Norbert Wiener and Prasanta Chandra Mahalanobis

Technology and nation-building in post-Independence India

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***Abstract*—For seven months from late 1955, Norbert Wiener (1894-1964) worked at the Indian Statistical Institute at the invitation of Prasanta Chandra Mahalanobis (1893-1972). Mahalanobis had achieved a remarkable feat, the creation of a world class institution within a decade of India's independence. Wiener was also at the peak of his career, having established the field of cybernetics a few years earlier. These two major 20th century leaders in the application of technology shared similarities in their backgrounds, and in their approach to the social value of science and technology. For Mahalanobis, Wiener's visit was one of many which he oversaw, bringing international experts to his students and staff. For Wiener as the initiator of modern factory automation, India provided an opportunity to work on an idea important to him, alternative development models to the "smokestack industrialization" of the European industrial revolution. Both made contributions to the development of the sophisticated technology environment we see in India today.**

Keywords—Norbert Wiener, Prasanta Chandra Mahalanobis, Indian Statistical Institute, technology history, technology in India

I. INTRODUCTION

Prasanta Chandra Mahalanobis and Norbert Wiener were two internationally important figures in the application of technology in the mid-20th century. Their technical legacies each remain important in the 21st century. The Mahalanobis D^2 measure and the Wiener Filter are familiar to students of statistics and control systems respectively. On a broader plain, Mahalanobis founded the Indian Statistical Institute (ISI) in 1931, which was to become a major international institution by the 1950s and remains important today. Norbert Wiener developed the field of cybernetics, the science of control and communication in the animal and machine, in the late 1940s, and his work has become a household subject through cyborgs (cybernetic organisms) and cyberspace.

Wiener made two visits to the Indian Statistical Institute at the invitation of Mahalanobis. He visited briefly in 1953 and then returned for seven months from late 1955. ISI had the extraordinary achievement in that period, in a country which had won its independence just a few years earlier, of being one of the three leading statistical institutions in the world (alongside the Rothamstead Experimental Station in England and the US Bureau of the Census) [1, p254].

Mahalanobis prioritized visits by prominent scientific figures as a way to bring international thinking to his students and staff. However, Wiener's visits were more than just accidental stops in a busy international itinerary in response to invitations. Wiener had extensive links with institutions in developing countries, particularly Mexico, and placed significant emphasis on ideas from outside of Europe and the US.

The purpose of this paper is to compare the backgrounds and approaches of these two figures as a basis for understanding the importance of Wiener's visits for both people. It is an attempt to address the question, did Wiener's views on technology influence India's subsequent technology development?

This paper commences with a brief background on Mahalanobis and Wiener and the similarities of their backgrounds, goals and approaches. It then looks at the ISI at the time of Wiener's visits, and provides some details regarding these visits. The subsequent section considers Wiener's views on the future of Indian technology development. This is followed by the conclusion and suggestions for further research.

This paper sits within the field of technology history, overlapping with the field of technology biography. Its theme, the influence of individuals on long-term policy in technology development, has wider relevance for attempts to set and achieve development goals over periods of several decades.

II. MAHALANOBIS, HIS HISTORY AND IMPORTANCE

Prasanta Chandra Mahalanobis was born in colonial India in 1893, and grew up within the intellectual tradition of the Brahmo Samaj reformist movement founded by Raja Rammohun Roy in Bengal. Several writers have described the life and influence of Mahalanobis [1-5] Rudra [1] in particular provides a detailed description of his life and environment. He quotes Mahalanobis's description of the movement: 'The Brahmo Samaj in those days was very active on various fronts—removal of caste barriers, beginning of female education, reform of religion and society and, along with this, the beginning of political movements [1, p.10].' A key figure in this was the poet and Nobel Prize-winner Rabindranath Tagore. Mahalanobis was a close friend of Tagore, and was for many years his literary agent [1, p.93]. Family friends included Upendra Kishore Roy Choudhury, grandfather of world renowned film director Satyajit Ray.

After graduating with Honors in Physics in 1912, Mahalanobis travelled to the UK and studied at Cambridge until 1915. Mahalanobis's interest in statistics began on his return to India, particularly around the use of statistics in physical anthropology. His strong interest in minimizing errors in this field took him into multivariate analysis where he developed the D^2 statistic, the Mahalanobis Distance as it was named by leading statistician R.A. Fisher [1, p.132]. His interest in errors included errors of observation, errors of measurement and sampling errors. He was later to develop a close collaboration with Fisher that continued through their lives. Fisher supported the ISI approach which he compared to 'the great technological Institutions in which knowledge of physical and of engineering principles are pursued simultaneously.' [1, p.322]

In Mahalanobis's view, 'statistics is not a branch of mathematics but is a technology which is essentially concerned with the contingent world of reality … as distinguished from a world of abstraction'. [1, p.176] From the late 1920s he began to take a major interest in institution building, and in 1931 undertook to launch the independent Indian Statistical Institute. He also launched the *Sankhyā* research journal (after the rejection by Karl Pearson of his initial paper on the Mahalanobis Distance submitted to *Biometrika*) [1, p.320].

In the period leading up to Indian independence, the ISI began to play an important role as a national research institute (it was formally recognized as a tertiary institution under a Government of India Act in 1959). Faced with an early need to undertake a census of India, Mahalanobis played a key role. In his earlier survey work on jute in Bengal, using a random sampling approach he was able to show an error rate of 2.8 per cent and speedy delivery at less than a tenth of the cost of a full survey [1, p.153].

From the early 1950s until his death in 1972 he shifted his focus to planning and economic development. In the 1960s he also developed what he called a Fractile Graphical Analysis, a means of assessing socio-economic conditions of a group of people at different points of time. For example, rather than being satisfied with overall consumption, he asked 'whether there is any differential increase in the consumption of cereals between the "poor" and "rich" sections [fractiles] of the population.' [1, p.243] His concern with raising the living standards of all Indians was a central theme in his life.

By the time of his death, ISI had the following units: Anthropometry and Human Genetics, Biochemistry, Biometry, Botany, Computer Science, Crop Science, Demography, Economics, Electronics, Embryology, Geology, Leaf Protein, Linguistics, National Income, Pre-census Population Studies, Psychometry, Statistics and Mathematics, Sociology, Planning and Regional Survey, Statistical Quality Control, Library and Information Service, Documentation Research and Training, Survey Research. [1, p.193] He also attempted to set up a computer manufacturing center within ISI.

US statistician Edward Deming wrote, regarding Mahalanobis's survey approach, 'The main feature of the interpenetrating network of samples is its simplicity in the calculation of the standard error of an estimate…. For 14 years I have used interpenetrating network of samples, initiated by [Mahalanobis], as every one knows, about 1936.' [2, p.476]

III. Wiener's unique approach

Norbert Wiener was born in Columbia, Missouri, in 1894. His father became a professor of languages at Harvard, raising Norbert in an intellectual milieu, as was Mahalonibis. After a brief attempt at biology, Wiener commenced his professional life in philosophy. At 19 he undertook post-doctoral study under Bertrand Russell, having written his dissertation on Russell and Whitehead's *Principia*. Key sources on Wiener's life include his own two volume autobiography [6, 7], along with Heims [8], Masani [9] and Conway & Siegelman [10].

Wiener then headed into science and mathematics, gaining a position at Massachusetts Institute of Technology in 1919. Basing himself on Gibbs' work on statistical mechanics, Wiener examined Brownian motion and provided an advance in probability theory called the 'Wiener measure'. Einstein had undertaken earlier famous work on Brownian motion, but Wiener's concern, unlike Einstein's, was with 'the mathematical properties of the curve followed by a single particle' [9, p.83].

His approach here continued a view that he had held since an early age (when he wrote his first philosophical paper at 10), and one that would remain central to his work, his view of the role of approximation, uncertainty and incompleteness of all human knowledge [6, p.96].

Wiener had a strong interest in mathematics, which grew into a detailed study of the role of feedback in both science and engineering. This work included research he did with Julian Bigelow during World War II on theories to model anti-aircraft fire. He later described it as follows: 'The balance between errors of imprecision and errors of instability is something which we can compute only on a statistical basis. Why not, then, assume the statistical basis at the very beginning and obtain both mean result and error by a unified method of computation?' [7, p.259]

Wiener and Bigelow developed methods of negative feedback to increase stability, observing the limitations of these. Wiener then asked a physician colleague Rosenblueth whether there were any known nervous disorders reflecting these limitations. The answer was yes, reinforcing Wiener's view of the similarity of control in the human and the machine on a statistical basis. [7, p.253] These discoveries led to Wiener's identification of the new field of cybernetics.

Wiener's most famous book, *Cybernetics: or Control and Communication in the Animal and the Machine* [11], was published in 1948. In this book he drew together his multi-disciplinary approach developed through a series of conferences organized by the Macy Foundation in New York. These conferences attracted an interdisciplinary group of several dozen specialists in the 1940s and 1950s, including von Neumann and Shannon, alongside whom Wiener made major contributions to the foundation of modern information theory. These included the 'Wiener filter', a method of reducing noise present in a signal, initially written as part of his military research in 1942, and released publicly in 1949 [12].

According to Heims [8, p.219], Wiener's key contribution to knowledge was 'not so much a mathematical discovery as an insight into how to think about problems'.

Wiener placed priority on scientists' ability to step beyond their own discipline in order to achieve interesting results. For him, multidisciplinary work involved more than having people of different backgrounds working in the same team: 'The mathematician need not have the skill to conduct a physiological experiment, but he must have the skill to understand one, to criticize one, and to suggest one. The physiologist need not be able to prove a certain mathematical theorem, but he must be able to grasp its physiological significance and to tell the mathematician for what he should look.' [11, p.3]

Wiener saw significant parallels between human and machine processes. For example he wrote: 'In the ear, the transposition of music from one fundamental pitch to another is nothing but a translation of the logarithm of the frequency, and may consequently be performed by a group-scanning apparatus' [11, p.141] Some have criticized cybernetics for underestimating the features that make humans unique (discussed at length in Hayles [13]). Wiener's concern was not with distinguishing the human and the machine, but with ensuring that humans didn't themselves become part of a 'machine' in the organizational sense: 'When human atoms are knit into an organization in which they are used, not in their full right as responsible human beings, but as cogs and levers and rods, it matters little that their raw material is flesh and blood. *What is used as an element in a machine, is in fact an element in the machine*.' [14]

IV. Wiener's visits to ISI

The goals of the Indian Statistical Institute were never narrowly statistical. Fisher wrote of the diversity of activities at the Institute: 'I take these bold excursions to mean that the Director [Mahalanobis] believes, as I most certainly do myself, that teaching, instruction or training in statistics, at whatever level, is bound to be concerned, on the one side with fact-finding projects in the traditional statistical fields of demography and economics, and on the other side with opportunities to gain first hand familiarity with at least some field in the natural sciences.' [2, p.467]

Mahalanobis saw the ISI as an important contribution to the development of technical expertise within India. He spent a significant effort convincing world leaders in statistics, science, engineering and other fields to visit the ISI. These visitors included K.A. Fisher, Harold Hotelling, Frank Yeatts, A.N. Kolmogorov, Herman Wold, J.B.S. Haldane, Simon Kuznets, Paul Baran, Joan Robinson, Jan Tinbergen, Michael Kalecki, Nicholas Kaldor, David and Ruth Glass, A. Edwin Harper Jr, and J.K. Galbraith.

Mahalanobis saw these visits as an alternative to Indian graduates travelling abroad for advanced study. As he explained to students, 'Where would you go? Will you ever be able to come within miles of R.A. Fisher or Frank Yates?' [1, p.329] He was broad in his affiliations, becoming a Fellow of the Royal Society in the UK, an honorary member of the Academy of Sciences in the USSR, and an honorary member of the American Academy of Sciences [1, p.331].

Mahalanobis first met Wiener during a visit to Cambridge, Massachusetts, in February 1953. In June that year he wrote a letter organising a visit which he concluded, 'I have been trying for many years to have you with us in India.' [1, p.304] Wiener visited briefly that year as part of a broader Indian visit. Mahalanobis then organised a further extended visit in 1955, for which ISI was the primary host. Wiener stayed for seven months, delivering nearly 60 lectures from September 1955 to March 1956 on Ergodic Theory, Generalized Harmonic Analysis, the Hopf-Wiener Integral Equation, Prediction in Single Time Series, Multiple Predictions, Non-linear Predictions, and topics of special interest. These visits were significant for both Wiener and ISI.

Within two years of the publication of Cybernetics, April 1950, Mahalanobis had presented a cybernetic view of statistics for planning. [1, p.208] He also pointed to the Shewhart Control Chart as 'the earliest example of a feed-back or a Cybernetic System based on statistical principles.' [1, p.285] Mahalanobis engaging with a cybernetic approach was not surprising, as he had a habit of drawing on all relevant trends in technology. Applying it to planning, however, it is interesting to note that while the Soviet Union was a major source of planning theory, during this period cybernetics as a field was proscribed in the Soviet Union. [15]

After his first, 1953, visit Wiener wrote: 'As in the case of my earlier experiences in China and Mexico, so in my Indian trip my motive was more than restlessness or idle curiosity. More and more Indian authors are publishing in our scientific journals, and we need the Orient more and more to supplement a West which is showing the intellectual and moral enfeeblement following two World Wars.' [8, p.339]

The second of Wiener's two-volume autobiography concludes with a description of his 1953 visit, during which he stayed for a week at ISI. He describes collaborative work with Pesi Masani, who would later edit Wiener's four-volume collected works. 'When I went to India I had already been at work on the problem of prediction of multiple time series such as, for example, the weather at two or more points. This led to a certain formal mathematical problem in factoring what are known as matrices. I thought that I had a complete solution of the problem already, but when I spoke to Masani, he showed me that the question should be conceived in a larger way than that in which I had conceived it and that there remained much to be done.' [8, p.352-3]

Wiener's second visit made a significant contribution to the work of ISI colleagues. Ghosh et al [3] describe one case: 'Exposure to Wiener's prediction theory, generalized harmonic analysis and chaos expansion changed the directions of Kallianpur's research which culminated in the now-famous Kallianpur-Striebel function space version of Bayes formula and foundations of the theory of optimal filtering in the context of stochastic differential equations.' [3, p.26]

Masani [10, p.193] provides an example of the work that Wiener himself was able to achieve during his stay. Wiener completed work on a prediction theory, 'the Kolmogorov-

Wiener theory in its systematized multivariate version, which was worked out during Wiener's visit to the Indian Statistical Institute in 1955-1956'.

For Wiener the visit reinforced his beliefs about the importance of Asian scholars on the world stage: 'I have never felt the advantage of European culture over any of the great cultures of the Orient as anything more than a temporary episode in history, and I was eager to see these extra-European countries with my own eyes and to observe their modes of life and thought by direct inspection.' [8, p.182] He stated this more generally: 'With my wide acquaintance among scholars of many races and many countries, I had not been able to discern that scientific ability and moral discipline were the peculiar property of those of blanched skin and English speech.' [8, p.301]

From the history of these two figures, we can see the some commonalities including:

- The importance of technical education: Wiener and Mahalanobis made substantial contributions to technical education and institution building.
- Support for Indian development: Mahalanobis placed a significant emphasis throughout his life on assisting the development of India. Wiener's own activities supported this view.
- An enthusiasm for the practical application of mathematics: Wiener saw mathematics as a way to state the essential and bury the inessential [16] Mahalanobis put his view in these words: 'I will not support anybody working on problems of aero-navigation in viscous fluid.' [1, p.429]

Wiener's visit met the goal that Mahalanobis sought from his ambitious visitors program: Bringing a world-famous scientist, mathematician and engineer who could directly communicate with ISI's staff and students

V. SHARED INTEREST IN TECHNOLOGY FOR SOCIETY

India's first post-Independence prime minister, Jawaharlal Nehru, spoke and wrote on challenges of science and technology adoption in India. In his view industrialization 'gives rise to new problems and difficulties, but it also shows the way to overcome them.' In 1958 he wrote, 'I do not see any way out of our vicious cycle of poverty except by utilizing the new sources of power that science has placed at our disposal.' [1, p.229]

One reason suggested for ISI's success under Mahalanobis is that the field of statistics was at an early stage as ISI was developing, with India following the UK but preceding the US. As a result the Indian school of statistics could develop with its own mix of theory and application [3]. As examples earlier in this paper show, Mahalanobis was able to influence the development of the field of statistics globally.

In 1999, Ghosh et al [3] wrote that 'the policies advocated by Mahalanobis helped in India's rapid post independence industrialisation'. I am not considering the economic reforms of 1991, under which there were extensive changes to previous industry protectionism. For the purpose of this paper it is worth noting, however, that the companies which today provide major IT services such as Infosys and Tata Consulting Services were established during this period of industrial protection.

Wiener shared an interest in assisting India's development. However, he had concerns for the path that this development would follow.

After a 1953 visit to Delhi he wrote that 'The unchecked growth of a nineteenth-century factory system is already making the outskirts of the great city into an unlovely hybrid of Indian famine and Manchester drabness.' This led him to consider the problem of employment and Indian industrialization. While he described Indian scientists as the intellectual equals of those in any country, he was concerned at an absence of a class of skilled technicians, 'the non-commissioned officers of science and technology', who were much more difficult to recruit. Beyond he saw a huge supply of unskilled and not very efficient labor, making the country 'susceptible to a devastating proletarianization of even worse character than that which took place in England under the early days of the industrial revolution'.

In the face of this he hoped that advanced industrial technology would provide India an alternate path of development. 'The automatic factory makes its demands on human efforts not at the bottom but at the very high level of the scientist-engineer and at the relatively high level of the small group of highly skilled trouble shooters and maintenance workers. It is quite in the cards that India can supply both of these within a matter of decades, while it can not supply a large group of fairly skilled factory workers able to earn enough to maintain themselves in a half-decent life for a large part of a century.' [8, p.354-6]

Wiener wrote, 'I am told that Nehru is interested in thinking out the possibilities of this alternative path to industrialization. [7, p.356] Government investment from the early 1950s included the creation of Indian Institutes of Technology, along with other institutions which provided a substantial source of graduates, laying the basis for India's current skill set.

Mahalanobis and Wiener reflected on the impact of their own approach. While supporting government funding for scientific and technical institutions Mahalanobis had a strong dislike of bureaucracy: 'My struggles have been mostly against a machine which is impersonal, and incapable of responding to changing needs.' [1, p.202]. For Wiener, while his work laid the basis for factory automation and many technologies we see in the 21st century, he was the first to call attention to both negative and positive impacts of these. His warnings about the effect on employment through automation were popularized as the subject of science fiction writer Kurt Vonnegut's first novel, *Player Piano*.[17]

VI. CONCLUSION

Wiener's engagement with ISI at the initiative of Mahalanobis showed a confluence of interest of two important figures in the application of technology who grew up in the first half of the 20th century. Wiener's approach to the importance of diverse sources of thinking gave him a reason for responding to Mahalanobis's project to introduce Indian students to some of the leading minds of the day.

Further, the similarities of their views on applying technology to social challenges provided the basis for a productive and continuing exchange between the two.

During research for this paper I was unable to find a detailed history of modern Indian technology capability during the second half of the 20th century, although Mahalanobis himself provided a description of the connection he saw between technology and development [18]. It would therefore be speculative to estimate the extent of Wiener's influence on this development. Nevertheless, some elements are clear.

Indian policy of the time under Nehru emphasized nation building. Wiener saw alternative paths of Indian industrial development. Within Nehru's general promotion of science and technology to encourage Indian development, Wiener argued for a particular path. He warned of a dependence on smokestack industrialization, and argued for an approach which would see India develop key technical personnel within 'a matter of decades'. At the time of his visits to India such a workforce didn't exist. By the end of the century India had taken a leading place in providing these services to the world.

There is significant opportunity for further development of knowledge in this field. While there are some excellent histories of technology development in India since independence, particularly the Rudra biography of Mahalanobis, in preparing this paper I was not able to locate any significant body of literature on the growth of advanced Indian technological capacity. In particular, I was not able to locate a documented history of the Indian Institutes of Technology or other relevant institutions that would provide a general view of what assisted or hindered the growth of current capacity. This would appear to be a fruitful field of research for a student of technology history.

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