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CONTENTS

ANNOUNCEMENT

WORKSHOP IN HONOUR OF THE MEMORY OF HENK F. MOED (1951—2021)

10 JUNE 2022, SAPIENZA UNIVERSITY OF ROME (ITALY)

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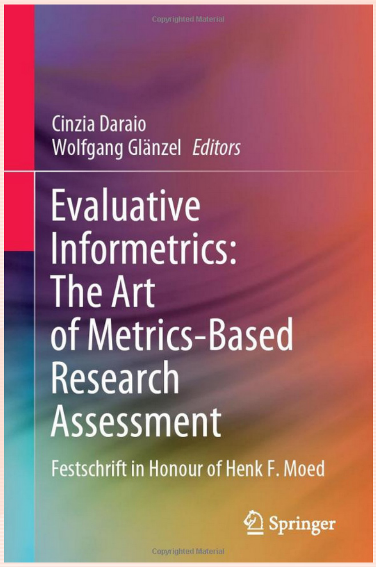
On June 10, 2022, Sapienza University of Rome in collaboration with the European Summer School for Scientometrics (ESSS) will hold a workshop in honor of the memory of Henk F. Moed who sadly left us last year.

The basis for the Workshop will be the Festschrift in Honour of Henk F. Moed edited by Cinzia Daraio and Wolfgang Glänzel and published by Springer Nature in 2020.

The first part of the Festschrift summarizes Henk's most important publications in the field. These include contributions on:

This picture was taken during the ISSI 2019 Conference, 5 September 2019 during the announcement of the Conferral of the Doctorate Honoris causa in Research Assessment Methodologies to Henk F. Moed.

Photo by Maurizio Perciballi.



Daraio, C., Glänzel, W. (Eds.). (2020). Evaluative Informetrics: The Art of Metrics-Based Research Assessment: Festschrift in Honour of Henk F. Moed. Springer Nature.

- Bibliometric databases,
- Journal citation measures,
- Indicators of research performance in science, social science and humanities,
- Theoretical understanding and proper use of bibliometric indicators,
- Usage-based metrics and altmetrics,
- International collaboration and migration,
- The future of bibliometric and informetrics.

The second part of the Festschrift presents 13 original research papers by experts in the field who have worked and collaborated with Henk addressing the following topics:

- Advancement of bibliometric methodology
- Evaluative informetrics and research assessment
- New horizons in informetric studies.

Table 1 taken from Daraio and Glänzel (2020, pp. 2-6), reports a selection of the most important publications by Henk F. Moed.

Table 2, taken from Daraio and Glänzel (2020, p. 7), shows the authors and the titles of the 13 contributions.

Beginning with the contents of the Festschrift in Honour of Henk that contain his scholarly legacy, the workshop of the 10 June 2022 in Honour of Henk will develop:

- The impact of Henk's work on the community
- Policy-relevant implications of bibliometric methodology for the evaluation of research
- Challenges for bibliometrics in the era of Open Science and non-academic impact assessment
- Opportunities and Limitations of Metrics at the Institutional and Individual level

It will be possible to follow the workshop online on Zoom. The link to the workshop, the detailed program, and the speakers will be available on the ESSS website in May 2022.

Keep up to date by checking the ESSS website (https://esss.info/) where you will also find information and the program of the next ESSS Summer School to be held in Berlin from September 19-23, 2022.

(continues on next page)

BIBLIOGRAPHIC DATABASES Exploring the use of existing, primarily bibliographic databases for bibliometric purposes has been the most important subject of the first half of Henk Moed's career, although he has made several database-oriented studies also in the second half. It was a topic of great general interest in the field. This topic involves the following sub-topics: the creation of bibliometric databases; combining databases; comparing databases; and the assessment and enhancement of their data quality.	
1	Moed, H.F. (1988). The Use of Online Databases for Bibliometric Analysis. In: Informetrics 87/88. L. Egghe and R. Rousseau (eds.), Elsevier Science Publishers, Amsterdam, ISBN 0-444-70425-6, 15-28.
2	Moed, H.F., Vriens, M. (1989). Possible Inaccuracies Occurring in Citation Analysis. Journal of Information Science, 15, 2, 95-107. Sage Journals
3	Moed, H.F. (2005). Accuracy of citation counts. In: H.F. Moed, Citation Analysis in Research Evaluation. Springer, Dordrecht (Netherlands). ISBN 1-4020-3713-9, 173-179.
4	López-Illescas, C., De Moya-Anegón, F., Moed, H.F. (2008). Coverage and citation impact of oncological journals in the Web of Science and Scopus. Journal of Informetrics, 2, 304-316. Elsevier
5	Moed, H.F., Bar-Ilan, J, Halevi, G. (2016). A new methodology for comparing Google Scholar and Scopus. Journal of Informetrics, 10, 533-551. Elsevier
JOURNAL CITATION MEASURES Journal impact factors and related citation measures are even today probably the most frequently used bibliometric indicators. The articles relate to a critique on existing indicators, proposals for new indicators, and a more reflexive paper addressing criteria for evaluating indicators on the basis of their statistical soundness, theoretical validity, and practical usefulness. Also, one paper examines the effect of the Open Access upon citation impact.	
1	Moed, H.F., van Leeuwen, Th.N. (1995). Improving the accuracy of Institute for Scientific Information's journal impact factors. J. of the American Society for Information Science, 46, 461-467 Wiley publisher
2	Moed, H.F., van Leeuwen, Th.N., Reedijk, J. (1999). Towards appropriate indicators of journal impact, Scientometrics, 46, 575-589. Springer
3	Moed, H.F., van Leeuwen, Th.N., Reedijk, J. (1999). Towards appropriate indicators of journal impact, Scientometrics, 46, 575-589. Springer
4	Moed, H.F. (2007). The effect of "Open Access" upon citation impact: An analysis of ArXiv's Condensed Matter Section. Journal of the American Society for Information Science and Technology, 58, 2047-2054. Wiley publisher
5	Moed, H.F. (2010). Measuring contextual citation impact of scientific journals. Journal of Informetrics, 4, 265-277. Elsevier
6	Moed, H.F. (2016). Comprehensive indicator comparisons intelligible to non-experts: the case of two SNIP versions. Scientometrics, 106 (1), 51-65. Springer
INDICATORS OF RESEARCH PERFORMANCE IN SCIENCE, SOCIAL SCIENCE AND HUMANITIES The development of appropriate quantitative research assessment methodologies in the various domains of science and scholarship and various organizational levels has been Henk Moed's core-activity during the first two decades. Bibliometric indicators were applied to research groups, departments, institutions, and countries.	
1	Moed, H.F., Burger, W.J.M., Frankfort, J.G., van Raan, A.F.J. (1985). The Use of Bibliometric Data for the Measurement of University Research Performance. Research Policy, 14, 131-149. Elsevier
2	Moed, H.F., de Bruin, R.E., van Leeuwen, Th.N. (1995). New bibliometric tools for the assessment of national research performance: database description, overview of indicators and first applications. Scientometrics, 33, 381-422. Springer
3	Moed, H.F., Hesselink, F.Th. (1996). The publication output and impact of academic chemistry research in the Netherlands during the 1980's: bibliometric analyses and policy implications. Research Policy, 25, 819-836. Elsevier
4	Van den Berghe, H., Houben, J.A., de Bruin, R.E., Moed, H.F., Kint, A., Luwel, M., Spruyt, E.H.J. (1998). Bibliometric indicators of university research performance in Flanders. Journal of the American Society for Information Science, 49, 59-67. Wiley publisher
5	Moed, H.F. (2002). Measuring China's research performance using the Science Citation Index. Scientometrics, 53, 281-296. Springer
6	Moed, H.F., Nederhof, A.J, Luwel, M. (2002). Towards performance in the humanities. Library Trends, 50, 498-520. JHU Press

(Table 1. — continues on next page)

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THEORETICAL UNDERSTANDING AND PROPER USE OF BIBLIOMETRIC INDICATORS This topic comprises articles of Henk Moed discussing and proposing theories about what citations and other bibliometric indicators measure. Moreover, it includes reflexive articles addressing the issue as to what are appropriate ways to use these indicators in research assessment processes.	
1	Moed, H.F. (2000). Bibliometric indicators reflect publication and management strategies. Scientometrics, 47, 323-346. Springer
2	Moed H.F., Garfield E. (2004). In basic science the percentage of 'authoritative' references decreases as bibliographies become shorter. Scientometrics, 60, 295-303. Springer
3	Moed, H.F. (2005). Towards a theory of citations: Some building blocks. In: H.F. Moed, Citation Analysis in Research Evaluation. Springer, Dordrecht (Netherlands). ISBN 1-4020-3713-9, 209-220.
4	Moed, H.F. (2008). UK Research Assessment Exercises: Informed Judgments on Research Quality or Quantity? Scientometrics, 74, 141-149. Springer
5	Moed, H.F., Halevi, G. (2015). Multidimensional Assessment of Scholarly Research Impact. Journal of the American Society for Information Science and Technology, 66, 1988-2002. Wiley publisher
USAGE-BASED METRICS AND ALTMETRICS Nowadays publication- and citation based indicators of research performance are not seldom denoted as ‘classical’, and new, alternative types of indicators are being proposed and explored. Two articles by Henk Moed listed below relate to ‘usage’ indicators, based on the number of times full text articles are downloaded from publishers’ publication archives. A third article discusses the potential of so called altmetrics, especially those that reflect use of social media.	
1	Moed, H.F. (2005). Statistical relationships between downloads and citations at the level of individual documents within a single journal. Journal of the American Society for Information Science and Technology, 56, 1088-1097. Wiley publisher
2	Moed, H.F. (2016). Altmetrics as traces of the computerization of the research process. In: C.R. Sugimoto (Ed.), Theories of Informetrics and Scholarly Communication (A Festschrift in honour of Blaise Cronin). Walter de Gruyter, Berlin–Boston. ISBN 978-3-11-029803-1, 360-371.
3	Moed, H.F., Halevi, G. (2016). On full text download and citation distributions in scientific-scholarly journals. Journal of the American Society for Information Science and Technology, 67, 412–431. Preprint version available at https://arxiv.org/ftp/arxiv/papers/1510/1510.05129.pdf Wiley publisher
INTERNATIONAL COLLABORATION AND MIGRATION Scientific collaboration and migration are important phenomena that can be properly studied with bibliometric-informetric methods. Below three contributions by Moed are listed, two on collaboration, and one on migration.	
1	Moed, H.F. (2005). Does international scientific collaboration pay? In: H.F. Moed, Citation Analysis in Research Evaluation. Springer, Dordrecht (Netherlands). ISBN 1-4020-3713-9, 285-290.
2	Moed, H.F. (2016). Iran's scientific dominance and the emergence of South-East Asian countries as scientific collaborators in the Persian Gulf Region. Scientometrics, 108, 305-314. Preprint version available at http://arxiv.org/ftp/arxiv/papers/1602/1602.04701.pdf. Springer
3	Moed, H.F., Halevi, G. (2014). A bibliometric approach to tracking international scientific migration. Scientometrics, 101, 1987-2001. Springer
THE FUTURE OF BIBLIOMETRIC AND INFORMETRICS The articles of Moed in this section provide a perspective of the future, both in the development of informetric indicators, and in their application in research assessment processes. His monograph Applied Evaluative Informetrics contains several chapters on these topics. Therefore, the executive summary of this book is also listed below.	
1	Moed, H.F. (2007). The Future of Research Evaluation Rests with an Intelligent Combination of Advanced Metrics and Transparent Peer Review. Science and Public Policy, 34, 575-584. Oxford University Press.
2	Moed, H.F. (2016). Toward new indicators of a journal’s manuscript peer review process. Frontiers in Research Metrics and Analytics, 1, art. no 5. Available at: http://journal.frontiersin.org/article/10.3389/frma.2016.00005/full
3	Moed, H.F. (2017). A critical comparative analysis of five world university rankings. Scientometrics, 110, 967–990. Springer
4	Moed, H.F. (2017). Executive Summary. In: H.F. Moed, Applied Evaluative Informetrics. Springer, ISBN 978-3-319-60521-0 (hard cover); 978-3-319-60522-7 (E-Book), DOI: 10.1007/978-3-319-60522-7.

Table 1. Festschrift in Honour of Henk F. Moed: a selection of the most important publications by Henk F. Moed. (Source: Daraio and Glänzel, 2020, pp. 2-6).

TOPIC	AUTHORS	TITLE
1. Advancement of bibliometric methodology		
1.1	Braam R.	Citation profiles and research dynamics
1.2	Luwel L., van Eck N. J., and van Leeuwen T.	Characteristics of publication delays over the period 2000-2016.
1.3	Pendlebury D.A.	When the data do not mean what they say: Japan's comparative underperformance in citation impact.
1.4	Zhao Y., Han J., Du J. and Wu Y.	Origin and Impact: A Study of the Intellectual Transfer of Professor Henk F. Moed's works by Using Reference Publication Year Spectroscopy (RPYS).
2. Evaluative informetrics and research assessment		
2.1	Calero-Medina C., Noyons Ed, Visser M. and de Bruin R.	Delineating Organizations at CWTS – A story of many pathways.
2.2	Halevi G.	Research Trends - Practical Bibliometrics and a Growing Publication.
2.3	Pallari E. and Lewison G.	The evidence base of international clinical practice guidelines in prostate cancer: a global framework for clinical research evaluation.
2.4	Robinson-Garcia N. and Ràfols I.	The differing meanings of indicators under different policy contexts. The case of internationalisation.
2.5	Gorraiz J., Martin Wieland M., Ulrych U. and Gumpenberger C.	De profundis: a decade of bibliometric services under scrutiny
3. New horizons in informetric studies		
3.1	Costas R. and Ferreira M.R.	A Comparison of the Citing, Publishing, and Tweeting Activity of Scholars on Web of Science
3.2	Torres-Salinas D., Arroyo-Machado W.	Library Catalog Analysis and Library Holdings Counts: origins, methodological issues and application to the field of Informetrics
3.3	De-Moya-Anegón F., Guerrero-Bote V.P. and Herrán-Páez E.,	Cross-national comparison of Open Access models: A cost/benefit analysis
3.4	Bar-Ilan J. and Halevi G.	The Altmetrics of Henk Moed's publications

Table 2. Festschrift in Honour of Henk F. Moed: Authors and contributed chapters (Source: Daraio and Glänzel, 2020, p. 7).

DROP IN CHINA-USA INTERNATIONAL COLLABORATION

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Following reports of withdrawal of Chinese researchers from collaboration with the United States in response to political conflict, we examined publication data among 'big three' players, including the European Union-28. China's rise in global engagement has been well documented (Leydesdorff and Zhou 2005; Zhou and Leydesdorff 2006, 2008; Zhou et al. 2009; Kostoff et al. 2007; Glänzel et al. 2008; Rousseau 2008). International collaboration has been a growing share of the rise, accounting in 2019 for 24% of China's indexed publications in Web of Science (Cao et al., 2020), and for an outsized share of citations compared to other countries (Cao et al., 2020; Wagner et al., 2015). China bested the United Kingdom to become the top collaborating country with the United States in 2015. Yet, Schüller & Schüler-Zhou (2020) claimed evidence the China and USA were 'decoupling' their S&T systems, which warranted a closer look.

The increases in China's scientific collaboration arise in part due to Chinese student and scholar migration (Cao et al., 2020). The migrations and resulting collaborations have benefitted nations in many ways: Lee & Haupt (2021b) found that, without Chinese coauthorships, U.S. scholarly output would have dropped as a share of global output in the 2010s. China-U.S. publications are increasingly highly cited. Similarly, Chinese collaborations with the EU have raised numbers of publications and citations (Wang & Wang, 2017).

China's increase in engagement, scholarly output, and research quality has caused alarm in the United States, where government suspicions were raised about

Table. The number and global share of publications, China, the US, and EU-28. Articles and Reviews, full counting, 2016-2021.

YEAR	WORLD TOTAL INDEXED IN WEB OF SCIENCE (ONLY)	CHINA PUBLICATIONS	PERCENTAGE SHARE OF WORLD TOTAL	US PUBLICATIONS	PERCENTAGE SHARE OF WORLD TOTAL	EU-28 PUBLICATIONS	PERCENTAGE SHARE OF WORLD TOTAL	REST OF WORLD (EXCLUDING CHINA, US, AND EU-28)	PERCENTAGE SHARE OF WORLD TOTAL
2016	1,717,411	313,159	18.2	457,327	26.6	592,864	34.5	491,356	28.6
2017	1,790,380	350,298	19.6	471,850	26.4	608,466	34.0	508,282	28.4
2018	1,859,761	402,857	21.7	476,484	25.6	617,594	33.2	523,130	28.1
2019	2,068,920	494,997	23.9	509,017	24.6	669,083	32.3	575,725	27.8
2020	2,218,432	554,498	25.0	519,664	23.4	711,279	32.1	624,225	28.1
2021	2,153,070	581,017	27.0	473,943	22.0	677,942	31.5	601,040	27.9

Data source: Clarivate Incites online queried January 28, 2022

the depth and breadth of China's involvement in U.S. science (Lloyd-Damnjanovic & Bowe, 2020; Lee & Haupt, 2019). Lewis (2018) and Appelbaum et al. (2018) noted the rise in competition between the two nations, which continued into 2021 in response to the COVID-19 pandemic.

To explore this question, we queried Clarivate Incites for Web of Science data online to collect indicators related to research output of China, US, European Union – 28 (EU-28), and Rest of World (ROW) during 2016-2021[1]. Articles and reviews are considered; preprints are not included in the count. Full counting is used to calculate totals for internationally coauthored papers, where each involved country in a scientific publication is assigned full unit. Clarivate Web of Science gathers and presents data for "China Mainland" not including Hong Kong, thus, articles written by authors from China Mainland and Taiwan or Hongkong are considered as international collaborations. The EU-28 includes the United Kingdom for ease of comparison. Data were queried in January 2022.

We compare the collaborative patterns of China, the EU-28, and the US before and after the pandemic period. We compare China's cooperation with EU-28 and the United States to one another to assess whether political more than pandemic effects are influencing the relationship with China. The Table shows numbers of articles and reviews indexed in Web of Science from 2016 through 2021, with total publication output (articles and reviews) of the three largest economies and the rest of the world, with percentage shares held by each. Since 2016, China's numbers of publications have gained shares each year, and the percentage share of indexed articles has steadily increased. Correspondingly, the US and EU-28 show increases in numbers of articles from 2016 to 2020, with a drop in 2020; 2021 shows a corresponding percentage share drop for these two economies. The percentage share drop for the US and the EU-28 is taken up by China, not the rest of the world, as ROW does not gain in share.

The drop in China's international participation as a share of their output led us to ask where, among collaborators, the drop is being experienced. The figure shows collaborative activity between China and the

1 Data collected for each year from Clarivate Incites online, including full 2021 data as of January 28, 2022.

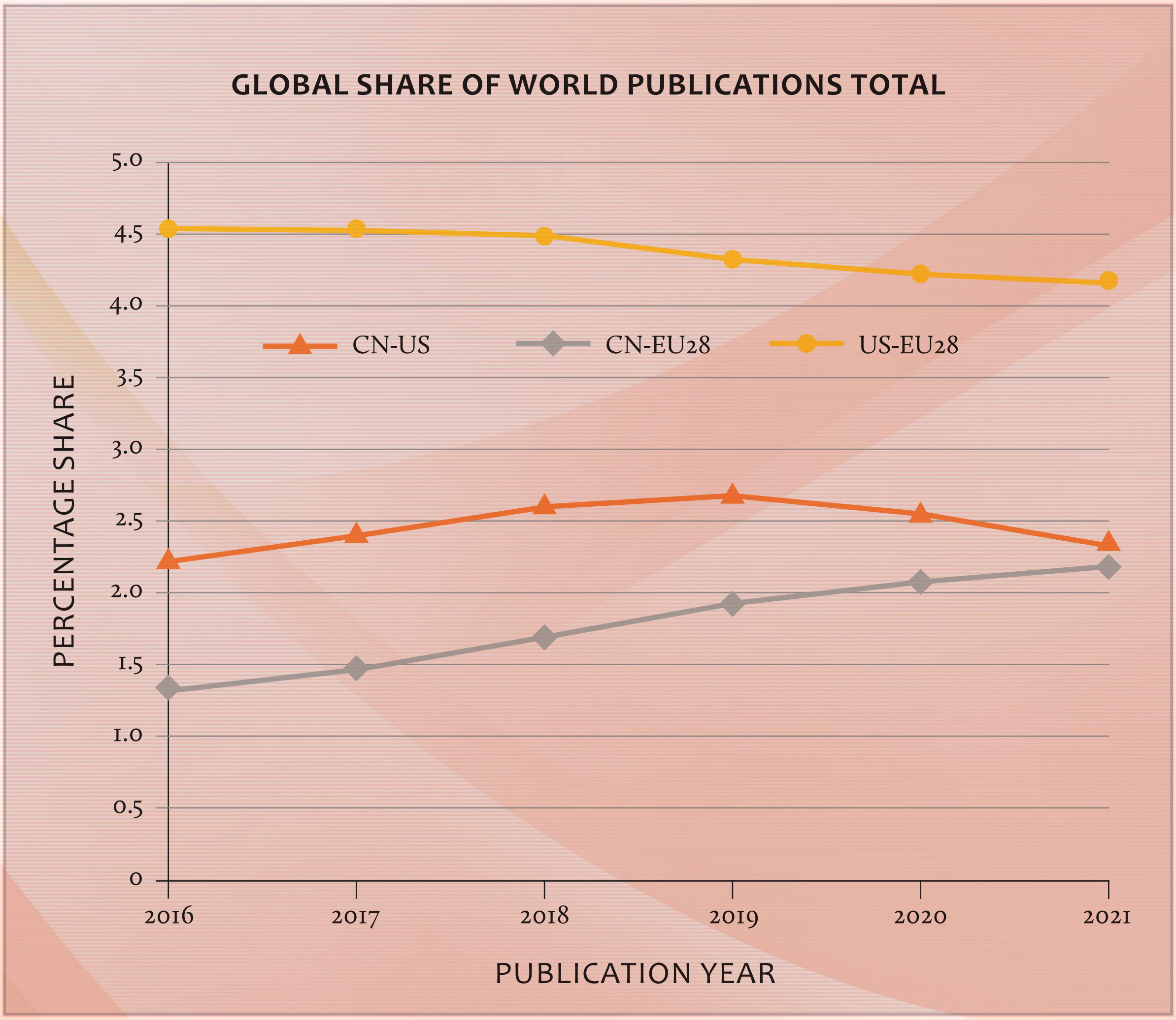

Figure. Percentage share of coauthorships between China-US, China-EU, and US-EU-28 in global publications, 2016-2021 (full counts). Data: Clarivate Incites online, accessed January 28, 2022

USA, between China and EU-28 and between the USA and the EU-28. It is evident that the share of China-US collaboration in global system shows a sharp decrease in 2021, from 2.71% in 2019 to 2.36% in 2021. The US continues to collaborate more with EU-28 than with China, although that cooperation is dropping from 4.49% in 2016 to 4.17% in 2021. The collaboration between China and EU-28 continues to increase but at slower rate.

The drop in China-USA collaborations can also be found within the percentage share of the totals represented by the partnerships. The data reveals a clear drop in the share of China-US collaboration in China beginning in 2019—before the pandemic. In fact, for Chinese publications, the share of China-USA collaborations decreased since 2016 at an even faster pace, while that for USA publications started to decrease in 2019. In contrast, the case for China-EU collaboration and USA-EU collaboration do not show significant change.

China's international collaborations dropped sharply in 2021 overall and most notably with the United States. Multiple reasons appear to be influencing the decline. Chinese students and scholars were restricted from visiting overseas due to pandemic travel restrictions and denial of visas. Distant communications between researchers became strained by lock-downs, illness, family obligations, and funding issues. If this were simply due to the pandemic, one would expect that the same patterns would be seen for China's relationship with the EU-28 as well as with the United States, but this is not what we see. The drop is between China and the United States.

Whether international collaborations will return to pre-pandemic levels depends on the reasons for the decline. The United States recently announced that is it dropping the "China Initiative" which was started to scrutinize Chinese participation in U.S. science. It appears from the data that political tensions have been more influential than pandemic issues, especially for China's cooperation with the United States – which had been the largest international collaborative relationship in the world, pre-pandemic. However, political tensions of many kinds appear to have cooled the demand for visas and the offer on the US side of study and research opportunities. Individuals respond to the tensions by looking elsewhere, or looking internally, for collaborators.

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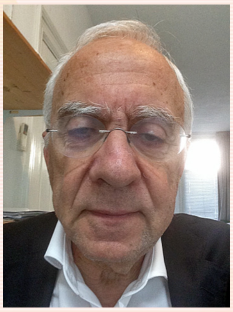
Zhou P, Thijs, B., Glänzel, W. (2009). Is China also becoming a giant in the social sciences? *Scientometrics* 71(3), 593-621

SCIENCE STUDIES AND SOCIOLOGY*



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On the occasion of celebrating "100 years of sociology in the Netherlands" with a theme issue of *Sociologischl Magazine*, the editors of this journal invited me to discuss the development of science and technology studies (STS) in relation to sociology. STS has been developed at some distance from sociology; their relation is asymmetrical. From the disciplinary perspective of sociology, the study of scientific research can be considered as an application; for STS, sociology is a discipline-based frame of reference, like economics or the philosophy of science.

1. STS AND THE SOCIOLOGY OF SCIENCE

Merton (1942) specified the *institutional* conditions for "academic" scientific practices such as the CUDOS norms of science. Κυδος is classical Greek for a watchman, and serves here as an acronym for the norms of science: Communalism, Universalism, Disinterestedness, and Organized Scepticism. By focusing on institutional dynamics, Merton's sociology of science accorded with Popper's ([1935] 1959) philosophy of science. Pre-war sociologists of *knowledge* like Simmel and Mannheim were overshadowed by Merton's institutional sociology of science. Popper proposed to distinguish between the context of discovery and the context of validation. The development of the content of science—the context of validation—could then be considered as the subject of the history and philosophy of science, while sociology focuses on how institutions and practices are shaped in science and by science. From Popper's perspective, the study of the latter contexts can be left to sociologists.

This division of labour between sociology and philosophy in studying the sciences was increasingly abandoned with the more recent development of STS (e.g., Lakatos & Musgrave, 1970). In 1962, the Organization

* This text is a (revised) translation of "Wetenschapsdynamica en Sociologie", *Sociologie Magazine* (in press). I am grateful to Rob Hagendijk and referees for commenting on an earlier version.

for Economic Co-operation and Development (OECD) was established for the civilian development of science and technology policy analysis (in addition to military cooperation in the context of NATO). In the decade thereafter, science and technology policies were shaped accordingly in all Western countries (Elzinga, 1980). In the Netherlands, for example, in 1980 the government funded a chair and provided a substantial budget for the university with the most promising program proposal.

Since that time, STS has been further institutionalized both in the Netherlands and in other developed countries in terms of journals, professional associations, etc. For example, the Centre for Science and Technology Studies (CWTS) in Leiden is an international centre for quantitative science studies. Previously, this international function was mainly carried out by the Department of Science Dynamics at the University of Amsterdam. The latter was abolished in 2000 for a number of reasons. In the Netherlands, STS is coordinated nationally by the Graduate School for Science, Technology and Modern Culture (WTMC). These further developments reflect the changing relations in STS as an interdidsiplinaru specialty among the research agendas in the relevant disciplines.

2. A NEW SOCIOLOGY OF KNOWLEDGE

For contemporary sociologists, it has often become an almost paradigmatic assumption that the units of analysis are people or groups of people. Even if the objects of research do not exclude other units of analysis, such as language in the sociology of language, or knowledge in the sociology of science, a sociologist will still be inclined to look mainly at language *use* or scientific *practices*. The focus is on the practices of agents and the historical construction ("sociogenesis"; cf. Archer, 1982) of institutions.

A more radical *sociology of scientific knowledge* emerged in science studies during the late sixties and early seventies. As against the Mertonian (sometimes also called normative) perspective, it was argued that sociology should also be able to address the contents of the sciences. Sociologists could, for example, analyze scientific developments in terms of knowledge interests.

Authors in this so-called "strong program"—based on the assumption that everything is the result of human construction and therefore accessible to sociological analysis—argued that one should even be able to explain the historical development of mathematics sociologically (Bloor, 1982). Unintentionally, this greater ambition of the sociologists to investigate the sciences sociologically led sociologists, philosophers, historians, and others to cooperate in STS across disciplinary lines; the field of science studies thus became increasingly interdisciplinary.

3. SCHOLARLY COMMUNICATION AND MEASUREMENT

From this background it came as a surprise (at least to me) when Luhmann (1995) provocatively stated—in his discussions with Habermas in the early seventies—that it is not people but communications that make and reproduce society (Habermas & Luhmann, 1971). Luhmann called his program *Soziologische Aufklärung* because it was no longer the individual and "agency" that were central, but coordination mechanisms at the supra-individual level. In addition to regarding the market as an economic coordination mechanism, knowledge can also be used to make interpersonal relationships more efficient. However, the links—feedbacks and feedforwards between, for example, private and public—can be different in science from the couplings in economics or politics.

Such a systems-theoretical approach to studying science and technology may encounter resistance among social scientists because the structures then tend to be reified. However, the meaning-connections are constantly being changed by new insights. As against the dynamics of science, a statics of science would be an oxymoron: “The ship must be rebuilt while a storm rages at sea” (Neurath, 1932/33). All relationships are subject to change; existing relationships are continuously tested for their robustness in social practices. Latour (2005) even proposed in this context to speak of an “associology”: whether it concerns people, ideas, or things, the relationships among “actants” remain networked and networking.

The theory that Latour developed (together with Callon) is also called “translation sociology” or “actor-network theory” (ANT; Latour,1987). According to these authors, the analytical schemes of Mertonian sociology can be discarded in favour of a radical antropology of processes of change in which both people and things are involved. The networks are therefore heterogeneous! By naming the heterogeneous units, however, these units can be brought back as empirical into the semantic/semiotic coherence of networks. Changes in these relationships can be measured using semantic or so-called “co-word” maps. The quantitative and qualitative research questions can thus be integrated pragmatically as texts into new research programs (Callon, Courtial, Turner, & Bauin, 1983; Luukkonen, 1990).

4. SCIENTOMETRICS

The quantitative direction in science studies is best known for citation analysis. Citation analysis can of course be used (or abused) for informative and administrative purposes. One then arrives at business and public administration or other application-oriented disciplines. However, a sociological orientation is also possible. For example, one can aggregate citations and then look at groups or even entire countries as producers or suppliers of knowledge and highly educated people. It is also possible to discover patterns in aggregated citations

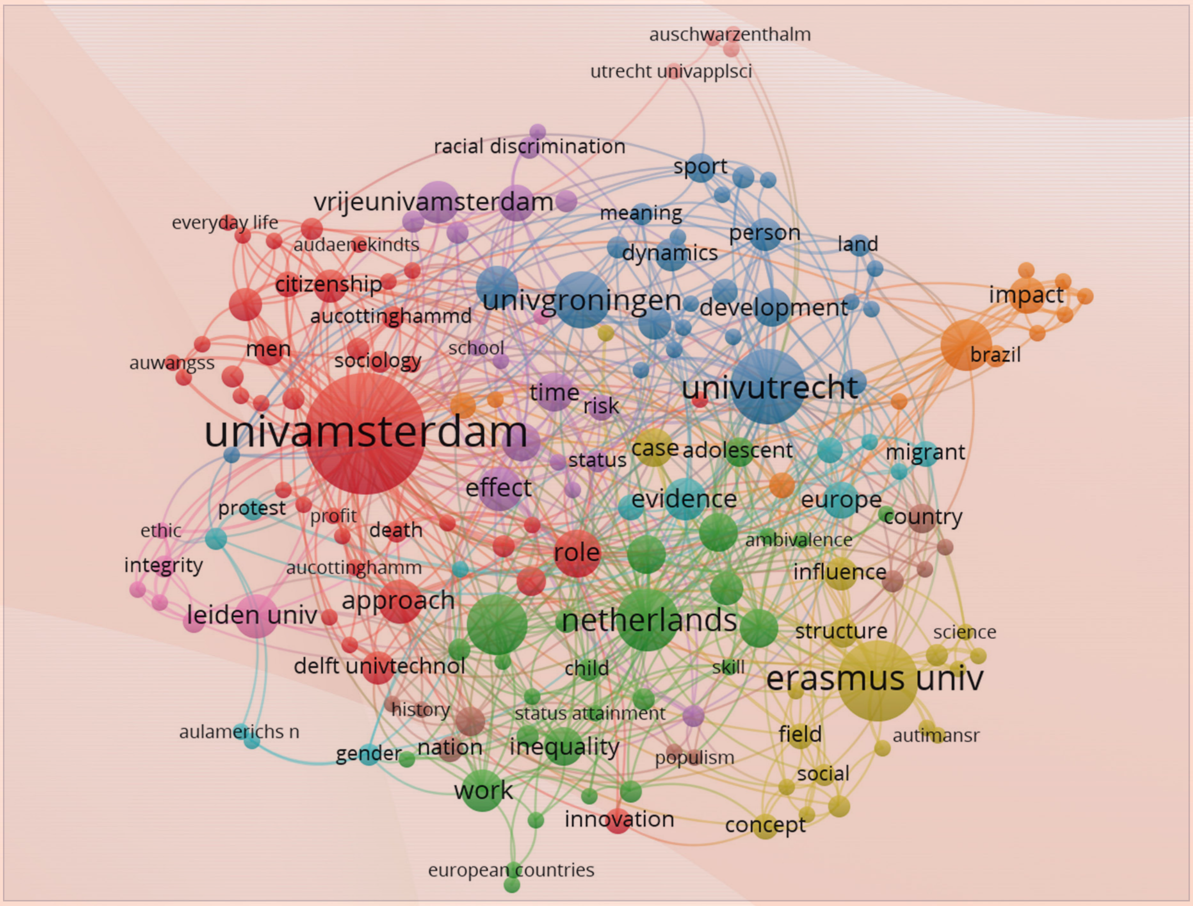

Figure 1: The institutional structure and semantic organisation of sociology in the Netherlands; 2019

between journals, and evaluate individual texts in those contexts. Instead of scientific journals, patent classes can be analyzed analogously. Both the relations among authors and inventors and the semanttics in their communications can be mapped.

For example, if we use the search term “sociology”in the leading citation and publication databases of the Institute of Scientific Information (Clarivate, Philadelphia PA), we can find (as of 22 May 2021) 317 journal articles with a Dutch address published in 2019. These 317 articles were already cited 602 times in the following year (2020). Figure 1 displays both the 178 title words that occur more than once and their institutional addresses in a single picture to demonstrate how we can almost routinely represent such heterogeneous networks.

Figure 1 shows that the universities each carry specific semantic fields. For example, at the top of the figure, the institutional relationship between Utrecht and Groningen is clearly visible as different from the relations of the University of Amsterdam and the Vrije Universiteit on the left. Erasmus University is stretching the network along a different axis.

One can color the nodes and links (relations) in the network, or change their size in accordance with the numbers of citations or publications, etc. In addition to possible errors in the calculation method, there are also numerous detail errors in the files, which are processed at an aggregated level. However, when it comes to evaluation, there should be no errors in the final reports. Correcting such errors and specifying the margin of error is an important part of the work of institutes dedicated to citation analysis.

5. SUMMARY AND CONCLUSIONS

Sociologically more interesting questions can also be addressed by using citation patterns. At the discipline level, for example, one can investigate whether the social sciences are developing at a pace different from the natural sciences by, for example, distinguishing between rapid (transitory) citations at a research front and reputations that are built up over longer periods of time. Repeated citation patterns indicate codification and therewith power (Price, 1970; e.g., Baumgartner & Leydesdorff, 2014). Codes in the communications cannot be attributed directly to agents at the nodes, but evolve with the communications as second-order variables in a cybernetics of communication and control (Krippendorff, 1994; Leydesdorff, 2007; Luhmann, 1990).

The interdisciplinary research programs of STS lead to interesting research questions and empirical findings (Milojevič & Leydesdorff, in prepration). As a field of research, science, technology and innovation have become important for the further development of the economy and of society. Although many STS scholars were trained as sociologists, the contribution of STS to sociology itself is no longer easy to delineate (Wyatt et al., 2017). In summary, I have argued that STS has been developed in the overlaps at the margins of sociology with other disciplines (Leydesdorff, 2021). I have given examples above about the Dutch research portfolio and how it relates to the international agenda. Due to the interdisciplinary nature of this type of research, further developments can be expected in the coming decades. Science research is also strongly stimulated in China (Zhao, Du, & Wu, 2020).

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THE LOGIC BEHIND THE MATHEMATICAL TREATMENT OF IMPACT

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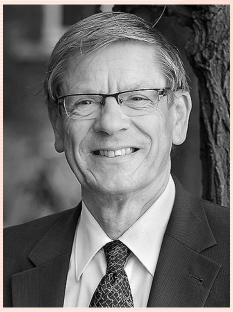

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ABSTRACT: We propose a definition for the fundamental notion of impact in informetrics.

INTRODUCTION

There are many possible interpretations of the intuitive notion of impact. Impact occurs when a car collides with another object, or when a person's acts or decisions influence the life of another person (e.g., by criminal behavior, and for the perpetrator, facing the consequences in court). In these examples, we notice an influence of one "object" on another "object" through an action. It is also possible not to specify the "receiving object" and just focus on an action of one object (e.g., a person) for which we can describe impact without specifying on which object. A typical example is the impact of a scientific publication as measured by the received number of citations. Here the "receiving object" is not specified since it can be another publication, a researcher, a scientific community, or even the whole world (in case of an important invention with widespread practical consequences). In this informetric example (and we will continue henceforth in the field of informetrics) we can speak of one-dimensional impact in the sense that impact is measured by one number (e.g., the number of citations). Similarly, but broader, in the UK Research Excellence Framework (REF) the outside impact of research was defined as 'an effect on, change or benefit to the economy, society, culture, public policy or services, health, the environment or quality of life, beyond academia'.

It is much more interesting to consider impact in two dimensions through the connection of publications and received citations or – in general terminology – sources and the corresponding number of items (that they possess or have produced). The basic function in this framework (Egghe, 2005) is the rank-frequency function Z describing, for every rank r, the number Z(r) of items in the source on rank r = 1,2,…,T, where sources are ranked in decreasing order of the number of items (ties are solved in a certain – here not specified – way) and where T (fixed) denotes the total number of sources. A typical, discrete, rank-frequency function occurs when a set of authors is ranked according to the number of publications, or when a scientist's publications are ranked according to the number of received citations. In this framework, the classical "impact measures" such as the h-index, h = h(Z) (Hirsch, 2005), the g-index g = g(Z) (Egghe, 2006)) and many variants, see e.g., (Egghe, 2010) can be applied and one says that a situation Z (another rank-frequency function) has (strictly) less impact than situation Y if m(Z) < m(Y) where m is the used impact measure (e.g., m = h or m = g). Note that in the previous lines the terms, "impact" and "impact measure" are used in a heuristic way. It is the purpose of this note to show how to select from these classical measures those mathematical aspects of impact and impact measures that are essential and hence come to rigorous definitions of these notions.

OUR FRAMEWORK

We will highlight now how we came to the definitions we were aiming at (Egghe, 2022, Egghe & Rousseau, 2022a,b,c) and what the logic is behind their introduction. For comparative reasons and further use, we will also use the measure μ(Z) (the arithmetic average (or mean) of Z). To work in a more comfortable framework, we will henceforth assume that the rank-frequency functions Z, Y are continuous functions with domain the interval [0,T], replacing the discrete set {1,…,T}, with T fixed.

What we learned from studying the classical measures such as h(Z) or g(Z) for a specific situation Z is the following: these measures focus on the sources with the higher number of items, those placed on the lower ranks r, and on their number of items. In other words: they focus on

the production (A) of the most productive sources (B) *(J)*

For aspect B this means that the left-hand side of the graph of Z, where ranks are low, is the part that really matters. These measures are not influenced by the production of the low productive sources, those with high ranks r. From this observation, we can already conclude that μ(Z) does not satisfy this principle since it depends on the total number of items in all sources and hence does not focus on (or is determined by) the most productive sources. This is where the notion of "measure bundle" (***"bundle"*** for short) enters this story. For all measures m we can introduce an ad hoc parameter version m_θ with the purpose of "scanning" the rank-frequency function Z. Concretely, we consider the following two examples. For the bundle m=h we define (for θ a positive number): $x = h_\theta(Z) \Leftrightarrow Z(x) = \theta x$ (Egghe, 2021). Note that the classical h-index h(Z) is equal to $h_1(Z)$. All these measures h_θ have the property to focus on the production of the most productive sources. An analogous definition can be given for the generalized g-index g_θ (Egghe, 2021). This technique also shows the way to use μ (in its "bundle version") as a tool for measuring impact: for all θ in [0,T], we define $\mu_\theta(Z)$ as the average number of items in the sources on ranks

$r \leq \theta$. Note that $\mu_T(Z) = \mu(Z)$ but that all other $\mu_\theta(Z)$ values focus on the "left-hand part" of the graph of Z, here the interval $[0,\theta]$ (while for these measures also the production is taken into account) and hence satisfy the requirement $(\mathcal{I})$ for measuring impact.

We observe that $(\mathcal{I})$ consists of two parts A and B. It is clear that A deals with 'pure' production while B deals with the notion of "concentration" or "inequality", well-known in other fields such as econometrics. So $(\mathcal{I})$ is a combination of aspects A and B and hence the exact notion of "impact" must also be a combination of these two aspects. So far, we still used the word "impact" in a heuristic way but from now on we will replace this heuristic notion with a mathematically exact formulation.

IMPACT MEASURES AND IMPACT BUNDLES

We noted already above that the B-part in $(\mathcal{I})$ focuses on the left-hand side of the graph of Z. That is why we proposed in Egghe (2022) the following basic form of the definition of an ***impact measure*** m. A function m is an impact measure if

> for every rank-frequency function Z, there exists a number a_Z in $]0,T[$ such that the condition $Z < Y$ on $[0,a_Z]$ implies that $m(Z) < m(Y)$

We note that the definition in Egghe (2022) slightly differs from the above definition (for technical reasons) but – essentially – it is the same definition and, for reasons of simplicity, we work with the one above. It is easy to see that h and g are impact measures and that for $m = h$, $a_Z = h(Z)$ and for $m = g$, $a_Z = g(Z)$ while for $m = \mu$, a_Z does not exist and hence is not an impact measure for the reason mentioned above: μ also depends on the production of the least productive sources so that the value $\mu(Z)$ is not determined by the values of Z on a "left-hand part of the graph of Z".

It is intuitively clear that, when we work with bundles m_θ, all these different measures (assumed to be impact measures) generate a range of values a_Z in $]0,T[$, so that we have:

> for all values a in $]0,T[$ and all rank-frequency functions Z, Y the condition $Z < Y$ on $[0,a]$ implies $m_\theta(Z) < m_\theta(Y)$, for all θ in a certain interval.

This is the condition for an ***impact bundle***, see (Egghe & Rousseau, 2022a). It is easy to see that the bundles h_θ and g_θ are impact bundles but also the bundle μ_θ satisfies this condition: indeed, here we can take – given any value $a > 0$ – all θ in $[0,a]$. So μ_θ is an impact bundle while μ (the overall average, such as the journal impact factor) is not an impact measure in the sense explained above.

GLOBAL IMPACT BUNDLES

The above definition of impact bundle is fine to define objects (bundles) that measure impact but is not suited to define "impact" itself. Yet it can be used in the following reasoning to define impact, based on $(\mathcal{I})$. We may delete the bundle m_θ in the above definition of impact bundle but then we end up with the condition "$Z < Y$" (since the number a is not defined). This is not a wrong assumption for the notion of impact but it is too strict since it requires $Z(x) < Y(x)$ for all x in $[0,T]$ and it is clear that we want to have a wider range of situations Z, Y where Y has more impact than Z (or vice-versa) as suggested by condition B in $(\mathcal{I})$. This condition is related to the classical notion of concentration where more or less concentration is defined via a relation between two functions Z and Y known as the dominance relation (Hardy et al., 1934) based on the classical Lorenz curve (Lorenz, 1905; Rousseau et al., 2018). We recall that the classical Lorenz curve is described within the unit square, i.e., two normalizations have been applied. Now, because of condition A in $(\mathcal{I})$ – we will define the easier non-normalized version of the Lorenz curve and show that this is a good decision. For a rank-frequency function Z, we define

$$I(Z)(r) = \int_0^r Z(x)\,dx$$

for r in [0,T] (or in the discrete setting:

$$I(Z)(r) = \sum_{i=1}^{r} Z(i) \qquad),$$

the cumulative number of items in the first r (most productive) sources. It is the normalized version of this function that is used in concentration theory (the Lorenz curve) but, as indicated above (because of A and B in ($\mathcal{I}$)), it is this simple non-normalized version that we need here. Indeed:

For all rank-frequency functions Z, Y we define the impact order -< as:

Z -< Y iff I(Z) ≤ I(Y) on [0,T]

Moreover, we define Z $-<_{\neq}$ as Z -< Y with Z ≠ Y (i.e., there exists an x such that Z(x) ≠ Y(x)). With this powerful tool we can formulate the following definition of a ***global impact bundle*** m_θ:

For all rank-frequency functions Z, Y:

the condition Z $-<_{\neq}$ Y implies that m_θ(Z) and m_θ(Y) respect the impact order $-<_{\neq}$ of Z and Y for all θ in a certain interval.

What does this definition mean? Take two rank-frequency functions Z and Y. We consider their difference Y – Z and suppose that this function does not switch between zero and non-zero an infinite number of times. Such a situation, infinitely many transitions, can exist in a purely mathematical sense but does not occur in practical cases. So, we can suppose that Y – Z has only a finite number of transitions (FNT) between 0 and a non-zero number. In that case, it is easy to show (Egghe & Rousseau, 2022b)) that the condition "Z $-<_{\neq}$ Y" implies one of the following two properties:

(i) Z < Y on [0,a] for a certain a > 0

(ii) Z = Y on [0,a] and Z < Y on]a,b] for certain numbers a and b such that 0 ≤ a < b.

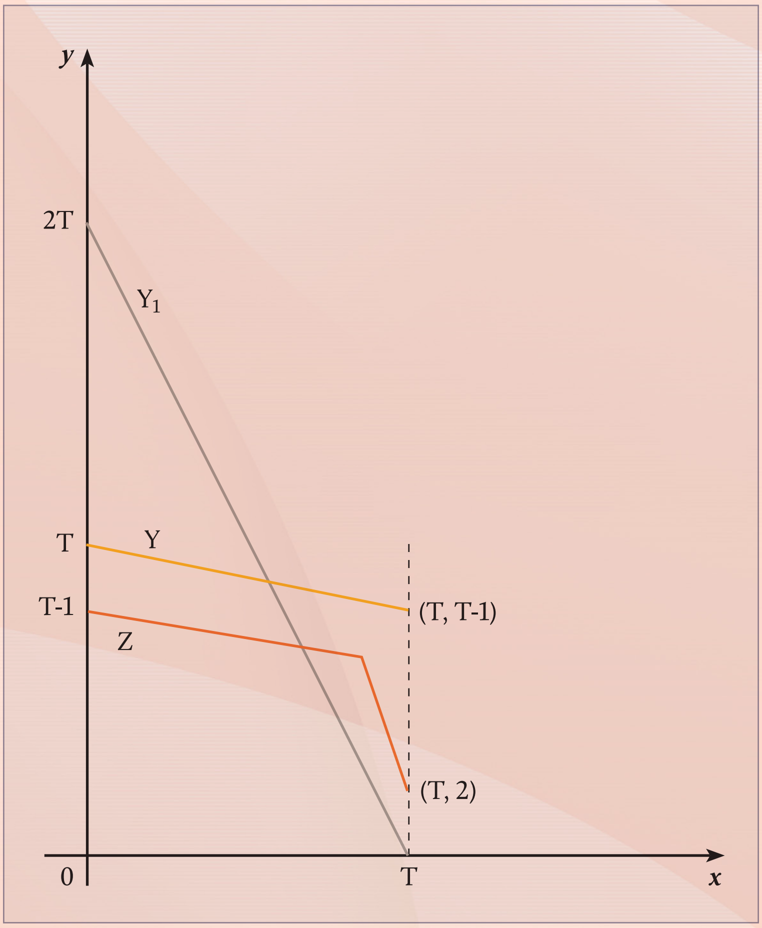

Figure 1. Impact (Y) vs. concentration (Z); Y_1 has a higher impact than Y.

Now we can make the definition of global impact bundle m_θ above more concrete by requiring that the same relations < (in case (i)) or = followed by < (in case (ii)) are valid for m_θ for all θ in a certain interval. It follows immediately from this definition and the one of impact bundle that every global impact bundle is an impact bundle (since for the latter only (i) applies). It is also intuitively clear that situations as in (ii) ("equal left-hand parts") are allowed in measuring (different) impact as long as such an equal part is followed by an unequal (<) part. It is now easy to prove that the impact bundles h_θ, g_θ and μ_θ (and others) are global impact bundles.

IMPACT

Based on the above results we now define impact (independent of the measure m or the bundle m_θ) in the following sense: for two rank-frequency functions Z and Y, we say that

Z has less impact than Y
if and only if Z $-\!<_{\neq}$ Y

In Egghe and Rousseau (2022c) we present results on the relation between the order relation -< and its normalized analog as used in concentration theory or its opposite, diversity theory. Heuristically (but exact results are in Egghe and Rousseau (2022c)) we can say that A and B in ($\mathcal{I}$) represent (respectively) production and the normalized -< and that they together, i.e. ($\mathcal{I}$)) represent the non-normalized -< hereby presenting the link between inequality and impact, the latter being "productivity + inequality" (in a heuristic sense).

AN ANALOGY WITH THE CLASSICAL LORENZ CURVE

If the concave Lorenz curve C_1 is situated above the concave Lorenz curve C_2, different from C_1, then any acceptable concentration measure must lead to a strictly larger value for the data associated with C_1, than for the data associated with C_2. Similarly, with fixed T, if I(Y), the integral function of the rank-frequency function Y is situated above I(Z), the integral function of the rank-frequency function Z, $Z \neq Y$, then any impact measure or impact bundle, must give a value that is strictly larger for Y than for Z. Yet, if Lorenz curves intersect, then the relation between the concentration values of the two cases depends on the used – valid! – concentration measure. Similarly, if the graphs of I(Z) and I(Y) intersect, then one may have a higher impact than the other, or vice versa, depending on the impact measure or bundle one uses. For bundles, this relation is determined by m_θ where $m_\theta(Z)$ and $m_\theta(Y)$ respect the impact order $-\!<_{\neq}$ of Z and Y for all θ in a certain interval.

Figure 1, illustrates the difference between the notions of concentration and impact. Y has a higher impact than Z (obvious because Y > Z), but Z is more concentrated. Moreover, Y_1 with equation $y = (2T - 2x)$ has a higher impact than Y, with equation $y = (T - x / T)$ because $I(Y_1) > I(Y)$. Indeed $I(Y_1)(x) = x(2T - x)$, while $I(Y)(x) = Tx - x^2 / (2T)$ and for all $0 < x \leq T$, $x(2T - x) > Tx - x^2 / (2T)$.

We close this short note by remarking that, before we wrote our articles, Egghe (2022) and Egghe and Rousseau (2022a,b,c), many articles in informetrics already dealt with impact and impact measures but this only in what we consider as a heuristic sense. We ourselves (Egghe, 2021; Egghe & Rousseau, 2021) began with a study of impact-related measures and bundles but without studying impact itself (at least not in a mathematical way). We hope that our approach to the fundamental notion of impact will prove to be essential for the field of informetrics.

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