*-core, i.e. papers whose citations count towards the *h*-index

Publication rank r	r2	Publication list A			Publication list B		
		number of citations per paper	cumulative number of citations	indexes	number of citations per paper	cumulative number of citations	indexes
1	1	7	7		56	56	
2	4	7	14		40	96	
3	9	6	20		25	121	
4	16	6	26		7	128	
5	25	5	31	$h=5$ | $g=5$	6	134	$h=5$
6	36	4	35		5	139	
7	49	4	39		4	143	
8	64	3	42		3	146	
9	81	3	45		2	148	
10	100	0	45		1	149	
11	121	–	–		–	149	
12	144	–	–		–	149	$g=12$
				$A=6.2$ $R=5.6$			$A=26.8$ $R=11.6$

Source: own elaboration.

In Table 1 I also present values of two additional measures of academic quality: the *A*-index (which is just the arithmetic average of citation counts received by the publications in the *h*-core) and the *R*-index which is meant to capture the best qualities of both *h*- and *A*-indexes. The *R*-index is calculated as the square root of the product of *A*-index and *h*-index, i.e. it is the geometric mean of the two indexes.[28] However, one should note that there is no agreement among bib-

[28] B.H. Jin, L.M. Liang, R. Rousseau, L. Egghe, *The R- and AR-indices: Complementing the h-index*, "Chinese Science Bulletin" 2007, no. 52, pp. 855-863.

liometricians as to which index is the best, i.e. the most meaningful measure of academic excellence.[29]

2.3. Measure of the influence of journals, or what journals to read

Both researchers and people outside of academic circles (e.g., managers) need some easy to understand measures of the quality of academic journals. For a manager who is not trained technically but, for some reason, supervises a team of R&D workers, being able to assess the quality of knowledge sources used by them would be essential. One can do it based on some established measure of journal influence, since it is easy to see if the team is referring to good quality journals in their everyday work.

The impact factor (IF), a measure used by the Web of Knowledge database and available through Journal Citation Reports, can be computed for a journal for the year, say, 2012, by obtaining two numbers: total number of papers published in that journal in 2010 and 2011, and the total number of citations received by these papers in 2012. The impact factor for 2012 is the ratio of the second number divided by the first. Currently, Journal Citation Reports also provide IFs based on a 5-year publication period.

Journal quality may also be assessed through the PageRank algorithm which takes into account the quality of journals from which the citations came: citing articles „weigh" more if they were themselves published in better cited journals. One could argue that while IF is a measure of „popularity," weighing introduces the notion of „prestige" in journal assessment.[30] A measure SJR used by the SCImago Journal & Country Rank portal (based on Elsevier's Scopus database) uses the citation time window of three years (rather than the two or five in measurement of IF) and the system of weighing citations is based on the PageRank algorithm.[31]

The SCImago portal is more easily accessible to users from outside the academic world (such as managers or business people), but does not provide information about individual research papers and their citations. It is excellent for general orientation in the quality of journals or of geographic regions. Knowledge about journals, down to the level of subscription costs, may be obtained from the website www.eigenfactor.org.

As with citations to individual papers, disciplines vary widely in their journals' measures of influence. For example, the median value of SJR for journals

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[29] G. Abramo, C.A. D'Angelo, F. Viel, *Assessing the accuracy of the h- and g-indexes for measuring researchers' productivity*, "Journal of the American Society for Information Science and Technology" 2013, no. 64, pp. 1224-1234.

[30] P. Ball, *Prestige is factored into journal ratings*, "Nature" 2006, no. 439, pp. 770-771.

[31] SCImago 2007, *SJR – SCImago Journal & Country Rank*, www.scimagojr.com [27.06.2013].

in the field of classics (arts and humanities) is 0.1 (while the top 10 journals' SJR scores range from 0.333 down to 0.140), in philosophy – 0.13, in ocean engineering – 0.18, and in metals and alloys – 0.24. In the area of biotechnology the median value of SJR is about 0.48, and in genetics – it is about 0.82 (with scores for top the 10 journals' SJR ranging from 19.919 down to 6.546). Very specialized journals, by definition, have a limited potential to generate high citation interest (when the population of researchers is small), and consequently have lower measures of influence than journals of a broader scope.

2.4. Assessing the speed of change in a field

From a business point of view, one could also be interested in the speed of change occurring in a given field or even an emergence of a new R&D frontier. This information is captured in the Journal Citation Reports 2012 by the „immediacy index", which reflects the degree to which a given journal is topical or urgently cited. It is computed by dividing the number of citations received in a given year by the articles in a journal, by the number of articles published in this journal in the same year. Some rapidly developing fields, such as biotechnology will be characterized by higher immediacy indexes than others, such as philosophy. For example, among 159 journals in biotechnology and applied microbiology, the median value of this index was about 0.3, but for the most immediately cited three journals in this category the values were 8.7, 7.1 and 3.4. Similar data for history and philosophy of science are as follows: median value for 41 journals was 0.12, and the top three journals had values of only 4.5, 1.0, and 0.6.

Another, more refined characteristic is the speed with which knowledge in a given journal becomes obsolete. How well do the papers published within withstand the test of time? Do they become irrelevant very quickly? A journal's „cited half-life" is the median age of the articles from that journal that were cited in a given year. For example, if a journal's half-life in 2012 was 10 years, it means that among all the citations received by that journal in 2012, 50% of them were referring to papers published in that journal during the period of 2003-2012; the other half of the citations are to papers published there before the year 2002. Journals in disciplines developing at a fast rate (e.g. biotechnology, with the value of 6.4 years) will have shorter cited half-lives than journals journals in other fields like history and the philosophy of science (about 10 years).

One may also ask if the journal is, maybe, too old-fashioned or „sentimental", by citing too many old articles, rather than new ones. A journal's „citing half-life" for the year 2012 can be computed by arranging all the papers according to their year of publication (from all journals) cited in this journal in 2012. Then, the list is divided in half, and the year of the median publication, several years back, determines the value of this index.

3. Why is the academic discipline of business and management so weak in Poland?

A simple comparison of quantitative data (originally briefly outlined elsewhere[32]), illustrates the thesis that intellectual isolationism, as expressed in the custom of publishing in Polish and accepting standards of quality based entirely on Polish-language publications, results in a substantial weakening of the disciplines of organization and management in Poland. One could question then, if there even exist any academically trained and university (or even business school) based experts and consultants of good quality in Poland, if they tend to avoid comparisons with their international academic counterparts. The most effective strategy of such avoidance is publishing in Polish since it removes any possibility of external evaluation of the quality of academic output (see also Osiński[33] for an example from another field).

The logic of analysis is as follows: I first assess the quality of scientific production in the academic area of business and management within Poland, and I collect similar data for a completely different discipline. I also conduct a parallel analysis for another country (Spain), analyzing the same disciplines. I argue that both countries are well suited for this kind of analysis (see below), but one can, of course, expect that there are still many confounding variables that affect the differences between two countries in the quality of academic production. Therefore, a direct comparison between the two countries would not be methodologically appropriate. Instead, I ask if the difference between the analyzed disciplines in Spain is similar to the difference observed in Poland. The magnitude of the difference between disciplines *within* each country will be the basis for the conclusions about the state of business and management research in Poland.

3.1. Why Poland versus Spain?

Spain can be used as a demanding benchmark for international comparisons with Poland. There are several important similarities, but the comparisons may lead to conservative conclusions. It is a country of similar population size (Spain has 46.7 million vs Poland's 38.5 million, i.e. 1.2 times larger), but with a substantially (1.5 times) higher per capita GDP (PPP). According to the Eurostat data for

[32] M. Jasieński, *Edukacja menedżerów w Polsce: więcej heurystyki i jakości*, in: *Edukacja ekonomiczna wobec przemian otoczenia społeczno-gospodarczego*, eds. J. Dietl, Z. Sapijaszka, Fundacja Edukacyjna Przedsiębiorczości, Łódź 2012, pp. 63-68.

[33] Z. Osiński, *Bibliometria metodą analizy i oceny dorobku naukowego historyków najnowszych dziejów Polski*, in: *Kultura, historia, książka. Zbiór studiów,* eds. A. Dymmel, B. Rejakowa, Wyd. UMCS, Lublin 2013, pp. 605-616.

2011, the population size of researchers in the higher-education sector (expressed in full-time equivalents, FTE) was 1.8 times larger in Spain (80 900 FTEs) than in Poland (44 154 FTEs). More specifically, in natural sciences, there were 2.15 times more active researchers in Spain than in Poland (16 688 FTEs versus 7 769 FTEs, respectively) and in social sciences, 2.06 times more in Spain than in Poland (19 973 versus 9 685; Eurostat data for 2011, used for the higher education sector only; Total R&D personnel and researchers by sectors of performance, sex and fields of science).

Spain occupies the 21st position, and Poland the 29th position in the ranking built with respect to the number of professional researchers engaged in R&D per million people in the country.[34] This index is derived from the World Development Indicators for the years 2000 to 2005. Importantly, however, the argument presented below is not affected by the difference in absolute population size, since it is based on size-independent measures of academic quality.

In addition, Spain and Poland occupy the 28th and the 29th positions, respectively, in the ranking of the Talent Index which measures both human capital and size of the, so called, creative class[35] (i.e. a fraction of a country's labor force that is engaged in relatively sophisticated problem solving in everyday work).[36] Finally, Spain's English Proficiency Index (EPI) for 2012, a measure of the average level of English skills among adults, was 55.89 (indicating moderate proficiency) and was lower than Poland's EPI of 59.08 (indicating a high proficiency). This removes one important objection to any attempts at criticizing the performance of Polish academic authors. Since knowledge of English among Spaniards is even lower than that among the Polish population, any comparisons between Spanish and Polish authors do not favor the former.

3.2. Cross-discipline comparisons: the data

One can use data from the Science Citation Index (SCI), i.e. database covering natural sciences, about that field for which Polish scientists are known to represent high standards. In the combined fields of astronomy, astrophysics and mathematical physics, Spanish authors have, in the period 2001-2010, published 3750 papers which received 16 803 citations, with an h-index of 37. In comparison, Polish scientists published 3102 papers, which received 25 523 citations. The Hirsch index for this population of papers was substantially higher, at $h = 56$.

[34] *Creativity and Prosperity: The Global Creativity Index*, Martin Prosperity Institute, Joseph L. Rotman School of Management, University of Toronto, Toronto, Ontario 2011.

[35] *Klasa kreatywna w Polsce. Technologia, talent i tolerancja jako źródła rozwoju regionalnego*, ed. K. Klincewicz, Wyd. Naukowe Wydziału Zarządzania UW, Warszawa 2012.

[36] GCI Report, 2011.

In the Social Science Citation Index (SSCI) – part of Web of Science – for the years 2001-2010, there are 3081 papers in the area of "management, business and finance" published by authors with a Spanish address. During that period, these papers received 13 552 citations and their *h*-index was 41. During that same period, Polish authors in "management, business and finance" published only 188 papers in the journals covered by SSCI, which were cited 874 times. Their Hirsch index was only $h = 12$.

3.3. Cross-discipline differences: possible causes

Let us build the following comparison: Spanish specialists in the field of business and management published only 1.2 times *fewer* good quality papers (those published in journals covered by Web of Science) than did the Spanish astronomers, astrophysicists and mathematical physicists. In contrast, the Polish specialists in business and management published in Web of Science-listed journals 16 times *fewer* papers than did the Polish astronomers, astronomers and mathematical physicists. Why is there such a big discrepancy in the productivity of Polish and Spanish authors in the area of business and management?

The first explanation is that maybe the structure of academic specialization is so different in both countries that there are relatively very few Polish researchers in the business and management field, although it would be hard to imagine that this "soft" academic area was to be so unpopular in Poland. In fact, the population of researchers working in Poland in fields of social sciences (including business and management) was, in 2011, 1.25 times greater than of those in the field of natural sciences (including astronomy, astrophysics and mathematical physics). This pattern is almost identical in Spain: there were 1.20 more researchers in social science fields than in the fields of natural sciences.[37] Therefore, the striking absence of the high quality publishing output of Polish researchers in business and management relative to the output of their Polish colleagues in astronomy, astrophysics and mathematical physics, must be explained by factors other than the structure of academic specialization.

The second explanation assumes that Polish authors in business and management are academically just as good as the Polish astronomers and physicists, but, for some reason, they choose to publish their findings in Polish, and in journals not covered by SSCI. After all, there must have been many more papers (than the discovered group of 188 publications) published by Polish authors during the studied period. It would be a daunting task to try evaluating their number, however, since there are no databases listing them. Such publications are marinated in various

[37] *Science, Technology and Innovation in Europe, 2013 edition*, Eurostat Pocketbooks, Publications Office of the European Union, Luxembourg 2013.

local, Polish-language and for all practical purposes peer-*non*-reviewed "prace naukowe" (scientific work) and "monografie" (monographs), safely hidden from verification by the international, anonymous and impartial academic community.

A third explanation suggests that Polish business and management authors represent a substantially lower academic quality than their colleagues in natural science. I explored this option through citation analysis which showed that while being 16 times less numerous (188 versus 3102 papers), Polish publications in business and management received 29 times *fewer* citations than Polish publications in astronomy and astrophysics (874 versus 25 523 citations)! One could argue that business and management is a discipline characterized by different academic customs, resulting in fewer citations received per paper. However, Spanish publications in business and management managed to receive only 1.2 times (13 552 versus 16 803) fewer citations than the publications of Spanish astronomers and astrophysicists. Since, as we saw earlier, such publications were themselves only 1.2 times less numerous (3081 versus 3750 papers), the number of citations received by these publications is actually closely proportional to their number!

Notably, this means that papers in both disciplines can, in principle, be citable with the same frequency. In other words, business and management is a discipline which is not inherently less active (as measured by citation rates) than astronomy and astrophysics! Therefore, the lower number of citations received by a certain pool of papers (representing Polish authors' productions in the area of business and management) does indeed reflect lower academic quality of such papers.

4. How governmental incentives become counterproductive

One could ask: why is the academic production of business and management in Poland of poor quality? Governmental institutions, such as the Ministry of Science and Higher Education (Ministerstwo Nauki i Szkolnictwa Wyższego – MNiSW), the National Centre for Research and Development (Narodowe Centrum Badań i Rozwoju – NCBiR), and the National Science Centre (Narodowe Centrum Nauk – NCN) use various rules and incentives which create an environment affecting professional behavior in the world of R&D. Decisions of what and where to publish, and in what language, depend on cost-benefit analyses carried out in that environment, by academic researchers.

MNiSW assigns points for academic publications, subsequently used by the Ministry in a parametric evaluation of academic institutions. In 2012, an the English-language chapter published in a monograph volume, yielded 7 points. In contrast, a Polish-language chapter brought only 4 points. In 2013, the rules were changed and English-language chapters yielded only 5 points, i.e. only 1.25 times more than chapters written in Polish. When the Ministry changed the structure of incentives, the results became immediately noticeable, since the added effort (and cost) of preparing English text has become even more acutely undercompensated by the offered parametric points.

For example, two volumes following the annual 2012 conference of the Polish Society for Production Management (Polskie Towarzystwo Zarządzania Produkcją – PTZP) comprised of 85 Polish-language papers and 52 English-language papers (which was only 38% of all 137 papers). In 2013, there were only 24 English-language papers, which constituted only 17% of all 141 papers in the post-conference volumes. This dramatic, and statistically significant (comparison of two proportions, $Z=3.915$, $p<0.0001$), more than 2-fold drop in the English-language academic production shows that authors responded in their publishing decisions by optimizing the effort with respect to the expected payoffs (in this case: points for parametric assessment). The previous system did not provide sufficient incentives for the authors to publish in English (since there were too few English-language papers, 38%); the current system generates results that are even further (17%) from the minimum goal of 50%. I estimate that at least 8 points given to an English-language paper versus 4 points for a Polish-language paper would be necessary for the frequencies of the Polish- and English-language papers to be equalized. The rules established by the NCN for the preparation of grant proposals in social sciences (which include areas of organization and management) require them to be written in Polish, only with a summary or abstract in English. This rule removes the possibility for the proposals being reviewed by international referees thus creating a cost of lost opportunity to obtain valuable feedback from external experts. Both institutions, MNiSW and NCN have inadvertently created a system which pushes Polish social sciences into provincialism.

Conclusions

Are Polish entrepreneurs, then doomed to rely on the consulting power of the local experts, who cannot document superior academic credentials but whose only reason for priority is that they are cheaper to hire and ensure easier communication in Polish with their local customers? The current academic system indeed gives them the priority and is set up with rules that preserve this priority.[38] However, once (if ever...) we open the system to competition from foreign experts, verified through scientometrics, the overall quality of academic research and of innovation in Poland will increase. I believe that industry managers and entrepreneurs, by

[38] M. Jasieński, *Rozpędzić uczelniane stadka*, "Rzeczpospolita" 27.11.2008, pp. A16-17.

creating a sufficiently high expectations for experts in the consulting market, may have an important role to play in this process.

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Analiza cytacji jako praktyczne narzędzie dla menedżerów i przedsiębiorców: wybrane pojęcia z naukometrii służące poprawie modeli biznesowych

Streszczenie. *Przedsiębiorcy stają coraz częściej przed wyzwaniem nawiązania współpracy z badaczami, którzy są potencjalnym źródłem wiedzy eksperckiej i mogą służyć jako partnerzy biznesowi, współpracownicy lub eksperci. Ponieważ wynajęcie ekspertów może być kosztowne, istotne jest, aby byli to najlepsi specjaliści. Artykuł zawiera przegląd podstawowych narzędzi naukometrycznych (np. indeksy h oraz g), dzięki którym menedżer lub przedsiębiorca może ilościowo oszacować naukową jakość konkretnych osób albo instytucji. Informacja uzyskana w ten sposób jest ogólnie dostępna, zrozumiała i w dużym stopniu oparta na wartości merytorycznej (a nie np. na aktywności administracyjnej) ekspertów, aczkolwiek należy jej używać z ostrożnością. Porównawcza ocena całych dyscyplin może być zilustrowana krytyczną analizą aktywności krajowych badaczy w dziedzinie biznesu i zarządzania, którzy w znanych czasopismach publikują niewiele prac i o niskiej jakości. Naukometria może również dokumentować niską jakość przyjętych standardów ministerialnych (np. przy ocenie parametrycznej), które zniechęcają autorów do publikowania prac w języku angielskim.*

Słowa kluczowe: *analiza cytacji, bibliometria, h-index, konsulting, naukometria, przedsiębiorczość, zarządzanie*