A Bibliometric Assessment of Actuarial Science Research Trends

Asmat Ali[1], Nahida Hassan[2] and Asif Ali[3]

[1]*(Librarian /Ph. D Scholar) J&K, Higher Education Department (Govt. Amar Singh College, Cluster University Srinagar)*
[2]*M.Sc Statistics (Actuarial) (PG Student) Islamic University of Science and Technology (Dept of Mathematical Sciences)*
[3]*MBA (PG Student) University of Kashmir (Department of Management studies)*
E-mail: [1]asmatali999@gmail.com, [2]aanahida44@gmail.com, [3]asifalii.mba@gmail.com

Abstract—*Actuarial science is an ardent to the study of annuities and insurance plans. Actuaries examine the risk of investments in the financial world where their risk-management capabilities are particularly applicable therein risk analysis entails the methodical use of historical information to determine the frequency, magnitude and effects of unexpected events. The present study is based on the data harvested from web of science- one of leading scientific citation database in the fields of science, social sciences, Arts, Humanities. Data congregated encompasses research publications published on Actuarial science for the period, 1990-May 2019. At present 1690 documents are published in form of Articles, conference proceedings, Book reviews, and Abstracts. The data has been analyzed for Publication type, Most productive Authors, Geographical distribution, Top ranked Journals, Institutes; frequency of keywords. The findings of the study reveals that USA ranks first with (35.4%) publications followed by UK (8.0%), Canada (7.7%) at second and third rank respectively. Further results indicate that researchers have cited nearly 81.4% of Journals wherein International Journal of Radiation Oncology biology physics is the acme cited journal ranking first with (27.35%) followed by Insurance Mathematics and Economics ranking at second with (12%).University Texas has been found as the leading institute in the field of Actuarial Science. The present study is an attempt to understand the Global research output trend on Actuarial science by analyzing the literature published in this area using Bibliometric techniques.*

Keywords: Actuarial science, Financial Mathematics, Bibliometric Analysis, Annuities.

1. Introduction

Actuarial science has been devoted to the study of Annuities and Insurance plans. The Actuarial profession started out from life insurance and pension plans. Later, its development ran parallel to the accounting profession **Hickman (2006).** In the 60`s and 70`s, mainframe computers were used to generate thick reports from which Actuaries would copy numbers onto a worksheet, and use of mechanical and then electronic calculators eased the work of computation of insurance rates. Whereas, in late 70`s some Actuaries got access to mainframe computers and the use of statistical software packages such as SAS. With the introduction of personal computers in late 80`s many Actuaries got expertise in usage of spread sheet software

therein, a variety of data sources also became available into the Actuarial work environment. These details included credit reports, Econometric Time series, and Geographical information system and census data. Combining the data with the detailed statistical plan data enabled many insurers to continue refining their claim places **Frees, Richard & Dearing (2014).** Actuarial science is most commonly applied to mortality analysis for life insurance; many of the same procedures are also used for property, liability and other kinds of insurance. Most Actuaries work at insurance companies, where their risk-management capabilities are particularly applicable. Risk analysis entails the systematic use of historical information to determine the frequency, magnitude and effects of unexpected events **Georgina, Frederick & Alain (2016)**. Bibliometrics is a useful tool for research evaluation therein helps to determine patterns of scholarly communication. It is the application of Mathematics and Statistical methods to books and other media of communication **(Pritchard, 1969).** Bibliometric techniques help in benchmarking individual, institutional and subject research outputs. There have been several bibliometric studies on Mathematics, finances but so far there has been no bibliometric study on Actuarial science. The present study has been attempted to understand the Global research output trend on Actuarial science by analysing the literature published in this area

2. Objectives of the Study

- To find out the status of Literature published on Actuarial Sciences during 1990- May 2019

- To Assess the characteristics of Actuarial Sciences publication including Geographical research output; prominent Journals and Authors

- To Identify the most Popular keywords used for Actuarial science

- To Identify the Top contributing Institutions in the field of Actuarial Science.

3. Methodology

The bibliographic data for this study was obtained from the Web of Science- an Online Leading subscription-based scientific citation indexing database in the fields of science, social sciences, Arts, Humanities. The Search terms `Actuarial Sciences OR financial mathematics` was used to explore publications from 1990- May 2019. The bibliographic records were exported to Microsoft Excel for Analysis.

4. Analysis and Discussion

4.1 Growth of Actuarial science literature

The overview of the Growth in research output of Actuarial science from the period of 1990 to May, 2019 has been analysed. Table- 1 depicts that there is a steady increase in the production of research output from 1999 onwards. Increase in number of research publications (625) can be found during 1999-2003 whereas the growth of research has declined from 2003-2018.

Table 1: Growth of literature on Actuarial sciences.

Time period	No. of publications	Percentage
1990-1994	21	1.24
1995-1998	281	16.63
1999-2003	627	37.10
2004-2008	165	9.76
2009-2013	273	16.15
2014-2018	302	17.87
2019	21	1.24
Total	**1690**	

4.2 Characteristics of Actuarial Science Publications

The study retrieved 1690 documents on Actuarial science that were indexed in Web of Science during the period of 1990-2019. These publications were distributed among six different document types. Research articles were the most preferred type of publication and ranks first with 81.4% (1375 articles) of the total research output ,followed by conference Articles 15.9%(269) ranking at second.

Table 2-Actuarial Science Publications (1990-2019)

Document Type	Number of Publications (%)	Cumulative Numbers (%)	Rank
Article	1375(81.4)	1375(14.11)	1
Article; Proceedings Paper	269(15.9)	1644(16.87)	2
Editorial Material	23(1.4)	1667(17.10)	3
Book Review	16(0.9)	1683(17.27)	4
Biographical-Item	4(0.2)	1687(17.31)	5
Meeting Abstract	3(0.2)	1690(17.34)	6
Total	**1690**		

4.3 Publication distribution by countries

Most productive countries were ranked by the number of articles (Table 2). As predicted from table, USA ranks at first with 35.4% of articles followed by UK at second and Canada at Third with 8.0% and 7.7% respectively.

Table -3 Publication distribution by Countries

Country	Publications (%)	Rank
USA	598(35.4)	1
UK	136(8)	2
Canada	130(7.7)	3
Peoples R China	101(6)	4
Germany	97(5.7)	5
France	94(5.6)	6
Belgium	91(5.1)	7
Unknown	87(5.1)	8
Italy	84(5)	9
Netherlands	68(4)	10
Spain	56(3.3)	11
Australia	50(3)	12
Japan	37(2.2)	13
Switzerland	31(1.8)	14
South Africa	24(1.4)	15
Turkey	23(1.4)	16
Israel	21(1.2)	17
Austria	20(1.2)	18
Brazil	20(1.2)	18
Taiwan	19(1.1)	19
Iran	18(1.1)	20
Poland	17(1)	21
India	16(0.9)	22
South Korea	16(0.9)	22
Sweden	16(0.9)	22
Denmark	15(0.9)	23
Greece	15(0.9)	23
Russia	15(0.9)	23
Cyprus	9(0.5)	24
Czech Republic	7(0.4)	25
Hungary	7(0.4)	25
Portugal	7(0.4)	25

4.4 Analysis of keywords associated with Actuarial Science

The Keywords to an Article represent the nucleus of information that an Author is likely to articulate. It provides the central idea that has been expressed in the research article. Table 4 represents top 30 keywords which have been frequently used while writing Actuarial articles. On the basis of ratio, it is found that cancer, Radiotherapy, patients, Risk, carcinoma, financial, treatment, radiation, Therapy, results, prostate, Analysis, Dose, outcome, term, Actuarial are most commonly used keywords.

Table 4: Most popular keywords used for Actuarial Science

Keywords	Publications	%age
Cancer	225	13.3
Radiotherapy	160	9.5
Patients	141	8.3
Risk	135	8.0
Carcinoma	116	6.9
Financial	114	6.7

Treatment	108	6.4
Radiation	106	6.3
Therapy	103	6.1
Results	98	5.8
Prostate	94	5.6
Analysis	93	5.5
Dose	86	5.1
Outcome	79	4.7
Term	75	4.4
Actuarial	72	4.3
Brach therapy	71	4.2
Long	71	4.2
Mathematics	71	4.2
High	67	4.0
Cell	66	3.9
Model	66	3.9
Stochastic	65	3.8
Stage	60	3.6
Applications	59	3.5
Pricing	59	3.5
Models	57	3.4
Clinical	54	3.2
Irradiation	54	3.2
Rate	54	3.2

4.5 Productive Journals on Actuarial science

The Ranking list of Journals is a practical tool to opt for journals of utmost efficacy in relation to their coverage of new & important literature in a meticulous subject area. The 1375 articles were published in 200 journals. The list of top 20 journals publishing articles on Actuarial Science is given in Table- 5. It is evident from the table that International Journal of Radiation Oncology Biology Physics ranks 1st with (27.35%) articles followed by Insurance Mathematics & Economics with (12%), European Journal of cardio-thoracic surgery with (6.25%), Radiotherapy & Oncology (5.53%), Urology (2.69%), Quantitative finance (2.11%) ranking at 2nd , 3rd , 4th & 5th respectively & remaining all are below 2%.

Table-5: Productive Journals on Actuarial science.

Name of Journal	Number of articles (%)	Rank	Cumulative numbers (%)
International journal of radiation oncology biology physics	376(27.35)	1	376(1.14)
Insurance mathematics & economics	165(12)	2	541(1.64)
European journal of cardio-thoracic surgery	86(6.25)	3	627(1.9)
Radiotherapy and oncology	76(5.53)	4	703(2.13)
Urology	37(2.69)	5	740(2.24)
Quantitative finance	29(2.11)	6	769(2.33)
Journal of computational and applied mathematics	27(1.96)	7	796(2.41)
Astin bulletin	15(1.09)	8	811(2.46)
European journal of cancer	15(1.09)	8	826(2.5)
Lung cancer	15(1.09)	8	841(2.55)
Cardiovascular surgery	14(1.02)	11	855(2.59)
European journal of operational research	13(0.95)	12	868(2.63)
Theory of probability and its applications	13(0.95)	12	881(2.67)
Stochastic processes and their applications	12(0.87)	14	893(2.7)
Communications in statistics-theory and methods	11(0.8)	15	904(2.74)
Annals of applied probability	10(0.73)	16	914(2.77)
Scandinavian actuarial journal	10(0.73)	16	924(2.8)
Journal of applied probability	9(0.65)	18	933(2.83)
Journal of risk and insurance	8(0.58)	19	941(2.85)
Mathematics and computers in simulation	8(0.58)	19	949(2.87)
Oral oncology	8(0.58)	19	957(2.9)
Siam journal on control and optimization	8(0.58)	19	965(2.92)
Journal of banking & finance	7(0.51)	23	972(2.94)
Annals of probability	6(0.44)	24	978(2.96)
Applied mathematics and computation	6(0.44)	24	984(2.98)
Bernoulli	6(0.44)	24	990(3)
Journal of multivariate analysis	6(0.44)	24	996(3.02)
Journal of statistical computation and simulation	6(0.44)	24	1002(3.03)
Journal of statistical planning and inference	6(0.44)	24	1008(3.05)
Methodology and computing in applied probability	6(0.44)	24	1014(3.07)
Statistical science	6(0.44)	24	1020(3.09)
8 journals with 5 records	40(2.91)	32	1060(3.21)
14 journals with 4 records	56(3.38)	40	1116(3.38)
17 journals with 3 records	51(3.71)	54	1167(3.53)
78 journals with 2 records	156(11.35)	71	1323(4.01)
58 journals with 1 records	52(3.78)	149	1375(4.16)

4.6 Most productive Authors (1990-May, 2019):

The list of top 15 authors with 10 or more research papers on the area Actuarial science research during the period of (1990-May,2019) is given in Table- 6. It can be found that Dhaene, J (28 articles) ranks 1st followed by Denuit M (20 articles), Leach PGL (14 articles) ranking at 2nd, 3rd

Table 6: Most productive Authors (1990- May, 2019)

Author	Total Publications	Rank	Total Citations
Dhaene J	28	1	907
Denuit M	20	2	824
Leach PGL	14	3	77
Zelefsky MJ	14	3	2639
Cheung KC	12	5	90
Goovaerts M	12	5	126
Zagars GK	12	5	850
Goovaerts MJ	11	8	697
Martinez AA	11	8	751
Pollack A	11	8	841
Vicini FA	11	8	654
Wannenmacher M	11	8	444
Hanlon AL	10	13	743
Leibel SA	10	13	2364
Vanmaele M	10	13	116

4.7 Institutional research output

Table-7 provides the List of top 07 institutes. It is found that During 1992-2019, at the institutional level the largest share of research output is held by University of Texas with 50(3.6) publications. Katholieke University Leuven with 39(2.8), university Amsterdam with 34(2.5), Mem Sloan Kettering Canc Ctr with 30(2.2) ,Univ Wisconsin 28(2), Univ Toronto. Rests of institutes contribute less than 2% of research output.

Table- 7 Institutional research output on Actuarial Sciences

Institution	Publications (%)	Rank	Citations
University Texas	50(3.6)	1	3216
Katholieke University Leuven	39(2.8)	2	921
Univ Amsterdam	34(2.5)	3	794
Mem Sloan Kettering Canc Ctr	30(2.2)	4	4253
Univ Wisconsin	28(2)	5	864
Univ Toronto	27(2)	6	1664
Harvard Univ	23(1.7)	7	1369

5. Conclusion

The Bibliometric study of Actuarial science provides an overview of the research trends. Analysis done validates that research done in Actuarial field is showing a gloomy picture during 1990-2019. Some of countries show exemplary growth of literature like USA, UK, and Canada. Though India has joined the clan but Geographical Research output depicts that India is ranking at 22nd with 16(0.9%) publications only. Based on this study, it can be concluded that Actuarial research could be continued in future considering the importance of this field. Research has an immense role to play in terms of all round development of Nation whether it is economic, mathematical, social, cultural or individual. Acknowledging the significance of research in Actuarial sciences it becomes evident from the present study that it's high time now to deliberate upon various causes that impede the research activity in the particular field in India.

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