The myth of frugal innovation in India

Gangan Prathap

We examine the evidence from large bibliometric databases to see if India is on the way to be able to 'market its distinctive expertise in frugal innovation to the world' and to 'establish a research programme on "science of science and innovation policy" '; two of the recommendations that a recent celebrated report on India's potential for frugal innovation made. We find that there are countries which are more profligate than India in the scramble for leadership in innovation, and also that there are countries which are harnessing their resources more effectively toward the same goal.

Keywords: Bibliometric database, frugal innovation, notional ideal, scientific research.

WE revisit an issue which was first introduced to the readers of *Current Science* a few years ago[1]. The immediate provocation then was a question asked by Marburger[2]: 'How much should a nation spend on science?' This cannot be easily answered unless one reviews the supply-side economics of R&D activity in terms of money spent and manpower deployed. The provocation now is the release of two new studies[3,4]. Analysts from Thomson Reuters put out a Global Research Report[3] which looked at the impact of the members of the G20 in scientific research and innovation activity, analysing each region based on its scholarly output and innovation capacity. It was emphasized that such activities are key predictors of economic growth and prosperity, not only for the G20, which is a self-elected group of world economic leaders from 19 participating nations and the European Union, but also for the rest of the world at large. The bibliometric data for the report are drawn from proprietary databases of Thomson Reuters, including *Web of Science* and Derwent World Patents Index and then organized neatly and displayed for each of the participating nations and region of the G20 membership[3].

An equally well-noticed and celebrated report was from Nesta[4]. It is an honest appraisal of the Indian innovation system and argues that 'the pressure for financial austerity and environmental sustainability are making frugal approaches to innovation attractive to developed economies'. India is cited as an example where such a pressure prevails and had 'potential as a laboratory for frugal innovations'. The Nesta report[4] goes on to make two key recommendations for India in its goal for frugal innovation: It should to be able to 'market its distinctive expertise in frugal innovation to the world' and it should take steps to establish a research programme on 'science of science and innovation policy'.

But if we examine the data carefully, we see that the academic research environment in India does not really work in a situation of financial austerity. The cost of doing research is high compared to the per capita income. Also, we find that there are countries which are more profligate than India in the scramble for leadership in innovation, and also that there are countries which are harnessing their resources more effectively toward the same goal.

Data analyses

Table 1 collates data from the Thomson Reuters Global Research Report[3] and reorganizes it so that the total R&D expenditure (GERD for Gross Expenditure on R&D) as a percentage of Gross Domestic Product (GDP) can be related to the number of researchers in R&D per million of population. Of the 20 members of the G20, crucial data are missing for India, Brazil and Saudi Arabia, and the data for Indonesia are wrongly inputted. However, some data for India and Brazil have been supplemented from another recent report, also from Nesta[5]. We next compute a dimensionless leverage term, the indicator

(GERD/GDP)/(Researchers/population).

This can also be expressed as

(GERD/researchers)/(GDP/population).

In other words, the leverage term[1] is a measure of the multiple of the per capita income of a nation that each nation is willing to invest in each of its R&D workers (total of salary and infrastructure costs). The fact that the same leverage term can be stated in two different ways indicates that the data in Table 1 can be reorganized as

Gangan Prathap is in the CSIR National Institute for Interdisciplinary Science and Technology, Thiruvananthapuram 695 019, India.
e-mail: gp@niist.res.in

Table 1. Data collated from the Thomson Reuters Global Research Report[3]

Country	Population (in millions)	Researchers (FTER; thousands)	Researchers in R&D per million population	GERD (billion current PPP$)	GDP (billion current PPP$)	%GERD/GDP	Leverage
Argentina	41.7	69.7	1671.46	4.6	743	0.62	3.70
Australia	23.1	137.5	5952.38	20.6	971	2.12	3.56
Brazil	193.9	136.5	704	27.3	2,356	1.16	16.48
Canada	33.5	149.1	4450.75	24.3	1,535	1.58	3.56
China	1,353.80	1,318.10	973.63	208.2	12,405	1.68	17.24
EU	507.9	1,595.60	3141.56	320.5	15,821	2.03	6.45
France	65.4	239.6	3663.61	51.9	2,254	2.30	6.28
Germany	80.4	328	4079.60	93.1	3,197	2.91	7.14
Great Britain	63.2	262.3	4150.32	39.6	2,316	1.71	4.12
India	1,210.20	164.6	136	35.8	4,711	0.76	55.88
Italy	59.7	106.8	1788.94	24.8	1,833	1.35	7.56
Japan	126.7	656.7	5183.11	146.5	4,779	3.07	5.91
Mexico	117.4	46.1	392.67	8.2	1,759	0.47	11.87
Russia	143.4	447.6	3121.34	35	3,380	1.04	3.32
South Africa	53	19.8	373.58	4.4	609	0.72	19.34
South Korea	50	288.9	5778.00	59.9	1,687	3.55	6.15
Turkey	75.6	72.1	953.70	10.8	1,306	0.83	8.67
The United States	316.3	1412.60	4466.01	415.2	15,685	2.65	5.93

FTER, Full time equivalent researcher; PPP$, Purchasing power parity dollars.

Table 2. Data collated from the Thomson Reuters Global Research Report[3] rearranged in terms of per capita income and R&D investment per FTER

Country	GDP (billion current PPP$)	Population (in millions)	Per capita income (thousand PPP$)	GERD (billion current PPP$)	Researchers (FTER; thousands)	R&D investment per FTER (thousand PPP$)	Leverage
Argentina	743	41.7	17.82	4.6	69.7	66.00	3.70
Australia	971	23.1	42.03	20.6	137.5	149.82	3.56
Brazil	2356	193.9	12.15	27.3	136.5	200.21	16.48
Canada	1535	33.5	45.82	24.3	149.1	162.98	3.56
China	12,405	1353.80	9.16	208.2	1318.10	157.95	17.24
EU	15,821	507.9	31.15	320.5	1595.60	200.86	6.45
France	2254	65.4	34.46	51.9	239.6	216.61	6.28
Germany	3197	80.4	39.76	93.1	328	283.84	7.14
Great Britain	2316	63.2	36.65	39.6	262.3	150.97	4.12
India	4711	1210.20	3.89	35.8	164.6	217.54	55.88
Italy	1833	59.7	30.70	24.8	106.8	232.21	7.56
Japan	4779	126.7	37.72	146.5	656.7	223.09	5.91
Mexico	1759	117.4	14.98	8.2	46.1	177.87	11.87
Russia	3380	143.4	23.57	35	447.6	78.19	3.32
South Africa	609	53	11.49	4.4	19.8	222.22	19.34
South Korea	1687	50	33.74	59.9	288.9	207.34	6.15
Turkey	1306	75.6	17.28	10.8	72.1	149.79	8.67
The United States	15,685	316.3	49.59	415.2	1412.60	293.93	5.93

FTER, Full time equivalent researcher; PPP$, Purchasing power parity dollars.

shown in Table 2 and that both data can then be displayed in two different ways, as shown in Figures 1 and 2.

Figure 1 shows how the percentage of GDP spent on R&D varies with the number of researchers as a proportion of total population for the members of the G20. The red dashed line in Figure 1 is a notional ideal for developed countries – about 3% of GDP should be spent on R&D and about 0.5% of the population should be engaged in R&D activities. We see from Figure 1 that this ideal is nearly met by developed and mature economies like South Korea, Japan, the United States, France and the EU taken as a whole. The leverage is 6.0. Of the BRICS countries, Brazil, China, India and South Africa appear on an arc of much higher leverage, with India having the highest leverage of nearly 56.

Figure 2 replots the data in Table 1 and Figure 1 according to the tabulation shown in Table 2. It shows how the R&D investment per full time equivalent researcher (FTER) in thousands of purchasing power parity dollars (PPP$) varies with per capita income also estimated in

thousands of PPP$. We see from Figure 2 that this ideal leverage of 6.0 is nearly met by economies like South Korea, Japan, the United States, France and the EU taken as a whole. Of the BRICS countries, India now stands out prominently as having the highest leverage, in terms of its per capita income, its costs of academic research are high; hardly the case of frugal innovation. We also see that it is Russia and Argentina which are really practising frugal innovation; their researchers are funded very lowly in terms of per capita income compared to the notional ideal. Countries like Great Britain, Australia and Canada also seem to be in a regime of comparatively frugal innovation when it comes to academic research.

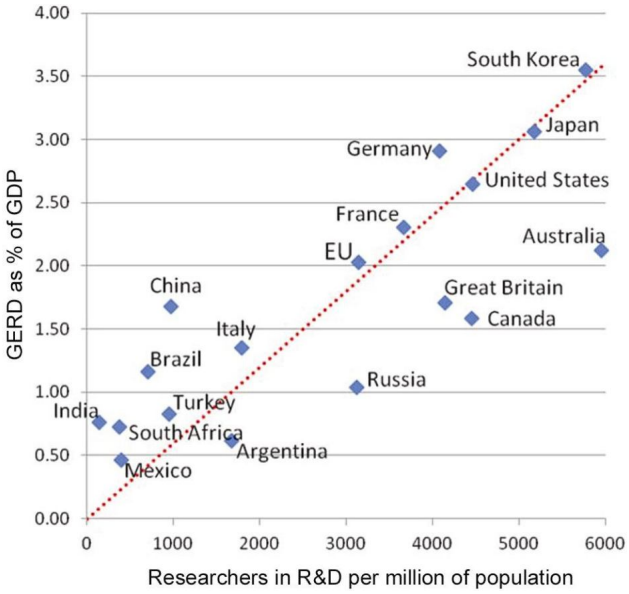

Figure 1. Percentage of GDP spent on R&D varying with the number of researchers as a proportion of total population for the members of the G20.

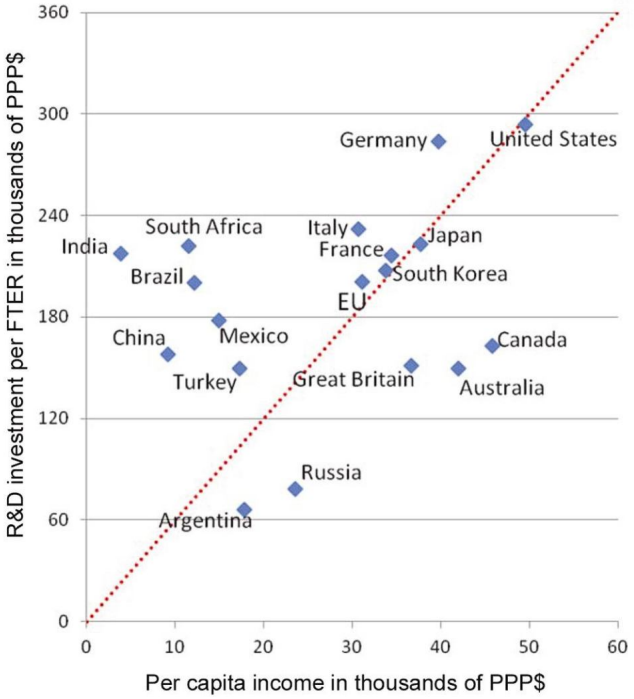

Figure 2. R&D investment per full time equivalent researcher (FTER) in thousands of purchasing power parity dollars (PPP$) varying with per capita income also estimated in thousands of PPP$.

Conclusion and recommendations

The foregoing analysis suggests that a country like India has to invest in a disproportionally high manner of both money and manpower to fully exploit R&D and S&T processes to achieve economic growth and prosperity. Of the BRICS nations, Russia appears on the other side of the divide delineated by the ideal line. The probable implication is that for the scientific manpower deployed, it needs to spend far more on R&D, i.e. implying a shortage of funding and/or a surfeit of performers, one of the scenarios predicted by Marburger[2].

It will be worthwhile to complete this study to see how these investments translate to output in academic research. We use the *Web of Science* database and query it using the advanced search option for the various countries in our list (the EU is excluded for obvious reasons) for the period 2003–2012. Table 3 and Figure 3 display the results. There is a cluster of low performance where surprisingly, Japan and South Korea are seen to join China and Russia. Although China's world share of academic research has increased from 5.6% in 2003 to 14% in 2012 (ref. 3), it seems to be going about it in an

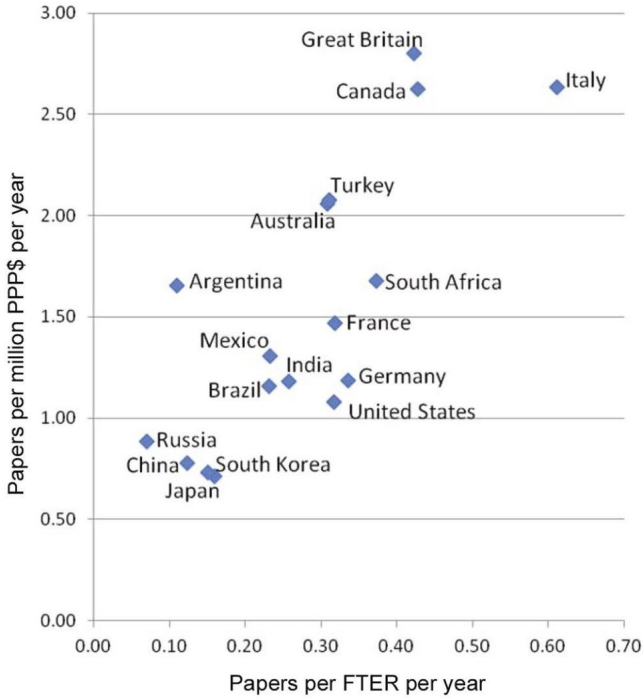

Figure 3. Output statistics using *Web of Science* data for the period 2003–12.

Table 3. Output statistics using *Web of Science* (*WoS*) data for the period 2003–2012

Country	GERD (billion current PPP$)	Researchers (FTER; thousands)	*WoS* papers 2003–12	Papers/FTER/ year	Papers/ million PPP$/year
Argentina	4.6	69.7	76,194	0.11	1.66
Australia	20.6	137.5	423,918	0.31	2.06
Brazil	27.3	136.5	316,643	0.23	1.16
Canada	24.3	149.1	637,853	0.43	2.62
China	208.2	1318.10	1,619,584	0.12	0.78
France	51.9	239.6	761,821	0.32	1.47
Germany	93.1	328	1,102,609	0.34	1.18
Great Britain	39.6	262.3	1,108,374	0.42	2.80
India	35.8	164.6	423,637	0.26	1.18
Italy	24.8	106.8	652,806	0.61	2.63
Japan	146.5	656.7	1,046,891	0.16	0.71
Mexico	8.2	46.1	107,146	0.23	1.31
Russia	35	447.6	310,263	0.07	0.89
South Africa	4.4	19.8	73,835	0.37	1.68
South Korea	59.9	288.9	436,705	0.15	0.73
Turkey	10.8	72.1	224,531	0.31	2.08
The United States	415.2	1412.60	4,483,734	0.32	1.08

FTER, Full time equivalent researcher; PPP$, Purchasing power parity dollars.

inefficient way. The East Asian tigers, Japan and South Korea, also seem to be inefficient in their use of manpower and money resources when it comes to output of scientific publications. The cluster of high performance sees Italy in the company of Great Britain and Canada. India, Brazil and Mexico are clustered close to the United States and Germany when it comes to measuring effectiveness of the academic research enterprise in terms of output per FTER and per million PPP$.

Although India's record of scientific publications lags behind that of China, and the gap is ever widening[4], the output metrics we see in Table 3 shows that India seems to leverage its scientific manpower and R&D investment resources much more effectively than China. But even among the BRICS fraternity, South Africa seems to leverage these resources more effectively than India. Even though in terms of scientific publications per PPP$ of R&D spending, India has an edge over USA, it lags behind countries like Argentina, Mexico, South Africa and Turkey. From Table 1 we see that India has the lowest figure for the number of FTER per million of population; it has a long way to go to harness what is called its 'demographic dividend' in science and technology innovation.

India's potential as a 'laboratory for frugal innovations'[4], was probably over-rated; it still remains a reluctant and 'uneven innovator'[6].

1. Prathap, G., How much should a nation spend on academic research? *Curr. Sci.*, 2010, **98**, 1182–1184.
2. Marburger, J. H., Wanted: Better benchmarks. *Science*, 2005, **308**, 1087.
3. The research and innovation performance of the G20; http://sciencewatch.com/sites/sw/files/images/basic/research-innovation-g20.pdf
4. Bound, K. and Thornton, I., Our frugal future: lessons from India's innovation system, 2012; http://www.nesta.org.uk/library/documents/OurFrugFuture.pdf
5. China's absorptive state, 2013; http://www.nesta.org.uk/home1/assets/features/chinas_absorptive_state_innovation_and_research_in_china
6. Bound, K, *India: The Uneven Innovator*, Demos, London, 2007.

Received 11 November 2013; accepted 11 December 2013