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Open Access: Making Science Research Accessible

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Even as the government makes huge investments in science and technology, research publications produced by Indian institutions are not easily available or accessible, thus undermining the visibility and ranking of these institutions. The adoption of an open access policy can close the gap between research outcomes and their dissemination. Expanding access to publicly-funded scientific research through open access has the potential to spur innovation and lead to a growth in patentable discoveries and their commercial applications.

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Information revolution has transformed our lives to such an extent that there is no field or sector left untouched by information technology applications. Information and communication technologies (ICTs) play an important role in the dissemination of knowledge, innovation and technology transmission. The Government of India has established a number of national bodies[1] for research and development (R&D) activities, with a vision to better the lives of the people through technological advancement. In addition, there are about 3,960 publicly funded R&D institutions, which include universities, Indian Institutes of Technology (IITs), and various other academic institutions in the country (Table 1). This article will critically examine the availability of research output in the context of public investment in R&D.

R&D in Publicly-Funded Institutions

The R&D activities in the country are promoted through huge investments – primarily of public funds – with the expectation that the results will accelerate the pace of scientific discovery, stimulate innovation, and improve the livelihood of the people. According to the R&D Statistics (2009), 84.1% of the R&D expenditure is incurred by 12 major scientific agencies[2] and the rest by other central ministries/departments/public sector industries. Among the major scientific institutions, the Defence Research and Development Organisation accounted for 30.3% of the expenditure. According to the latest data available, in 2007-08, India had invested Rs 37,777 crore in R&D activities (Table 2), out of which 62.6% was allocated to central government institutions involved in basic and applied research (ibid). The Minister of State for Science and Technology and Earth Sciences had announced[3] the government's intent to raise the R&D expenditure to 2% of the gross domestic product (GDP). Accordingly, the union budget of 2010-11 increased the allocation to various science and technology sectors by 22%-58% over the previous year (Table 3, p 20).

Compared to other developing countries, India's allocation of funds to R&D is high (Table 4, p 20); however, we are still nowhere close to the developed countries. India's gross domestic expenditure on R&D (GERD) was 2.2% of the world's expenditure in 2007 and 2.2% of the world's researchers are from India (Table 5, p 20). From the revised estimate of Rs 925 crore in 2009-10, the government has increased the allocation to Rs 1,222 crore for 2010-11. For example, the allocation to R&D in biotechnology in particular has been increased to Rs 394 crore from the revised estimate of Rs 309 crore and the allocation for assistance to autonomous institutions under the DBT has been increased from Rs 229 crore to Rs 330 crore. This

Table 2: National Expenditure on R&D in Relation to GNP/GDP

Year	R&D Expenditure at Current Prices (Rs Crore)	R&D as % of GNP	R&D as % of GDP
1995-96	7,484	0.70	0.69
1996-97	8,914	0.71	0.71
1997-98	10,611	0.76	0.76
1998-99	12,473	0.78	0.77
1999-2000	14,397	0.81	0.81
2000-01	16,199	0.85	0.84
2001-02	17,038	0.82	0.81
2002-03	18,000	0.81	0.80
2003-04	20,086	0.80	0.79
2004-05	24,117	0.84	0.84
2005-06	28,777	0.89	0.88
2006-07	32,941*	0.88	0.87
2007-08	37,778*	0.89	0.88

(i): GNP: Gross National Product; GDP: Gross Domestic Product; R&D: Research & Development; (ii) GNP/GDP figures are based on 1999-2000 series; (iii) R&D/GNP and R&D/GDP ratio have been revised as per the New Series GNP/GDP figures; (iv) *Estimated.
Source: Data on R&D expenditure collected and compiled by DST.

Table 1: R&D Institutions and Investment on R&D Activities

R&D Institutes	Number of Institutions	% of National Investment on R&D (2003-04)
Central government R&D institutions	707	62.6
Public sector institutions	115	4.5
State government institutions	834	8.5
Universities and institutions of national importance	284	4.1
Private sector institutions	2,020	20.3
Total	3,960	100

Source: Directory of R&D institutions, September 2006.

shows that investments in science and technology are being increased to strengthen our institutions. With all the above investments, India ranks 44th in the world universities ranking;[4] and only IIT Mumbai figures in the top 200 world universities – at the 187th position (Times Higher Education 2009). Entry into this list was made possible by the rigorous R&D work along with capacity building in the field of arts, science and technology; and publications on the R&D results. However, non-availability and lack of accessibility to these publications undermines the visibility and ranking of these institutes. Many Indian journals are not online, and are not indexed by journal indexing agencies such as Thomson Reuters. Hence they lack visibility and peer recognition.

Limited Access to Research

The volume of investments in research across sectors in India is enormous. The GERD per researcher in 2005 was $1,26,700 (in PPP terms) resulting in a GERD per article of Rs 2.47 crore in 2007 when analysed for indexed journals and publications (Table 6). There are about 308 scientific indexed journals publishing 14,000 papers annually (Thomson Reuters 2008). It is interesting to note that the number of scientific and technical publications in 2007 (15,312) represented a 50% increase over 1985 (Table 6).

It is unfortunate that after having spent such a huge amount of money on research, the taxpayer has to again pay $20 to access a paper published in a foreign journal. These figures highlight the gap between investment and research efforts, and the poor visibility of our research in the rest of the world. At the same time, it is important to note that most of these periodicals are printed, and confined to subscribers, libraries and bookshelves. They are not accessible to people across disciplines and to the cross section of the peer groups irrespective of the subject matter specialisation.

From the available data, it was found that Indian authors have published 2,62,231 documents between 1985 and 2008 (World Bank 2010; SCImago 2007) (Table 7, p 21). However, during 1998-2007, 2,35,679 articles were published from India, out of which only 0.32% are cited at least 100 times (Muthu et al 2010).

Table 3: Increase in Budget Allocation for Some of the Departments (in %)

Department	FY 2008-09	FY 2009-10	FY 2010-11
Agricultural research and education	0	23	31
Atomic energy	3	25	25
AYUSH	55	37	18
Biotechnology	14	32	33
Health research	NA	NA	25
Higher education	41	133	38
Information technology	63	18	56
Science and technology	17	20	21
Scientific and industrial research	13	13	25
Space	46	27	58

Source: Various budget documents, http://www.cbec.gov.in/ and http://indiabudget.nic.in/

Table 4: R&D Expenditure as a % of GDP of Various Countries

0.0-1.0%		1.1-2.0%		Above 2.0%	
Argentina	0.39	Australia	1.55	Austria	2.21
Cuba	0.62	Brazil	1.04	Denmark	2.51
Egypt	0.19	Canada	2.00	France	2.27
India	0.80	China	1.23	Germany	2.64
Nepal	0.67	Czech Republic	1.30	Israel	5.11
Pakistan	0.27	Hungary	1.01	Japan	3.11
Sri Lanka*	0.20	Italy	1.11	Rep of Korea	2.91
Thailand	0.24	Russian Federation	1.24	Singapore	2.20
Venezuela	0.38	Spain	1.04	Sweden	4.27
		UK	1.88	USA	2.67

(i) The data for China does not include Hong Kong (ii) *Data only for the year 1996.
Source: UNESCO Institute for Statistics (UIS) 2005, UNESCO.

Table 5: R&D Expenditure Indicators (2002 and 2007)

Particulars	Year	World	Asia	India
GERD (in billions PPP$)	2002	788.5	213.3	12.9
	2007	1,137.9	371.6	24.8
% world GERD	2002	100.0%	27.1%	1.6%
	2007	100.0%	32.7%	2.2%
GERD as % of GDP	2002	1.7%	1.5%	0.7%
	2007	1.7%	1.6%	0.8%
GERD per capita (in PPP$)	2002	125.5	57.0	11.9
	2007	170.6	93.7	21.2
Researchers ('000)	2002	5,774.3	2,058.6	115.9 (year 2000)
	2007	7,093.6	2,940.2	154.8
% of world researchers	2002	100.0%	35.7%	2.3%
	2007	100.0%	41.4%	2.2%
Researchers per million inhabitants	2002	919.3	550.5	110.8 (year 2000)
	2007	1,063.3	741.6	136.5 (year 2005)
GERD per researcher	2002	136.6	103.6	102.8 (year 2000)
(thousands PPP$)	2007	160.4	126.4	126.7 (year 2005)

GERD: Gross Domestic Expenditure on R&D; PPP: Purchasing Power Parity.
Source: UNESCO Institute for Statistics estimates, September 2009.

Table 6: Gross Expenditure on R&D and Number of Publications

Year	GERD (Rs crore)#	Scientific and Technical Publications in India@	GERD/Article or Paper (Rs crore)
1996	8,913	9,753	NA
1997	10,611	9,618	NA
1998	12,473	9,945	NA
1999	14,398	10,190	NA
2000	16,199	10,276	1.58
2001	17,038	10,801	1.58
2002	18,000	11,665	1.54
2003	19,727	12,461	1.58
2004	21,640	13,367	1.62
2005	28,777	14,608	1.97
2006	32,941	14,160*	2.33
2007	37,778	15,312*	2.47

Source: #UNESCO Institute for Statistics estimates, September 2009; @World Bank; *SCImago (2007).

Open Access to Publications

It is the scientist's own discretion and confidence that matters while choosing a particular journal to publish his/her research output or findings. However, the high cost of journal subscriptions, especially foreign journals, and restrictive licensing terms severely limits public access to the articles published in foreign journals. The scenario is somewhat different for Indian journals – many of them are not available online and even if they are, they are not accessible. The internet, which has revolutionised the sharing of information across the globe should be utilised in India to share research information among peers and also with the public.

The Indian government is making huge investments on e-Infrastructure like National Knowledge Network (NKN) which will interconnect all institutions engaged in research, higher education and scientific development in the country. This would enable the researchers to share their research papers online and make them accessible to the public without any restrictions. This is possible through what is called as open access (OA). Open access literature is "digital, online, free of charge, and free of most copyright and licensing restrictions". What makes it possible are the internet and the consent of the author or copyright-holder (Suber 2004). The copyright law of any country exists to credit the author and to promote the

Table 7: Growth Rate of Publications (1985-2008)

Year	Scientific and Technical Publications	Growth (in %)
1985	9,586	–
1986	9,925	3.54
1987	9,051	-8.81
1988	8,882	-1.87
1989	9,744	9.71
1990	9,200	-5.58
1991	9,517	3.45
1992	10,100	6.13
1993	9,763	-3.34
1994	9,928	1.69
1995	9,370	-5.62
1996	9,753	4.09
1997	9,618	-1.38
1998	9,945	3.4
1999	10,190	2.46
2000	10,276	0.84
2001	10,801	5.11
2002	11,665	8
2003	12,461	6.82
2004	13,367	7.27
2005	14,608	9.28
2006	14,160*	-3.07
2007	15,312*	8.14
2008	15,009*	-1.98
Total	2,62,231	
Growth rate (%) for 1985-2008		56.57
Average annual growth rate (%)		2.36

* Data from SCImago (2007).
Source: http://data.worldbank.org/indicator (Retrieved on 11 May 2010).

progress of arts and sciences; when copyright impedes the progress of science, science must push copyright out of the way to safeguard the quality in science (Stallman 1991).

Open access is the most modern way of prompt dissemination of scientific findings to the public, especially the informed public community of scientists, physicians, educators, business owners, citizens, etc, and peers in different contexts or situations. When an institution or an author makes a copy of the pre/post-prints of a research article produced from publicly funded research directly available to the public through a website, it has the potential to advance science, spur innovation, surpass re-invention of the wheel and improve welfare of the people. Such open availability of research articles/papers or technology does not preclude publication in a commercially published professional journal or magazine with high impact factor or similar ratings. There are two ways in which OA can be achieved – "green" route and "gold route". Through the green route, the authors can publish their articles in the journals of their choice, and then make their peer-reviewed, accepted final drafts freely accessible online, by self-archiving them in their institution's open access repository. Some of the tools for achieving green road are DSpace (developed by Massachusetts Institute of Technology); Eprints (developed by University of Southampton) and Fedora (developed by Cornell University and University of Virginia). Through the gold route, authors can publish their articles in an OA journal which makes all of its articles freely accessible online. The choice of journal, however, remains entirely up to the author (Harnad et al 2004). The tool for achieving gold route is Open Journal Systems (OJS) which is one of the most popular open source journal management and publishing solutions, developed by the Public Knowledge Project (PKP).

Making Research Accessible

The adoption of the OA paradigm through any of the means explained above would make research output more accessible, and therefore lead to greater visibility. OA increases the readership and visibility of a journal through increased citations, since the citations of OA literature are higher than the subscription based scholarly literature (Lawrence 2001). Expanding access to publicly funded scientific research through OA offers potential for economic stimulus. The expanded sharing of credible scientific results will lead to a growth in patentable discoveries and their commercial applications. By adopting OA, professional societies can improve their journals' impact factor, a case in point being the medical journals published by MedKnow (Sahu 2006). Renowned journals such as *Nature* permit authors to archive pre-prints and post-prints with six months embargo.[5] From the scientists' point of view, the number of citations and the visibility of their research work over a period of time would gradually build up impact of their work, thereby bringing them professional recognition and fame to the institution. It also helps to advance their careers and obtain more funding for their research projects. If OA is practised across research disciplines, Indian research can be better showcased at the international level too. A recent report by the Committee for Economic Development[6] makes the core recommendation that colleges and universities should embrace the concept of increased openness in the use and sharing of information to improve higher education (CED 2009).

It is evident that many active researchers in our country are concerned about the complexities of intellectual property issues like copyright violation, possible dilution of recognition of their research work, and plagiarism, when their work is freely available. Many publishers are also of the view that if the journal becomes OA, they would lose revenues for their print subscriptions. In our view, it is time to consider such concerns in the light of available success stories with respect to OA globally. Based on such enriching experiences, Indian researchers can adopt the concept of OA and attract active researchers working in the same domain or allied disciplines for collaborative research work. This has had success across the globe.

Open access is gaining momentum in India. The Indian Academy of Sciences and the Indian National Science Academy has already adopted an OA policy and allowed open access to all their publications. The Directory of Open Access Journals and Scopus are respectively indexing 193 and 15 journals from India.[7] Recently, CSIR has also adopted an OA policy in its 38 laboratories and made 21 journals open access (ROARMAP 2010). The Indian Council of Agricultural Research had made its two journals open access (ICAR 2010). However open access policy for all its established institutes is not yet mandated. The CSIR had created Open Archives Initiative Protocol for Metadata Harvesting (OAI-PMH) compliant national open access periodicals repository for the e-journals and built a national science digital library for e-books. Likewise, the International Crops Research Institute for Semi-Arid Tropics has also announced OA for all its publications. Till date, 55 open access repositories have been established by various institutes and universities in India.[8] NIT-Rourkela was the first to mandate OA in India in 2006 to share and disseminate wisely the results of the institute's R&D activities (ROARMAP 2010).

Conclusions

Considering the vast demographic size of our country, and the kind of public investment in research, it is essential to disseminate the results of publicly funded scientific research to the rest of the society through cost and time effective means by making them publicly available online after publication. Over the last five years there is a significant amount of OA advocacy and awareness by way of workshops, seminars, conferences, etc, in the western world. Similar efforts need to be made in India. There must be a clear understanding of copyright issues among authors, alongside awareness programmes about OA. These should be taken up among the Indian scientific authors to retain copyrights themselves and use OA as a measure of broader access to knowledge, to accelerate use and innovation, and also to avoid reinventing the wheel. The National Institute of Health (NIH) of United States of America had mandated that research funded by its grants be made available online to the public at no charge within 12 months of its publication (NIH 2008) (Table 8). In December 2009, the Office of Science and Technology Policy launched a public consultation on Public Access Policy to seek public inputs on access to publicly funded research results, such as those that appear in academic and scholarly journal articles. The government needs to pass an open access policy legislation in India to enable open scholarship. Every educational and R&D institution should adopt it and make it mandatory for every author from their institute to self-archive the articles accepted for publication in their institutional repository. Once this is achieved, research articles will be made available by search engines for everyone and research produced by Indian institutes would attain greater visibility in the world.

Table 8: Manuscripts Deposited in Public Open Access Archives (NIH Policy)

Year	Manuscripts	% Increase Over Previous Year
2005	2,943	
2006	4,830	64
2007	12,703	163
2008	32,047	152
2009	59,101	84

Source: NIHMS STATS (2010), http://www.nihms.nih.gov/stats/

NOTES

1 Some of these include the Indian Council of Agricultural Research (ICAR), Council of Scientific and Industrial Research (CSIR), Indian Council of Medical Research (ICMR), Defence Research and Development Organisation (DRDO), Department of Atomic Energy (DAE), Department of Space (DoS), Department of Electronics (DoE), Department of Science and Technology (DST), Department of Biotechnology (DBT) and many other specialised bodies. See DSIR (2007) for details.

2 These include CSIR, DRDO, DAE, DBT, DST, DoS, Department of Ocean Development (DoD), ICAR, ICMR, Ministry of Information Technology (MIT), Ministry of Non-conventional Energy Sources (MNEs) and the Ministry of Environment and Forests (MoEF).

3 Inaugural address by Prithviraj Chavan at the 97th Indian Science Congress in Kerala, see Chavan (2010).

4 This ranking is based on the publications, citations, Google Scholar ranking, etc. See Webometrics (2009) for more details.

5 This means that until six months of publication date, the authors are not permitted to post them online. See SHERPA/RoMEO (2010).

6 A non-profit, non-partisan business led public policy organisation based in United States of America.

7 See DOAJ (2010) and Scopus (2010) for details.

8 See ROAR (2010).

REFERENCES

CED (2009): "CED Releases Harnessing Openness to Improve Research, Teaching and Learning in Higher Education: Committee for Economic Development", 6 November, viewed on 17 June 2010 (http://www.ced.org/news-events/digital-economy/395-ced-releases-qharnessing-openness-to-improve-research-teaching-and-learning-in-higher-educationq).

Chavan, Prithviraj (2010): "Science and Technology Challenges of 21st Century – National Perspective", inaugural address at the 97th Indian Science Congress, January, Kerala. Viewed on 1 October 2010 (http://www.dst.gov.in/scie_congrs/04-01-10/Minister_speech_ISCA.pdf).

DOAJ (2010): "Directory of Open Access Journals", viewed on 17 June 2010 (http://www.doaj.org/).

DSIR (2007): "Research and Development in Industry: An Overview", DSIR, November, viewed on 1 October 2010 (http://dsir.nic.in/tpdup/irdpp/07rndoverview.pdf).

Harnad, S, T Brody, F Vallieres, L Carr, S Hitchcock, Y Gingras, C Oppenheim, C Hajjem and E Hilf (2004): "The Access/Impact Problem and the Green and Gold Roads to Open Access: An Update", *Serials Review* 34: 36-40.

ICAR (2010): "ICAR Journals in Open Access", April, Viewed on 1 October 2010 (http://www.icar.org.in/openaccess/jlist.php).

Lawrence, S (2001): "Free Online Availability Substantially Increases a Paper's Impact", *Nature*, 411(6837):521.

Muthu, Madhan, G Chandrasekar and Subbiah Arunachalam (2010): "Highly Cited Papers from India and China", *Current Science*, 99(6): 738-49.

NIH (2008): "National Institutes of Health Public Access", January , viewed on 17 June 2010 (http://publicaccess.nih.gov/policy.htm).

NIHMS (2010): "NIHMS Statistics: Monthly Aggregate Submission Statistics", viewed on 17 June 2010 (http://www.nihms.nih.gov/stats/).

R&D Statistics (2009): *Research and Development Statistics (2007-2008): NSTM,* May, (New Delhi: GoI), viewed on 17 June 2010 (http://www.nstmis-dst.org/rndststo7-08.htm).

ROAR (2010): "Registry of Open Access Repositories", viewed on 17 June 2010 (http://roar.eprints.org/).

ROARMAP (2010): "Registry of Open Access Repository and Material Archiving Policy", viewed on 17 June 2010 (http://www.eprints.org/openaccess/policysignup/).

Sahu, D K (2006): "Open Access: Boon for Journals from India", paper presented at the 93rd Indian Science Congress, 03-07 January 2005, Hyderabad (http://openmed.nic.in/1255/).

SCImago (2007): "SJR – SCImago Journal and Country Rank", viewed on 17 June 2010 (http://www.scimagojr.com).

Scopus (2010): "Scopus Title List", viewed on 4 October 2010 (http://www.info.sciverse.com/scopus/scopus-in-detail/content-coverage-guide/sources).

SHERPA/RoMEO (2010): "Publishers Copyright Polices and Self-Archiving", viewed on 17 June 2010 (http://www.sherpa.ac.uk/romeo/).

Stallman Richard (1991): "Science Must Push Copyright Aside", viewed on 17 June 2010 (http://www.gnu.org/philosophy/push-copyright-aside.html).

Suber, Peter (2004): "A Very Brief Introduction to Open Access", viewed on 17 June 2010 (http://www.earlham.edu/~peters/fos/brief.htm).

Thomson Reuters (2008): "Indian Scientific Research Continues to Grow", 21 October, viewed on June 17, 2010 (http://thomsonreuters.com/content/press_room/sci/293977).

Times Higher Education (2009): "The World Top 200 Universities", viewed on 17 June 2010 (http://www.timeshighereducation.co.uk/hybrid.asp?typeCode=438).

UNESCO (various years): "Institute for Statistics Public Reports: Science and Technology", viewed on 17 June 2010 (http://stats.uis.unesco.org/).

Webometrics (2009): "Ranking of Web of World Universities", viewed on 17 June 2010 (http://www.webometrics.info/).

World Bank (2010): "World Bank Indicators", viewed on 17 June 2010 (http://data.worldbank.org/indicator).