Informetric Portrait of Elinor Ostrom, the Nobel Laureate in the Field of Economic Sciences

Praloy Kr Bhattacharyya[1], Nivedita Bhattacharyya Sahu[2,*]

[1]Central Library, Garhbeta College, Garhbeta, Paschim Medinipur, West Bengal, INDIA.
[2]Department of Library and Information Science, Vidyasagar University, Midnapore, Paschim Medinipur, West Bengal, INDIA

ABSTRACT

The publication productivity of Elinor Ostrom, the renowned American Political economist and the first woman laureate to win the most aspired highest prize that is the Nobel Prize in Economics in 2009 for her analysis of economic governance is analysed. The present study has analysed her 197 publications as indexed in Scopus using bibliometric methods covering the period 1965-2018. It is observed that during her 54 years of publication she published average 3-4 works each year. The years 2006, 2008- 2013 accounts for 103 publications i.e. 52.28% and they are the most productive years in her life. She published 85 single-authored papers and 112 multi-authored papers. James Michael Walker who co-authored 19 publications is the most prominent collaborator. Natural resources management is the prominent area of her research. Ostrom used 116 channels prominently being the journal articles covering 119 (60%) of her publications. Ostrom's works had high reception which can also be seen from the citations received; 50552 citations as per Scopus. Her Recency Index is nearly 0.47 which indicates that nearly 47% of her works are cited in the last five years. Ostrom's works are an inspiration for the future Nobel aspirants and researchers in economics because she designed a new principle and argued with proof that common resources are best utilised and best managed when they are managed by the localities of the areas where those resources are found. This provided an opportunity for the common people to earn a living as well as helped in the best utilisation of the resources which is a unique idea. Her works therefore opened up avenues to find out the new resources of various areas and continues to be important in the future. The bibliometric analysis attempts to draw some insights of her interesting and important work.

Keywords: Informetric Portrait, Nobel laureate, Elinor Ostrom, Common resources, Economic Sciences.

INTRODUCTION

The Nobel Prize is the highest prize for research accomplishment. The reputation of a nation and its scientific community depends upon these highest awards and the intellectuals eagerly wait to earn such appreciation for their hard work. In 1901, the Nobel Prizes were started in physics, chemistry, medicine or physiology, literature and peace. In 1968, the Central Bank of Sweden (Sveriges Riksbank), concurrence with its tercentenary celebration introduced a new award, "The Central Bank of Sweden Prize in Economic Science in Memory of Alfred Nobel" on the basis of an economic assurance by the bank in infinity. The award followed the same principles and rules as the original Nobel prizes.[1]

So, till date this prize is called as "The Sveriges Riksbank Prize in Economic Sciences in Memory of Alfred Nobel". From 1969 to 2019 the total number of Nobel Laureates in economic sciences is 83. In the initial years and till 2008 no woman was awarded the Nobel Prize in Economic sciences but Elinor Ostrom, Professor at the University of Indiana, USA became the first woman to be honoured with the award in 2009 jointly with Oliver E. Williamson from University of California, Berkeley, CA, USA. Her win ensured that 2009 was a record-breaking Nobel year for women in Economic Sciences.

Ostrom's work was to go underneath the usual economic statements of the problem and examine the microeconomic nature of how institutions evolved to alleviate common property issues. In the process she became one of the leading political economists of her time.[2] Ostrom's ideas are so pertinent because they are not simply theoretical proposals or the result of some laboratory experiment. Rather, they are based on far-reaching compilation of real life cases in many different countries and cultures and for different types of commons. This type of research provides insights

based on the empirically observed behavior of individuals under conditions they live in.[3] Kevin Gallagher, one of the reporters in the Guardian after Ostrum's win reports on Oct 13, 2009 "Ostrom won the Nobel prize for showing that privatising natural resources is not the route to halting environmental degradation." Actually she contradicted with many environmental experts and proved that the government may not be the best allocator of public resources either. Often governments are seen as illicit, or their rules cannot be imposed. Indeed, Ostrom's Governing the Commons: The Evolution of Institutions for Collective Action looking at forests, lakes, groundwater basins and fisheries shows that the commons can be an opportunity for communities themselves to manage a resource. When communities are given the right to self-organise they can democratically govern themselves to preserve the environment.[4] In the Obituary column of the Economist on June 30, 2012, it has been very rightly mentioned that "while others wrote gloomily of the tragedy of the commons, seeing only overfishing and over farming in a free-for-all of greed, Mrs Ostrom, with her loud laugh and louder tops, cut a cheery and contrarian figure."[5]

So studying her life and works and analyzing them through scientometric indicators in this paper turns out to be very interesting from cross-disciplinary point of view. Such studies are either called as bio-bibliometrics or informetric portraits. 'Bio-bibliometrics' the term was first coined by Sen and Gan[6] to describe the quantitative and analytical method for finding and generating functional relationships between bio-data and biblio-data elements. Recently the term 'Bio-bibliometrics' is being used for a method of retrieving and visualizing biological information that uses co-occurrence of gene naming terms in Medical Sciences to generate semantic links between genes.[7] Kalyane and Kalyane[8] for the first time used the phrase 'Scientometric Portrait' to carry out bio-bibliometric studies on scientists while Sinha and Bhatnagar[9] and Sinha and Ullah[10] used the term 'Information profile' for such studies.

Therefore from the different studies, it is suggested that 'Scientometric Portrait' is the appropriate phrase for the studies on scientists and 'Informetric Portrait' can be used for the studies on personalities in other disciplines such as arts, humanities and social sciences. The importance of the study can be comprehended from the fact that by analysing individual bibliographical and biographical data those who have touched the top position in academic and research life may inspire the younger generations. The study of famous women who reached the top position in academic life makes the women society more stimulating.

Related works and Objectives of the study

Some previous studies like Dutta[11] conducted a bibliometric study with the works of Bimal Kanti Sen, a professional librarian and information scientist. The year-wise distribution of authorship pattern, collaborative authors, degree of collaboration, core journals and highly cited publications are studied in this paper. Bhui and Bhattacharyya[12] studied the scientometric portrait of the scholarly publications of Dr. S. R. Ranganathan, mathematician and librarian from India and also considered as the father of Library Science in India. They analyzed Ranganathan's publications as well as citations received by him as delineated in the Google Scholar database. Barik and Jena[13] presented a study on the publications of Dr. Amartya Kumar Sen, Nobel laureates in Economic Sciences and analyzed his 111 publications from Scopus database during 1969-2015. The results reveal that Sen published an average of 2-3 scholarly article per year, his 21(18.9%) papers are more than 100 times cited and 2 papers are more than 300 times cited, his core domain of research are economics and applied areas of economics. Munnolli, Pujar and Kademani[14] highlighted quantitatively the publication productivity of Harald Zur Hausen a renowned scientist and Nobel Laureate in Physiology who published 285 papers during 1964-2009. The main domains of publications were studied and publication density was found as 3.60, publication concentration was 3.49 and the productivity coefficient was 0.50. Kademani, Kalyane and Kumar[15] carried out the Scientometric analysis of 190 scientific publications by Harold W. Kroto, the Nobel laureate in Chemistry (1996) published during 1985 –2000. They found the core journals publishing his papers, publication concentration as 4.5, publication density as 3.05 and the average Bradford multiplier as 3.5. They also indicated his research impact assessment by keyword occurrence in the titles. Kademani, Kalyane and Kumar[16] analysed 246 papers by Ahmed Hassan Zewail, the Nobel laureate in Chemistry in 1999 and found his productivity coefficient as 0.52 and opined that it is a clear sign of consistent publication productivity behaviour during his 19 years of research. Akakandelwa[17] tried to portray the life-sketch of Professor Seter Siziya, a medical bio-statistician. After analyzing 152 papers published by Professor Seter Siziya between 1988 to 2008, he showed that 241 researchers from various institutions at local and international level collaborated with Siziya and found that he was the primary author in 27 papers, second author in 40 papers, third in 50 papers. His productive co-efficient was 0.92. González-Alcaide[18] presented the study on bibliometric indicators on Santiago Grisolia's scholarly creation in the field of biochemistry and molecular biology. Sife and Bernard[19] conducted a scientometric study to evaluate the publication productivity of Prof. Rudovick R. Kazwala. They analyzed 111 scholarly publications and showed that Kazwala attained the 50-percentile productivity life at the productivity age

of 18. His productivity co-efficient was 0.69, publication density was 2.18 and publication concentration was 23.68. El Aichouchi and Gorry[20] explores Hagenmuller's (a figure of French solid-state chemistry) works using scientometric analysis. They reveal the impact of his research, main research topic and his collaboration with other collaborators.

The above studies which focused on the works of different scholars as well as Noble laureates from various fields provided grounding for the present study on Elinor Ostrom.

The study aims to find out why Ostrom inspite of being a Political scientist with all her degrees in Political science became so famous among the Economists that she was awarded one of the highest prizes. For this concentration has been paid on Ostrom's publication productivity over the years, the most prominent researchers with whom she collaborated for her researches, the major subject domains on which Ostrum worked, the works which received highest citations and the most used keywords used in the titles of Ostrom's works. The main research questions drawn from these objectives are therefore:

a) How the publication productivity of Ostrom changed over the years?

b) How collaboration in researches has been observed from Ostrom's works?

c) Which subject domain received most attention from Ostrom?

d) How the top cited works affected the winning of noble prize by Ostrom?

e) Which field of Ostrom's work received wide acclamation?

METHODOLOGY

The data presented in this paper have been accessed from Scopus (an Elsevier's abstract and citation database launched in 2004). The basic data, relating to the bibliometric characteristics of Elinor Ostrom were collected using 'Author Search' option in Scopus. Due to non-availability of exact name search facilities in the database, the search result was refined by author affiliation. Affiliation of the author was determined by authors' address. All the searched results were first saved in CSV file and then imported into MS-Excel. Only for the citation analysis two other databases as Google scholar and Web of Science in addition to Scopus are consulted to collect data. However book citations of Elinor Ostrom are not found in Web of Science database probably because they are not indexed in that database and hence are omitted in the tabular data. After sorting the data in MS-Excel the data is analysed to satisfy the objectives.

The following formulae have been used to calculate the Collaborative Index and Collaboration co-efficient in the Table 1.

Collaborative Index (C.I.) = $\dfrac{\sum_{j=1}^{A} j f_j}{N}$

Collaboration Co-efficient (C. C.) = $1 - \dfrac{\sum_{j=1}^{A} \frac{1}{j} f_j}{N}$

where, f_i = The number of papers j authors in collection K

N = The total no. of papers in collection K

A = The total no. of authors in collection K

Degree of collaboration is defined as the ratio of the number of collaborative research papers to the total number of research papers published in the disciplines during a certain period of time. Degree of collaboration (DC) = $\frac{N_m}{N_m + N_s}$, where N_m number of Multiple-authored research papers in the discipline published during a year and N_s = number of single-authored research papers in the discipline published during the same year.[21] It is also shown in Table 1.

Biographical sketch of Elinor Ostrom

Elinor Ostrom or Lin, as she is often called was born on 7th August 1933 in Los Angeles, California and grew up in a family of simple means. She lived with her divorced mother. She graduated with honours in political science from the University of California. She got her Ph.D. awarded in 1665. She married political economist Vincent Ostrom. She started her academic career at Indiana University, was also a founding director of the Centre for the Study of Institutional Diversity at Arizona State University. She published several books during her career like Governing the Commons (1990) and Understanding Institutional diversity (2009). She was the first woman to receive the prestigious Nobel in economic sciences in 2009 which raised some eyebrows. On December 8, 2009 she delivered her Nobel Prize lecture in Stockholm, Sweden entitled "Beyond Markets and States: Polycentric Governance of Complex Economic Systems" which was published in American Economic Review by American Economic Association in June 2010.[22] Her award-winning scholarly work demonstrates how communities can successfully share common resources, such as waterways, livestock grazing land and forests, through collective property rights that best define her legacy. She died on 12th June 2012 in Bloomington, USA. [23,24]

DATA ANALYSIS AND DISCUSSIONS
Growth of Publications

Table 1 depicts that Ostrom published 197 scholarly publications with an average of 3-4 publications per year, during her long publication productivity age of 54 years from

Qui.	BA	PY	Number of Papers under various authorship		Main author	Co-author	APC	CAPC	%CAPC	PPA	DC	CI	CC
			Single	MAP									
Q1	32	1965		1		1	1	1	0.51	1	1	2	0.75
	33	1966						1	0.51	2			
	34	1967						1	0.51	3			
	35	1968	1			1		2	1.02	4	0	1	0
	36	1969						2	1.02	5			
	37	1970						2	1.02	6			
Q2	38	1971	1			1		3	1.52	7	0	1	0
	39	1972						3	1.52	8			
	40	1973	1			1		4	2.03	9	0	1	0
	41	1974		1		1		5	2.54	10	1	3	0.89
	42	1975	1			1		6	3.05	11	0	1	0
Q3	43	1976	1			1		7	3.55	12	0	1	0
	44	1977						7	3.55	13			
	45	1978	1	1		2		9	4.57	14	0.50	2.50	0.75
	46	1979						9	4.57	15			
	47	1980						9	4.57	16			
Q4	48	1981		1			1	10	5.08	17	1	9.00	0.99
	49	1982		1			1	11	5.58	18	1	2.00	0.75
	50	1983	2			2		13	6.6	19	0	1	0
	51	1984						13	6.6	20			
	52	1985	1	1		1	1	15	7.61	21	0.50	1.50	0.50
Q5	53	1986	1			1		16	8.12	22	0	1	0
	54	1987						16	8.12	23			
	55	1988	1			1		17	8.63	24	0	1	0
	56	1989	1	1		1	1	19	9.64	25	0.50	2.00	0.67
	57	1990	2	2		2	2	4	23	11.67	26	0.50	2.00	0.67
Q6	58	1991	1	3		1	3	4	27	13.71	27	0.75	1.75	0.64
	59	1992	2	2		3	1	4	31	15.74	28	0.50	1.75	0.60
	60	1993	1	1		2		2	33	16.75	29	0.50	2.00	0.67
	61	1994	1	2		2	1	3	36	18.27	30	0.67	2	0.69
	62	1995	2	3		2	3	5	41	20.81	31	0.60	1.60	0.56
	63	1996	1			1		1	42	21.32	32	0	1	0
Q7	64	1997							42	21.32	33			
	65	1998	1			1		1	43	21.83	34	0	1	0
	66	1999	1	4		2	3	5	48	24.37	35	0.80	3.80	0.90
	67	2000	5	3		5	3	8	56	28.45	36	0.38	2	0.64
Q8	68	2001		4			4	4	60	30.46	37	1	3.50	0.90
	69	2002	3	1		3	1	4	64	32.49	38	0.25	1.75	0.54
	70	2003	2	7		4	5	9	73	37.01	39	0.78	2.44	0.79
	71	2004		5		1	4	5	78	39.6	40	1	2.20	0.79

Table 1: Year and age-wise distribution of publications by Elinor Ostrom.

Q9	72	2005	3	4	4	3	7	85	43.15	41	0.57	2.14	0.71
	73	2006	3	9	4	8	12	97	49.24	42	0.75	2.17	0.74
	74	2007	2	6	4	4	8	105	53.3	43	0.75	5.63	0.92
	75	2008	4	7	4	7	11	116	58.88	44	0.58	2.18	0.71
	76	2009	9	8	10	7	17	133	67.51	45	0.47	1.88	0.61
Q10	77	2010	9	12	11	10	21	154	78.17	46	0.57	14.76	0.96
	78	2011	5	7	8	4	12	166	84.26	47	0.58	3.75	0.84
	79	2012	7	4	7	4	11	177	89.85	48	0.36	2.82	0.73
	80	2013	3	7	3	7	10	187	94.92	49	0.70	3.50	0.86
	81	2014	5	3	5	3	8	195	98.98	50	0.38	2	0.62
	82	2015	1		1		1	196	99.49	51	0	1	0
Q11	83	2016						196	99.49	52			
	84	2017						196	99.49	53			
	85	2018		1		1	1	197	100	54	1	2	0.75
		Total	85	112	104	93	197						

1965–2018 which are indexed by Scopus database. Year-wise and the cumulative number of publications are shown in Figure 1. As shown in the Table 1 and Figure 1, maximum number of articles are published in the years 2006, 2008– 2013 which accounts for 103 publications i.e. 52.28% and they are the most productive years in her life, Ostrom published on an average 12-13 articles during those years. The highest number of contributions is found when Ostrom's age was 77 years in 2010 with 21 publications (9 single authored and 12 multi-authored papers) followed by 2009 when she was 76 years, with 17 publications the year after and the year of winning the Nobel Prize. No publications are seen during 1966-1967, 1969-1970, 1972, 1977, 1979-1980, 1984, 1987, 1997, 2016-2017. It also appeared that many years after her death in 2012, her contributions are being published. She published 85 single-authored papers and 112 multi-authored papers. She was the main author in 104 (52.79%) of her publications and in 93 publications acted as co-author. Her productivity co-efficient was found to be 0.80 which indicates her publication productivity was steady throughout the period.

$$\text{Productivity Co-efficient} = \frac{\textit{Fifty percentile age}}{\textit{Total productivity age}} = \frac{43}{54} = 0.80$$

Again Table 1 depicts the quinquennium publication data of Elinor Ostrom which shows that the highest publication output of 62 papers (31% of her total contributions) is found during the 10th quinquennial during 2010-2014 (age range 77-81) and second highest is found during the 9th quinquennial during 2005-2009 (age range 72-76) i.e. 55 papers (28% of her total contributions). It is worth mentioning that Prof. Ostrom received the Nobel prize during these two quinquennium.

The contribution of Ostrom was least during the age range 32-36 years i.e. since 1965-1969. It is seen that Ostrom's contribution increased with her age.

Co-Authorship pattern

It appears from the Table 1 that Prof. Ostrom contributed 85 publications under single authorship and 112 publications are result of collaboration out of total 197 publications. Two-authored collaboration resulted in the largest number of publications, i.e. 51, 27 publications are found to be three-authored collaboration, 16 publications by four-authored collaboration, 6 publications by four-authored and remaining publications are more than five authored. Ostrom collaborated with 421 different authors in various publications. The highest number of collaborators in Ostrom's papers is found to be 256 in a paper published in 2010 and the second highest number of collaborators is found to be 22 in a paper in 2011.

Collaboration in scientific research is a growing phenomenon and the proportion of co-publications in the total number of scientific publications is growing steadily. The proportion of co-authorship of Prof. Ostrom increases significantly since 1999, at least 421 different collaborators are associated with her in various publications. Table 2 shows the prominent collaborators associated with her. The most prominent co-author is James Michael Walker who co-authored 19 publications over 21 years and both are affiliated to the same university, followed by Marco A. Janssen, Professor, Arizona State University where she was founding director of the Centre for the Study of Institutional Diversity, co-authored 12 publications over 7 years.

Table 2: Prominent Collaborators Associated with Elinor Ostrom ≥ 5 papers.

Sl. No.	Co-Author's name	No. of papers contributed with ElinorOstrom	First Publication year	Last Publication year	Total Years	Co-Author's Affiliation
1	Walker, James Michael	18	1990	2010	21	Indiana University, United States
2	Janssen, Marco A.	12	2005	2011	7	Arizona State University, United States
3	Ahn, T. K.	9	2000	2011	12	Seoul National University, South Korea
4	Basurto, Xavier	6	2009	2018	10	Duke University, United States
5	Gardner, Roy J.	6	1990	2010	21	Indiana University, United States
6	Nagendra, Harini	5	2006	2014	9	AzimPremji University, India
7	Poteete, Amy R.	5	2004	2010	7	University Concordia, Canada

Degree of collaboration

Value of Degree of Collaboration (DC) gives a fairly clear idea of degree of collaboration with Prof. Ostrom. From Table 1 it has been observed that in her 54 years of productive life, DC=1 only for 7 years which implies that no single author publications of the author appear in these years. Value of DC lies between 0.5 and 1 for 12 years means multi–authored papers of Ostrom are published more than her single authored papers in these years, value of DC equal to 0.5 for 6 years means multi–authored publications and single–authored publications are equal in number, value of DC is less than 0.5 for 5 years means multi–authored papers of Ostrom are published less than her single authored papers in these years and value of DC equal to zero for 11 years i.e. only single–authored publication appears in these 11 years.

Domain-wise contribution

Prof. Ostrom's research area can broadly be categorized into 17 subfields of social science. Her publications are not limited to a specific area of research. Natural resources management is the prominent area of her research, she has contributed total 84 (42.64%) publications followed by the Environmental economics with 21 (10.66%) publications and Public finance with 21 (10.66%) publications. Ostrom's work has wide dispersion covering 116 journals. 'Science' (published by American Association for the Advancement of Science, USA), published the maximum number of her works i.e. 9 in number and 4.57% works of her total contributions followed by Journal of Theoretical Politics (7) and Ecological Economics (6). There are four channels carrying 5 publications, four channels carrying 4 publications, three channels carrying 3 publications, 20 channels 2 publication and 82 channels carrying 1 publication each. Top 14 channels published 34% of her total works.

Item type distribution

Figure 2 depicts the item type distribution of Ostrom's works. Journal articles top the list with 119 (60%) publications followed by book chapter (31), review (18), book (10), editorial (7) and note (6). Only two contributions each are made in the item categories namely conference paper, letter and short survey.

Citation analysis

After publication, research results are used by other researchers for their own studies and cited as references in their subsequent articles. The citation of one article by another is characteristic of scientific publications and it is generally accepted that the number of citations of a particular article is a reflection of its impact in the scientific community.[25] Citations provide data that can be used statistically and mathematically to quantify the relative importance of a particular article or a particular journal. There is positive correlation between citation and *H*-index of a researcher.

As per SCOPUS record, a total of 197 scholarly publications have received 50718 citations, while Google scholar reports the citation number to be 204963 and Web of Science indicates the number of citations to be 20277. So we can say that Google scholar outshines the reporting for the number of citations when compared to other databases.

Table 3 depicts the list of works of Ostrom which are cited more than 100 times in Scopus database. It is noticed that the first two highly cited works are books and then the next three highly cited works are the publications in the Journal Science. Seven of her works published in the journal Science received 100 or more than 100 citations. Among the 63 works which received 100 or more citations 24 works are published post Nobel Prize and rest are published prior to the receiving of Nobel Prize.

Scientometric Indicators of Elinor Ostrom

Table 4 depicts the different indexes calculated for Elinor Ostrom. The *h*-index is 77 according to Scopus. The Recency Index of Ostrom is nearly 0.47 which indicates that nearly 47% of her works are cited in the last five years i.e. in between
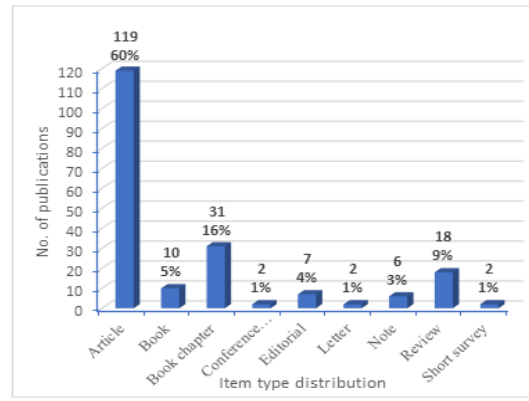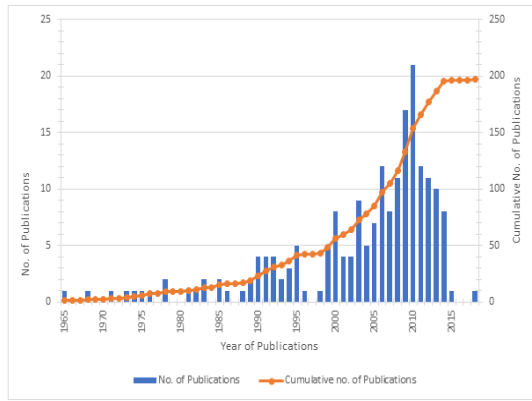
Figure 1: Publications productivity.

Figure 2: Item type distribution.

Sl. No.	Title	Year	Source	Citation received (SCOPUS)
	Table 3: Citation profile of significant works by ElinorOstrom ≥ 100 citation (as on April 19, 2020).			
1	Governing the commons: the evolution of institutions for collective action	1990	Cambridge University Press	13889
2	Understanding institutional diversity	2009	Princeton University Press	2931
3	A general framework for analyzing sustainability of social-ecological systems	2009	Science	2756
4	The Struggle to Govern the Commons	2003	Science	2063
5	Complexity of coupled human and natural systems	2007	Science	1679
6	Collective action and the evolution of social norms	2000	Journal of Economic Perspectives	1471
7	A behavioral approach to the rational choice theory of collective action presidential address, American political science association, 1997	1998	American Political Science Review	1468
8	Revisiting the commons: Local lessons, global challenges	1999	Science	1393
9	A diagnostic approach for going beyond panaceas	2007	Proceedings of the National Academy of Sciences of the United States of America	1245
10	Property-rights regimes and natural resources: a conceptual analysis	1992	Land Economics	1059
11	Beyond markets and states: Polycentric governance of complex economic systems	2010	American Economic Review	1022
12	Covenants with and without a Sword: Self-Governance Is Possible	1992	American Political Science Review	999
13	Crossing the great divide: Coproduction, synergy and development	1996	World Development	806
14	Polycentric systems for coping with collective action and global environmental change	2010	Global Environmental Change	782
15	Working together: Collective action, the commons and multiple methods in practice	2010	Princeton University Press	682
16	Coping with tragedies of the commons	1999	Annual Review of Political Science	599
17	The concept of scale and the human dimensions of global change: A survey	2000	Ecological Economics	575
18	A grammar of institutions	1995	American Political Science Review	541
19	Governing the commons: The evolution of institutions for collective action	2015	Cambridge University Press	487
20	Background on the Institutional Analysis and Development Framework	2011	Policy Studies Journal	484
21	Coupled human and natural systems	2007	Ambio	469
22	The globalization of socio-ecological systems: An agenda for scientific research	2006	Global Environmental Change	459

23	Going beyond panaceas	2007	Proceedings of the National Academy of Sciences of the United States of America	448
24	An agenda for the study of institutions	1986	Public Choice	439
25	Collective action, property rights and decentralization in resource use in India and Nepal	2001	Politics and Society	397
26	Social-ecological system framework: Initial changes and continuing challenges	2014	Ecology and Society	362
27	Analyzing decentralized resource regimes from a polycentric perspective	2008	Policy Sciences	343
28	Insights on linking forests, trees and people from the air, on the ground and in the laboratory	2006	Proceedings of the National Academy of Sciences of the United States of America	328
29	Local enforcement and better forests	2005	World Development	325
30	Heterogeneity, group size and collective action: The role of institutions in forest management	2004	Development and Change	313
31	Connectivity and the governance of multilevel social-ecological systems: The role of social capital	2009	Annual Review of Environment and Resources	308
32	Earth system science for global sustainability: Grand challenges	2010	Science	288
33	Trust and Reciprocity: Interdisciplinary lessons from experimental research	2003	Trust and Reciprocity: Interdisciplinary Lessons from Experimental Research	286
34	Consumers as coproducers of public services: some economic and institutional considerations	1981	Policy Studies Journal	283
35	The Samaritan's Dilemma: The Political Economy of Development Aid	2005	The Samaritan's Dilemma: The Political Economy of Development Aid	276
36	Reconnecting to the biosphere	2011	Ambio	275
37	Moving beyond panaceas: A multi-tiered diagnostic approach for social-ecological analysis	2010	Environmental Conservation	272
38	The contested role of heterogeneity in collective action: Some evidence from community forestry in Nepal	2001	World Development	268
39	How types of goods and property rights jointly affect collective action	2003	Journal of Theoretical Politics	237
40	Robustness of social-ecological systems to spatial and temporal variability	2007	Society and Natural Resources	181
41	Human ecology and resource sustainability: The importance of institutional diversity	1995	Annual Review of Ecology and Systematics	179
42	Resilience, vulnerability and adaptation: A cross-cutting theme of the International Human Dimensions Programme on Global Environmental Change	2006	Global Environmental Change	177
43	Toward a behavioral theory linking trust, reciprocity and reputation	2003	Trust and Reciprocity: Interdisciplinary Lessons from Experimental Research	176
44	Lab experiments for the study of social-ecological systems	2010	Science	172
45	Nested externalities and polycentric institutions: Must we wait for global solutions to climate change before taking actions at other scales?	2012	Economic Theory	160
46	Rational choice theory and institutional analysis: Toward complementarity	1991	American Political Science Review	149
47	Aligning key concepts for global change policy: Robustness, resilience and sustainability	2013	Ecology and Society	145
48	Constituting Social Capital and Collective Action	1994	Journal of Theoretical Politics	142
49	Analyzing collective action	2010	Agricultural Economics	140
50	The challenge of common-pool resources	2008	Environment	138
51	The Nature of Common-Pool Resource Problems	1990	Rationality and Society	132
52	The meaning of social capital and its link to collective action	2009	Handbook of Social Capital: The Troika of Sociology, Political Science and Economics	126

53	The value-added of laboratory experiments for the study of institutions and common-pool resources	2006	Journal of Economic Behavior and Organization	124
54	Reciprocity, trust and the sense of control: A cross-societal study	1999	Rationality and Society	117
55	Generalizing the core design principles for the efficacy of groups	2013	Journal of Economic Behavior and Organization	116
56	What do people bring into the game? Experiments in the field about cooperation in the commons	2004	Agricultural Systems	112
57	Polycentric governance of multifunctional forested landscapes	2012	International Journal of the Commons	109
58	The social-ecological system framework as a knowledge classificatory system for benthic small-scale fisheries	2013	Global Environmental Change	108
59	Rent dissipation in a limited-access common-pool resource: Experimental evidence	1990	Journal of Environmental Economics and Management	106
60	Collective action and the evolution of social norms	2014	Journal of Natural Resources Policy Research	104
61	Planetary opportunities: A social contract for global change science to contribute to a sustainable future	2012	BioScience	104
62	Crafting analytical tools to study institutional change	2011	Journal of Institutional Economics	104
63	Climate change and the integrity of science	2010	Science	100

Table 4: Values of different indexes calculated for Prof. Elinor Ostrom.

Index	Values
No. of Publications	197
Citations Received till date (19th Apr,2020)	50552
Citations received (last five years- i.e., 2015-2019)	23866
Recency = Citations Received (last five years)/ Citations received till date	0.47
h-index	77
i_{10}-index	159
Total citations received by all papers in the h-core (C_{total})	47706
Excess Citations (EC) = $C_{total} - h^2$	41777
e-index=	204.4
Ratio of e-index and h-index=e/h	2.65
a-index= C_{total}/h	619.6
R-index= $\sqrt{C_{total}}$	218.4

Figure 3: Visualization of keywords appeared from the titles of the publications by Prof. Ostrom.

2015–2019. It means that her works got more recognition and importance over time and there is rare chance of obsolescence of her works in the coming future. As scientists like Ostrom receives large recognition for her works so it is not only sufficient to evaluate the academic performance based on h-index and therefore to get accurate results e-index is calculated in addition to h-index depicted in the citation database to make up the loss of citation information. The quality of Ostrom's papers is evaluated by the a-index and R-index.

Keyword Tomography

The titles of the publications express the reflective content of the papers. Keyword in the titles is one of the best indicators of understanding the thought content of the scholarly writings. Therefore, if certain key-words are used repeatedly in the titles of an author's research writings, then it reflects an idea of the theme of her research.

The most frequent keyword (after removing the commonly used English word like Article, preposition, pronoun etc.) appeared in the titles of writing of Prof. Ostrom are commons(24), collective(23), action(22), institutional(21), systems(19), institutions(19), change(14), social(13), social–ecological(12), common-pool(10), polycentric(10), approach(10) and resource(10).

CONCLUSION

This study on Elinor Ostrom, the first woman Nobel laureate in Economic sciences is indeed interesting as one can get an overview of some of the most vital publications and the trend of her research publications. Her publications are found for 54

long years in Scopus database and the scientometric indicators indicate a very high recognition of her works. She has a high *h*–value and *e*–value which jointly reflects that her works are highly cited. Also the papers are highly qualitative and that brought her the real laurel with the award of the highest prize. Her works are so worthy that they are continued to be published even after her death. She is such a scholar with simple living but high thinking and great modesty that even in her Nobel lecture which was published in the American Economic Review in 2010 she included 195 references which is worth praising. Even if we leave her 45 self–citations, the number of others references are still 150. She shows her reverence for other researchers which included Noble laureates like Amartya Sen, Oliver E. Williamson among many others. Her argument that individuals and communities could manage their own collective resources challenged Hardin's approach to the "Tragedy of the Commons". She set some design principles while working in Maine, Indonesia, Nepal and Kenya and showed that the common resources are well managed when they are managed by the localities who live in close proximity of those resources. She showed the real path for the sustainable development of the communities and reflected clearly that government interventions will not be effective unless and until they are well supported by individuals and communities (Elinor Ostrom– The "non-tragedy of the commons.[26]

CONFLICT OF INTEREST

The authors declare no conflict of interest.

ABBREVIATIONS

BA: Biological age, **PY:** Year of Publication, **APC:** Annual Publication Count, **MAP:** Multi Authored Publication, **PPA:** Publication Productivity Age, **DC:** Degree of collaboration **CI:** Collaborative Index, **CC:** Collaboration Co–efficient, **Qui.:** Quinquennium, **CAPC:** Cumulative no. of Annual Publication Count.

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