Scientific Research Contribution of Prof. Ivan Gutman: A Bio-bibliometric Analysis

Avadhesh Kumar Patel
Junior Research Fellow
Department of Library and Information Science
Banaras Hindu University
Varanasi-221005, Uttar Pradesh, India
Email: akpbhu20@gmail.com
ORCID: http://orcid.org/0000-0002-7989-091X

Ramesh Kuri
Assistant Professor
Department of Library & Information Science
Rani Channamma University
Belagavi, Karnataka-591156, India
Email: rameshkuri.rcu@gmail.com
ORCID: https://orcid.org/0000-0003-4137-5995

Kunwar Singh
Professor, Faculty of Library and Information Science
School of Social Sciences, IGNOU
New Delhi-110068, India
Email: singhdlisbhu2015@gmail.com
ORCID: http://orcid.org/0000-0002-5615-5656

Ayush Kumar Patel*
Junior Research Fellow
Department of Library and Information Science
Banaras Hindu University, Varanasi-221005, Uttar Pradesh, India
*Corresponding Author
Email: ayush.kumarvns2012@gmail.com
ORCID: http://orcid.org/0000-0002-5668-1103

Raju Gadad
Librarian
KAHER Institute of Physiotherapy
Belagavi-590010
Karnataka, India
Email:gscsraju@gmail.com
ORCID: https://orcid.org/0000-0001-7781-5070

Abstract

The purpose of a bio-bibliometric study is to objectively investigate a renowned scientist's publications to determine his status in the field and raise the visibility of an otherwise unknown scientist. This research gives a bio-bibliometric analysis of Ivan Gutman's (IG's) research publications, one of the most influential writers in the fields such as chemistry and mathematics. Many topological indices, a notion derived from theoretical chemistry and other areas, were introduced by IG. The Scopus database was searched, and the results yielded 899 publications. The primary elements used to analyze IG's contributions are publication productivity and citations, authorship pattern, research collaboration, and communication channels. According to the findings, Dr. Ivan Gutman's publication productivity is 18 papers per year, and 788 (86%) of his publications are collaborative. The paper "Molecular orbitals and graph theory Alternate hydrocarbons' total -electron energy "traced an article with a lot of citations (1204). Bradford's law is violated because the highest 157 of his publications appeared in the source item of MATCH-Communications In Mathematical and in Computational Chemistry, and the spreading of IG's papers among journals. As a result of this bio-bibliometric examination of Professor IG's scholarly works, it is clear that he is a role model for other researchers aspiring to be successful scholars in their fields, notably in Chemistry and Mathematics.

Keywords: Bibliometrics; Bio-bibliometrics; Scientometric portrait; Bradford's law; Research productivity; Ivan Gutman; VOSviewer; Graph theory

Introduction

Research is essential for the generation of new knowledge in every field. The scientific literature contains new knowledge developed by scientists. Doing research has been crucial for knowledge growth, and communicating the study's findings to the rest of the world is an important part of the research cycle. For the country's long-term development, continuous research activities are essential (Haq, 2021; Naseer and Mahmood, 2009). Every country sets a standard for evaluating the quality of its scientific, socioeconomic, and educational research. In a variety of methods, every country, its researchers, and its institutions can be assessed on the quality and quantity of their research achievements (Madhu and Kannappanavar, 2020). Bibliometric analysis is a term used in the Library and Information domain to describe the measurement of a growing discipline.

Pritchard coined the term "bibliometric" and defined it as "the application of mathematical and statistical techniques to books and other media" (Das et al., 2022 Patel and Singh, 2022). The term bio-bibliometric refers to the branch of bibliometrics that is used to track and analyse an individual author's research growth (Pritchard, 1969). The term "bio-bibliometrics" was coined and defined as a quantitative and analytical technique for finding and forming functional linkages between bio- and biblio-data elements (Koley and Sen, 2006; Manjunath and Ramesha, 2015). A Bio-Bibliometrics study is concerned with the bibliographical study of scientists' and researchers' individual careers, and it correlates the bibliographical analysis of publications with their academic scientific discoveries (Kuri and Ravi, 2014). It is a quantitative process of counting the various parameters of articles, books and other forms of publications of prolific writers. Such studies can be appropriate for any branch of knowledge to find out the tendency and productivity of targeted literature. The main purpose of the study is to demonstrate Ivan Gutman's bio-bibliometric appraisal of scientific literature, which he performed as a Professor of Physical Chemistry at the University of Kragujevac.

Biographical Sketch of Prof. Ivan Gutman

Ivan Gutman (IG) was born in 1947 in Sombor, Serbia. His parents are Dr. Mirko Guttman and Katarina Guttman. In Sombor, IG attended elementary and secondary school. He studied chemistry at the University of Belgrade's Faculty of Sciences from 1966 to 1970, graduating in 1970. He then worked as a teaching assistant at the Faculty of Chemistry in Belgrade for a short time. Prof. I.G. worked as a research assistant and senior assistant in the Theoretical Chemistry group in the Department of Physical Chemistry at the Ruder-Boskovic Institute in Zagreb. Later, in 1973, he earned an M. Sc. in Theoretical Organic Chemistry and a Ph.D. in chemistry with a thesis titled "Studies of Topological Properties of Conjugated Hydrocarbons" from the University of Zagreb's faculty of science (the University of Kragujevac, n.d.). He held the positions of Assistant Professor, Associate Professor, and Full Professor beginning in 1984. He retired in October 2012 and is now a professor emeritus at the same faculty (Crown, n.d.). Prof. I.G. taught a variety of courses in physical, computational, and theoretical chemistry. Aside from physical chemistry, which he taught continuously from 1977 to 2012, "Chemical Thermodynamics", "Quantum Chemistry and Molecular Structures", "Quantum Chemistry", "Theoretical Organic Chemistry", "Elaboration of Experimental Data in Chemistry",

"Informatics for Chemists", "Programming in Chemistry", "Computer Chemistry", "History of Chemistry", and "History and Philosophy of Chemistry" (Aminer, n.d.), among others.

Review of literature:

In recent years, Bio-Bibliometric studies have gained popularity in academia for assessing research productivity of individual authors. There are numerous articles on Bio-Bibliometrics and Scientometrics Portrait that have been published. The following are a few of the closest articles that have been reviewed for this study:

Mukit et al. (2021) conducted a bibliometric and thematic assessment of Professor M. Kabir Hassan's scientific legacy. This study showed that Professor M. Kabir Hassan has published scores of publications and research papers on finance and Islamic banking in top-ranking refereed academic journals, and his network extends to different places throughout the world.

Haq (2021) presented the bio-bibliometric portrait of the research productivity created by Dr. Tasawar Hayat. He is a distinguished Professor of Mathematics at Quaid-e-Azam University, Pakistan. This study pointed out that Dr. Hayat contributed in 21 subject-categories and the highest number of papers had been written on the subject of Physics, Astronomy, and Mathematics. He is the most productive author in the country profile of Pakistan as well as Saudi Arabia.

Kappi et al. (2020) carried out a bio-bibliometric study on research work of physics scientist Dr R. G. Sonkawade. This study analyzed 90 research publications of Dr R. G. Sonkawade and found that he published 03 (3.33%) articles as solo author and in the rest 87 articles with co-authors. The year 2010 found to be the most productive year with 18 articles. The research productive journey of Dr R. G. Sonkawade is still continuing.

Madhu and Kannappanavar (2020) examined the 442 research articles produced by Prof P Balaram during his productive years from 1973 to 2019. This study analyzed that Prof P Balaram is more collaborative in nature compared to individual output and this degree of collaboration is 0.036. He is a genius in the field of Bio-organic Chemistry and Molecular Biophysics and contributed excellent work and collaborated with a number of foreign and Indian authors.

Haq and Ahmad (2019) studied a bio-bibliometric analysis of the works of Professor Dr. Kanwal Ameen. The study identified that Dr. Kanwal Ameen is the most prolific female writer in the Library and Information Science field in Pakistan. Her study team consisted of 28 young and seasoned researchers, including three foreigners, and the majority (70.07 %) of her work was collaborative.

Mondal et al. (2018) evaluated the contribution of Professor Prasanta Chandra Mahalanobis to the statistics field in India. The study revealed that Professor Prasanta Chandra Mahalanobis contained 6 books, 142 journal articles, 87 conference papers, 38 research reports and his research productivity peaked during 1934 to 1938 at the ages 41-45, with contributions of 77 scientific works.

The major goal of this paper is to acknowledge Professor Ivan Gutman's scholarly work and to examine his contributions to the fields of chemistry and mathematics. In today's world, he is a top international specialist in mathematical chemistry. In his field of research, Professor Gutman has extensive international collaboration with different scientists all over the world.

Objectives:

The data was analyzed with the following objectives:

- To know the year-wise contribution of papers by Ivan Gutman;
- To find out year-wise distribution of Citations;
- To examine the authorship pattern and identify author's collaboration;
- To identify the channel of communications and test Bradford's law;
- To find out the geographical distribution of publications; and
- To analyze the top cited publications and forms of publications.

Methodology:

Data Source

This retrospective analysis was undertaken on the publications output of Ivan Gutman, renowned Professor of Physical Chemistry at the University of Kragujevac. For the present study, the data

set was collected from the Scopus bibliographic database. Scopus is one of Elsevier's most comprehensive abstracting and citation databases of peer-reviewed literature (Patel et al., 2022).

Search Strategies

The data was extracted from the database within the Scopus domain. The search term "Ivan Gutman" was used to search data from 1972-2020. The Scopus database indexed Dr. Ivan Gutman's documents under the Scopus Author ID No. 7102696936. The following search string was used in this study "AU-ID ("Gutman, Ivan" 7102696936) AND (EXCLUDE (PUBYEAR, 2021))". The bibliographic data were retrieved on July 7, 2021. A total of 899 articles were found during the data extraction.

Data Analysis

The retrieved data was analyzed using bibliometric indicators in order to support the study objective. MS Excel spreadsheets were used to elucidate data and represented in corresponding tables and graphs. Also, The VOSviewer software version 1.6.16 was used to make the results more visible. The VOS (Visualization of Similarities) viewer was created by Nees Jan van Eck and Ludo Waltman of Leiden University's Center for Science and Technology Studies (Wang et al., 2021). The key benefit of VOSviewer software is the ease with which bibliographic data may be shown (Fabregat-Aibar et al., 2019; Mashroofa et al., 2023). The research process during the study is shown in Figure 1.
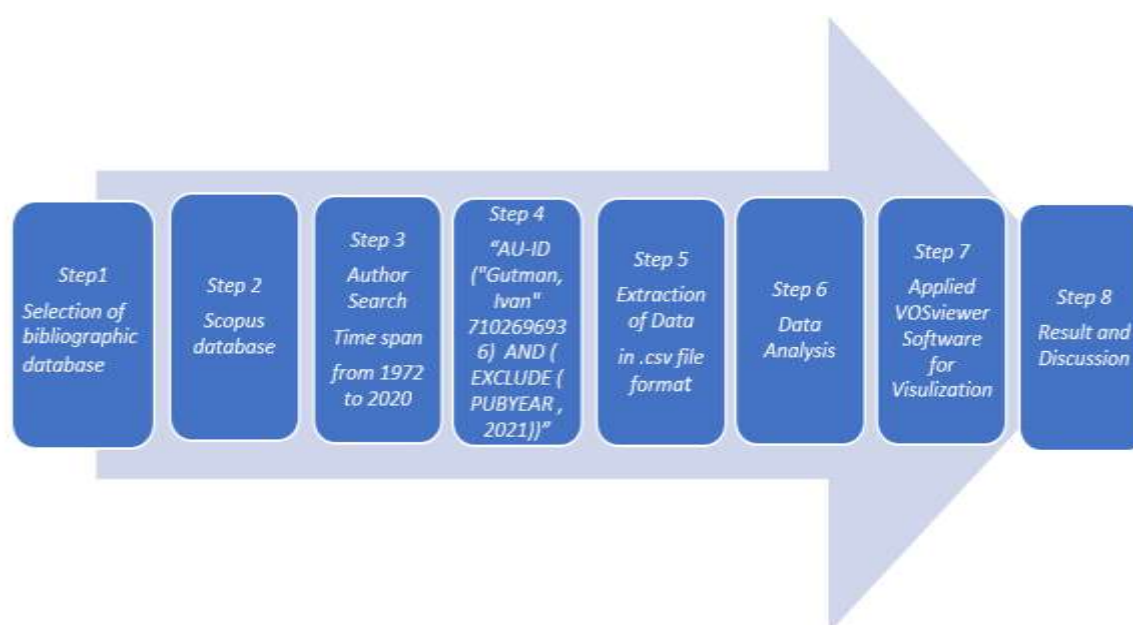

Fig. 1: the steps taken during the research

Results and Discussions:

Chronological publication productivity

An attempt was made to examine the amount of literature contributed by Prof. Ivan Gutman, a well-known chemist who accomplished approximately nine centuries (899 publications) in a half-century life span (49 years) with an average of (18.34~) 18 publications per year. Fig. 2 depicts the publication output in the form of a scatter diagram. The publication trends are depicted in this image by a curve that follows the sine(sin) function after 90^0 phases, or sinusoid trends with three degrees of the polynomial. Prof. I Gutman has 39 articles in 2008 and only one publication in 1982.
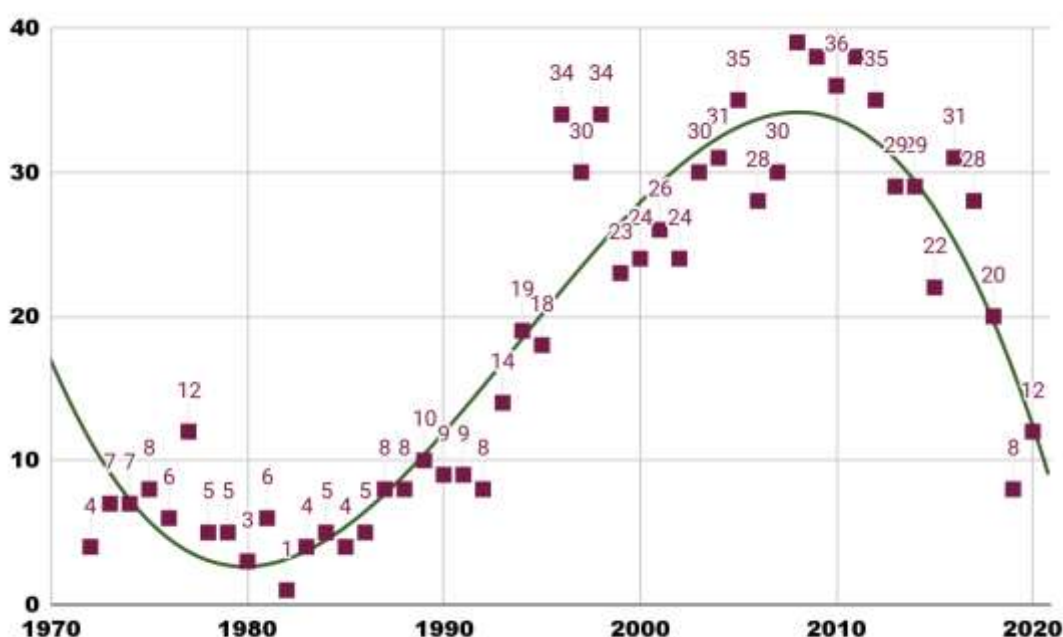

Figure 2: Scatter graph for chronological publication distribution

Scattering of citations

The annual pattern of citations to Prof. Ivan Gutman's articles is depicted in Fig. 3. Every year, there is a consistent frequency of citations. The majority of citations range from 0 to 250, with an average of (24.12~) 24 citations per publication and (442.59~) 443 citations per year. The

ScimagoGraphica software was used to create this image. The highest number of citations was 1432 in 1972, the first year of publishing.
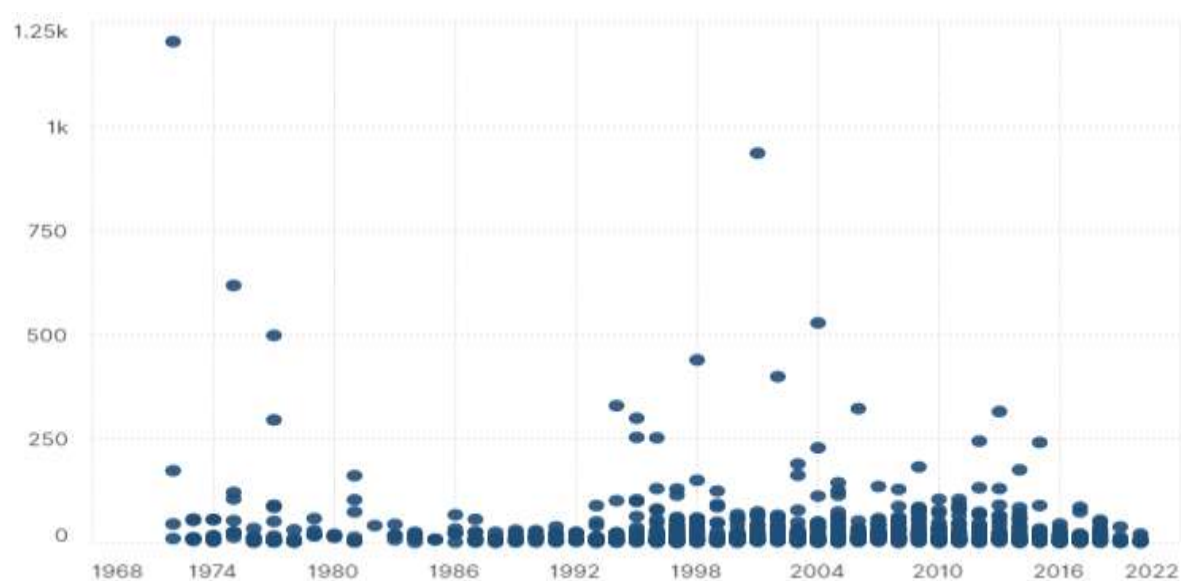

Figure 3: Scattering graph of citations

Authorship pattern

Prof. Ivan Gutman's entire productivity life spans the 4th (2002-11) and 3rd (1992-2001) decadal eras, with the most significant number of publications appearing during the 4th (2002-11) and 3rd (1992-2001) decadal periods, with 329 and 230 publications, respectively. This is followed by the 5th decadal era, 2012-2020, with 214 publications; the first (1972-81) and second (1982-91) with 63 publications each. Three-authored publications, on the other hand, have the most (289), two-authored publications have the second most (237), and single-authored (Ivan Gutman) articles have the lowest (119). As a result, the researchers conclude that multi-authored publications outweigh single-authored publications, implying that IG published the majority of his papers in collaborations. Ivan Gutman selfly produced nearly 13.24 % publication. Table 1 demonstrates an increasing trend in co-authored articles as well as a decadal distribution of publications.

Table 1

Decadial distribution and Authorship pattern

Decades	Single	Two	Three	Four	Five	Six &+	TMAP	Total
1972-81	22	19	16	5	1	0	41	63
1982-91	14	29	15	4	0	1	49	63
1992-2001	32	75	67	34	14	8	198	230
2002-11	37	86	96	82	20	8	292	329
2012-20	14	28	95	46	25	6	200	214
Total	**119**	**237**	**289**	**171**	**60**	**23**	**780**	**899**
** TMAP=Total Multi-Authored Publications								

Author's collaboration

Prof. IG maintained an extensive international collaboration with several of the world's leading experts in mathematical chemistry today. He has extended his collaboration with 653 authors, with B. Furtula topping the list of Prof. IG's collaborators with 102 articles. Boris Furtula is a specialist in a variety of fields, including mathematical chemistry, computational chemistry, chemoinformatics, and chemometrics. Furtula and Gutman are both graduates of the same university. It is followed by S. Radenkovic (same institution, similar field of work) with 46 articles, K. C. Das with 37 publications, N. Trinajstic with 29 publications, S.J. Cyvin with 27 publications, and a slew of others. Indian authors are included in the partnerships, such as K.C. Das (Ph.D. at IIT Kharagpur INDIA in June 2004), who is the third collaborator in the top ten list. Figure 4 depicts a network visualization of Gutman's collaborations with other authors such as Furtula, Radenkovic, Das, Trinajstic, and Cyvin, who are among Gutman's top five co-authors.
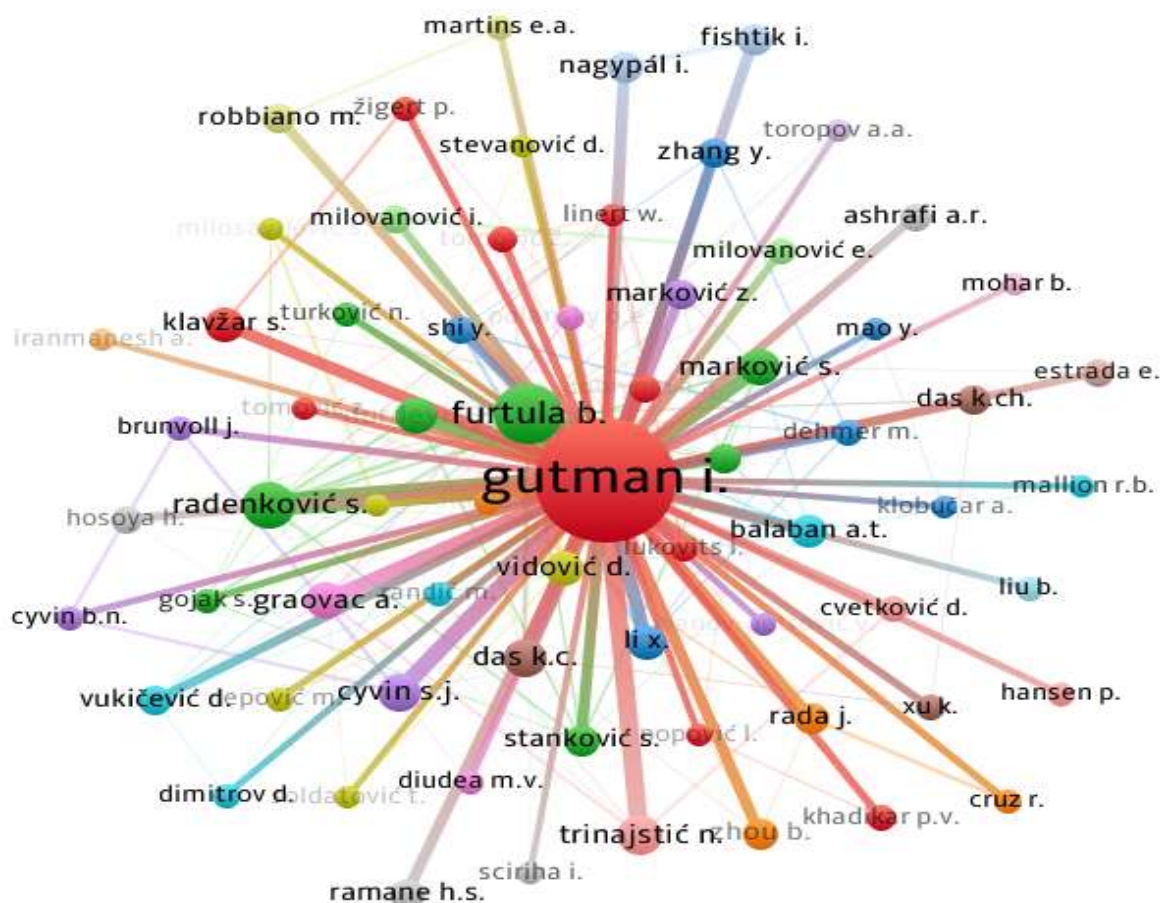
Figure 4: Network visualisation of Author's collaboration

Channels of Communication

Prof. Ivan Gutman, a pioneering mathematical and physical chemist, published all 899 papers in 100 journals. Table 2 shows which journals published the most papers published or co-authored by Professor Gutman. Between 1990 and 2020, he published 157 publications in MATCH-Communications in Mathematical and Computer Chemistry. On the other hand, 5183 of his documents' 21687 citations are related to those published in MATCH. It is followed by the journals Chemical Physics Letters and Journal of The Serbian Chemical Society, in which he has published 85 articles with 2916 and 1277 citations, respectively. Furthermore, the Indian Journal of Chemistry Section A Inorganic Physical Theoretical and Analytical Chemistry published 42 documents, while the Journal Of Chemical Information And Computer Sciences and Zeitschrift

Fur Naturforschung Section A Journal Of Physical Sciences each published 37 documents, each of which was authored or co-authored by the given researcher.

Table 2
Channels of Communications used by Prof. Ivan Gutman

Source	TP	%	Cit.	FPY	LPY
MATCH-Communications In Mathematical And In Computer Chemistry	157	17.46	5183	1990	2020
Chemical Physics Letters	85	9.45	2916	1972	2016
Journal Of The Serbian Chemical Society	85	9.45	1277	1996	2016
Indian Journal Of Chemistry Section A Inorganic Physical Theoretical And Analytical Chemistry	42	4.67	1146	1996	2012
Journal Of Chemical Information And Computer Sciences	37	4.12	2279	1993	2004
Zeitschrift Fur Naturforschung Section A Journal Of Physical Sciences	37	4.12	629	1977	2016
Journal Of Mathematical Chemistry	35	3.89	875	1988	2019
Polycyclic Aromatic Compounds	32	3.56	378	1992	2018
Croatica Chemica Acta	26	2.89	1063	1996	2020
Linear Algebra And Its Applications	26	2.89	1010	2002	2018
Discrete Applied Mathematics	21	2.34	565	1986	2020
Journal Of Molecular Structure THEOCHEM	21	2.34	324	1986	2006
Monatshefte Fur Chemie	21	2.34	370	1998	2012
Applied Mathematics And Computation	20	2.22	458	2012	2019
Theoretica Chimica Acta	16	1.78	907	1972	1992
** **TP**=Total Papers, **Cit.**=Citations, **FPY**=First Publications Year, **LPY**=Last Publications Year					

Application of Bradford law in Ivan Gutman's research publication

Choosing a journal in a specific subject has become a difficult chore for librarians in this day and age. Bradford's law of scattering assists librarians in acquiring a journal for their library or information centre. With this Bradford's scattering journals on a specific subject area will be divided into three major zones based on the average number of total articles further which will be divided zone-wise, following Table 3 replicates the same.

Table 3

Bradford Multiplier

Zones	Journals	Articles	Bradford multiplier
I	3	327	--
II2	10	298	3.33
III3	87	260	8.7
Total;	100	885	Avg. 6.015

In the above Table-3 dataset has been tested with Bradford law, in which total number of articles were divided into 3 major zones as per the Bradford law of scattering, where Bradford states 1: n: n^2. Thus, the first zone consists of 327 articles that were published in 3 most productive journals and will be considered as nucleus zone journals, whereas 298 articles are scattered in 10 journals, similarly 260 articles published in the 87 journals. Thus, the dataset is calculated according to Bradford's multiplier as 3: 3×6.015: 3×6.015^2.

Further, the dataset examined with the % of error is 34.91 thus which is comparatively more so we can say Gutman's publication does not follow Bradford law.

Top Ten Affiliations and Countries collaborating by Gutman

Based on the affiliation of co-authors the research identified top ten affiliations and countries collaborated by Prof. Ivan Gutman. (GholampourandNoruzi, 2021). Institutions collaboration for at least two documents have been presented in Table 4. Interestingly, many publications of Prof. I G were the results of scientific collaboration with researchers from the University of Kragujevac in Serbia with 725 publications and the Institute Ruder Boskovic in Croatia with 63 publications. Furthermore, institutions including the Szegedi Tudományegyetem SZTE with 60 publications, Sungkyunkwan University with 42 publications, the Norgesteknisk-naturvitenskapeligeuniversitet with 31 publications and others have institutional collaborations with Gutman. Reviewing Gutman's international involvement or collaboration in Figure 5 and Table 4, it is seen that Gutman, mainly affiliated with University of Kragujevac in Serbia, has developed scientific collaborations with researchers from 86 countries during his 49 years of scientific activity. Moreover, Gutman's scientific collaboration network reveals that most collaborators are from European and Asian countries, so that he has had the highest amounts of

scientific collaboration with those from Serbia and China with 576 and 101 publications respectively. It is followed by the United States, Yugoslavia, Hungary, Croatia, India, South Korea, Germany and Slovenia with 62, 62, 56, 48, 44, 42, 41 and 39 documents, respectively. Furthermore, Figure 5 demonstrates that Gutman worked in some of these countries (Serbia, China and the United States) and had several scientific co-authorships with researchers from these countries. In addition to the countries shown in Fig. 5, further countries from Eastern Europe, Western Europe, North America, South America, Asian countries and South Africa are present among Gutman collaborating countries.

Table 4

Top Ten Affiliations and Countries

Sl. No.	Affiliation	TP	Country	TP
1	University of Kragujevac	725	Serbia	576
2	Institute Ruder Boskovic	63	China	101
3	Szegedi Tudományegyetem SZTE	60	United States	62
4	Sungkyunkwan University	42	Yugoslavia	61
5	Norgesteknisk-naturvitenskapeligeuniversitet	31	Hungary	56
6	Univerza v Mariboru	23	Croatia	48
7	Nankai University	21	India	44
8	South China Normal University	20	South Korea	42
9	University of Niš	20	Germany	41
10	Texas A and M University at Galveston	19	Slovenia	39

Figure 5: GeoMap of Gutman's collaborative countries

Top Cited Gutman's Publications

Fig. 6 depicts a network visualisation of Prof. Ivan Gutman's most-cited works. Among the most-cited works is one named "Graph theory and molecular orbitals are two examples. Total ω-electron energy of substituted hydrocarbons "Wiener index of trees: Theory and applications," published in 1972 in Chemical Physics Letters Journal, has received the most citations (1204), followed by "Graph theory and molecular orbitals. XII. Acyclic polyenes", with 618 citations, and "The first Zagreb index 30 years after", with 528 citations. Gutman's 10 most-cited publications have more than 300 citations and are published in nine different journals, with Acta Applicandae Mathematicae Journal having two publications among the 10 most cited, "Wiener index of trees: Theory and applications (936 citations)" in 2001 and "Wiener index of hexagonal systems (399)" in 2002.
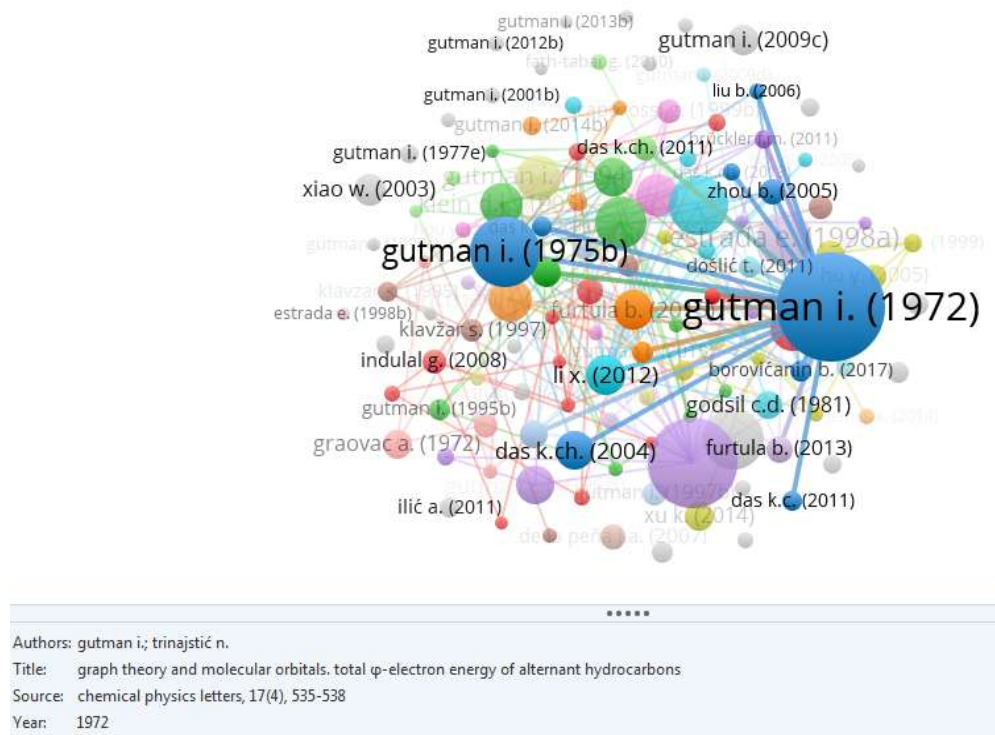
Authors: gutman i.; trinajstić n.
Title: graph theory and molecular orbitals. total φ-electron energy of alternant hydrocarbons
Source: chemical physics letters, 17(4), 535-538
Year: 1972

Fig. 6: Network visualisation of most cited publications

Forms and Disciplines of Gutman's Publications

During the research period, Prof. Ivan Gutman published 899 scientific publications, including 841 (93.54%) journal articles, 19 editorials, 19 reviews, and 6 conference proceedings and other forms of publishing (Table 5). Prof. Ivan Gutman is a well-known Serbian chemist and mathematician, but his publications cover a wide range of topics, including Chemistry, Mathematics, Computer Science, Physics, and Astronomy, as well as Biochemistry and Genetics, Molecular Biology, Material Science, Chemical Engineering, Agricultural, and Biological Sciences, Social Sciences, Pharmacology and Toxicology, Medicine, Decision Science, Engineering, and Multidisciplinary Research (Figure7).

Table 5

Forms of Publications

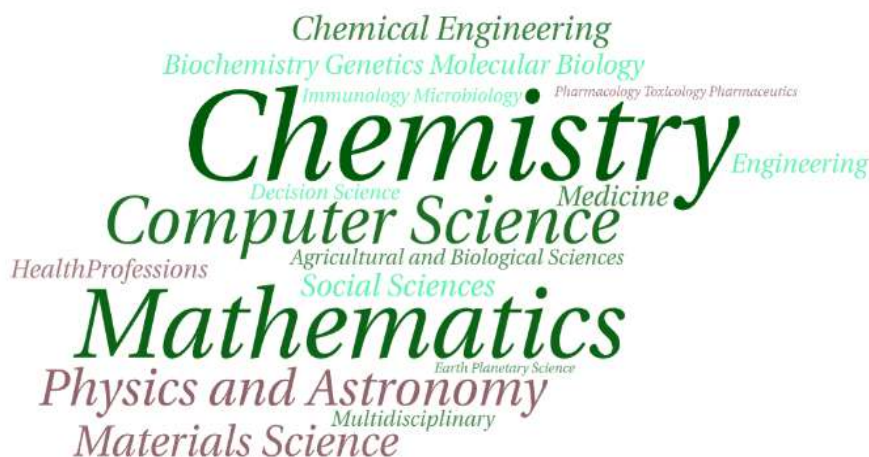| Document type	Doc
Article	841
Editorial	19
Review	19
Conference Paper	6
Note	6
Book Chapter	4
Book	2
Erratum	1
Letter	1

Figure 7: Disciplines of Gutman's publications

Occurrences Outputs

Fig. 8 depicts the terms that Gutman used and repeated the most in his 49-year career as a scientist. Graph theory, article, wiener index, energy, molecular graph, molecular structure, cyclic conjugation, eigenvalues and eigenfunctions, topological index, chemical graph theory, mathematical techniques, graph energy, matrix algebra, isomer, polynomials, absolute values, laplacians, topology, graph spectrum, and other emerging terms were found to be more frequently in Gutman's papers. As a result, it can be argued that over the years, this famous researcher from the University of Kragujevac in Serbia has primarily focused on such issues or themes in his studies and investigations.
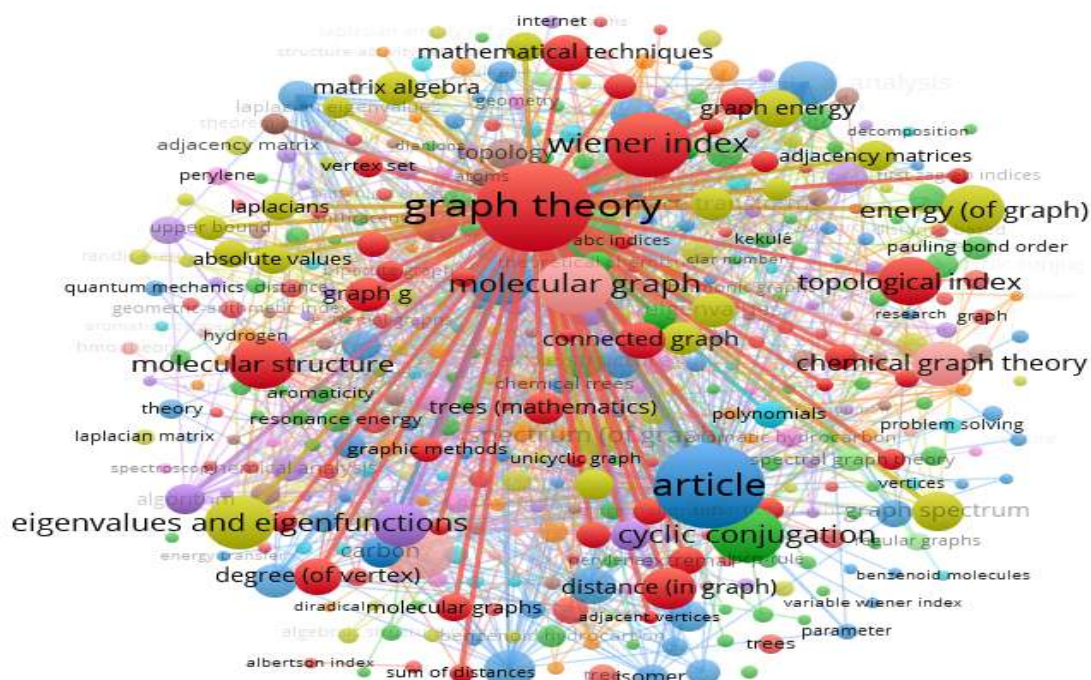
Fig. 8: Network visualisation of preferred terms

Conclusion

Bio-bibliometric studies give insight into several facets of a scientist's academic career, including research productivity, collaborative and authorship patterns, productivity curve increase and decline, and other features. These studies can be quite beneficial to the scientist in question since they can assist them in determining their status among their peers. This research will almost certainly raise the profile of a good scientist who is otherwise unknown. Thus, researchers in this study attempted to emphasize Prof. Gutman's research papers, where they discovered the highest productivity year, the core author's communication channels, authorship pattern, and top affiliations and countries collaboration.

Based on an examination of Ivan Gutman's research publications, he authored the majority of his papers in collaboration, with the exception of 119 pieces where he was the sole author. Boris Furtula (102 articles), S. Radenkovic (46 publications), and K.C. Das were all collaborators on his core authorship (37 publications). From 1972 to 2020, his most productive years saw him produce the most collaborative works, with 289 three-authored publications. The most widely utilized communication channel (157 articles) was MATCH-Communications In Mathematical

and Computer Chemistry, and highly cited papers came from the same source (5183 times). Graph theory is one of the top author keywords.

Finally, this bio-bibliometric analysis of Professor Ivan Gutman's academic works demonstrated that he is a role model for other researchers aiming to be successful scholars in their fields, notably chemistry and Mathematics. It inspires a lot of young people who are involved in research and development in the same area. Furthermore, studying the citations received by his scientific articles would be fascinating to determine the sociological impact on future mathematical science researchers.

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