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# Scientometric Analysis of Nuclear Science and Technology Research Output in Iran

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*The main purpose of this study is to evaluate internationally published research productivity and make quantitative and qualitative assessments of the status of nuclear science and technology in Iran. The data have been collected from the Science Citation Index Expanded (SCIE) for the years 1990–2010. The results of this work reveal that the Iranian literature on nuclear science and technology has grown exponentially during the study period. The average number of citations per paper is 5.64. Academic institutions are the main source of research productivity. About 93 per cent of the papers are co-authored. Internationally co-authored papers enjoy higher citation rates in comparison with domestic papers. Disciplinary characterization of the Iranian nuclear science and technology research identifies that emphasis is placed on physics and chemistry and that the publications in which the research appears are distributed evenly among a number of scientific fields.*

*Keywords: nuclear science and technology, Iran, scientometric analysis, publication productivity*

The importance of nuclear science and technology to Iran was demonstrated as early as 1968. That year saw the establishment of an atomic research centre affiliated with Tehran University that oversaw the operation of a 5 megawatt (MW) pool-type research reactor. Later, in 1973, the Atomic Energy Organization of Iran (AEOI) was established, primarily to supervise the implementation of a 23,000 MW nuclear power program. In 1979, the objectives and priorities of the AEOI became subject to thorough fundamental revision. It underwent a complete reorganization in which emphasis was placed particularly on peaceful research and development. Many new research centres and divisions were established,

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and the technological and scientific nuclear infrastructure in Iran was greatly enhanced.<sup>1</sup> Currently, the AEOI is the main body responsible for implementing regulations and operating nuclear energy installations in the country. Iran has been a party to the Treaty on the Nuclear Non-Proliferation of Nuclear Weapons since 1970 and has had a safeguards agreement with the UN nuclear watchdog, the International Atomic Energy Agency (IAEA), since 1974.<sup>2</sup> In recent years Iran has identified nuclear science and technology as a national priority and has implemented strategies to foster the development of indigenous nuclear scientific and technological capabilities. It is the seventh country to produce uranium hexafluoride (or UF<sub>6</sub>).<sup>3</sup>

Evidence suggests that, until 1972, no Iranian-authored scientific paper on nuclear science was published in an international journal. In this year an article in nuclear medicine entitled ‘Diagnostic Value of Liver Scan in Operated Echinococcus Cyst’ was published in a German journal.<sup>4</sup> Other recent scientometric studies of Iranian publication output indicate that Iran’s contribution to global knowledge has increased during the recent decades.<sup>5</sup> Archambaut notes in his report that ‘Iran’s publications have emphasized inorganic and nuclear chemistry, nuclear and particle physics and nuclear engineering. Publications in nuclear engineering grew faster than the world average—although medical and agriculture research also increased.’<sup>6</sup>

Scientometric studies on nuclear science and technology in different countries are uncommon. Arunachalam, Dhirendra, and Shrivastava found that Israel was relatively more productive in nuclear physics and atomic and molecular physics—areas in which Israeli-authored published research exceeded 1.3 per cent of the world’s literature—than in all of physics—an area in which Israeli authors produced only 0.89 per cent of published research.<sup>7</sup> Van Leeuwen and Tussen reviewed Dutch nuclear energy research.<sup>8</sup> Uzun, who has studied the publication patterns of Middle Eastern physicists in international journals, found that Iranian authors tended to be more active in physics and nuclear science and technology.<sup>9</sup> Kademani et al.,<sup>10</sup> Jeevan and Sen,<sup>11</sup> and Sagar, Kademani, and Kumar<sup>12</sup> conducted studies on nuclear science in India. Ackermann<sup>13</sup> and Yanagisawa et al.<sup>14</sup> have recently estimated the research output of nuclear science in the United States and Japan, respectively.

However, the quest of the Iranian government to develop its country's nuclear capabilities is leading to an international crisis. A literature review shows no study related to an analysis of Iranian contributions to internationally published nuclear science research. Therefore, it would be valuable to study, from an international perspective, the current status of nuclear science and technology research in Iran being done to enhance domestic capabilities in this area.

#### OBJECTIVES

The main purpose of the current study is to evaluate internationally published research productivity and make quantitative and qualitative assessments of the status of nuclear science and technology in Iran. This will be achieved by focusing on tangible outputs of research and the following scientometric dimensions:

- growth of publications
- distribution of the contributions among subjects
- authorship and collaboration pattern
- identification of highly productive institutions, prolific authors, and highly cited papers
- communication pattern of Iranian nuclear scientists
- citation pattern of the research output

Such analyses will provide an appropriate picture of Iranian nuclear research performance from an international perspective.

#### METHODOLOGY

The data for this study were collected from *Science Citation Index Expanded (SCIE)*, published by Thomson Reuters (formerly the Institute for Scientific Information) in the years 1990–2010. *Journal Citation Reports (JCR)* was also used to find out the impact factor (IF) of journals. A suitable search strategy ('Iran' was entered in the author affiliation field and 'nuclear' in the topic field) was used to download records for the years 1990–2010 on 7 May 2011. The study used these data for both publications and citation impact. A total of 1071 records were downloaded. The data were analysed as per the objectives of the study. The analysis is based on all documents (including articles, proceedings papers, letters, notes, and reviews) recorded in the *SCIE (Web of Science)*.

## FINDINGS

*Publication Productivity*

During the twenty-one years under examination (1990–2010) Iranian researchers published a total of 1071 publications in the field of nuclear science and technology. Table 1 displays the publication output and year-to-year growth in the number of articles published during the period under study.

TABLE 1. Growth in the number of nuclear science and technology publications, 1990–2010

Year	Publications from Iran	% of total	Cumulative %	Growth rate	Publications published worldwide
1990	1	0.09	0.09	–	3675
1991	7	0.65	0.74	600.00	12904
1992	8	0.75	1.49	14.29	13625
1993	5	0.47	1.96	–37.50	13864
1994	8	0.75	2.71	60.00	15632
1995	7	0.65	3.36	–12.50	16270
1996	14	1.31	4.67	100.00	16855
1997	18	1.68	6.35	28.57	17850
1998	13	1.21	7.56	–27.78	18832
1999	13	1.21	8.77	0	19379
2000	18	1.68	10.45	38.46	19454
2001	26	2.43	12.88	44.44	20654
2002	34	3.18	16.06	30.77	20071
2003	42	3.92	19.98	23.53	22266
2004	52	4.86	24.84	23.81	21424
2005	62	5.79	30.63	19.23	24717
2006	74	6.91	37.54	19.35	23314
2007	116	10.83	48.37	56.76	24170
2008	143	13.35	61.72	23.28	26843
2009	199	18.58	80.30	39.16	26632
2010	211	19.70	100	6.03	26446
Total	1071	100	–	52.50 (average)	404877

There was only one paper published in 1990—the least productive of all years under examination. The most productive year was 2010, when 211 papers were published. Iran produced, on average, fifty-one relevant publications per year. Analysis of the data indicates that Iranian-produced nuclear science and technology research can be divided into two spans of time: 1990–1999 and 2000–2010. The first span is characterized by some ups and downs in output, but the second period shows a steady rise in output. In the second span, the highest growth rate—56.76 per cent—was observed in 2007 and the lowest growth rate—6.03 per cent—was observed in 2010. Ninety-one per cent (977 items) of the total number of publications was published in the second half of the study period (2000–2010). About 70 per cent (743 items) was published from 2006 to 2010. Iranian research output in the area of nuclear science increased about 53 per cent during the study period. Because just one paper was published in 1990, the rate of growth of Iran's nuclear science and technology research output during these twenty-one was about 200 times that of the world average, but during the 2000–2010 period, it was about ten times that of the world average. The rate of growth in this period is not normal. Normal scientific literature growth is characterized by a slower, steadier, cumulative growth pattern resulting from new ideas developing logically from preceding ones.<sup>15</sup> Although Iran has in recent decades been able to increase its share of world publication in nuclear science and technology research, its share is still only 0.26 per cent.

#### *Highly Productive Institutions*

There are more than 754 Iranian institutions involved in research activity in the field of nuclear science and technology. Table 2 indicates the productivity of the top ten institutions that produce nuclear science and technology research. These ten institutions contributed 76 per cent (814 items) of the total output, while the remaining 24 per cent came from the other 744 institutes. Tehran University topped the list with 145 publications, followed by Tarbiat Modares University with 115 publications, and Islamic Azad University with 107 publications. The AEOI, which produced 7.19 per cent of total output, is the major non-academic contributor. More than 65 per cent of the total 6042 citations of Iranian research pointed to research from these same ten institutions.

TABLE 2. Highly productive Iranian institutions in nuclear science and technology research, 1990–2010

Rank	Institution	Papers	% of Iranian output	Total citations	Mean citations per paper
1	Univ. Tehran	145	13.54	678	4.68
2	Tarbiat Modares Univ.	115	10.74	507	4.41
3	Islamic Azad Univ.	107	9.99	193	1.80
4	Shiraz Univ.	86	8.03	529	6.15
5	AEOI	77	7.19	530	7.07
6	Tehran Univ. of Medical Sciences	72	6.72	325	4.58
7	mirkabir Univ. of Technology (Tehran Polytechnic)	64	5.97	429	7.53
8	Shaheed Behshti Univ.	56	5.23	257	4.85
9	Razi Univ.	48	4.48	384	8.00
10	Sharif Univ. of Technology	44	4.11	149	3.39
Total		814	76.00	3981	

#### *Communication Pattern*

The 1071 publications were spread over 490 journals published in different countries. A detailed analysis of the top fifteen journals in terms of the number of publications and IF for the period 1990–2010 is shown in Table 3. Of the 1071 Iranian publications from 1990 to 2010, 232 (21.66 per cent) were published in these journals. The three leading journals preferred by the scientists were *Annals of Nuclear Energy*, *Physical Review C* and *Nuclear Physics A*. The IFs of the journals have been taken from *Journal Citation Reports (JCR)* published by Thomson Reuters for the five years up to 2009. The journals' IFs range from 0.238 to 3.178.

#### *Subject Distribution of Publications*

The publications in nuclear science and technology have been spread over 125 main ISI subject categories. The findings reveal that several distinct disciplines are involved. This may be because nuclear science and technology research is a multidisciplinary and interdisciplinary endeavour. By ranking the subject categories by number of publications it is possible

TABLE 3. Major journals preferred by Iranian nuclear scientists, 1990–2010

Journal title	Country of origin	Iranian papers	% of total Iranian research output	5 years IF
<i>Annals of Nuclear Energy</i>	England	28	2.61	0.691
<i>Physical Review C</i>	USA	23	2.15	3.178
<i>Nuclear Physics A</i>	Netherlands	21	1.96	1.858
<i>Acta Cytologica</i>	Switzerland	17	1.59	0.800
<i>Journal of Radioanalytical and Nuclear Chemistry</i>	Netherlands	16	1.49	0.652
<i>Journal of Molecular Structure: THEOCHEM*</i>	Netherlands	15	1.40	1.212
<i>International Journal of Modern Physics E—Nuclear Physics</i>	Singapore	14	1.31	0.649
<i>Asian Journal of Chemistry</i>	India	12	1.12	0.238
<i>Nukleonika</i>	Poland	12	1.12	0.254
<i>Progress in Nuclear Energy</i>	England	12	1.12	0.746
<i>Applied Radiation and Isotopes</i>	England	11	1.03	1.101
<i>Iranian Journal of Radiation Research</i>	Iran	11	1.03	–
<i>Journal of Fusion Energy</i>	USA	10	0.93	0.825
<i>Journal of Molecular Structure</i>	Netherlands	10	0.93	1.698
<i>Journal of Solution Chemistry</i>	USA	10	0.93	1.400
<i>Yakhteh</i>	Iran	10	0.93	–

\* Now titled *Computational and Theoretical Chemistry*.

to obtain an overview of the scientific profile and disciplinary characteristics of Iranian nuclear science and technology research (see Table 4). The highest number of publications was in the category Nuclear Science & Technology (143 publications or 13.35% of the total); followed by Chemistry, Multidisciplinary (117 publications or 10.92%); Chemistry, Physical (105 publications or 9.80%); and Physics, Nuclear (100 publications or 0.33%). These four sub-fields together constitute 43.41% of the total output.

TABLE 4. ISI subject categories of Iranian nuclear science and technology research, 1990–2010

Subject area	Papers	% of total Iranian research output	Citations	Mean citations per paper
Nuclear Science & Technology	143	13.35	434	3.03
Chemistry, Multidisciplinary	117	10.92	469	4.01
Chemistry, Physical	105	9.80	683	6.50
Physics, Nuclear	100	9.34	684	6.84
Chemistry, Inorganic & Nuclear	76	7.10	450	5.92
Biochemistry & Molecular Biology	63	5.88	487	7.73
Physics, Multidisciplinary	53	4.95	450	8.49
Radiology, Nuclear Medicine & Medical Imaging	48	4.48	128	2.67
Cell Biology	43	4.01	332	7.72
Physics, Particles & Fields	42	3.92	260	6.19
Physics, Atomic, Molecular & Chemical	39	3.64	250	6.41
Chemistry, Analytical	36	3.36	179	4.97
Pathology	33	3.08	143	4.33
Plant Sciences	32	2.99	242	7.56
Pharmacology & Pharmacy	28	2.61	246	8.79
Physics, Condensed Matter	26	2.43	91	3.50
Spectroscopy	26	2.43	110	4.23
Evolutionary Biology	25	2.33	432	17.28
Genetics & Heredity	25	2.33	344	13.76
Medicine, Research & Experimental	23	2.15	36	1.57
Polymer Science	23	2.15	65	2.83
Crystallography	22	2.05	203	9.23
Engineering, Chemical	22	2.05	68	3.09



Further analysis of data indicates that in the study period, only 367 (34.34 per cent) of the total 1071 publications are in the following categories: Nuclear Science & Technology; Physics, Nuclear; Chemistry, Inorganic & Nuclear; and Radiology, Nuclear Medicine & Medical Imaging. The fact that the majority of the published research doesn't fall under these categories emphasizes how nuclear research in Iran is of an interdisciplinary nature. The table shows that nuclear research in Iran revolves around physics, chemistry and related disciplines.

In order to analyse the scientific activity of the country in the field of nuclear science and technology research, the citation impacts were also considered. According to the data in Table 4, citation patterns and publication activity are not similar across the subject categories. The difference in the average number of citations per paper in different subject categories shows that citation practices differ markedly. The Evolutionary Biology category's twenty-five papers were cited 432 times—an average of 17.28 citations per paper—while the Medicine, Research & Experimental category's twenty-three papers received only 36 citations—an average of 1.57 citations per paper. Analysis of the pattern of citations in different categories indicates that Evolutionary Biology has the highest number of citations per paper, followed by Genetics & Heredity, Crystallography, and Pharmacology & Pharmacy.

#### *Authorship*

The data indicate that a total of 3015 authors contributed the 1071 publications during the study period. The average number of authors per paper is 2.81, ranging from a minimum of one to a maximum of seventy-five. Three-author papers accounted for 26.61 per cent of all papers, followed by two-author papers with 22.69 per cent, four-author papers with 16.34 per cent and five-author papers with 8.22 per cent. More than 65 per cent of the papers were written by two to four collaborators. Authorship pattern among Iranian nuclear scientists is given in Table 5. Only 7.38 per cent of publications (79) were written by single authors while 92.62 per cent of publications (992) involved multiple-author collaboration (both national and international) during 1990–2010, indicating a high degree of collaboration in the field.

Table 6 lists the most prolific authors. Sixteen authors (as first author or co-author) contributed ten or more papers each. These authors contributed 350 papers (32.68 per cent of the total). Papers by these authors

TABLE 5. Number of Iranian authors per nuclear science and technology research paper, 1990–2010

Number of authors ( <i>x</i> )	Papers by <i>x</i> authors	% of all papers
1	79	7.38
2	243	22.69
3	285	26.61
4	175	16.34
5	88	8.22
6	62	5.79
7	43	4.01
8	27	2.52
9	17	1.59
10	11	1.03
11–20	27	2.52
>20	14	1.31
Total	1071	100

were cited 2211 times (39.69 per cent). The average number of citations per article for the prolific authors is 6.32, more than the combined average for all Iranian nuclear research output.

#### *Nature of Collaboration*

The rate of collaboration varied from field to field. The co-publications obviously show systematic patterns of scientific cooperation within and between countries. The natures of collaborations were determined by information derived from the institutional addresses listed on co-authored publications. To evaluate the level of collaboration, three types of authorship have been identified:

- single author: one author only (i.e., no collaboration)
- national co-authorship: collaboration between authors in the country
- international co-authorship: collaboration between authors from different countries

Table 7 provides information on the collaboration pattern in Iranian nuclear science and technology research. There were 270 publications

TABLE 6. Most prolific Iranian authors, 1990–2010

Author	Institution	Papers	Total citations	Mean citations per paper
Shamsipur, M.	Razi Univ.	43	483	11.23
Hadipour, N. L.	Tarbiat Modares Univ.	36	179	4.97
Modarres, M.	Tehran Univ.	34	349	10.26
Mirzaei, M.	Islamic Azad Univ.	25	158	6.32
Ashrafi, A. R.	N/A	20	117	5.85
Bordbar, G. H.	Shiraz Univ.	20	235	11.75
Sadeghi, M.	N/A	19	22	1.16
Moshfegh, H. R.	N/A	18	94	5.22
Seif, A.	N/A	16	35	2.19
Samadi-Maybodi, A.	Univ. Mazandaran	14	68	4.86
Jalilian, A. R.	AMIRS-NSTRI, Karaj	13	36	2.77
Kumar, P. V.	Shiraz Univ. of Medical Sciences: Shiraz Inst. for Cancer Research	13	76	5.85
Alizadeh, N.	Univ. Guilan	12	70	5.83
Behkami, A. N.	Islamic Azad Univ.	12	31	2.58
Boroushaki, M.	Sharif Univ. of Technology	12	43	3.58
Darafsheh, M. R.	Univ. Tehran	11	72	6.55
Lucas, C.	Univ. Tehran	11	42	3.82
Setayeshi, S.	Amir Kabir Univ. of Technology	11	42	3.82
Nasr-Esfahani, M. H.	Royan Inst. for Stem Cell Biology and Technology	10	59	5.90

(25.21% of the total) that resulted from collaboration between Iranian researchers and researchers from other countries and 722 publications (67.41%) from collaboration between Iranian researchers only. The high proportion of national collaboration suggests that there are enough resources and colleagues to work with within the country. However, international collaboration in science and technology has become of high interest for the Iranian government and scientific policymakers.<sup>16</sup>

The study used the following formula<sup>17</sup> for determining the degree of collaboration in quantitative terms:

TABLE 7. Collaboration in Iranian nuclear science and technology research

Authorship	Papers published	% of total	Papers cited	% of papers published	Papers not cited	% of papers published	Total citations	Mean citations per paper
Single author	79	7.38	44	55.70	35	44.30	319	4.04
National collaboration	722	67.41	496	68.70	226	31.30	2876	3.98
International collaboration, Iranian first author	172	16.06	127	73.84	45	26.16	1052	6.12
International collaboration, non-Iranian first author	98	9.15	83	84.69	15	15.30	1795	18.32
Total	1071		750		321		6042	

$$C = NM / (NM + NS)$$

Where  $C$  = degree of collaboration

$NM$  = number of multi-author papers

$NS$  = number of single-author papers

In this study  $NM = 992$  and  $NS = 79$ ; therefore,  $C = 0.93$ . Thus, the degree of collaboration in Iranian nuclear science is 0.93, which clearly indicates collaboration's dominance over individual authorship.

#### *Citation Pattern*

The frequency with which an article is cited by other scientists is a classic measure of its importance within the domain of the concerned area of the discipline.<sup>18</sup> Table 8 details the distribution of citations to the 1071 Iranian nuclear science and technology papers published from 1990 to 2010. The table shows the number of publications in a particular year, the number of citations to these publications, and the average number of citations per paper. The mean citation rate for all 1071 papers is 5.64 citations per paper. The table also displays the significant difference between the citation rate of Iranian papers and citation rate of all papers.

The number of citations and mean citations per paper for nationally collaborative, internationally collaborative, and non-collaborative research have been assessed. Citations of nationally and internationally collaborative papers are reported in Table 7. The data indicate that only 29.97 per cent of the papers were not cited at all in *SCIE*-indexed journals. The number of cited papers is 750—that is, 70.03 per cent of the total. Table 7 also indicates that 55.70 per cent of single-author papers, 68.70 per cent of national collaborations and about 77.77 per cent of international collaborations have been cited. So approximately half of the single-author papers, one-third of the national collaborations and one-fifth of the international collaborations were invisible apart from their original appearances in the years 1990–2010.

The average number of citations per paper is 4.04 for single authorship, 3.98 for national co-authorship, 6.12 for international co-authorship (Iranian first author), and 18.32 for international (non-Iranian first author). International collaborations have been recognized more than papers of primarily Iranian authorship. The papers whose first authors are from other countries were highly cited. An ANOVA test was done

TABLE 8. Distribution of citations to Iranian nuclear science and research papers, 1990–2010

Publication year	Citations	% of total citations	Mean citations per paper	World mean citation*
1990	5	0.08	5.00	24.04
1991	183	3.03	26.14	36.36
1992	68	1.13	8.50	38.01
1993	65	1.08	13.00	39.62
1994	77	1.27	9.62	33.17
1995	118	1.95	16.85	36.02
1996	347	5.74	24.78	34.41
1997	334	5.53	18.55	35.09
1998	227	3.76	17.46	37.19
1999	178	2.95	13.69	35.96
2000	130	2.15	7.22	35.66
2001	158	2.61	6.07	32.48
2002	237	3.92	6.97	29.14
2003	541	8.95	12.88	26.85
2004	418	6.92	8.03	23.52
2005	676	11.19	10.90	19.44
2006	537	8.89	7.25	16.42
2007	647	10.71	5.57	11.90
2008	505	8.36	3.53	8.76
2009	390	6.45	1.95	5.02
2010	201	3.33	0.95	2.18
Total	6042	100		

\* The world mean citation rate is the average number of citations made worldwide of nuclear science and research papers that are indexed in the *SCIE*.

to analyse the significance of the difference in the three citation rates. The test results ( $df = 3$ ,  $P = 0.001$ ) indicate that the visibility or citation rate of the papers produced through international collaboration is significantly higher than the other types. This finding highlights the strategic importance of collaboration at the international level.

The number of highly cited papers (based on *h*-index numbers provided in the *SCIE* citation reports) is thirty-three. These papers have received more than 35 citations each.

Table 9 shows the eleven highly cited papers that have more than fifty citations each. The thirty-three highly cited papers accounted for 1936 citations, or 32.04 per cent of all citations.

#### CONCLUSION

In an assessment of Iranian nuclear research activities, it is essential to distinguish between a national and an international point of view. This study has attempted to describe the internationally-published scientific output of nuclear science and technology research in Iran through the analysis of data obtained from the *SCIE*.

Nuclear science and technology research performance in Iran has improved appreciably during the past few years, in terms of both relative output of publications and impact on internationally published research productivity. Iranian research's share of global research output during the period 2000–2010 shows a spectacular increase when compared to the period 1990–1999. It can be concluded that the deployment strategies and priorities of policy makers and managers of the nation's resources regarding nuclear science and technology changed in 2000. This development may be the result of highly coordinated efforts of different branches of the Iranian nuclear research community. However, it should be noted that Iran produces 0.25 per cent of the world's research in nuclear science and technology. Out of the 125 subject categories in nuclear science and technology, four categories—Nuclear Science & Technology; Chemistry, Multidisciplinary; Chemistry, Physics; and Physics, Nuclear—were most productive in terms of the number of publications.

Academic institutions are the main source of nuclear science productivity. Among 754 Iranian institutions, the top ten each published more than 814 papers—76 per cent of the total number of publications.

A significant finding of the study is that about 93 per cent of the papers were written by multiple authors. Budd and Hurt concluded that multiple authorship is one of the indicators of a fast-moving research front.<sup>19</sup> A large proportion of the papers (74.79 per cent) were written solely by Iranian authors, either individually or in collaboration. It can thus be concluded that Iran has developed its scientific resources in accordance with national priorities for indigenous knowledge. Evalua-

TABLE 9. Highly cited Iranian nuclear science and technology papers, 1990–2010

Title	Author(s)	Publication Year	Total citations	Mean citations per paper
Evidence for a Kaon-Bound State $K^-pp$ Produced in $K^-$ Absorption Reactions at Rest	M. Agnello, G. Beer, L. Benussi, et al.	2005	188	26.86
LMNA Mutations in Atypical Werner's Syndrome	L. S. Chen, L. Lee, B. A. Kudlow, et al.	2003	179	19.89
Apo B versus Cholesterol in Estimating Cardiovascular Risk and in Guiding Therapy	P. J. Barter, C. M. Ballantyne, R. Carmena, et al.	2006	142	23.67
Origin and Radiation of the House Mouse: Mitochondrial DNA Phylogeny	P. Boursot, W. Din, R. Anand, et al.	1996	81	5.06
The Effects of Vegetation and Burning on the Chemical Composition of Soil Organic Matter in a Volcanic Ash Soil as Shown by C-13 NMR Spectroscopy	A. Golchine, P. Clarke, J. A. Baldock, et al.	1997	78	5.20
The Observation of MO84	W. Gellely, M. A. Bentley, H. G. Price, et al.	1991	74	3.52
Complex Formation of Silver Thallium and Alkali Cations with Dibenzo-30-Crown-10 in Some Nonaqueous Solutions	M. K. Amini, M. Shamsipur	1991	62	2.95
Deregulated GSK3 Beta Activity in Colorectal Cancer: Its Association with Tumour Cell Survival and Proliferation	A. Shakoobi, A. Ougolkov, Z. W. Yu, et al.	2005	61	8.71
Foundation Review: Trends in the Development of Radioprotective Agents	S. M. Hosseimehr	2007	58	11.60
Origin and Radiation of the House Mouse: Clues from Nuclear Genes	W. Din, R. Anand, P. Boursot, et al.	1996	57	3.56
The Role of Epstein-Bar Virus in Hodgkin's Disease from Different Geographical Areas	M. Werinreb, P. J. R. Day, F. Niggli, et al.	1996	52	3.25



tion data from this perspective also reveal that Iran does not increase its contribution marginally, but its nuclear national science system grows endogenously. However, about 26 per cent of the papers were published jointly with scholars in developed countries; therefore, Iran has also been somewhat assimilated into the world system of nuclear science. Moreover, this result shows the relative opening up of Iran for global exchanges.

The present study confirmed the results of earlier studies that internationally co-authored papers enjoy higher citation rates in comparison with domestic papers.<sup>20</sup> The average citation rate of Iranian nuclear research output is 5.64 citations per article, which suggests published Iranian nuclear research has a significant impact on the international community. Salanger-Meyer state that, among the developing countries, Iran has a remarkable impact on world scientific research.<sup>21</sup> This may be reason to believe that the structure and the characteristics of Iranian research partly differ from those of many other comparable developing countries. Disciplinary characterization of Iranian nuclear science and technology research identifies that emphasis is placed on physics and chemistry and that the publications are distributed evenly among a number of scientific fields. As Kim notes, because the fusion of technology and interdisciplinary research is one of the mainstreams of new technologies, basic science must be emphasized as the key to interdisciplinary research.<sup>22</sup> The diversity of disciplines confirm that nuclear science and technology research in Iran is the result of the interests of individual researchers and not part of an orchestrated effort to develop particular lines of expertise and research in the country.

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#### NOTES

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