

# Authorship Pattern of Digital Architecture Research Output : A Scientometric Analysis

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## ABSTRACT

The study deals with the Scientometric study on the publication of "Digital Architecture". The records are collected from Web of Science Databases for the period of 1999-2013. A total of 6335 papers were identified in Web of Science database. The study reveals that, most of the researchers preferred to publish their research results in journals; as such 79.41% of articles were published in journals. More numbers of articles were published in the year 2012. The authorship trend shows that, out of total 6335 literature published, 89% of the publication published under the joint author. It is observed that author productivity is not in agreement with Lotka's law, but productivity distribution data partially fits the law when the value of Chi-square to 727.37. Further this study also identified to analyses coverage growth rates, coverage growth rates, sourcewise. Degree of collaboration, Areas of research concentration, word frequency, Geographical distribution of the literature and citation analysis is also noted.

**Keyword: Digital Architecture, Digital, Authorship Pattern, Scientometric Analysis, Lotka's Law**

## 0. INTRODUCTION

Digital technology of the current age has grown so boundlessly that it is triggering a radical change throughout culture, art, science and lifestyle. It has rapidly penetrated into our everyday lives. Of the three fundamental human needs - clothing, housing and food - the first two appear to have various phases of digital evolution. Meanwhile, urban spaces, including architecture, are carefully seeking their role as electronic interfaces. The new environment, created by digital technology, has freed humanity from the borders of physical limits of time and space. It is now transforming this era's paradigm of value: from being static to diversion, materialism to immaterialism, heaviness to lightness, logical relationship to indefiniteness and clarity to obscurity. Architecture is restructured according to the contents within an electronic world, and the image of structured space expresses these contents. The digital architecture can be defined as 'an architecture which eliminates geometrical artificiality by creating non-geometrical space, as digital information and human perception meet and handle multidimensional space'.

The major focus of the study is to apply the scientometric analysis with a view to analyse the authorship pattern of research out put in Digital Architecture. This study related to authors and their productivity; collaborative patterns and other aspects is important and useful to understand the mechanism underlying the growth of knowledge of a discipline. This study also to analyse the authorship pattern of Digital Architecture research output interms of its content and coverage relative growth rates, doubling time, sourcewise. Degree of collaboration, Collaborative index, Areas of research concentration, author productivity, authorship Pattern, and citation analysis is also noted.

## 1. OBJECTIVES OF THE STUDY

1. To examine the growth of literature in Digital architecture in scientometric analysis during the period from 1999 to 2013.
2. To examine the various sources of research publications in digital architecture.
3. To identify the nature of Authorship pattern and determine the degree of collaboration.
4. To identify the proportion of single and multi-authored papers of digital architecture research output.
5. To test the applicability of Lotka's law to the scientific productivity of authors.
6. To identify the Countrywise research output performance in Digital architecture in bibliometrics.

## 2. METHODOLOGY

The present study is carried out about source documents and research output. The data for the study was downloaded from the web of science database in May 2013. All the Publications retrieved from the Scopus database on Digital Architecture and cover the period from 1999 to 2013, Further; the research has downloaded the bibliographical data in the form of notepad files. Then the bibliographical details are converted to using Histcite software. Overall data retrieved by the researcher are 6335 records and the researcher chosen only 6335 records for analyzing the present study.

## 4. ANALYSIS AND DISCUSSION

### 4.1 GROWTH OF PUBLICATION RESEARCH OUTPUT AND CITATION SCORES

To analysis the year wise publication of research on digital architecture, the data has been presented in the above table-1. It could clearly see that during the period 1999 - 2013 a total of 6335 publications were published in Global level within the fifteen years. Highest percentage of papers were published in the year 2012, 2011 and 2009 constituting 9.39 % and 8.71% and 8.70% respectively.

**Table -1: Year Wise Distribution of the Research Output and Citation Scores**

No	Publication of Year	Publication output	Percentage	TLCS	TGCS
1	1999	320	5.05	332	4355
2	2000	306	4.83	281	4887
3	2001	288	4.55	228	4003
4	2002	319	5.03	178	6832
5	2003	371	5.86	352	5727
6	2004	370	5.84	368	5440
7	2005	451	7.12	380	5608
8	2006	479	7.56	313	4458
9	2007	449	7.09	368	4940
10	2008	502	7.92	283	4560
11	2009	551	8.70	221	3300
12	2010	530	8.37	135	2179
13	2011	552	8.71	80	1205
14	2012	595	9.39	23	366
15	2013	252	3.98	3	23
<b>Total</b>		<b>6335</b>	<b>100</b>		<b>57883</b>

The highest publication is 595 in the year of 2012 with 366 Global Citation Scores followed by 552 papers in 2011 with 1205 Global Citation Scores. The lowest publication is 288 in 2001 with 4003 Global Citation Scores. But the publication is 319 in 2002 with highest Global Citation Scores (6832). It shows that even minimum numbers of records were scored higher global citations. The study also reveals all these 6335 publications have 57883 cited references it shows that there is a healthy trend in citing reference is found among the Scientists belongs to digital architecture.

#### 4.2 GROWTH RATE AND DOUBLING TIME IN DIGITAL ARCHITECTURE RESEARCH OUTPUT

A study of the growth rate of Digital architecture literature is an important factor in analyzing the research and development in the field. Table-2 indicates the relative growth rate of research output in Digital Architecture at the global level. It is apparent that the relative growth rate has increasing trend or more or less similar trend -0.04 in 1999 to -0.85 in 2013. The mean relative growth rate for the period 1999 and 2005 is worked out to 0.05 and it is 0.91 for the period 2006 – 2013. The overall study period has witnessed a mean relative growth rate of 0.06. Invariably the doubling time for publications of research output in Digital Architecture has increased from -17.32 year in 2000 to 9.9 in 2012. Quite obviously the whole study period has recorded a mean doubling time for publication as 0.24 years. The mean doubling time for the period 1999 to 2006 is worked out to -0.26 years and for the period 2007 to 2013 it is calculated as 0.82 years. It is evident from the above discussion that the relative growth rate of publication has shown more or less a similar trend. Consequently, the mean doubling time for publication of Digital Architecture has shown an increasing trend.

**Table-2 Relative Growth Rate and Doubling Time of Overall Research Output**

Year	No. of Output	Cumulative No. of Output	W1	W2	R (a)	Mean R(a)	Doubling Time Dt (a)	Mean Dt(a) 1-2
1999	320	320		5.76				<b>-0.26</b>
2000	306	626	5.76	5.72	-0.04		-17.32	
2001	288	914	5.72	5.66	-0.06		-11.55	
2002	319	1233	5.66	5.76	0.10		6.93	
2003	371	1604	5.76	5.91	0.15		4.62	
2004	370	1974	5.91	5.91	0.00		0	
2005	451	2425	5.91	6.11	0.19		3.64	
2006	479	2904	6.11	6.17	0.06	<b>0.05</b>	11.55	<b>0.82</b>
2007	449	3353	6.17	6.10	-0.06		-11.55	
2008	502	3855	6.10	6.21	0.11		6.3	
2009	551	4406	6.21	6.31	0.09		7.7	
2010	530	4936	6.31	6.27	-0.03		-23.1	
2011	552	5488	6.27	6.31	0.04		17.32	
2012	595	6083	6.31	6.38	0.07		9.9	
2013	252	6335	6.38	5.52	-0.85	<b>0.91</b>	-0.81	

<b>Mean R(a)</b>	<b>0.06</b>	<b>0.24 years</b>
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### 4.3 AUTHORSHIP PATTERNS

The table-3 indicates the authorship pattern of research publication on Digital Architecture research output. It could be noted that three author publications contribute 24.35%, it is followed by Double author publication with 22.05 %, four authorship publications with 17.14%, single author research output with 10.53, five author publications with 10.34%, six authors 5.74% and above ten author research output with 3.39% respectively.

**Table 3 – Showing Year wise Authorship pattern**

Year	1	2	3	4	5	6	7	8	9	10	Total
1999	57 (8.49)	74 (5.29)	72 (4.66)	38 (3.50)	26 (3.98)	16 (4.40)	15 (7.14)	8 (6.4)	3(4)	11 (5.16)	320 (5.05)
2000	62 (9.23)	80 (5.72)	83 (5.37)	49 (4.52)	15 (2.29)	5 (1.37)	5 (2.38)	2 (1.6)	1 (1.33)	4 (1.87)	306 (4.83)
2001	46 (6.85)	83 (5.94)	68 (4.40)	34 (3.13)	19 (2.90)	12 (3.30)	5 (2.38)	5 (4)	6(8)	10 (4.69)	288 (4.54)
2002	38 (5.66)	77 (5.51)	88 (5.69)	53 (4.88)	29 (4.44)	14 (3.85)	8 (3.80)	4 (3.2)	4 (5.33)	4 (1.87)	319 (5.03)
2003	32 (4.76)	94 (6.72)	105 (6.80)	62 (5.71)	29 (4.44)	18 (4.95)	11 (5.23)	7 (5.6)	5 (6.66)	8 (3.75)	371 (5.85)
2004	30 (4.47)	80 (5.72)	116 (7.51)	63 (5.81)	20 (3.06)	17 (4.68)	17 (8.09)	7 (5.6)	4 (5.33)	16 (7.51)	370 (5.84)
2005	52 (7.47)	97 (6.94)	98 (6.34)	88 (8.11)	45 (6.89)	28(7.71)	14 (6.66)	8 (6.4)	5 (6.66)	16 (7.51)	451 (7.11)
2006	42 (6.25)	118 (8.44)	119 (7.70)	71 (6.54)	59 (9.03)	27 (7.43)	13 (6.19)	8 (6.4)	8 (10.66)	14 (6.57)	479 (7.56)
2007	51 (7.60)	112 (8.01)	100 (6.47)	69 (6.36)	43 (6.58)	25 (6.88)	11 (5.23)	12 (9.6)	9(12)	17 (7.98)	449 (7.08)
2008	51 (7.60)	99 (7.08)	128 (8.29)	106 (9.77)	42 (6.43)	31 (8.53)	14 (6.66)	9(7.2)	2 (2.60)	20 (9.38)	502 (7.92)
2009	49 (7.30)	112 (8.01)	127 (8.22)	100 (9.22)	64 (9.80)	37 (10.19)	20 (9.52)	17 (13.6)	7 (9.33)	18 (8.45)	551 (8.69)
2010	47 (7.00)	108 (7.73)	128 (8.29)	102 (9.40)	62 (9.49)	32 (8.81)	20 (9.52)	7 (5.6)	4 (5.33)	20 (9.38)	530 (8.36)
2011	48 (7.15)	114 (8.16)	130 (8.44)	86 (7.93)	82 (12.55)	40 (11.01)	18 (8.57)	13 (10.4)	7 (9.33)	14 (6.54)	552 (8.71)
2012	49 (7.30)	104 (7.44)	130 (8.44)	103 (9.50)	90 (13.78)	43 (11.84)	28 (13.33)	14 (11.2)	7 (9.33)	27 (12.67)	595 (9.39)
2013	17	45	52	60	28(4.28)	18	11	4	3(4)	14	252

	(2.53)	(3.22)	(3.36)	(5.53)		(4.95)	(5.23)	(3.2)		(6.57)	(3.97)
<b>TOTAL</b>	<b>671</b> <b>(10.53)</b>	<b>1397</b> <b>(22.05)</b>	<b>1544</b> <b>(24.35)</b>	<b>1084</b> <b>(17.14)</b>	<b>653</b> <b>(10.34)</b>	<b>363</b> <b>(5.74)</b>	<b>210</b> <b>(3.31)</b>	<b>125</b> <b>(2.00)</b>	<b>75</b> <b>(1.25)</b>	<b>213</b> <b>(3.39)</b>	<b>6335</b> <b>(100)</b>

From the result we come to know that the multi author publication is the highest compare to single author publication.

Out of the fifteen year analysis, year 2012 has recorded the highest publication distribution of 9.39 percent among the fifteen years. The year 2011 recorded 8.71 percent, year 2009 recorded 8.69 percent, 2010 recorded 8.36 percent and 2008 recorded 7.92 percent respectively. In view of this analysis the following year distribution 2000, 2001 and 2013 have contributed less than five percent on Digital Architecture.

#### 4.4 SINGLE VS MULTIPLE AUTHORED RESEARCH OUTPUT AND DEGREE OF COLLABORATION

It is observed that the single version multi author research output during the period 1999 to 2013. At the overall level, the single author contributed papers constitute 10.59 per cent of the total publications: where as the remaining majority 89.40 of the papers are contributed by multi authorship. It is inferred from the table -4 that at the aggregate level, the degree of collaboration is of 0.89 during the study period 1999 to 2013 i.e., that is out of total 6335 literature published, 96% of them or published under the joint author of publications in Digital Architecture research output. The period wise analysis indicates that its level is somewhat less in the first period [1999-2005: 0.86] and it has shown. An increasing trend during the period [2006-13: 0.91]. This brings out clearly the high level of prevalence of collaborative research in Digital Architecture. Based on this study, the result of the degree of collaboration  $C=0.89$  i.e., 89 percent of collaboration authors articles published during the study periods.

**Table-4 Single Vs Multiple Authored Research Output and Degree of Collaboration**

Year	Single Author		Multiple Author		Total (%)	Degree of collaboration	Mean Degree of collaboration
	No. of Out put	Percentage	No. of Out put	Percentage			
1999	57	17.81	263	82.18	320(5.05)	0.82	
2000	62	20.26	244	79.73	306(4.83)	0.79	
2001	46	15.97	242	84.02	288(4.54)	0.84	
2002	38	11.91	281	88.08	319(5.03)	0.88	
2003	32	8.62	339	91.37	371(5.85)	0.91	
2004	30	8.10	340	91.89	370(5.84)	0.91	
2005	52	11.52	399	88.47	451(7.11)	0.88	0.86
2006	42	8.76	437	91.23	479(7.56)	0.91	
2007	51	11.35	398	88.64	449(7.08)	0.88	
2008	51	10.15	451	89.84	502(7.92)	0.89	
2009	49	8.89	502	91.10	551(8.69)	0.91	
2010	47	8.86	483	91.13	530(8.36)	0.91	
2011	48	8.69	504	91.30	552(8.71)	0.91	
2012	49	8.23	546	91.76	595(9.39)	0.91	
2013	17	6.74	235	93.25	252(3.97)	0.93	0.91
<b>Total</b>	<b>671</b>	<b>10.59</b>	<b>5664</b>	<b>89.40</b>	<b>6335</b>	<b>0.89</b>	

#### 4.5 RANKING OF AUTHORS PRODUCTIVITY BASED ON PUBLICATIONS

Table- 5 indicates ranking of authors by number of publications. Authors “Kim J” published highest number of articles for the study period with 39 records, consecutive authors “Kim S” are published next highest number of articles for the study period with 20 records. “Muhammed K” having highest Global Citation Scores of 597 with just 12 publications followed by “Balsara PT” is having Global Citation Score of 256 with just 10 publications, while Kim S having lowest Global Citation Score of 48 with just 20 publications. Thus the most-cited authors are distinguished from the most-published ones. It is found from the analysis that Lotka’s law may not be applicable with regard to author productivity in proliferation of research in Digital Architecture as the research papers equally distributed by a large number of authors.

**Table – 5 Ranking of Authors Productivity based on Publications**

No	Author	No. of Articles	TLCS	TGCS
1	Kim J	<u>39</u>	69	588
2	Kim S	<u>20</u>	5	48
3	Lee J	<u>17</u>	7	55
4	Chandrakasan AP	<u>16</u>	55	500
5	Kim B	<u>16</u>	36	200
6	Lee H	<u>16</u>	3	93
7	Parhi KK	<u>16</u>	13	86
8	Staszewski RB	<u>16</u>	139	856
9	Rodriguez-Vazquez A	<u>15</u>	8	144
10	Meher PK	<u>14</u>	22	67
11	Moon UK	<u>14</u>	39	220
12	Varandas CAF	<u>14</u>	12	94
13	De Caro D	<u>13</u>	11	103
14	de la Rosa JM	<u>13</u>	3	76
15	Fontaine R	<u>13</u>	24	116
16	Lee S	<u>13</u>	5	77
17	Maloberti F	<u>13</u>	4	40
18	Roy K	<u>13</u>	5	130
19	Sousa J	<u>13</u>	12	92
20	Wang ZH	<u>13</u>	7	73
21	Gabrielli A	<u>12</u>	7	37
22	Geraci A	<u>12</u>	22	134
23	Lecomte R	<u>12</u>	23	112
24	Morie T	<u>12</u>	18	76
25	Muhammad K	<u>12</u>	104	597
26	Strollo AGM	<u>12</u>	11	102
27	Wang Y	<u>12</u>	6	416
28	Chen CY	<u>11</u>	2	35
29	Hu Y	<u>11</u>	5	289
30	Karim KS	<u>11</u>	21	143

#### 4.6 LOTKA'S LAW OF AUTHOR PRODUCTIVITY

The Lotka's law of author productivity is tested with the applications of scientific productivity Chi-square model, and it is applied in relation to number of authors contributing to the number of publications. Potter (1981) identified the Lotka's fraction  $1/na = 4.65$  on the basic of Euler – maclaurin formula of summation. This model is applied in the present study. The Chi-square can be computed as  $(f-p)^2/p$ , where  $f$  = observed number of authors with “n” publications;  $p$  = Expected number of authors. In this study, the productivity of Digital Architecture research scientists is examined. At the first observation, the analyzed data invalidate Lotka's findings that the proportion of all contributions that make a single contribution is less than 60 percent. Further, Lotka's Chi square model confirms the source trend. It explains the fact that the calculated  $x^2$  value is 727.32 which is less than the tabulated value at 5 percent level of significance.

**Table-6 Showing Lotka's Law of Author Productivity**

No. of Publication	Observer No. of Authors with n (an) or F	Observed % of authors $100 \times an/ al$	Expected No of Authors $(an=al/n^2)$ (P)	Expected percentage of authors predicate by Lotka's $100/n^2$	$(F-P)^2 / p$
1	3100	100	3100	100	0
2	211	6.80	775	25	410.44
3	136	4.38	344.44	11.11	126.14
4	117	3.77	193.75	6.25	30.40
5	63	2.03	124	4	30.00
6	59	1.90	86.11	2.77	8.53
7	58	1.87	63.26	2.04	0.43
8	49	1.58	48.43	1.56	0.00
11	39	1.25	25.61	0.82	6.98
12	34	1.09	21.52	0.69	7.22
14	33	1.06	15.81	0.51	18.66
15	26	0.83	13.77	0.44	10.84
16	25	0.80	12.10	0.39	13.72
19	24	0.77	8.58	0.27	27.66
21	23	0.74	7.02	0.22	36.28
<b>Total</b>				<b><math>X^2</math></b>	<b>727.37</b>

#### 5. MAJOR FINDINGS

1. The finding of growth of publication of Digital Architecture research output brings out the highest percentage of papers were published in the year 2012, 2011 and 2009 constituting 9.39 % and 8.71% and 8.70% respectively. It shows that even minimum numbers of records were scored higher global citations. The study also reveals all these 6335 publications have 57883 cited references it shows that there is a healthy trend in citing reference is found among the Scientists belongs to digital architecture.

2. The findings of overall relative growth rate of literature in Digital Architecture in examine the following facts. Relative growth rate of publication has shown more or less a similar trend. Consequently the mean doubling time for publication of Digital Architecture has shown an increasing trend.
3. It is found that three author publications contribute 24.35%, it is followed by double author publication with 22.05 %, four authorship publications with 17.14%, single author research output with 10.53, five author publications with 10.34%, six authors 5.74% and above ten author research output with 3.39% respectively. From the result we come to know that the multi author publication is the highest compare to single author publication.
4. The findings of degree of collaboration analysis reveal the following facts that the case of single author contributed papers is less. It brings out clearly the high level prevalence of collaborative research in digital architecture. Based on this study, the result of the degree of collaboration  $C=0.89$  i.e., 89 percent of collaboration authors articles published during the study periods.
5. The findout author contribution “Kim J” published highest number of articles for the study period with 39 records, consecutive authors “Kim S” are published next highest number of articles for the study period with 20 records. “Muhamed K” having highest Global Citation Scores of 597 with just 12 publications followed by “Balsara PT” is having Global Citation Score of 256 with just 10 publications, while Kim S having lowest Global Citation Score of 48 with just 20 publications.
6. The findings of author productivity in terms of Lotka's law implications reveal the following facts that the analyzed data invalidate Lotkas findings. Lotka's Chi square model confirms the source trend. It explains the fact that the calculated  $\chi^2$  value is 727.32 which is less than the tabulated value at 5 percent level of significance.
7. The findings of country wise analysis examine the following facts. The European Country top the list in using number cowards in the literature in Digital Architecture in bibliometric the North American countries the second, the Asia countries the third, the Oceania countries and the African countries the last respectively.

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