fact, I was paid to give a presentation not to suppress my criticisms of the DOI. To my amazement they overlook the two strenuous objections that I raised from the floor at the workshop. No ITU staff member at the time came forward to discuss my points of criticism.

Kelly and Biggs refute my claim that there is barely any criticism of the weights used in the DOI. They point to discussions in numerous parts of the world where this issue was apparently debated. This is entirely besides the point since I was referring solely to the documents available at the workshop. It is not part of my job to follow each and every occasion where the ITU hosts 'open meetings'.

It is a pity that the authors have to allude to a typo when they attempt to refute my suggestion of an alternative weighting system. It is also a pity that they seem not to think that my proposal has a theoretical foundation. The fact is that several pages in my article are devoted specifically to this task. One can reasonably disagree with my reasoning, but to ignore it says much about the seriousness with which they have taken my article.

Kelly and Biggs then go on to defend the use of and the weight given to mobile coverage in the DOI. They refute my claim that the use of this measure has the effect of distorting the index in favour of the opportunity component and against the use indicator, which I believe is the culmination of the others and as such deserves a higher weight. I use the data in table 4 to show that the world average of the opportunity component is seven times larger than the use measure and that this has much to do with the inclusion of the undemanding, variable mobile coverage. The authors claim that the value of this variable is 'considerably less' in many developing countries than in developed. Yet, the largest developing country, China, has a mobile coverage of 80% and even in some of the poorest developing countries, the figure is above this amount.

Throughout their comments, Kelly and Biggs fall back on the defence that the DOI is the most practical measure, able as it is, to cover 180 countries. The relevant question though is whether improvements to the index justify the costs entailed in gathering extra information. If the revised measures were to help policymakers, the impracticality defence loses its force.

I would, finally, have welcomed a serious debate over the points that I raise in my article. But if even the basic argument I advance is glossed over or misunderstood, I see little prospect of that happening.

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NEWS

S. R. Srinivasa Varadhan receives Abel Prize

On 22 March 2007 the Norwegian Academy of Science and Letters announced S. R. Srinivasa Varadhan as the awardee of the Abel Prize for 2007.

What is the Abel Prize? The well-known mathematician Marius Sophus Lie had advocated the creation of the Abel Prize for mathematics around the time that plans for the Nobel Prize were made public, and did not include a prize for mathematics[1]. King Oscar II of Norway and Sweden was willing to finance a mathematics prize in Abel's name. Ludwig Sylow and Carl Stormer even did some groundwork to create this award, but this first effort collapsed following the dissolution of the Union between Sweden and Norway in 1905.

The Niels Henrik Abel Memorial Fund, to award the Abel Prize for outstanding scientific work in the field of mathematics, was eventually established on 1 January 2002, to commemorate the bicentenary of Abel's birth. In many ways the Abel Prize is the counterpart of the Nobel Prize for mathematics (this is reflected also in the amount of prize money).

Varadhan is being awarded the Abel Prize in its fifth year for his fundamental contributions to probability theory and in particular for creating a unified theory of large deviation. The earlier Abel laureates are Jean-Pierre Serre (2003), Michael F. Atiyah and Isadore M. Singer (2004), Peter D. Lax (2005), and Lennart Carleson (2006).

Varadhan is the first mathematician of Asian origin to have won this prize. Born in Chennai (2 January 1940), Varadhan got his B Sc Honours degree in statistics from Presidency College, Chennai in 1959. He then went to Indian Statistical Institute (ISI), Kolkata, as a Ph D student.

At ISI, Varadhan was initially asked to work on statistical quality control. But probability theory interested him more, especially because some of his seniors from Chennai, such as V. S. Varadarajan, K. R. Parthasarathy and R. Ranga Rao, had formed a group to study probability theory and other related areas such as measure theory, topology, operators on Hilbert spaces and topological groups. Varadhan decided to join this group. The chief focus at ISI in those days was on statistics and statistical inference, and there were no professors to teach courses in probability. But the Institute encouraged its Ph D students to foray into areas of their choice. So Ph D students in this probability group lectured to each other and mastered themes on their own.

Varadhan chose to study the Central Limit Theorem in an infinite dimensional setting – that of a Hilbert space. The challenge here was that the Fourier analysis techniques, which were the backbone of the argument in the finite-dimensional case, were no longer applicable. Varadhan instead used concentration functions to obtain limit theorems on Hilbert space. This work formed a part of Varadhan's Ph D thesis entitled 'Convolution properties of distributions on topological groups'. C. R. Rao was the formal advisor, but the work was done by Varadhan independently. The tradition in ISI (that continues to this day) is to invite leading experts in the area of the work as external examiners for Ph D theses. For Varadhan's thesis, A. N. Kolmogorov, the father of modern probability theory, was chosen as the examiner.

After finishing work on his thesis, Varadhan worked with Varadarajan to undertake an extensive study of Lie groups and obtained significant results. Thereafter, Varadhan went to Courant Institute of Mathematical Sciences in 1963, first as a postdoctoral fellow and then as a faculty. He was later to serve as the Director of the Courant Institute during 1980–84 and again during 1992–94.

At Courant Institute, Varadhan returned to probability theory and began collaborating with his colleagues Donsker and Stroock on two different themes – the theory of large deviations, and diffusion processes, and made significant contributions in each of these themes.

Markov processes and martingale problems: With Stroock, Varadhan developed a new approach – via what are called martingale problems – to construct and study diffusion processes. The classical approaches to the construction and study of diffusion processes are via (i) partial differential equations and (ii) semigroups and their generators. Ito had introduced his theory of stochastic integration and stochastic differential equations with the aim of constructing a larger class of diffusion processes. Stroock and Varadhan took this one step further. In their approach, a Markov process is characterized via the requirement that a certain class of associated processes are martingales. Over the last four decades, this has turned out to be the most powerful approach to the theory of Markov processes. The condition that a given process is a martingale essentially means that (several) integral equations should be simultaneously satisfied. The advantage of stability of integral equations, compared to say differential equations, with regard to limiting operations is well known. The martingale requirement is therefore more suitable for analysis compared to a conditional probability equation, which is a statement involving the Radon–Nikodym derivative.

Markov processes occupy a central position in applications of probability theory to physical sciences, biological sciences, behavioural sciences, economics and finance. The martingale problem has deep connections to the fundamental concepts of no-arbitrage principle and completeness of markets in mathematical finance. The martingale problem approach has also been instrumental in significant advances in stochastic filtering theory and stochastic control theory.

Large deviations: Consider a (fair) coin being tossed repeatedly and an observer being interested in the proportion p_n of heads in the first n tosses. The law of large numbers says that as n becomes large, p_n is close to half with high probability. The Central Limit Theorem gives an estimate of this probability:

$$P(t_1 \le 2\sqrt{n}(p_n - \tfrac{1}{2}) \le t_2)$$
$$\to \frac{1}{\sqrt{2\pi}} \int_{t_1}^{t_2} \exp\left\{-\frac{1}{2}x^2\right\} dx.$$

As a consequence, the probability of observing a large deviation away from the mean is small, i.e. for any $t > 0$, $P(|p_n - \frac{1}{2}| \ge t)$ converges to 0, as n tends to infinity. The theory of large deviations gives a rate of convergence of these probabilities, with a precise estimate of probabilities of these rare events. In this case the answer is

$$P(|p_n - \tfrac{1}{2}| \ge t) \approx \exp\left\{-\frac{t^2}{2n}\right\}.$$

More precisely,

$$\lim_{n\to\infty} \frac{1}{n} \log\{P(|p_n - \tfrac{1}{2}| \ge t)\} \approx -\frac{t^2}{2}.$$

In general, if $\{X_n\}$ is a sequence of independent and identically distributed (i.i.d.) random variables with

$$\overline{X}_n = \frac{1}{n}(X_1 + X_2 + \cdots + X_n),$$

then the theory of large deviations gives

$$\lim_{n\to\infty} \frac{1}{n} \log\{P(\overline{X}_n \ge t)\} = -I(t).$$

Here, $I(t)$ is called the rate function and is related to the (common) distribution function of X_ns.

If X_n denotes the payout on an insurance policy in its lifetime (issued by a given company), then by the law of large numbers (assuming X_ns are i.i.d.), X_n is close to $E(X_1)$. But the company has to prepare itself for a rare event happening, such as the average payouts exceeding $E(X_1)$ say by 5. Indeed, the beginnings of the theory are precisely in this problem.

Estimating probabilities of rare events has become important when manufacturers are aiming at defect levels of the order of 0.0001% (one in a million). This has become important as quality has become a key ingredient for brand-building and so a defect rate of, say, one in a thousand is considered too high. It is the same case with service providers where the aim is to have service denial rates of the order of 0.0001% (one in a million).

Varadhan (jointly with Donsker) explored large deviations for Markovian systems (in which the dependence of the future on the past is entirely reflected in the dependence on the present). As discussed earlier, Markov processes appear in many applications of probability theory. In particular, in applications to physical systems that are evolutionary, the appropriate micro (stochastic) model turns out to be Markovian.

Varadhan formulated a large deviation principle which is applicable in a large number of seemingly different situations. Varadhan has developed several techniques to facilitate application of this theme. One of these is known as Varadhan's Integral Lemma. This is extensively used in proving that the large deviation principle holds in a given situation and in the computation of the rate function.

The results and techniques on large deviations have applications in several areas, including quantum field theory, statistical mechanics, electrical engineering, mathematical finance, and traffic engineering. Indeed, a web-search on each of these topics along with *large deviations* throws up a large number of hits.

Varadhan has also done some influential work on analysis of *hydrodynamical limits* describing the macroscopic behaviour of very large systems of interacting particles. We shall however not go into it here.

Varadhan is a very versatile mathematician who has contributed a good deal to the promotion of mathematics. A passing note about his personality may not be out of place at this point. Great scientists are supposed, in popular perception, to be absent-minded, eccentric, etc. Varadhan manifests a large deviation to this rule. So much so that people from other walks of life who meet him are surprised when they subsequently learn that they just met a great mathematician.

I would end this article with a paragraph from a popular-science presentation on Varadhan's work given by Tom Louis Lindstrom in connection with the announcement at the Norwegian Academy of Science and Letters on 22 March: 'He is a prolific scientist with deep insights and an impressive array of technical tools, and he is very highly regarded and esteemed in the probability community. This does not only have to do with his results, but also his style – listening to a lecture by Varadhan, one is not only exposed to the best and most recent results in the subject, but one is also introduced to a way of thinking. His talks always emphasize the basic ideas, the challenges, the obstacles, and the delicate balance between the desirable and the possible which one has to strike to produce top class mathematical results. S. R. S. Varadhan is certainly a worthy winner of the Abel Prize!' (http://www.abelprisen.no/nedlastning/2007/varadhan_en.pdf)

1. The Nobel Prize is awarded for achievements in physics, chemistry, physiology or medicine, literature, and peace. There is no Nobel Prize in mathematics. Contrary to popular belief, there is also no Nobel Prize for economics. What is called the Nobel Prize for economics is actually the Sveriges Riksbank Prize in Economic Sciences in memory of Alfred Nobel.

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Setting up a national agenda towards biosecurity

Biosecurity is a strategic and integrated approach that encompasses the policy and regulatory framework to efficiently handle risks in the sectors of human health and nutrition, animal and plant life and other environmental risks.

In view of the emerging concerns for biosecurity, the National Institute of Advanced Studies, Bangalore and M.S. Swaminathan Research Foundation, Chennai jointly organized a two-day discussion meeting at the National Institute of Advanced Studies, IISc Campus, Bangalore on the setting up of a national agenda towards biosecurity. The meeting sponsored by the Ministry of Agriculture, Government of India focused on various issues related to biosecurity, biosafety, biohazards and bioterrorism and its relevance to India in which biosecurity specialists, policy makers and other individuals participated.

Some of the conclusive recommendations of this meeting were: India needs a biosecurity policy to safeguard the income and livelihood of farm sector, enhance national capacity to monitor, warn, educate and build infrastructure for containment of any eventual pandemic. Convergence in the efforts of all Departments and Ministries to develop a coherent biosecurity strategy in which education, regulatory measures and social mobilization are vital in formulating a biosecurity strategy. Setting up of a National Agricultural Biosecurity Network that will serve as a coordinating and facilitating scientific partnership between various institutions and the establishment of a knowledge centre which will primarily act as a think tank for futuristic agricultural developments. Upgradation of biosafety level laboratories at the national level connected to the four regions of the country. Also, an operational programme to monitor the biosecurity in aquaculture. Control measures for exotic pathogens and disease management activities for already established ones. A national surveillance system and a Rapid Response Team to contain the problem of diseases prevalent in our country. Molecular epidemiology of nutrition deficiency/genetic susceptibility to degenerative diseases should be undertaken for early detection in which a multidisciplinary approach involving biotechnology, pharmacogenomics, molecular medicine and nanotechnology is important.

Classification of bioweapons, use of radiation techniques for protection from biohazards, close collaborations in emergency scenarios as done in the case of NIV (ICMR) and High Risk Security Lab (ICAR) for Avian flu and modernized plant quarantine stations including measures to strengthen plant quarantine facilities through training of officers in pest risk analysis, surveillance and molecular diagnosis of pests, etc.

Literacy drives towards biosecurity, a focused threat/risk analysis followed by capacity building in diagnosis and preparedness, developing emergency action plan and establishing a single integrated National Biosecurity Centre.