India's declining share in computational mechanics research

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Modern science began with Galileo's discourses on two new sciences, namely kinematics and materials science. Over five centuries, the discipline of mechanics which emerged from such studies has played a leading role in many engineering disciplines. Over the last five decades, with the advent of digital computing, mechanics has become 'algorithmized' and this new discipline of computational mechanics has played a very significant role in modern science and engineering, from the execution of megaprojects to the fabrication of nano and quantum devices. In this communication, using bibliometric techniques, we examine India's current place in the area of computational mechanics research and see stagnation and may be a steady decline.

Keywords: Bibliometrics, citation, computational mechanics, indicators, three-dimensional evaluation.

GALILEO's *Discourses and Mathematical Demonstrations Relating to Two New Sciences* (*Discorsi e dimostrazioni matematiche, intorno à due nuove scienze*), published in 1638, was the beginning of the new age of mechanics. Since then, this new science has played a pivotal role in the understanding of most hard-core engineering, whether it is civil engineering, or mechanical, or aerospace engineering, or for that matter, almost any branch of engineering, where statics, dynamics, materials science, flow behaviour, etc. play a key role. According to Albert Einstein, it was indeed the beginning of modern physics and modern science. The middle of the 20th century saw the emergence of computational mechanics, where the equations arising from mathematical models are recast in an algorithmic form suitable for digital computation. Computational mechanics has had a profound influence on the way modern engineering has progressed, from the largest scale of megaprojects like the building of massive dams, ships and aerospace vehicles, to the smallest nanoscale, where the incorporation of quantum and molecular effects has opened new vistas for applications of computational mechanics.

Nearly half a century ago, when the generation that this author and his teachers belonged to, were grappling with the then new-fangled areas of finite elements, finite differences, boundary elements, to name a few, India had a prominent place in the world order. There is now considerable anecdotal evidence that this is no longer the case. Bibliometric indicators allow this to be quantified in a more objective way and we use the *Web of Science* (*WoS*) database (querying 32,546,378 records in the data limits selected) to make this study.

We start our preliminary study using a simple search strategy, namely

Topic=('computational mechanics')
Timespan=All years. Databases=SCI-EXPANDED, CPCI-S, CPCI-SSH, CCR-EXPANDED, IC

using the *WoS* database (accessed on 5 November 2013). Such a strategy is only representative of the global output in the area of computational mechanics because of the stark simplicity involved, but suffices for the present purpose. The results for the 1986 – all years (updated 25 October 2013) for which a subscription was available from Thomson-Reuters, start with one record in 1987 and rise steadily to 108 records in 2012. India's share for this period is just 16 out of a total of 1354 records (1.18%).

We can further refine the search strategy to bring out the relative positions and contributions from various countries, organizations, authors and journals (source titles). Here, we shall restrict our attention to the leading countries and leading influential journals in the area of computational mechanics research. Three bibliometric indicators will be used, following the three-dimensional evaluation recently proposed by Prathap[1,2]. In this approach[3,4], the three components are quantity (productivity in terms of number of papers published), quality (specific impact as defined by citations per paper) and consistency η. Such an evaluation of the information production process is inspired by the '3Vs' metaphor of Laney[5] on 3D data management, where the number of papers P, indicates volume, the quality (or impact i), as measured by the ratio C/P, where C is the total number of citations received by P papers, indicates the velocity with which the ideas in P papers are communicated through citations C, and consistency η indicates the variety (variability) in the quality of the individual papers in the publication set, or in other words, the shape of the distribution curve.

The three components can be combined into a composite indicator, the z-index, which is scaled down from an energy-like term ($Z = \eta X = \eta^2 E$) as $z = Z^{1/3}$, which has the same dimensions as the number of publications, and therefore also the h-index. This index combines quantity, quality and consistency (or efficiency) in the true spirit of 3D evaluation and has the same units as the number of papers, or impact, or the now ubiquitous h-index, making a two-dimensional z–h map an easy to grasp picture of scientific performance.

While P and i are easily obtained from the *WoS* database, the precise computation of η requires in each case, knowledge of the complete citation sequence (i.e. the distribution curve). This is available directly from the *WoS* and the methodology to compute η is discussed below.

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Following Laney[5], we need at least three indicators to describe the information production and citation process. Thus scientific performance can be measured using the following parameter space.

Quantity: No. of papers/articles P published during a prescribed window which we will call the publication window (in our case, the window is from 1987, when the first paper appeared, according to our search query, to the date of access of *WoS* database).

Quality: The impact i computed as C/P, where C is the number of citations during a prescribed citation window of all the articles P. The citation window is the same as the publication window indicated above.

With the quantity P and quality i parameters defined, we postulate the following sequence of indicators of performance[4]:

Zeroth-order indicator: $P = i^0P$,
First-order indicator: $C = i^1P$,
Second-order indicator: $X = i^2P = i^1C$.

C is derived from the citation sequence, c_i of the citations of each paper in a publication portfolio of P papers as the total number of citations, $C = \sum c_i$, i = 1 to P. As defined above, both P and C serve as indicators of performance. The number of citations $C = iP$ can be thought of as a first-order indicator for performance. Prathap[3,4] showed that the exergy indicator $X = i^2P$, is an energy-like quantity which can be thought of as a second-order indicator of performance. With these definitions, a trinity of energy-like terms emerge[3,4]:

$$X = i^2P, \quad E = \sum c_i^2 \quad \text{and} \quad S = \sum(c_i - i)^2 = E - X$$

where $P = \sum 1$, $C = \sum c_i$ and $i = C/P$.

Apart from X, E also appears as a second-order indicator. The coexistence of X and E allows us to introduce a third attribute that is neither quantity nor quality. In the context of 3D data management, the attribute variety is introduced as a third component[5], but now in a bibliometric context, the appellation 'consistency' may be more meaningful. The simple ratio of X to E can be viewed as the third component of performance, namely the consistency term $\eta = X/E$. Perfect consistency ($\eta = 1$, i.e. when $X = E$) is a case of absolutely uniform performance, that is, all papers in the set have the same number of citations, $c_i = c$. The greater the skew, the larger is the concentration of the best work in a few papers of extraordinary impact, leading to very low values of η. The inverse of consistency thus becomes a measure of concentration.

Thus, for a complete 3D evaluation of publication activity, we need P, i and η. These are the three components of a quantity–quality–consistency or volume–velocity–variety landscape.

Consider the scientific output in the area described by Topic=('computational mechanics') as indexed in the *WoS*. We choose the period 1986 – all years (updated 25 October 2013) for which subscription was available. All articles P and citations C gathered by these P articles are counted. Then the impact i is computed for this period. From the citation sequence for each entity (author, country, organization or journal), consistency η can be computed using simple Excel spread-sheet functions.

We shall first refine the analysis using the 'countries' option adopting the following strategy:

Topic=('computational mechanics')
Refined by: Countries/Territories=(xxx)
Timespan=All years. Databases=SCI-EXPANDED, CPCI-S, CPCI-SSH, CCR-EXPANDED, IC.

Table 1. The leading 15 countries in computational mechanics arranged according to the default ranking in *Web of Science*, along with India, which is at the 19th position

Country	P	i	η	h	z
USA	336	20.85	0.09	40	23.22
Japan	215	5.17	0.30	18	11.94
Peoples R China	145	8.06	0.26	19	13.53
Germany	101	6.67	0.27	14	10.65
England	75	7.61	0.12	12	8.06
France	59	6.92	0.16	10	7.67
Iran	56	4.45	0.31	8	7.04
Spain	55	15.31	0.10	12	10.89
Singapore	48	19.44	0.49	17	20.78
Italy	37	4.35	0.25	7	5.57
Australia	35	4.46	0.27	7	5.74
Greece	33	9.97	0.26	11	9.49
South Korea	25	5.56	0.46	8	7.10
Canada	23	4.17	0.15	4	3.89
Portugal	21	6.05	0.38	7	6.62
India	16	1.56	0.45	3	2.60

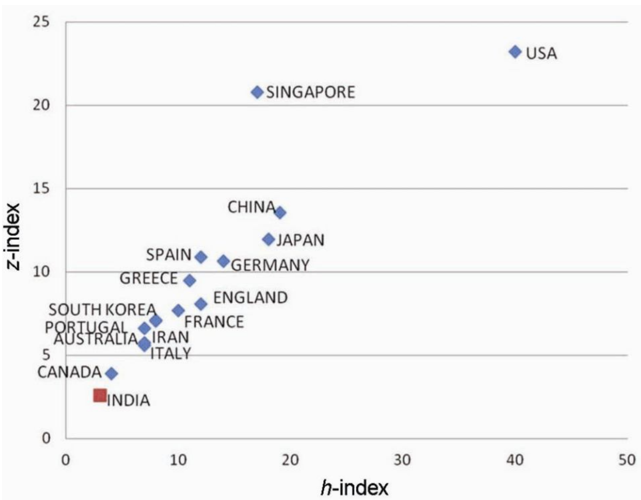

Figure 1. A two-dimensional z–h map of the 15 leading countries in computational mechanics research, along with India which is at the 19th position.

Table 2. The leading journals in computational mechanics research ranked according to the default quantity parameter P

Title	P	i	η	h	z
International Journal for Numerical Methods in Engineering	91	26.00	0.26	26	25.22
Computer Methods in Applied Mechanics and Engineering	90	24.76	0.18	23	21.66
Computational Mechanics	56	49.02	0.11	20	24.57
JSME International Journal Series A: Solid Mechanics and Materials Engineering	52	2.08	0.35	5	4.27
CMES Computer Modeling in Engineering Sciences	51	22.04	0.18	16	16.48
Engineering Analysis with Boundary Elements	49	10.20	0.55	14	14.08
JSME International Journal Series A: Mechanics and Materials Engineering	32	7.22	0.40	9	8.73
Computational Materials Science	29	3.21	0.11	4	3.21
Computers Structures	26	6.46	0.28	7	6.69
Composites Science and Technology	24	4.13	0.40	6	5.45

In January 1997, the JSME journal underwent a name change: in the period before that there were 32 papers, and subsequently, 52 papers, as per the *Web of Science* database.

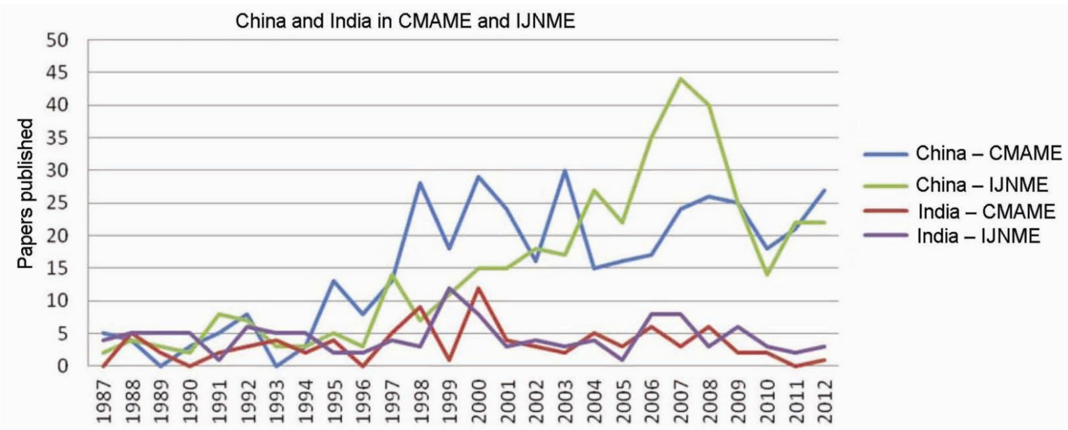

Figure 2. Time evolution of India's and China's presence in the two leading journals in the area of computational mechanics.

Table 1 shows the 15 leading countries in computational mechanics arranged according to the default ranking in *WoS*, along with India, which is at the 19th position. Not unexpectedly, USA is the leading player in terms of numbers of papers published. It also has the highest quality or impact of research, with Singapore a close second. Singapore also has the highest consistency of research. The very low consistency seen for USA indicates that most of its total impact is concentrated in a few star papers. We can also summarize this in a two-dimensional map of the h- and z-indices, as shown in Figure 1. The h-indices are obtained directly from the *WoS* citation report, while the z-index is computed using the protocol outlined above.

Next, we shall try to identify the most influential journals in which papers in this area are appearing. For this, we refine the analysis according to the source titles option:

Topic=('computational mechanics')
Refined by: Source Titles=(xxxx)
Timespan=All years. Databases=SCI-EXPANDED, CPCI-S, CPCI-SSH, CCR-EXPANDED, IC.

Table 2 shows the leading journals in computational mechanics research ranked according to the default quantity parameter P. *International Journal for Numerical Methods in Engineering* is the most popular journal, with *Computer Methods in Applied Mechanics and Engineering* a very close second. However, it is *Computational Mechanics* which has papers with the highest average impact. *Engineering Analysis with Boundary Elements* has the highest consistency. The low consistency value for *Computational Mechanics* and *Computational Materials Science* is indicative of a scenario where the highest citations are concentrated in just a few articles.

We started with the thesis that from anecdotal evidence and from personal memory, India's presence in the area of computational mechanics research has diminished over the years. At the same time, it is also a widely acknowledged fact that India's place has been taken by China, which has risen steadily to third position as seen in Table 1. We shall now take up the two most popular journals in Table 2, namely the *International Journal for Numerical Methods in Engineering* and *Computer Methods in Applied Mechanics and Engineering* for a direct comparison of how India has performed relative to China. A search strategy of the form:

Address=(china) AND Publication Name=(international journal for numerical methods in engineering)

Timespan=All years. Databases=SCI-EXPANDED, CPCI-S, CPCI-SSH, CCR-EXPANDED, IC

can be used to see how China and India have progressed over the recent past as far as their presence in these two journals is concerned. Figure 2 shows the time evolution of India's and China's presence in the two leading journals in the area of computational mechanics. While India has been stagnating after rising initially, China now outpaces India quite significantly.

In this paper, we have used a three-dimensional bibliometric analysis to identify the leading countries, and also the most influential journals in the key area of computational mechanics research. Scholarly performance is broken down into three components – quantity, quality and consistency. The citation data are retrieved from the *WoS* and used to categorize the entities according to these quantities. We see that India plays only a marginal role in this key area and of late this has been stagnating or diminishing.

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A study on channel migration of the Subansiri river in Assam using remote sensing and GIS technology

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The Subansiri is a major Trans Himalayan tributary of the River Brahmaputra, characterized by its extremely dynamic and unstable alluvial channel in Assam. In this study, the pattern of channel shifting as well as various other changes of the Subansiri river have been studied for the period from 1828 to 2011. Five different types of channel shift have been observed in the Subansiri river. They are (i) alternate bar-induced shifting, (ii) neck cut-off, (iii) chute cut-off, (iv) meander shift and (v) avulsion or rapid diversion. The channel pattern of the Subansiri river in Assam changes continuously with large number of channels being abandoned and new channels developed in the course of a few years. Large discharge and heavy sediment load during floods cause the river to be extremely unstable, because of which it consistently migrates laterally from the eastern side to the western side of the basin abandoning the earlier channels.

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Keywords: Channel migration, erosion, flood, sedimentation, Subansiri river.

THE present study was undertaken on the Subansiri river in Assam for assessment of changes in the positions of the channel, resulting from bank erosion as well as various changes in the channel pattern of the river from 1828 to the present. Evidences indicate that the reach of Subansiri in the plain section represents one of the most dynamic and unstable alluvial rivers in the Brahmaputra valley. The reach of the river downstream from Arunachal hills, especially towards its mouth, has a sluggish course subjected to intense braiding and anabranching of the channel. Formation of channel bars and meandering thalwegs is common. Since 1954, the river has been confined between its embankments. This leads to rising of the riverbed. The silt which used to be deposited in the plains, now gets deposited inside the river channel[1]. The map evidence together with records of flood history indicate that recurring large floods have breached the embankments, created areas of bar development and caused bank erosion and channel migration. According to Schumm and Lichty[2], and Schumm[3], floods of very high magnitude may be a contributing factor to channel widening and river bank erosion along with associated changes in the channel pattern. Erosion may be caused either by undercutting of the upper bank materials by channels during the high floods producing an overhanging cantilevered block that eventually fails or by oversteepening of bank materials due to migration of the thalweg closer to the bank during the falling stages[4]. Large-scale slumping of bank during the falling stages of the river was observed in many places, which may be associated with reverse flow from the formation back into the channel causing a lateral flowage of sand and silt into the channel resulting in subaqueous failure[5,6].

It is believed that the Great Assam Earthquake of 1950 and the associated flood episodes are primarily responsible for bringing a major change in the hydrologic regime of the Subansiri river. Before the great earthquake of 1950, the Subansiri was flowing through Bilmukh and this old course was shorter, measuring only 136.77 km. It is learnt that it had a still shorter course two centuries ago, when the Brahmaputra was flowing along the present course of Kherkatia suti and the Lohit Subansiri met