Growth of Literature and Collaboration of Authors in MEMS: A Bibliometric Study on BRIC and G8 countries

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Abstract

This paper is examined the research productivity on the subject MEMS literature for 25 years from 1988 to 2012. The data has been collected from the Scopus database. Relative growth rate, doubling time indicators is measured for the growth of publications. The authorship pattern is measured by different collaboration parameters such as collaborative index, degree of collaboration, collaboration coefficient and modified collaboration coefficient. BRIC and G8 countries were taken for the study and it is found that BRIC countries had a significant growth in both the number of articles productivity and compound annual growth rate.

Keywords: MEMS, G8, BRIC, Scientometric, Collaborative Coefficient, CAGR, DC, CI

Introduction

Counting the number of papers, articles, books, conference and seminar papers are the major creditability to an author in an educational or research institute. It gives more expertise in a field of subjects to the particular author. There are so many views on this study for counting articles by authors, institute, subject, country, etc. It analyses the quantitative analysis to describe the patterns of publications in the given field of study. Scientometric study is a simple statistical method of bibliography counting to evaluate and quantify the growth of a subject. An attempt has been made to study growth of the research productivity and author collaborations in MEMS among G8 and BRIC countries.

Scientometric Study

The growth and development of the Bibliometric study has been identified in different terms such as scientometrics, informetrics, webometrics, etc. The terms Scientometrics and Informetrics have become a standard tool of science policy and research management in the recent years. Pritchard (1969) defined the term Bibliometric as the application of statistical and mathematical methods to books and other communication. It is an important research method to

identify the thrust areas of the research and incorporating different branches of human knowledge. The recent study on measuring the Scientometric is mostly based on the work done by Derek J De Solla Price and Eugene Garfield. The methods of research are qualitative, quantitative and computational approaches, etc. However, the bibliometrics study is unique and common to all the subjects after sixties.

MEMS: A Brief Note

MEMS, acronym for Micro-Electro Mechanical Systems, are the one of the emerging filed in electronics. The 21st century is witnessing the developed technology using and identifying the potential to revolutionize both industrial and also consumer products. It is a combination of silicon-based microelectronics and micromachining technology used in the products. MEMS is interdisciplinary nature utilizing the various areas like design, engineering and manufacturing expertise from a wide and diverse range of technical areas including IC technology, IC fabrication technology, mechanical engineering, electrical and material engineering, chemistry and chemical engineering and also fluid engineering, optics, instrumentation and packaging. This technology is used for very small devices. The small devices are called to be nano-scale, so MEMS is also the same way to non-electromechnical systems (NEMS) and technology. This has been prepared as a proposal and submitted to DARPA in 1986 and introduced the term "microelectromechanical" systems. It has very good impact on global economy for using this techniques and micro system based devices. To create tiny integrated product or devices are both the combination of mechanical and electrical components. Integrated circuit (IC) has been used to fabricate the devices using these techniques and the ranges from millimeters to micromillimeters. The main is to reduce not only the size of the system but also reduce significantly the energy and material requirements which results in cost/performance advantage. These devices are possible to be embedded in a small area.

G8 and BRIC countries

The G8, or "Group of Eight," consists of eight large world economic powers. The G7, as the group is sometimes known, lacks Russia. The G8 has, for the most part, been replaced by the G-20 since 2008. The eight countries are Canada, France, Germany, Italy, Japan, Russia, United Kingdom and United States. The forum originated with a 1975 summit hosted by France that brought together representatives of six governments: France, the Federal Republic of Germany, Italy, Japan, the United Kingdom, and the United States. It became G7 the following with the addition of Canada. In 1997, Russia was added to the group which then became known as the G8.

In economics, BRIC is a grouping acronym that refers to the countries of Brazil, Russia, India and China, which are all deemed to be at a similar stage of newly advanced economic development. The acronym has come into widespread use as a symbol of the apparent shift in global economic power away from the developed G7 economies towards the developing world.

Related Literature

There are many reviews on scientometrics for different parameters and indicators used in different subjects in library and Information Science. The recent studies are reviewed on growth of literature and author collaborations.

Karpagam et al (2011) analysed the growth pattern of Nanoscience and Nanotechnology literature in India during 1990-2009 (20 years). The study measured the performance based on several parameters, country annual growth rate, authorship pattern, collaborative index, collaborative coefficient, modified collaborative coefficient, subject profile, etc. Further the study examines national publication output and impact in terms of average citations per paper. Savanur and Srikanth (2012) measured Collaborative coefficient (CC) that reflects both the mean number of authors per paper as well as the proportion of multi-authored papers. Although it lies between the values 0 and 1, and is 0 for a collection of purely single-authored papers, it is not 1 for the case where all papers are maximally authored, i.e., every publication in the collection has all authors in the collection as co-authors. We propose a simple modification of CC, which we call modified collaboration coefficient (or MCC, for short), which improves its performance in this respect.

Yang, Sixing and Guobin (2013) examined the research trends in Laparoscopy between 1997 and 2011. The study concentrated on the analysis by scientific output characters, international collaboration, and the frequency of author keywords used. Further, it applied to simulate the high correlation between cumulative number of articles and the year. Thirumagal and Sethukumar (2013) examined the rate and growth of scholarly publication, analyse the authorship pattern and to examine the publication type of research, application of Lotka's Law creating Label view, cluster view and find the citation map.

Singh (2013) analysed the various bibliometric components of the articles published in the Chinese Librarianship between 2009 and 2012. The study revealed are the quantitative growth of articles by number and year distribution of citations by number and year, range of citations per article, authorship patterns, authorship productivity, most prolific authors and authors by country. Baskaran (2013) analysed the author productivity, discipline-wise and institution-wise collaboration and ranking of authors in research contribution of Alagappa University during 1999-2011. Relative growth rate (RGR) was found to be fluctuating trend and doubling time (DT) was found to be increased and decreased trends. The Degree of collaboration and its mean value is found to be 0.963.

Bajwa, Yaldram and Rafique (2013) studied bibliometric on the research trends in Pakistan in the field of nanoscience and nanotechnology. The growth in the publications for period is studies through relative growth rate and doubling time. The authorship pattern is measured by different collaboration parameters, like collaborative index, degree of collaboration, collaboration coefficient and modified collaboration coefficient and further, the quality of papers is assessed by means of the h-index, g-index, hg-index and p-index.

Objectives

The main objective of this study is to analyse the trends of research articles related to MEMS. The study covers on MEMS documents have been published during the period 1988–2012 in

Scopus database. To analyse the research output, status, publication share and growth among G8 and BRIC countries, to study the pattern of author collaboration by using various scientific measures.

Methodology

This study used the data from Scopus an international database was searched on MEMS of papers. R&D activity has resulted in publication in peer-reviewed journals. Data was collected from Scopus database, (Scopus Info Site 2012) till 2012. It can be seen that 86,978 bibliographic records on MEMS over the period of 25 years (i.e.) 1988–2012. The publication progress and author collaboration on MEMS is measured using scientometric tools such as collaborative index (CI), collaborative coefficient (CC), and modified collaborative coefficient (MCC). The findings of the study revealed the coherent dynamic nature of the subject.

Indicators Used for the study

There are many indicators available for measuring bibliometric study, in this study, some of the indicators for measuring growth of literature study.

- Frequency of article productivity with year wise
- Compound Annual Growth Rate (CAGR)
- Relative Growth Rate (RGR)
- Doubling Time (Dt)

| Description | Formula |
|---------------------------------------|---|
| Compound Annual Growth Rate (CAGR) | $CAGR = \left(\frac{Ending Value}{Beginning Value}\right)^{\left(\frac{1}{\# of years}\right)} - 1$ |
| Relative Growth Rate (RGR) | $\frac{Log_{e_2}W - log_{e_1}W}{1-2 R} = \frac{1-2 R}{2}$ |
| Doubling Time (Dt (a)) | Dt (a) = $\frac{0.693}{1-2 \ \overline{R} \ (aa-1 \ year-1)}$ |
| Doubling Time (Dt (p)) | Dt (p)= $$ 1-2 R (pp-1 year-1) |

Author collaboration can be measured in the following indicators:

- Author collaboration Jointly publications
- Collaborative Index (CI)
- Collaborative Coefficient (CC)
- Modified Collaborative Coefficient (MCC)

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| Description | Formula |
|------------------------------------|--|
| Degrees of Collaboration DC | $DC = 1 - \frac{f_1}{N}$ |
| Collaborative Index (CI) | $CI = \frac{\sum_{j=1}^{A} jf_j}{N}$ |
| Collaborative Coefficient (CC) | $CC = 1 - \frac{\sum_{j=1}^{A} (1/j) f_j}{N}$ |
| Modified Collaborative Coefficient | $\kappa = \frac{A}{A-1} \left\{ 1 - \frac{\sum_{j=1}^{A} (1/j) f_j}{N} \right\}$ |

Year wise productivity of MEMS – G8, BRIC and Global

The year wise productivity of articles on the subject MEMS were tabulated in table 1. It shows the frequency and percentage of MEMS publication among G8, BRIC and Global.

| SLNo | Veen | G | 8 | BR | [C | Global | |
|--------------------------|------|--------|------|--------|------------|--------|------|
| 51. 1 1 0. | rear | Papers | % | Papers | % | Papers | % |
| 1 | 1988 | 662 | 1.56 | 48 | 0.35 | 1872 | 2.15 |
| 2 | 1989 | 1081 | 2.55 | 49 | 0.36 | 1995 | 2.29 |
| 3 | 1990 | 1112 | 2.62 | 32 | 0.23 | 2182 | 2.51 |
| 4 | 1991 | 830 | 1.96 | 85 | 0.62 | 1796 | 2.06 |
| 5 | 1992 | 775 | 1.83 | 102 | 0.74 | 1519 | 1.75 |
| 6 | 1993 | 789 | 1.86 | 127 | 0.92 | 1525 | 1.75 |
| 7 | 1994 | 744 | 1.76 | 79 | 0.57 | 1457 | 1.68 |
| 8 | 1995 | 850 | 2.01 | 117 | 0.85 | 1548 | 1.78 |
| 9 | 1996 | 1206 | 2.85 | 119 | 0.87 | 2104 | 2.42 |
| 10 | 1997 | 1214 | 2.86 | 113 | 0.82 | 2040 | 2.35 |
| 11 | 1998 | 1154 | 2.72 | 172 | 1.25 | 2115 | 2.43 |
| 12 | 1999 | 1148 | 2.71 | 138 | 1.00 | 2185 | 2.51 |
| 13 | 2000 | 1262 | 2.98 | 225 | 1.64 | 2623 | 3.02 |
| 14 | 2001 | 1343 | 3.17 | 245 | 1.78 | 2625 | 3.02 |
| 15 | 2002 | 1625 | 3.83 | 221 | 1.61 | 3208 | 3.69 |
| 16 | 2003 | 939 | 2.22 | 107 | 0.78 | 2097 | 2.41 |
| 17 | 2004 | 2354 | 5.55 | 530 | 3.85 | 3975 | 4.57 |
| 18 | 2005 | 2333 | 5.50 | 533 | 3.88 | 3961 | 4.55 |
| 19 | 2006 | 2432 | 5.74 | 626 | 4.55 | 4400 | 5.06 |

Table 1: MEMS Literature (year wise) - G8, BRIC and Global

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| 20 | 2007 | 2667 | 6.29 | 676 | 4.91 | 4833 | 5.56 |
|----|-------|-------|------|-------|-------|-------|--------|
| 21 | 2008 | 3252 | 7.67 | 1402 | 10.19 | 6918 | 7.95 |
| 22 | 2009 | 3470 | 8.19 | 1640 | 11.92 | 7696 | 8.85 |
| 23 | 2010 | 3726 | 8.79 | 1982 | 14.41 | 8208 | 9.44 |
| 24 | 2011 | 3214 | 7.58 | 2333 | 16.96 | 7878 | 9.06 |
| 25 | 2012 | 2203 | 5.20 | 2053 | 14.93 | 6218 | 7.15 |
| | Total | 42385 | 100 | 13754 | 100 | 86978 | 100.00 |



Figure 1: MEMS Literature (year wise) - G8, BRIC and Global

It revealed that in the years 2009-2011, there is more contribution from 7.67 % to 8.79% in G8 countries and 10.19% to 16.96% in BRIC countries and overall global is also confirm the growth of publications the same period. Further, it is found that 2003, there is low productivity G8, BRIC and Global.

| Sl.No. | Year | USA | UK | Germany | Japan | Canada | Russia | France | Italy | Total |
|--------|------|--------|--------|---------|--------|--------|--------|--------|--------|--------|
| 1 | 1000 | 387 | 61 | 81 | 48 | 33 | 11 | 26 | 15 | 662 |
| 1 | 1900 | (0.91) | (0.14) | (0.19) | (0.11) | (0.08) | (0.03) | (0.06) | (0.04) | (1.56) |
| 2 | 1020 | 677 | 101 | 120 | 66 | 51 | 12 | 37 | 17 | 1081 |
| Z | 1989 | (1.6) | (0.24) | (0.28) | (0.16) | (0.12) | (0.03) | (0.09) | (0.04) | (2.55) |
| 2 | 1000 | 687 | 117 | 96 | 71 | 74 | 9 | 37 | 21 | 1112 |
| 3 | 1990 | (1.62) | (0.28) | (0.23) | (0.17) | (0.17) | (0.02) | (0.09) | (0.05) | (2.62) |
| 4 | 1001 | 491 | 65 | 60 | 44 | 58 | 69 | 23 | 20 | 830 |
| 4 | 1991 | (1.16) | (0.15) | (0.14) | (0.1) | (0.14) | (0.16) | (0.05) | (0.05) | (1.96) |
| 4 | 1002 | 420 | 93 | 48 | 66 | 45 | 59 | 21 | 23 | 775 |
| 3 | 1992 | (0.99) | (0.22) | (0.11) | (0.16) | (0.11) | (0.14) | (0.05) | (0.05) | (1.83) |
| 6 | 1002 | 459 | 67 | 68 | 41 | 50 | 63 | 29 | 12 | 789 |
| 0 | 1995 | (1.08) | (0.16) | (0.16) | (0.1) | (0.12) | (0.15) | (0.07) | (0.03) | (1.86) |
| 7 | 1004 | 382 | 137 | 59 | 47 | 34 | 49 | 22 | 14 | 744 |
| / | 1994 | (0.9) | (0.32) | (0.14) | (0.11) | (0.08) | (0.12) | (0.05) | (0.03) | (1.76) |
| Q | 1005 | 459 | 112 | 71 | 44 | 43 | 65 | 35 | 21 | 850 |
| 0 | 1995 | (1.08) | (0.26) | (0.17) | (0.1) | (0.1) | (0.15) | (0.08) | (0.05) | (2.01) |
| 0 | 1006 | 684 | 157 | 108 | 70 | 68 | 62 | 34 | 23 | 1206 |
| 9 | 1990 | (1.61) | (0.37) | (0.25) | (0.17) | (0.16) | (0.15) | (0.08) | (0.05) | (2.85) |
| 10 | 1007 | 658 | 141 | 129 | 81 | 72 | 58 | 38 | 37 | 1214 |
| 10 | 1997 | (1.55) | (0.33) | (0.3) | (0.19) | (0.17) | (0.14) | (0.09) | (0.09) | (2.86) |
| 11 | 1998 | 624 | 134 | 125 | 73 | 54 | 59 | 50 | 35 | 1154 |

| Table 2: G8 | countries | productivity | on MEMS | and CAGR |
|-------------|-----------|--------------|---------|----------|
| | | | | |

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| | | (1.47) | (0.32) | (0.29) | (0.17) | (0.13) | (0.14) | (0.12) | (0.08) | (2.72) |
|----|-------|---------|---------|--------|--------|--------|--------|--------|--------|--------|
| 10 | 1000 | 587 | 139 | 153 | 82 | 69 | 38 | 53 | 27 | 1148 |
| 12 | 1999 | (1.38) | (0.33) | (0.36) | (0.19) | (0.16) | (0.09) | (0.13) | (0.06) | (2.71) |
| 12 | 2000 | 620 | 161 | 150 | 100 | 58 | 49 | 75 | 49 | 1262 |
| 15 | 2000 | (1.46) | (0.38) | (0.35) | (0.24) | (0.14) | (0.12) | (0.18) | (0.12) | (2.98) |
| 14 | 2001 | 650 | 154 | 178 | 110 | 74 | 64 | 64 | 49 | 1343 |
| 14 | 2001 | (1.53) | (0.36) | (0.42) | (0.26) | (0.17) | (0.15) | (0.15) | (0.12) | (3.17) |
| 15 | 2002 | 808 | 156 | 231 | 116 | 89 | 69 | 87 | 69 | 1625 |
| 15 | 2002 | (1.91) | (0.37) | (0.55) | (0.27) | (0.21) | (0.16) | (0.21) | (0.16) | (3.83) |
| 16 | 2003 | 476 | 98 | 156 | 65 | 43 | 16 | 38 | 47 | 939 |
| 10 | 2003 | (1.12) | (0.23) | (0.37) | (0.15) | (0.1) | (0.04) | (0.09) | (0.11) | (2.22) |
| 17 | 2004 | 1087 | 223 | 389 | 207 | 127 | 89 | 124 | 108 | 2354 |
| 17 | 2004 | (2.56) | (0.53) | (0.92) | (0.49) | (0.3) | (0.21) | (0.29) | (0.25) | (5.55) |
| 18 | 2005 | 1081 | 240 | 353 | 230 | 131 | 55 | 125 | 118 | 2333 |
| 10 | 2003 | (2.55) | (0.57) | (0.83) | (0.54) | (0.31) | (0.13) | (0.29) | (0.28) | (5.5) |
| 19 | 2006 | 1135 | 256 | 366 | 218 | 145 | 53 | 133 | 126 | 2432 |
| 17 | 2000 | (2.68) | (0.6) | (0.86) | (0.51) | (0.34) | (0.13) | (0.31) | (0.3) | (5.74) |
| 20 | 2007 | 1374 | 255 | 376 | 221 | 150 | 54 | 126 | 111 | 2667 |
| 20 | 2007 | (3.24) | (0.6) | (0.89) | (0.52) | (0.35) | (0.13) | (0.3) | (0.26) | (6.29) |
| 21 | 2008 | 1401 | 339 | 506 | 316 | 247 | 60 | 215 | 168 | 3252 |
| 21 | 2000 | (3.31) | (0.8) | (1.19) | (0.75) | (0.58) | (0.14) | (0.51) | (0.4) | (7.67) |
| 22 | 2009 | 1639 | 295 | 472 | 315 | 271 | 63 | 219 | 196 | 3470 |
| | 2007 | (3.87) | (0.7) | (1.11) | (0.74) | (0.64) | (0.15) | (0.52) | (0.46) | (8.19) |
| 23 | 2010 | 1747 | 348 | 563 | 317 | 228 | 126 | 156 | 241 | 3726 |
| 23 | 2010 | (4.12) | (0.82) | (1.33) | (0.75) | (0.54) | (0.3) | (0.37) | (0.57) | (8.79) |
| 24 | 2011 | 1444 | 310 | 548 | 266 | 229 | 69 | 178 | 170 | 3214 |
| 21 | 2011 | (3.41) | (0.73) | (1.29) | (0.63) | (0.54) | (0.16) | (0.42) | (0.4) | (7.58) |
| 25 | 2012 | 947 | 184 | 400 | 172 | 168 | 46 | 133 | 153 | 2203 |
| 23 | 2012 | (2.23) | (0.43) | (0.94) | (0.41) | (0.4) | (0.11) | (0.31) | (0.36) | (5.2) |
| | Total | 20924 | 4343 | 5806 | 3386 | 2611 | 1367 | 2078 | 1870 | 42385 |
| | ioui | (49.37) | (10.25) | (13.7) | (7.99) | (6.16) | (3.23) | (4.9) | (4.41) | (100) |
| | CAGR | 3.80 | 4.71 | 6.88 | 5.46 | 7.02 | 6.14 | 7.04 | 10.16 | 5.14 |

USA occupies the first position and has nearly 50% among the G8 countries. Followed by German more contribution on MEMS publications of 5806 (13.7%) with CAGR secured of 6.88. This table shows the year wise productivity of G8 Countries with their percentage in simple frequency and the total number of articles and its percentage. For this values were subject to calculate for Compound Annual Growth Rate (CAGR) values, the CAGR values are differed from the total number of items. From the calculated values, it is found that according to productivity of items in USA is higher but CAGR is very low, whereas the low productivity of items in Italy but the CAGR is very high. But the overall values of G8 countries CAGR value is 51.21. It is because of beginning of the production is very low and latest productivity is very high. From this it concludes that CAGR shows the values are higher means, the interest and research on that area is developed in the country. Accordingly, Italy, France, Canada are more concentrate on this subject.

BRIC countries contributions with CAGR

The year and country wise contribution of articles were tabulated with CAGR calculations in table 3 for the BRIC countries.

| Sl.No. | Year | Brazil | Russia | India | China | Total |
|--------|-------|------------|------------|-------------|-------------|-------------|
| 1 | 1988 | 1(0.01) | 11(0.08) | 24(0.17) | 12(0.09) | 48(0.35) |
| 2 | 1989 | 2(0.01) | 12(0.09) | 22(0.16) | 13(0.09) | 49(0.36) |
| 3 | 1990 | 2(0.01) | 9(0.07) | 11(0.08) | 10(0.07) | 32(0.23) |
| 4 | 1991 | 2(0.01) | 69(0.5) | 9(0.07) | 5(0.04) | 85(0.62) |
| 5 | 1992 | 7(0.05) | 59(0.43) | 15(0.11) | 21(0.15) | 102(0.74) |
| 6 | 1993 | 5(0.04) | 63(0.46) | 13(0.09) | 46(0.33) | 127(0.92) |
| 7 | 1994 | 2(0.01) | 49(0.36) | 11(0.08) | 17(0.12) | 79(0.57) |
| 8 | 1995 | 10(0.07) | 65(0.47) | 18(0.13) | 24(0.17) | 117(0.85) |
| 9 | 1996 | 7(0.05) | 62(0.45) | 19(0.14) | 31(0.23) | 119(0.87) |
| 10 | 1997 | 13(0.09) | 58(0.42) | 18(0.13) | 24(0.17) | 113(0.82) |
| 11 | 1998 | 16(0.12) | 59(0.43) | 24(0.17) | 73(0.53) | 172(1.25) |
| 12 | 1999 | 19(0.14) | 38(0.28) | 28(0.2) | 53(0.39) | 138(1) |
| 13 | 2000 | 42(0.31) | 49(0.36) | 31(0.23) | 103(0.75) | 225(1.64) |
| 14 | 2001 | 22(0.16) | 64(0.47) | 55(0.4) | 104(0.76) | 245(1.78) |
| 15 | 2002 | 20(0.15) | 69(0.5) | 31(0.23) | 101(0.73) | 221(1.61) |
| 16 | 2003 | 33(0.24) | 16(0.12) | 23(0.17) | 35(0.25) | 107(0.78) |
| 17 | 2004 | 53(0.39) | 89(0.65) | 74(0.54) | 314(2.28) | 530(3.85) |
| 18 | 2005 | 44(0.32) | 55(0.4) | 65(0.47) | 369(2.68) | 533(3.88) |
| 19 | 2006 | 72(0.52) | 53(0.39) | 91(0.66) | 410(2.98) | 626(4.55) |
| 20 | 2007 | 79(0.57) | 54(0.39) | 98(0.71) | 445(3.24) | 676(4.91) |
| 21 | 2008 | 158(1.15) | 60(0.44) | 169(1.23) | 1015(7.38) | 1402(10.19) |
| 22 | 2009 | 188(1.37) | 63(0.46) | 203(1.48) | 1186(8.62) | 1640(11.92) |
| 23 | 2010 | 218(1.58) | 126(0.92) | 172(1.25) | 1466(10.66) | 1982(14.41) |
| 24 | 2011 | 134(0.97) | 69(0.5) | 186(1.35) | 1944(14.13) | 2333(16.96) |
| 25 | 2012 | 140(1.02) | 46(0.33) | 274(1.99) | 1593(11.58) | 2053(14.93) |
| | Total | 1289(9.37) | 1367(9.94) | 1684(12.24) | 9414(68.45) | 13754(100) |
| | CAGR | 22.86 | 6.14 | 10.68 | 22.59 | 16.94 |

Table 3: BRIC countries productivity on MEMS and CAGR

This table 3 shows the year wise productivity of BRIC Countries with their percentage in simple frequency and the total number of articles and its percentage. It is found that CAGR values 22.68 and 22.59 for Brazil and China respectively, it means that these two countries are more concentrating research on this subject compared to remaining countries. The overall research productivity by BRIC countries is 16.94 only. As per CAGR indicator, BRIC countries have concentrate more on this subject recently.



Figure 2: Venn diagram for Global, G8 and BRIC productivity

| +: IVI CIVI | is Litera | ure Com | | RGR, Dt - G8 countries, BRIC and | | | | | |
|-------------|-----------|---------|-------|----------------------------------|-------|--------|------|--|--|
| SI No | Vear | G | 8 | BRI | C | Global | | | |
| 51.110. | Icai | RGR | Dt | RGR | Dt | RGR | Dt | | |
| 1 | 1988 | 6.50 | 0.11 | 3.87 | 0.18 | 7.53 | 0.09 | | |
| 2 | 1989 | 0.97 | 0.72 | 0.70 | 0.99 | 0.73 | 0.08 | | |
| 3 | 1990 | 0.49 | 1.40 | 0.29 | 2.43 | 0.45 | 0.08 | | |
| 4 | 1991 | 0.26 | 2.72 | 0.51 | 1.37 | 0.26 | 0.08 | | |
| 5 | 1992 | 0.19 | 3.63 | 0.39 | 1.78 | 0.18 | 0.08 | | |
| 6 | 1993 | 0.16 | 4.25 | 0.34 | 2.05 | 0.15 | 0.07 | | |
| 7 | 1994 | 0.13 | 5.23 | 0.16 | 4.22 | 0.13 | 0.07 | | |
| 8 | 1995 | 0.13 | 5.22 | 0.20 | 3.43 | 0.12 | 0.07 | | |
| 9 | 1996 | 0.16 | 4.27 | 0.17 | 4.06 | 0.14 | 0.07 | | |
| 10 | 1997 | 0.14 | 4.93 | 0.14 | 4.99 | 0.12 | 0.07 | | |
| 11 | 1998 | 0.12 | 5.90 | 0.18 | 3.85 | 0.11 | 0.07 | | |
| 12 | 1999 | 0.10 | 6.63 | 0.12 | 5.58 | 0.10 | 0.07 | | |
| 13 | 2000 | 0.10 | 6.69 | 0.17 | 3.97 | 0.11 | 0.07 | | |
| 14 | 2001 | 0.10 | 6.96 | 0.16 | 4.31 | 0.10 | 0.07 | | |
| 15 | 2002 | 0.11 | 6.38 | 0.13 | 5.52 | 0.11 | 0.07 | | |
| 16 | 2003 | 0.06 | 12.00 | 0.06 | 12.47 | 0.07 | 0.07 | | |
| 17 | 2004 | 0.13 | 5.27 | 0.24 | 2.92 | 0.11 | 0.07 | | |
| 18 | 2005 | 0.12 | 6.01 | 0.19 | 3.60 | 0.10 | 0.07 | | |
| 19 | 2006 | 0.11 | 6.44 | 0.19 | 3.70 | 0.10 | 0.06 | | |
| 20 | 2007 | 0.11 | 6.54 | 0.17 | 4.10 | 0.10 | 0.06 | | |
| 21 | 2008 | 0.12 | 5.99 | 0.28 | 2.48 | 0.13 | 0.06 | | |
| 22 | 2009 | 0.11 | 6.29 | 0.25 | 2.76 | 0.13 | 0.06 | | |
| 23 | 2010 | 0.11 | 6.52 | 0.24 | 2.92 | 0.12 | 0.06 | | |
| 24 | 2011 | 0.08 | 8.31 | 0.22 | 3.12 | 0.10 | 0.06 | | |
| 25 | 2012 | 0.05 | 12.98 | 0.16 | 4.29 | 0.07 | 0.06 | | |

| Table 4 | : MEMS | Literature | Comparison | RGR, Dt · | G8 countries, | BRIC and Global |
|---------|--------|------------|------------|-----------|-----------------------------------|------------------------|
|---------|--------|------------|------------|-----------|-----------------------------------|------------------------|

It table 4 shows the chronological distribution RGR, Dt of G8, BRIC and Global in the field of MEMS during 1988 -2012. It is observed that the RGR started with high score of 0.97 and decreased upto 0.05 in G8 countries whereas BRIC countries with high score of 0.70 and decreased up to 0.06 and the global level RGR is 0.73 and decreased up to 0.07. The Dt was calculated for G8, BRIC and Global, from the table, it is observed that the Dt is increasing from 1988 to 2003 and decreasing and regained in the year 2012 as 12.98. For BRIC countries Dt is increasing from 1988 to 2003 and decreased slowly, but as Global level, Dt is maintaining the 0.07 for almost all the years.

MEMS Publications Author, Type and Language wise

The table 5 shows the authors' collaboration, type of papers and language wise publications on MEMS.

| Authorship | | | Тур | Language | | | | |
|------------|-------|-------|-------------------|----------|--------|------------|-------|---------|
| Single | 19054 | 21.9% | Article | 56402 | 64.84% | English | 79317 | 91.19% |
| Two | 19991 | 23.0% | Conference Paper | 25705 | 29.55% | Chinese | 2383 | 2.74% |
| Three | 17690 | 20.3% | Conference Review | 765 | 0.88% | German | 2170 | 2.49% |
| Four | 11802 | 13.6% | Review | 2824 | 3.25% | Russian | 1490 | 1.71% |
| Five | 7016 | 8.1% | Book | 197 | 0.23% | Japanese | 451 | 0.52% |
| Six | 4177 | 4.8% | Abstract Report | 190 | 0.22% | French | 334 | 0.38% |
| >Six | 7248 | 8.3% | others | 895 | 1.03% | Portuguese | 146 | 0.17% |
| | 86978 | 100% | | 86978 | 100% | Spanish | 139 | 0.16% |
| | | | | | | Others | 548 | 0.64% |
| | | | | | | Total | 86978 | 100.00% |

Table: 5 MEMS Publications (1988-2012) Authors wise, Type Wise, Language Wise

Author collaboration has been calculated for the G8, BRIC and Global. The author collaboration has been calculated as single author, two authors, three authors, four authors and more than four authors and the total number of authors and presented in Table 6.

| Table 6 Total Number of Authors amo | ng G8, | , BRIC and Global |
|-------------------------------------|--------|-------------------|
|-------------------------------------|--------|-------------------|

| Authors | | | G8 | | BRIC | | | | Global | | | |
|-------------------|-------|-------|--------|-------|-------|-------|-------|-------|--------|-------|--------|-------|
| | ТР | % | ТА | TA% | ТР | % | ТА | TA% | ТР | % | ТА | TA% |
| Single Author | 8176 | 19.29 | 8176 | 6.34 | 1334 | 9.70 | 1334 | 2.89 | 19017 | 21.86 | 19017 | 7.54 |
| Two Authors | 9478 | 22.36 | 18956 | 14.69 | 2730 | 19.85 | 5460 | 11.85 | 19903 | 22.88 | 39806 | 15.79 |
| Three Authors | 8123 | 19.16 | 24369 | 18.89 | 3269 | 23.77 | 9807 | 21.28 | 17607 | 20.24 | 52821 | 20.95 |
| Four Authors | 5520 | 13.02 | 22080 | 17.11 | 2612 | 18.99 | 10448 | 22.67 | 11734 | 13.49 | 46936 | 18.61 |
| > Four Authors | 11088 | 26.16 | 55440 | 42.97 | 3809 | 27.69 | 19045 | 41.32 | 18717 | 21.52 | 93585 | 37.11 |
| Total | 42385 | 100 | 129021 | 100 | 13754 | 100 | 46094 | 100 | 86978 | 100 | 252165 | 100 |

(TP- Total Publication, TA – Total Authors)

It is observed from the table that total number of authors for single author and two authors' contributions are high in G8 countries compared with BRIC. Whereas three and four authors are high in BRIC countries compared with G8 countries.

The degrees of Collaboration, Collaborative Index, Collaborative Coefficient and Modified Collaborative Coefficient were calculated and presented in the table 6.

| S.No. YEAR | VEAD | | Gl | obal | | | C | 38 | | BRIC | | | |
|------------|------|------|------|------|------|------|-------|------|------|------|------|------|------|
| | YEAR | DC | CI | CC | MCC | DC | CI | CC | MCC | DC | CI | CC | MCC |
| 1 | 1988 | 0.79 | 2.96 | 0.53 | 0.55 | 0.77 | 2.51 | 0.43 | 0.45 | 0.67 | 2.65 | 0.45 | 0.46 |
| 2 | 1989 | 0.79 | 2.96 | 0.53 | 0.56 | 0.73 | 2.192 | 0.47 | 0.49 | 0.78 | 2.71 | 0.5 | 0.52 |
| 3 | 1990 | 0.79 | 2.95 | 0.53 | 0.55 | 0.79 | 2.481 | 0.44 | 0.46 | 0.81 | 3.03 | 0.55 | 0.57 |
| 4 | 1991 | 0.81 | 3.01 | 0.55 | 0.57 | 0.69 | 2.083 | 0.52 | 0.54 | 0.74 | 2.75 | 0.49 | 0.51 |
| 5 | 1992 | 0.79 | 2.87 | 0.52 | 0.55 | 0.67 | 1.937 | 0.53 | 0.54 | 0.67 | 2.58 | 0.44 | 0.46 |
| 6 | 1993 | 0.8 | 2.95 | 0.53 | 0.56 | 0.68 | 1.907 | 0.5 | 0.52 | 0.72 | 3.11 | 0.51 | 0.53 |
| 7 | 1994 | 0.77 | 2.81 | 0.51 | 0.53 | 0.71 | 2.129 | 0.49 | 0.51 | 0.82 | 3.25 | 0.57 | 0.6 |
| 8 | 1995 | 0.79 | 2.95 | 0.53 | 0.55 | 0.71 | 1.825 | 0.47 | 0.49 | 0.61 | 2.77 | 0.43 | 0.45 |
| 9 | 1996 | 0.8 | 2.94 | 0.54 | 0.56 | 0.7 | 2.026 | 0.5 | 0.51 | 0.72 | 2.86 | 0.49 | 0.51 |
| 10 | 1997 | 0.8 | 2.95 | 0.53 | 0.56 | 0.73 | 2.292 | 0.48 | 0.5 | 0.76 | 3.16 | 0.54 | 0.56 |
| 11 | 1998 | 0.8 | 2.93 | 0.53 | 0.55 | 0.71 | 2.35 | 0.5 | 0.52 | 0.74 | 3.2 | 0.53 | 0.55 |
| 12 | 1999 | 0.78 | 2.9 | 0.52 | 0.54 | 0.75 | 2.444 | 0.48 | 0.5 | 0.73 | 2.94 | 0.5 | 0.53 |
| 13 | 2000 | 0.78 | 2.87 | 0.52 | 0.54 | 0.77 | 2.472 | 0.47 | 0.48 | 0.79 | 2.92 | 0.53 | 0.55 |
| 14 | 2001 | 0.79 | 2.89 | 0.52 | 0.55 | 0.76 | 2.943 | 0.5 | 0.51 | 0.72 | 2.63 | 0.47 | 0.49 |
| 15 | 2002 | 0.78 | 2.92 | 0.52 | 0.55 | 0.76 | 3.007 | 0.49 | 0.51 | 0.86 | 3.01 | 0.57 | 0.59 |
| 16 | 2003 | 0.8 | 2.94 | 0.54 | 0.56 | 0.72 | 2.677 | 0.53 | 0.55 | 0.88 | 2.95 | 0.57 | 0.6 |
| 17 | 2004 | 0.77 | 2.86 | 0.51 | 0.54 | 0.78 | 3.125 | 0.47 | 0.49 | 0.9 | 3.2 | 0.61 | 0.63 |
| 18 | 2005 | 0.78 | 2.91 | 0.52 | 0.54 | 0.78 | 3.222 | 0.47 | 0.48 | 0.92 | 3.32 | 0.63 | 0.65 |
| 19 | 2006 | 0.77 | 2.89 | 0.52 | 0.54 | 0.81 | 3.319 | 0.44 | 0.46 | 0.92 | 3.38 | 0.63 | 0.66 |
| 20 | 2007 | 0.78 | 2.9 | 0.52 | 0.54 | 0.85 | 3.428 | 0.42 | 0.43 | 0.91 | 3.37 | 0.63 | 0.65 |
| 21 | 2008 | 0.79 | 2.91 | 0.53 | 0.55 | 0.87 | 3.537 | 0.39 | 0.41 | 0.95 | 3.52 | 0.66 | 0.69 |
| 22 | 2009 | 0.78 | 2.9 | 0.52 | 0.54 | 0.88 | 3.578 | 0.38 | 0.4 | 0.95 | 3.49 | 0.65 | 0.68 |
| 23 | 2010 | 0.78 | 2.9 | 0.52 | 0.54 | 0.89 | 3.718 | 0.38 | 0.39 | 0.93 | 3.4 | 0.64 | 0.67 |
| 24 | 2011 | 0.77 | 2.88 | 0.52 | 0.54 | 0.89 | 3.681 | 0.38 | 0.39 | 0.93 | 3.36 | 0.63 | 0.66 |
| 25 | 2012 | 0.76 | 2.81 | 0.51 | 0.53 | 0.91 | 3.784 | 0.36 | 0.37 | 0.92 | 3.53 | 0.64 | 0.67 |

 Table 7: Measuring of Author collaborations – Global with year wise

Based on the CI in the year 1988 it was 2.96, followed by the year 1991 (3.01), 1993 (2.95), 2000 (2.87), 2001 (2.89), 2008 (2.91), 2012 (2.81). CC and MCC were calculated to differentiate among the levels of multiple authors. CC is between 0.51 and 0.55 and the MCC is between 0.53 and 0.56.

From the table 7, it is observed that degree of collaboration ranges between 0.67 and 0.91. This indicates research in MEMS collaborative research among authors. The collaborative index ranges between 1.825 and 3.784. The collaborative coefficient is from 0.3 to 0.5.

Findings and Conclusion

- The growth of literature on MEMS subject is increasing every year, high growth in the recent years and there was low output in 2003.
- MEMS publications are increasing trends for G8, BRIC countries and overall global.
- As per CAGR indicator, BRIC countries have more concentrate on MEMS subject comparing with G8 countries.
- RGR value for G8 countries started with high score and decreased and the same way for BRIC countries also.
- Dt values are increasing and decreasing and regained for G8 countries whereas BRIC countries are increasing the values and decreasing slowly. But on the whole, Global level Dt is maintaining the same value for all the years.
- The Author collaboration is concerned the Single authorship is dominated in the productivity as Global. BRIC countries are less compared to G8 countries on single author productivity.
- DC is between the range of .76 and .80 as in the Global, .67 and .91 for G8 countries and .61 and .92 for BRIC countries.
- CI is between the range of 2.81 and 2.95 in the Global, 1.82, 3.78 for G8 Countries and 2.58 and 3.53 for BRIC countries.
- CC is between the range of 0.51 and 0.54 in the Global, 0.38 and 0.52 for G8 countries and 0.43 and 0.66 for BRIC countries.
- MCC is between 0.53 and 0.57 in the Global, 0.37 and 0.55 for G8 countries and 0.45 and 0.69 for BRIC countries.

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