Libri, 2002, vol. 52, pp. 88–98
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Libri
ISSN 0024-2667

Collaboration in Iranian Scientific Publications

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This study looks at international collaboration in Iranian scientific publications through the ISI *Science Citation Index*® (SCI) for the years 1995–1999, inclusive. These results are compared to and contrasted with the earlier findings for the periods covering 1985–1994 (Osareh & Wilson 2000). The results of Iran's increasing productivity over a 15-year period are presented. Iran doubled its output in the first two five-year periods and increased 2.8-fold from the second to the third five-year period. The rise in Iran's scientific publication output is due mainly to factors such as the ending of the war, better economic conditions, recent changes in the Iranian government's policy, basic changes in the political environment brought about by the Reformers, expansion of the Iranian presses for national publications, and the recent return of a large number of students trained overseas through government scholarships. External changes also account for the increased productivity, e.g., the acceptance of three Iranian source journals by the SCI, increased access to international databases through the Internet and better electronic communication facilities for international collaboration. One of the most important and significant factors that caused this dramatic rise seems to be the government's research policies in the last few years. Since 1999, the Iran Science, Research and Technology Ministry, has encouraged researchers to publish their non-Farsi language articles in highly ranked international scientific journals, for example, by giving prizes to researchers who publish their articles in ISI-ranked journals.

Introduction

A notable feature of the recent scientific literature is that international cooperation is increasing even faster than that of publication output. For all countries, the number of publications in *Science Citation Index*® increased from about 1.6 million to nearly 2.1 million during the interval of ten years (from 1982–1984 to 1992–1994), indicating an average annual growth rate of 2.6%. On the other hand, the number of collaborative links increased from about 0.2 million to over 0.6 million, indicating an average annual growth rate of 11.1% (Nagpaul 1999). These results are evidence of the increasing role that international collaboration is playing in the generation of scientific publications. International scientific collaboration has been of increasing interest in recent years due, in part, to:

- the fruitful exchange of ideas, research techniques, methods and knowledge which can be potentially beneficial to all collaborative partners;
- the higher quality of collaborative papers as shown by higher average impacts when compared to solely national publications – even in the case of developed countries (Van Raan 1998);
- less expensive and faster communication systems (e.g., electronic mail) as well as remote access to electronic information, databases and facilities through the Web;
- the promotion of international scientific programs and the provision of government funding for travel to attend international scientific conferences;

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- the fact that multi-country publications receive more citations than single country publications, hence, the assumption that multi-country publications are becoming a more important segment of the world literature (Narin & Whitlow 1990; Glänzel & Schubert 2001);
- the fact that international cooperation in science is becoming more frequent and more extensive and is playing a far greater role today in the production of scientific knowledge than ever in the past (Wagner et al. 2001); [This is reflected in the ever-growing number of multi-authored papers, even though, according to a recent study multinational co-authorship is leveling off (Abdel-Kader et al. 1998).]
- the benefits gained by peripheral countries from international collaboration for integrating their national publications into the international scientific network (Russell 1995);
- and finally, the overall positive effects of increase in publication productivity, in international visibility and in the quality of research (Bordons & Gómez 2000).

Aims and objectives

This paper studies the extent of international collaboration in Iranian scientific publications through the Science Citation Index® (SCI) for the years 1995–1999, inclusive. The results of this study will be compared to and contrasted with the earlier findings in Osareh & Wilson (2000).

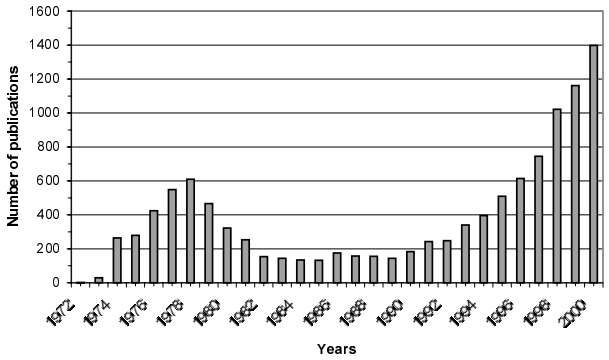
The study will attempt to answer the following questions:

- To what extent do Iranian scientists collaborate internationally with scientists from one or more countries?
- What is the rate (percentage) of international collaboration among Iranian scientists (1995–1999) and how does this compare to earlier publication periods, 1985–1989 and 1990–1994?
- What is the collaboration network among Iranian scientists with developed and developing countries?

We will also continue to investigate the growth and development of Iranian scientific publications in SCI for 1995–1999 versus the 1985–1989 and 1990–1994 periods. The following areas will be investigated:

- the emergence and departure of Iranian scientists with respect to productivity and influence or impact;
- the change in the ranking of journals in which Iranian scientists publish;
- the similarity or difference in the journals which Iranian scientists cite in their publications;

Figure 1: Iranian publications in SCI from 1972 to 2000.



- the major subject areas of scientific and technical research in Iran and the changes in the focus of these subject areas of research within each of the three five-year periods;
- and the subject areas of Iranian research compared with those of the Third World Countries (TWC) and with the world.

Methodology

As with the earlier study, the *SciSearch* file on the DIALOG information system was used to analyse the following fields, which addressed the aims and objectives above:

- the geographical location (GL) field to provide the initial set of documents of Iranian scientific and technical publications for the period 1995–1999;
- a further analysis of the GL field of the data set for Iranian publications to obtain information on international or cross-country collaboration;
- the publication year (PY) field to provide a 15-year growth profile of Iranian publications from 1985–1999;
- the author (AU) and corporate source (CS) fields to establish the most productive scientists and institutions/organizations;
- the journal (JN) and cited work (CW) fields to rank the journals in which Iranian scientists publish and from which they cite in their publications;
- and the subject categories (SC) of the journals in which Iranian scientists publish to establish the subject areas of Iran's research efforts;

Analysis of results

Iran's productivity in science and technology has increased dramatically during the 15-year period (1985 to 1999). Iran doubled its output in the first two five-year (from 1016 to 2045 publications),

Table 1: Extent of Iran's collaboration with other countries during three five-year periods.

1985 to 1989 (1016 total GL occs.)	No. occs.	% occs.	1990 to 1994 (2045 total GL occs.)	No. occs.	% occs.	1995 to 1999 (5545 total GL occs.)	No. occs.	% occs.
Iran	765		Iran	1410		Iran	4043	
USA	87	34.7	USA	177	27.9	USA	324	21.6
England	52	20.7	England	118	18.6	England	227	15.1
Canada	25	10.0	Canada	64	10.1	Canada	154	10.3
Germany	15	6.0	Germany	50	7.9	Australia	125	8.3
France	8	3.2	Australia	30	4.7	Germany	72	4.8
Scotland	8	3.2	France	22	3.5	Japan	61	4.1
Italy	7	2.8	Japan	22	3.5	India	48	3.2
Australia	5	2.0	Scotland	18	2.8	France	44	2.9
India	5	2.0	India	13	2.0	Italy	41	2.7
China	4	1.6	Sweden	12	1.9	Scotland	38	2.5
Switzerland	4	1.6	Spain	11	1.7	Belgium	27	1.8
Remaining countries	31	12.4	Remaining countries	98	15.4	Remaining countries	341	22.7
Total collaborative occs.	251		Total collaborative occs.	635		Total collaborative occs.	1502	

and increased 2.8-fold from the second to the third five-period (from 2045 to 5549 publications). Figure 1 shows the growth of Iranian productivity in *Science Citation Index*® (SCI) during the years 1972 to 2000 in more detail. In 1972 only one Iranian paper was indexed in SCI. The number of Iranian papers increased from one in 1972 to 610 in 1978. By 1979, the Iraq-Iran war was underway and the number of publications authored or co-authored by Iranian scientists declined sharply until 1985. The war ended in 1986 and from 1987 to 1989 the numbers of publications remained considerably lower than in the earlier years. However, by 1990 until the present, Iranian scientific publications have increased significantly. The same trend can also be seen in the percentage of Iran's publication vis-à-vis the rest of the world: from 0.019% in 1985 to 0.027% in 1990 and finally to 0.119% in 1999. This dramatic rise is due to a number of internal factors, such as: the ending of the war; better economic condition; the recent changes in the Iranian government's policy, e.g., increase in research funding; basic changes in the political environment brought about by the Reformers; expansion of the Iranian presses for national publications; and the recent return of a large number of students trained overseas through government scholarships. External changes also account for the increased productivity, e.g., the acceptance of three Iranian source journals by SCI; increased access to international databases through the internet; and better electronic communication facilities for international collaboration. One of the most important and significant factors that caused this dramatic rise seems to be the government's research policies in the last few years. In 1996, Iranian government announced the first national research call for papers and continued it for the next years. The researchers according to their areas selected topics and started working on large research grants. This can lead the researchers towards the research topics needed by the government.

Related to the corporate source (CS) field is the geographical location (GL) field – that is, the country where the corporate source or address of the author is located. Table 1 shows the number of occurrences (papers) from each of the top 11 countries collaborating with Iran in each of the five-year periods. Iran, of course, appears at the top (765, 1410 and 4043) representing the total number of publications where at least one author is affliated with an institution in Iran. It is the number of occurrences of the remaining geographical locations which gives a picture of Iran's collaborations with other countries. The percentages in columns three, six and nine are calculated using the total number of GL occurrences after Iran has been removed. For example, for 1995 to 1999 there are 1502 occurrences of GLs (other than Iran) and of these, 324 or 21.6% are attributed to the US. Although the USA and England rank first and second in all the three five-year period, the overall percentages have decreased in the last two five-year periods. Collaboration with Australia has increased substantially, both absolutely

Table 2: The most productive Iranian authors in SCI from 1985 to 1994 and from 1995 to 1999.

Rank	Source authors: 1985 to 1994	No. docs.	Ave. no. docs./year	Rank	Source authors: 1995 to 1999	No. docs.	Ave. no. docs./year
1	SOHRABI M	48	4.8	1	SHAMSIPUR M	94	18.8
2	SHAMSIPUR M	43	4.3	2	HERAVI MM	75	15.0
3	ZARRINDAST MR	40	4.0	3	YAVARI I	62	12.4
4	RUSTAIYAN A	35	3.5	4	DEHPOUR AR	51	10.2
5	FIROUZABADI H	23	2.3	5	IRANPOOR N	48	9.6
6	KUMAR PV	21	2.1	6	SARRAFZADEGAN N	48	9.6
7	KAVEH A	20	2.0	7	ZARRINDAST MR	47	9.4
8	SAFAVI A	19	1.9	8	SAFAVI A	46	9.2
9	SHAFIEE A	17	1.6	9	ENSAFI AA	42	8.4
10	DEHPOUR AR	16	1.6	10	MOOSAVIMOVAHEDI AA	42	8.4
11	ENSAFI AA	16	1.6	11	FIROUZABADI H	40	8.0
12	MOOSAVI MOVAHEDI AA	16	1.6	12	SOHRABI M	36	7.2
13	AMINLARI M	14	1.4	13	SHARGHI H	32	6.4
14	IRANPOOR N	14	1.4	14	KHORRAMI M	29	5.8
15	KARAMI G	14	1.4	15	MALLAKPOUR SE	29	5.8
16	RAHNAVARD MH	14	1.4	16	SABOURY AA	29	5.8
17	SOBOUTI Y	14	1.4	17	BOSHTAM M	28	5.6
18	BOUSHEHRI A	13	1.3	18	HAJIPOUR AR	27	5.4
19	FARSHAD M	12	1.2	19	SHAFIEE A	27	5.4
20	MARANDIAN MH	12	1.2	20	BOUSHEHRI A	24	4.8
21	RADJABALIPOUR M	12	1.2	21	ASGARY S	22	4.4
22	MAHMOUDIAN M	11	1.1	22	KUMAR PV	22	4.4
23	MASSOUMI A	11	1.1	23	NADERI G	22	4.4
24	ZAIM M	11	1.1	24	SAIDI MR	22	4.4
25	AZAD E	10	1.0	25	ABDOLLAHI M	21	4.2
26	EDRISSIAN GH	10	1.0	26	TANGESTANINEJAD S	20	4.0
27	KATOULI M	10	1.0	27	GHAVAMZADEH A	19	3.8
28	MAHMOODIAN ES	10	1.0	28	MALEKZADEH R	19	3.8
				29	MOSHFEGHIAN M	19	3.8
	Total	506			Total	1042	

and relatively; likewise, India shows substantial increases in numbers, though lagging relatively. Germany on the other hand has increased in absolute numbers, but has decreased (relatively) in the last five-year period. Canada has remained constant percentage-wise, but has more than doubled in the numbers of occurrences (papers) in each of the five-year periods.

Comparing the most productive Iranian authors from 1985 to 1999 in SCI displays interesting results. As can be seen in Table 2, there were 28 authors during 1985–1994 (combined ten-year period) each with at least 10 papers, producing 506 papers (23.3%). However, in 1995–1999 (the third five-year period) there were 29 authors with at least 19 papers, producing 1042 papers (25.8%). Eleven bolded authors (Sohrabi, Shamsipur, Zarrindast, Firouzabadi, Kumar, Safavi, Shafiee, Dehpour, Ensafi, Moosavi Movahedi, and Iranpoor) appear in each of the two lists. Of interest is the marked increase in the average number or papers per year for all of the authors appearing in both lists; for example, Shamsipur went from producing about 4 papers per year in the ten-year period to producing nearly 19 papers per year in the last five-year period. This increase could be attributed to increased collaboration with many authors within the same institution, other institutions in Iran or institutions in other countries. A further explanation could be a change in the publishing patterns of Iranian scientists – from either one or merely a few number of authors per paper to five or more authors per paper. An examination of Shamsipur's publication in the two lists (using the post productive year in each list) reveals the following. In 1993, this author produced 12 papers with the following distribution of the number of co-authors: 9 papers with only one co-author, 1 paper with two co-authors, and 2 papers with four co-authors. However, in 1999, Shamsipur

Table 3: The number of citations each author in Table 2 received in two time periods.

Rank	Source authors as cited authors (CA) 1985 to 1997	No. citns.	Ave. no. citns/yr	Rank	Source authors as cited authors (CA) 1995 to 2001 (June)	No. citns.	Ave. no. citns/yr
1	FIROUZABADI H	307	23.6	1	FIROUZABADI H	290	44.6
2	SHAFIEE A	297	22.8	2	ZARRINDAST MR	222	34.2
3	KUMAR PV	208	16.0	3	SAFAVI A	190	29.2
4	RUSTAIYAN A	171	13.2	4	IRANPOOR N	181	27.8
5	ZARRINDAST MR	169	13.0	5	SHAFIEE A	171	26.3
6	SHAMSIPUR M	163	12.5	6	SHAMSIPUR M	151	23.2
7	MAHMOUDIAN M	100	7.7	7	ENSAFI AA	139	21.4
8	IRANPOOR N	93	7.2	8	KUMAR PV	133	20.5
9	SAFAVI A	83	6.4	9	YAVARI I	113	17.4
10	SOHRABI M	78	6.0	10	HERAVI MM	89	13.7
11	EDRISSIAN GH	74	5.7	11	BOUSHEHRI A	72	11.1
12	BOUSHEHRI A	72	5.5	12	HAJIPOUR AR	69	10.6
13	KARAMI G	70	5.4	13	MALLAKPOUR SE	65	10.0
14	KAVEH A	55	4.2	14	DEHPOUR AR	62	9.5
15	KATOULI M	51	3.9	15	SHARGHI H	52	8.0
16	ENSAFI AA	48	3.7	16	KHORRAMI M	48	7.4
17	SOBOUTI Y	42	3.2	17	SAIDI MR	43	6.6
18	RADJABALIPOUR M	38	2.9	18	SABOURY AA	42	6.5
19	FARSHAD M	37	2.8	19	SOHRABI M	42	6.5
20	DEHPOUR AR	32	2.5	20	MOOSAVIMOVAHEDI AA	29	4.5
21	MOOSAVIMOVAHEDI AA	32	2.5	21	MOSHFEGHIAN M	18	2.8
22	MARANDIAN MH	31	2.4	22	ABDOLLAHI M	14	2.2
23	AMINLARI M	29	2.2	23	GHAVAMZADEH A	13	2.0
24	ZAIM M	23	1.8	24	TANGESTANINEJAD S	12	1.8
25	RAHNAVARD MH	10	0.8	25	MALEKZADEH R	10	1.5
26	AZAD E	9	0.7	26	SARRAFZADEGAN N	9	1.4
27	MAHMOODIAN ES	8	0.6	27	ASGARY S	0	0.0
28	MASSOUMI A	6	0.5	28	BOSHTAM M	0	0.0
				29	NADERI G	0	0.0

produced 30 papers with the following distribution of the number of co-authors: 10 papers with only one co-author, 7 papers with two co-authors, 3 papers with three co-authors, and 10 papers with four co-authors. As to the extent of collaboration, a quick examination of the same two sets of papers by Shamsipur for 1993 and 1999 revealed the following. In the 1993 papers, collaboration occurred only with Iranian inter- and intra-institutions. For 1999, both Iranian inter- and intra-institutional collaboration occurred with one other country, Canada.

Table 3 shows the source authors as in Table 2 (with the eleven bolded authors in both lists), but in rank order by the number of citations received in two time periods: 1985 to 1997 for 13 years, and 1995 to 2001 (June) for 6.5 years. Obviously, this simple measure of influence or impact has limitations; however, the results show a first approximation of how influential the most productive Iranian authors are according to the number of citations received from authors publishing in journals indexed by SCI. The most cited author, Firouzabadi, was cited in 562 papers in SCI from 1974 to 2001 (June, Week2) and of these, 406 (72%) were by papers not authored by Iranian scientists. A more detailed examination of the other citations needs to be made; however, a preliminary comment can be made as to the impact (internationally) of Iranian scientists. In addition, papers by Iranian scientists appear to receive (on average) more citations in the last 6.5 years than in the earlier years.

Table 4 shows the top ranking journal titles in which Iranian authors published their papers from 1985 to 1994 versus 1995 to 1999. In 1985 to 1994, there are 21 journals with 11 to 39 papers in each. However, in 1995 to 1999, there are 22 journals with 23 to 105 papers. Only six of the journals, which are bolded, are the same journals in both

Table 4: Top journals where Iranian scientists published from 1985 to1995 and 1995 to 1999

Rank	Journal Name (JN) 1985 to 1994 (Total = 2175 docs.)	No. docs.	Journal Name (JN) 1995 to 1999 (Total = 4043 docs.)	No. docs.
1	Nuclear Tracks and Radiation Measurements	39	Iranian Journal of Science and Technology	105
2	Abstracts of Papers of the American Chemical S	37	Journal of Chemical Research-S	98
3	Phytochemistry	30	Iranian Journal of Chemistry & Chemical Engine	93
4	General pharmacology	29	Synthetic Communications	68
5	Acta cytologica	26	Iranian Polymer Journal	58
6	Computers & structures	22	Atherosclerosis	52
7	Synthetic communications	20	Transplantation Proceedings	51
8	Talanta	20	Indian Journal of Chemistry Section B-Organic	39
9	Radiation Physics and Chemistry	19	Talanta	37
10	Astronomy and Astrophysics	16	Analytical Letters	32
11	European Journal of Pharmacology	15	Microchemical Journal	32
12	Indian Journal of Animal Sciences	13	General Pharmacology	31
13	Journal of the American Mosquito Control Assoc	13	Physics Letters B	29
14	Microwave and Optical Technology Letters	13	Journal of Applied Animal Research	28
15	Saudi medical journal	13	Gastroenterology	26
16	Analytical letters	12	Naunyn-Schmiedebergs Archives of Pharmacology	26
17	Bulletin of the Chemical Society of Japan	12	Bulletin of the Chemical Society of Japan	25
18	Journal of Physics A-Mathematical and General	12	Australian Journal of Chemistry	24
19	Journal of Materials Science	11	Analytica Chimica Acta	23
20	Journal of Organometallic Chemistry	11	Communications in Algebra	23
21	Journal of Phytopathology-Phytopathologische Z	11	Computers & Structures	23
22			Indian Journal o Heterocyclic Chemistry	23

periods. The major difference in the 1995 to 1999 period is the appearance of three Iranian journals (*Iranian Journal of Science and Technology*, *Iranian Journal of Chemistry & Chemical Engine* and *Iranian Polymer Journal*) in SCI. In these three Iranian journals 256 papers with at least one Iranian author in each have been published during 1995 to 1999. The remaining 61 papers in these three Iranian journals for the same period were papers by Indian and USA scientists. The USA, England and Australia were the major country collaborators of Iranian scientists for the 256 papers in the three Iranian journals from 1995 to 1999. Looking ahead, papers in these three journals for 2000 to June 2001 indicate India, Australia and Japan as Iran's top three country collaborators.

The journals cited (CW) by the papers in both periods are nearly all journals with high impact factors. The top 21 cited journals in 1985 to 1994 were cited at least 50 times, while those in 1995 to 1999 were cited at least 123 times. Table 5 shows fourteen journals (bolded) which are the same in all the studied periods and have been cited by papers authored (or co-authored) by Iranian scientists. *Nature*, *Science* and *Proceedings of the National Academy of Sciences* are general science journals that are highly cited not only by authors from Iran during the studied periods but also by all scientists worldwide. Although the journals which influence Iranian scientists do not (necessarily) add to their collaborative research patterns, it is interesting to note that highly cited journals are known, read and used even though they are not those in which Iranian scientists publish. There are two journals, however, that is in common in both Table 4 and Table 5; the journals in which Iranian scientists publish and cite, *Talanta* and *Analytica Chimica Acta*. As it was mentioned, Iranian Scientists have been publishing in and citing to high impact factor journals. Yet it is expected that they publish in even more important journals, since from 1999, the Iran Science, Research and Technology Ministry encouraged researchers to publish their non-Farsi language articles in highly ranked international scientific journals.

The ranked distribution of the corporate source (or address) field yielded a list which required extensive "cleaning" and "collapsing" of institutions with variant forms of addresses. Therefore, exact figures for each of the top ranking institutions cannot be easily determined. After the editing process, the top five institutions and the number of affiliations indicated by Iranian author

Table 5: The top frequently cited journals by Iranian scientists from 1985 to 1994 versus 1995 to 1999

Rank	Cited work (CW) 1985 to 1994	No. Occs.	Rank	Cited work (CW) 1995 to 1999	No. Occs.
1	J AM CHEM SOC	178	1	J AM CHEM SOC	511
2	NATURE	150	2	J ORG CHEM	394
3	SCIENCE	99	3	TETRAHEDRON LETT	340
4	J ORG CHEM	92	4	ANAL CHEM	263
5	ANAL CHEM	83	5	NATURE	254
6	P NATL ACAD SCI USA	82	6	TETRAHEDRON	245
7	TETRAHEDRON LETT	81	7	B CHEM SOC JPN	235
8	J BIOL CHEM	75	8	SYNTHESIS-STUTTGART	226
9	J PHYS CHEM-US	68	9	CHEM REV	215
10	J CHEM PHYS	63	10	ANAL CHIM ACTA	213
11	CHEM REV	60	11	TALANTA	198
12	TALANTA	60	12	SYNTHETIC COMMUN	194
13	EUR J PHARMACOL	57	13	J PHYS CHEM-US	190
14	LANCET	56	14	J CHEM SOC CHEM COMM	187
15	ANAL CHIM ACTA	54	15	SCIENCE	181
16	B CHEM SOC JPN	53	16	ANALYST	171
17	NEW ENGL J MED	53	17	PHYS REV LETT	168
18	BIOCHIM BIOPHYS ACTA	52	18	J CHEM PHYS	144
19	J PHARMACOL EXP THER	52	19	P NATL ACAD SCI USA	139
20	BRIT J PHARMACOL	50	20	NUCL PHYS B	126
21	PHYS REV LETT	50	21	INORG CHEM	123

over the combined ten-year period (1985–1994), versus the five-year period (1995–1999) are identified below in Table 6. In both periods the first four are universities and the fifth is an Institution. Shiraz University ranked first in both periods, while Tehran University of Medical Sciences dropped from second in the first period to fourth in 1995–1999. Tehran and Sharif Universities placed second and third in 1995–1999. The INST Studies of Theoretical Physics & Mathematics replaced the Atomic Energy Organization Iran (AEOI) in 1995 to 1999. It is apparent that institutions related to physics are major supporters of Iran's scientific research efforts (Osareh & Wilson 2000). Both the AEOI and the INST Studies Theoret Phys & Math are clearly related to the areas of theoretical physics and mathematics. Further, there is considerable national collaboration between universities and non-university institutions.

Table 6: The top-ranked Iranian Institutions from 1985 to 1994 versus 1995 to 1999

1985 to 1994		1995 to 1999	
Institutions	No. Docs.	Institutions	No. Docs.
Shiraz University	369	Shiraz University	600
Tehran University of Medical Sciences	325	Tehran University	467
Tehran University	229	Sharif University	355
Sharif University	157	Tehran University of Medical Sciences	318
Atomic Energy Organization Iran (AEOI)	124	INST Studies Theoretical Phys & Math	262

Table 7 lists the top 22 journal subject categories for documents in the combined ten-year period from 1985 to 1994 and the last five-year period from 1995 to 1999. Fourteen bolded journal subject categories appear in both periods, though the rankings are different. The 22 journal subject categories account for nearly 50% of the total number of occurrences in the 2175 papers, and more than 52% of the total number of occurrences in the 4043 documents. Each journal may have one or more subject categories.

Library of Congress Subject Headings (LCSH)

Each occurrence of ISI's journal subject categories (SC) for each of the five-year periods was mapped into five major subjects of the Library of Congress Subject Headings (LCSH). Table 8 shows the number and percentages of each of the five broad

Table 7: Top ranking journal subject categories for documents in the combined ten-year period (1985-1999) and the five-year period (1995-1999)

Rank	Journal subject category (SC) 1985 to 1994 (2175 docs.)	No. occs.	Rank	Journal subject category (SC) 1995 to 1999 (4043 docs.)	No. occs.
1	Pharmacology & Pharmacy	111	1	Chemistry	393
2	Chemistry	109	2	Chemistry, Analytical	233
3	Nuclear Science & Technology	100	3	Chemistry, Organic	230
4	Engineering, Electrical & Electronic	90	4	Engineering, Chemical	224
5	Chemistry, Analytical	80	5	Pharmacology & Pharmacy	214
6	Mathematics	77	6	Mathematics	144
7	Chemistry, Organic	74	7	Veterinary Sciences	141
8	Surgery	71	8	Polymer Science	139
9	Botany	63	9	Physics	129
10	Materials Science	59	10	Chemistry, Physical	119
11	Chemistry, Physical	57	11	Multidisciplinary Sciences	118
12	Engineering, Civil	53	12	Engineering, Civil	110
13	Computer Applications & Cybernetics	51	13	Engineering, Electrical & Electronic	108
14	Neurosciences	51	14	Immunology	108
15	Engineering, Chemical	48	15	Materials Science	108
16	Engineering	46	16	Surgery	104
17	Engineering, Mechanical	46	17	Mathematics, Applied	101
18	Mathematics, Applied	46	18	Plant Sciences	96
19	Biochemistry & Molecular Biology	44	19	Biochemistry & Molecular Biology	80
20	Physics	43	20	Engineering, Mechanical	79
21	Chemistry, Inorganic & Nuclear	40	21	Physics, Particles & Fields	75
22	Cytology & Histology	40	22	Mechanics	74
Rank 23 to 140		1430	Rank 23 to 163		2858

Table 8: The distribution of LCSH for Iran's scientific publications in the three five-year periods.

LCSH Major subjects – SCI's Subject Categories were mapped into one of the five broad headings below.	1985 to 1989 SCI Subject Categories (SC)		1990 to 1994 SCI Subject Categories (SC)		1995 to 1999 SCI Subject Categories (SC)	
	No.	%	No.	%	No.	%
Science (Q)	313	38.3	759	37.7	2332	39.0
Medical Sciences (R)	275	33.7	531	26.4	1693	28.3
Technology (T)	151	18.5	518	25.7	1239	20.7
Agricultural Sciences (S)	57	7.0	186	9.2	533	8.9
Social Sciences (H, L…)	21	2.6	18	0.9	188	3.1
Total	817		2012		5985	

LCSH subjects for the three five-year periods in ranked order. What is readily apparent in the comparison of the three five-year periods is the substantial decrease in the Technology subject category in 1995–1999. The Medical Sciences decreased markedly in the early 1990s; however, the downward trend appears to have stopped in the mid to late 1990s. The basic sciences (including chemistry) have remained stable throughout the fifteen-year period and accounts for nearly 40% of Iran's scientific publications; likewise the percentage output of papers in the Agricultural Sciences remained the same. As only the *Science Citation Index* was searched, not much can be said of Iran's output in the Social Sciences; however, there was a substantial increase in the 1995 to 1999 period.

Small and Garfield's (1985) subject categories

Besides using LCSH to group the *Science Citation Index's* journal subject categories, we also looked at Small and Garfield's (1985) groupings under seven major subject fields for the World's publications in SCI and SSCI. This categorization of subject fields will offer a comparison with earlier studies of publication by authors in the Third World Countries (TWCs 1985–1989 in Osareh

Table 9: Percentage distribution of publications over seven subject categories.

Small & Garfield's (1985) major subjects	World 1985 (%)	TWCs 1985 to 1989 (%)	Iran		
			1985 to 1989 (%)	1990 to 1994 (%)	1995 to 1999 (%)
Biomedicine & Biochemistry	38.5	57.6	41.6	27.2	25.6
Physics & Engineering	18.0	18.4	28.2	38.1	30.7
Chemistry	13.4	11.4	13.7	12.9	28.9
Agricultural Sciences	7.6	6.6	7.0	10.4	6.5
Geosciences	5.0	3.7	1.7	2.0	1.4
Mathematics & Computer Sciences	6.1	1.6	6.1	8.6	4.4
Social & Behavioural Sciences	11.7	0.8	1.6	0.8	2.3

1996); for Iran in two five-year periods from 1985 to 1989 and 1990 to 1994, Osareh & Wilson 1997, 2000) and with the results of this study for 1995 to 1999.

Table 9 shows that in the 1980's the percentage of the TWC or Third World Countries' (including Iran) publication output in Biomedicine & Biochemistry (57.6%) exceeded that of the World (38.5%). Considering Iran alone for the earlier five-year period, the percentage (41.6%) is still higher than that of the world; however, in 1990's the research publications in areas related to medicine dropped substantially to about 25%. The drop in medical publications is offset by an increase in Physics & Engineering and more particularly, in Chemistry (Osareh & Wilson 2000). There is an apparent decrease in publication output in the three subject areas of Agricultural Sciences, the Geosciences and in Mathematics & Computer Sciences. Again, little can be said about the Social & Behavioural Sciences as the *Social Sciences Citation Index* was not searched for any of the Third World Countries' (including Iran) studies.

Conclusions

Our study has shown that Iran's publication output in science and technology has increased over the three five-year periods in the *Science Citation Index®*. Iran doubled its output in the two five-year and increased 2.8-fold from the second to the third five-year period. This marked increase is noticeable especially from 1991 to 2000. As has already been stated, this rise in the numbers of publications by Iranian scientists is due to many factors; among these are the ending of the war, better economic condition, the recent changes in the Iranian government's research funding policy, basic changes in the political environment brought about by the Reformers, expansion of the Iranian presses for national journal publications, and the recent return of a large number of students trained overseas through government scholarships. External changes also account for the increased productivity, e.g., the acceptance of three Iranian source journals by the SCI; increased access to international databases through the internet; and better electronic communication facilities for international collaboration. One of the most important and significant factors that caused this dramatic rise seems to be the government's research policies in the last few years. In 1996, Iranian government announced the first national research call for papers and continued it for the next years. The researchers according to their areas selected topics and started working on large research grants. This can lead the researchers towards the research topics needed by the government.

Iran's main international collaborators for all three five-year periods are still authors with institutional affiliations in the US or the UK; however, it is obvious that Iran is looking more and more for collaborative partners elsewhere. Collaboration with authors in Canadian and Australian institutions has increased either in absolute numbers, relative percentages or both. This is not surprising as the period during the Iranian war saw many Iranian scholars sent to either Australia or Canada. Germany, Japan and India are also collaborative countries on the rise.

For authors publishing since 1985, the last five-year period has shown a two- to six-fold increase in the average number of papers published per year. Eleven of the 29 authors appear in both time

periods and all of the authors show increases in their productivity. An examination of the most productive author in the latest period revealed increased collaboration with researchers in the same institution, other institutions in Iran, as well as with researchers in other countries.

When the same lists of productive authors were ranked by the number of citations received in the two time periods, a slightly different picture emerges. For example, in the 1995 to 1999 period, the 11th ranked author (for productivity) received the most citation for 6.5 years (1995 to June 2001) and averaged nearly 45 citations per year. Again, the same eleven highly productive authors increased their average number of citations received per year in the later period. One can assume that increased collaboration (nationally and internationally) has brought greater visibility (or impact) to these authors.

The inclusion of three Iranian journals (in 1994, 1996 and 1997) by the *Science Citation Index*® accounts for a large number of papers by Iranian scientists in the later five-year period. However, a closer examination of papers (n=256) in these three journals authored by at least one Iranian scientist as compared to papers (n=61) authored only by non-Iranian scientists reveals an interesting picture. For those with at least one Iranian scientist, the top collaborating countries are (in ranked order) the USA, India, England and Australia. Authors from the same top two countries, USA and India, were also the major contributors of papers when there was no collaboration with Iran. A preliminary (and cautious) conclusion may be that co-country collaborators establish a publishing pattern which continues even without previous collaboration. Further studies into the co-authorship and publishing pattern (or behaviour) of scientists would be necessary to confirm (or otherwise) this conclusion. This study also found that, Iranian Scientists have been publishing in and citing to high impact factor journals. Yet it is expected that they publish in even more important journals, since from 1999, the Iran Science, Research and Technology Ministry, encouraged researchers to publish their non-Farsi language articles in high international scientific journals by giving prizes to researchers who publish their articles in ISI's journals.

Wagner et al. (2001, 14) classified Iran as one of 24 'scientifically developing countries' based on its investments made to participate in international Science and Technology (S&T). Countries in this category are seeking to invest further in science and in some cases have good capabilities that attract international partners. (The country categories are 'scientifically advanced', 'scientifically proficient', 'scientifically developing', and 'scientifically lagging'.) The composite index constructed for grouping countries into one of the four categories of S&T capacity include, inter alia, 'the number of S&T journal articles and patents produced by citizens of the nation to characterize S&T outputs'. One of the findings of this study is that 30 to 49% of the co-authorships of 12 countries in the Middle East and Africa (including Iran) were with the United States (2001, 29). Further, co-authorships between either Japan or Australia with Iran has increased over the 8% threshold from 1986–1988 to 1995–1997 (National Science Board 2000). The findings in our study appear to confirm those found in other (more detailed) studies on S&T indicators and collaboration.

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Editorial history:
Paper received 21 January 01 2002;
Final version received 22 March 2002;
Accepted 18 April 2002.