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Planning for science and technology in China and India

JAHNAVI PHALKEY* AND ZUOYUE WANG**

Abstract. Planning for science and technology was a global phenomenon in the mid-twentieth century. A few countries drew up comprehensive five-year plans adapting from the Soviet model: China and India were two new developing countries to do so. In this paper we examine the early efforts at national planning for science and technology as seen in the Chinese twelve-year science and technology plan (1956–1967) and the five-year (1974–1979) science and technology plan of India. These are two historically distinct moments globally and two separate attempts specifically. What tie them together are the goals both sought to accomplish: of science- and technology-led industrialization and development, many times in comparison and sometimes in competition with each other. We show that these two incomplete exercises show us the complex histories of institutions and processes that confirm state-led faith in and engagement with science and technology.

In late 1954, John Desmond Bernal, the British physicist and Marxist, was invited to Beijing by the Chinese Academy of Sciences to participate in the fifth anniversary of the founding of the People's Republic of China, and to conduct an extensive review of its scientific institutions. There, amidst the festivities, he met Prime Minister Jawaharlal Nehru of India, whom he had known from the latter's Cambridge days and who now invited him to revisit India to review its scientific progress. Inevitably, he was asked to compare the status of science in the two major Asian neighbours at the end of his stay in India. 'Science progress in India, though good, was not fast enough as compared to China', he ventured. Was it due to the different political systems? Bernal thought not completely: both had mixed economies but in China the government was in control while it was not clear who was in control in India.[1] Four years later, Bernal might have noticed that within the space of a few months, two

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1 Andrew Brown, *J.D. Bernal: The Sage of Science*, Oxford: Oxford University Press, 2005, pp. 392–399, esp. 399.

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visions for science- and technology-driven development found expressions in both India and China. On 4 March 1958, the Indian government under Nehru passed a Science Policy Resolution which called for the modernization of science, technology and education in India. Specifically, it foresaw the possibility that enhanced scientific training could lead to the build-up of 'skills which can be exported in return for raw materials'.[2] Three months later, on 3 June 1958, the official newspaper of the Central Committee of the Chinese Communist Party under Chairman Mao Zedong published an editorial on its front page entitled 'March on a technological revolution'. It stated that the Chinese revolution had entered 'a new historical epoch' marked by 'a technological revolution and cultural revolution'. It called for the building of 'a great socialist country with modern industry, agriculture and science and culture', and the editorial envisioned an industrialized China 'with chimneys of factories dotting towns and cities, big and small, all over the country'.[3]

In this paper we examine the early efforts at national planning for science and technology that were closely connected with these policy pronouncements in 1958 in India and the People's Republic of China (PRC): the series of Chinese national science and technology plans starting with the Chinese twelve-year science and technology plan formulated in 1956 and the lead-up to the five-year science and technology plan of India launched in 1973. These are two historically distinct moments globally and two separate attempts specifically. What tie them together are the goals both sought to accomplish: of science- and technology-led industrialization and development, many times in comparison and sometimes in competition with each other. By the end, we hope to show the merits in juxtaposing these two incomplete exercises to understand the complex histories of state-led faith in and engagement with science and technology in the two countries. As Bernal implied, India and China shared both obvious similarities – large populations, rich pasts and developmental aspirations – and dramatic differences, especially in terms of their political systems and their geopolitical international environments during the Cold War. Widely recognized as two rising powers in science, technology and economy challenging the dominance of the United States and Europe in these areas in the twenty-first century, it is important to better understand their historical trajectories that linked their science-planning and other early nation-building programmes to their progress in recent years.[4] Together it is hoped that such comparative studies will enrich our vocabulary in the history of science and technology and in the history of development, and extend our archives for Cold War history as well as twentieth-century transnational history.

2 'Science Policy Resolution 1958', at https://web.archive.org/web/20130116025514/http://dst.gov.in/stsysindia/spr1958.htm, accessed February 2016.

3 'Xiang jishu geming jinjun' (March on a technological revolution), *Renmin ribao* (*People's Daily*), 3 June 1958, p. 1.

4 For a recent discussion of the rise of India and China in the context of international science see, for example, Jon Agar, *Science in the Twentieth Century and Beyond*, Cambridge: Polity Press, 2012, pp. 509–516.

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War, independence and planning in India

There was a rather long lead into the first (and only) science and technology plan in India formulated in 1973. Given the discussions on the place of science in nation building at Independence, and the energetic pursuit of planning otherwise, one could argue that the science and technology plan perhaps came much later than one could have expected.[5] While there is no easy explanation for this delay, the process leading up to the plan nonetheless is interesting and suggests some clarifications that require further study. The plan's implementation was to fall within a period of deep political turmoil and discontinuity and is illustrative of the deep divisions in the thinking on science and technology in India after Independence.

The debate on state-led organization of science and technology began in earnest in late imperial India. The National Institute of Sciences of India (NISI) met in Calcutta during the Second World War (1943) to discuss the following questions: 'how should the war time infrastructure in science and technology be assimilated for peace time civil organisation; what should be the organisational model for science and technology adopted for post-war and independent India; and how should India benefit from the Commonwealth structure?' The NISI suggestion was to have a central organization only for the disbursement of research grants but not to set research priorities. Around the same time, the British physiologist and secretary of the Royal Society, Archibald Vivian Hill, visited India with the view to bring Indian science and technology into the war effort. In his report at the end of the visit the following year, he suggested – in contrast to NISI – a centralized state-led organization of science and engineering research.[6] Bracketing these two hotly debated proposals were the Indian National Congress-led National Planning Committee (1938) on the one end, and, on the other, Vannevar Bush's *Science: The Endless Frontier* (1945), both seen as events of significant importance by the Indian science community.[7]

Planning for the coordination of research and development of natural resources was not a new idea in India in 1945. It had been in progress for the previous seven years in two ways. Following the Government of India Act (1935) that allowed for provincial autonomy on the Indian subcontinent, the newly elected provincial government led mainly by the Indian National Congress established a National Planning Committee (NPC, 1938) comprising twenty-four subcommittees.[8] The Soviet experiment, Meiji

5 See Robert S. Anderson's comprehensive mapping of the science establishment in India in *Nucleus and Nation: Scientists, International Networks and Power in India*, Chicago: The University of Chicago Press, 2010; see also the last chapters in Gyan Prakash, *Another Reason: Science and the Imagination of Modern India*, Princeton, NJ: Princeton University Press, 2000; and David Arnold, *Science, Technology and Medicine in India*, Cambridge: Cambridge University Press, 1999. For planning and development see Benjamin Zachariah, *Developing India: A Social and Intellectual History, 1930–1950*, New Delhi: Oxford University Press, 2005.

6 Jagdish Sinha, *Science, War and Imperialism: India in the Second World War*, Leiden: Brill, 2008, pp. 52–53; and Jahnavi Phalkey, *Atomic State: Big Science in Twentieth-Century India*, Delhi: Permanent Black, 2013, pp. 61–64.

7 Phalkey, op. cit. (6), pp. 66–76.

8 The National Planning Committee comprised twenty-four subcommittees on Rural Marketing and Finance; River Training and Irrigation; Soil Conservation and Afforestation; Land Policy, Agricultural

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Japan and the American New Deal were looked at as accomplishments of planning. The physicist Meghnad Saha hoped that the NPC would provide for India something like Sun Yat-sen's *San Min Chu I* (Three Principles of the People) in China.[9] Saha believed that Sun Yat-sen had replaced Confucius in the minds of the Chinese masses, and even if it was only partially successful, this had strengthened their resistance to Japan.

Even though the NPC significantly drew upon the energies of scientists and engineers, it is now seen rather as a precursor to the Planning Commission of India (established in 1950) than to any science plan. The roots of this development may partially lie in the scientists' perception of their role in planning: Meghnad Saha summarized the representation of the National Institute of Sciences of India to the NPC:

> In the representation from the National Institute of Sciences we have therefore insisted on the necessity of separation of the two functions: of the industrial and scientific research and of industrial planning and development. I, as a scientific man, do not wish to take upon myself the responsibilities for which I am not fitted. Let it be thrown on the political and industrial leaders.[10]

With the outbreak of war and the intensification of the demand for self-rule, part of the Congress leadership was in prison. As a result, the work of the NPC was slowed down. However, planning towards the war effort – which Archibald Vivian Hill had set in motion – would soon begin to absorb the capacities of a section of the scientists and engineers involved with the NPC. The Council of Scientific and Industrial Research (CSIR, 1942) was established with the intensification of the war effort on the Eastern Front to include industrialists – like Tata House – scientists and engineers, and bureaucrats of empire. A couple of years later, an Industrial Research Planning Committee (1944) was created with only Indian scientists, engineers and industrialists, unlike the previous boards and committees whose members were primarily British.[11] These structures established for war effort became the institutions and mechanisms to inform and shape free

Labour and Insurance; Animal Husbandry and Dairying, Horticulture and Fisheries; Crops – Planning and Production; Rural and Cottage Industries; Power and Fuel; Chemical Industries; Mining and Metallurgical Industries; Manufacturing Industries; Industries Connected with Scientific Instruments and Engineering Industries; Labour, Population; Trade – Internal and Foreign; Public and Industrial Finance; Currency Exchange and Banking; Insurance – Individual and Social; Transport – Road, Rail, Air and Water; Communications – Post, Telegraphs, Telephones, and Radio; National Housing; Public Health; Education – General and Technical; and finally Women's Role in the Planned Economy.

9 Meghnad Saha to Jawaharlal Nehru, 7 October 1938, Saha Papers, Nehru Memorial Museum and Library.

10 Meghnad Saha to Shanti Swarup Bhatnagar, 29 March 1940, Saha Papers, Nehru Memorial Museum and Library.

11 Between July 1940 and December 1943 the following twenty committees were constituted under the CSIR: Glass and Refractories Committee; Electrochemical Industries Committee; Industrial Fermentation and Biological Products Committee; Dye-Stuffs Committee; Fuel Research Committee; Vegetable Oils Committee; Cellulose Research Committee; Heavy Chemicals and Chemical Industries Committee (Including Fertilizers and Salts); Pharmaceuticals and Drugs Committee; Plastics Committee; Atmospheric Research Committee; Essential Oils Committee; Metals Committee; Internal Combustion Engines Research Committee; Distillation and Other Chemical Plants Committee; Applied Physics Committee; Radio Research Committee; Statistics, Standards and Quality Control Committee; Leather Research Committee; Building Research Committee.

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India's science and engineering infrastructure and, eventually, the first science plan – but that would come only two and a half decades later.

The National Institute of Sciences of India recommended in 1943 the establishment of a National Research Council 'outside the control of official government machinery but accountable to the Government of India'.[12] The work of this council would be dominated by scientific institutions like the universities and research laboratories, 'to plan the main lines of scientific work in accordance with national needs; to ensure balanced development of all branches of science, and prevent duplication; to advise relevant authorities regarding the training and supply of scientific personnel for pure and applied research'. Not all agreed. Mokshagundam Visvesvaraya – briefly chair of the National Planning Committee – saw merit in the organization of a National Council of Industrial Research instead of a general council coordinating scientific research.[13]

Hill's suggestion could not have been further from the recommendations of NISI. He suggested the establishment of a centralized Department of Planning and Development within the British Government of India that would coordinate all scientific and industrial research, and the concentration within it of all executive powers. Hill included the NISI suggestion for a National Research Council and its various boards, but this would not be an autonomous body as NISI had suggested. Shanti Swarup Bhatnagar, the physical chemist leading the wartime science effort in India, agreed with Hill's suggestion. As a result, the wartime CSIR became the foundation for the organization of science research in India after Independence. There were disagreements within the Indian science community, but the disagreement was not centred on the idea of planning; it was instead focused on what kind of organization would draw up the plan for the futures of the national and university-based laboratories.

Vannevar Bush's *Endless Frontier* was published at about the same time as these debates were raging in India: this was – globally – the moment to dwell upon the nature of the relationship between science and the state after the scientific war effort during the Second World War that had nearly completely recast the terms on which this discussion could be conducted. Meghnad Saha had in fact met Bush in the United States (in 1944): 'We met Dr Vannevar Bush, the erstwhile MIT electrical engineer, who handled the fine wartime organization of scientists and technicians known as OSRD [Office of Scientific Research and Development], having a budget larger than

12 'Proceedings of the National Institute of Sciences of India' (1944), p. 10, The volume contains papers from the symposium of 27–28 September 1943 held in Calcutta. See V.V. Krishna, *S.S. Bhatnagar on Science, Technology and Development, 1938–54*, New Delhi: Wiley Eastern Ltd, 1993, pp. 13–15.

13 NISI further suggested that the National Research Council be organized under four boards – Board of Scientific Research, Board of Agricultural Research, Board of Medical and Public Health Research and Board of Engineering Research – all of which would organize research committees in turn to inform research in the national laboratories. On Visvesvaraya see Mokshagundam Visvesvaraya, *Reconstructing India*, London: P.S. King & Son Ltd, 1920; Visvesvaraya, *Planned Economy for India*, Bangalore City: Bangalore Press, 1934; Visvesvaraya, *Nation Building: A Five Year Plan for the Provinces*, Bangalore City: Bangalore Press, 1937; Visvesvaraya, *Reconstruction in Post-war India: A Plan of Development All Round*, Bombay: The All-India Manufacturers' Organisation, 1944. His appreciation for ultra-nationalist reconstruction was not exceptional; many in India among the nationalist leadership viewed Japanese, Italian and German governments of the interwar period favourably.

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that of peace-time Government of India'.[14] In his continuing arguments about the organization of science in free India, Saha referred in great detail to Bush's report, where the idea of a National Research Foundation was first broached, consisting of national official scientists with an elected chairman, which was to be entrusted with

> the development and promotion of a national policy for scientific research and scientific education, the support of basic research in non-profit organisations, development of scientific talent in American youth by means of scholarships and fellowships, with the support of long range research on military matter by means of contract or otherwise.[15]

The debate in India was settled in favour of the Hill–Bhatnagar model. A Department of Planning and Development was created (August 1944) and the Council for Scientific and Industrial Research (CSIR) was brought under its control.[16] On the recommendation of Hill and of a further appointed Industrial Research Planning Committee, a national laboratory system was created under the CSIR.[17] While the CSIR laboratories continued to expand, the department wound up in a short span of two years:

> Somehow, the department was under the idea that its function was not confined to only planning, but extended also to include the execution of those plans [development]. It was this idea which brought the department into direct conflict with other departments of the Government of India as each of them felt that their sphere of activity were to be very much curtailed and they were going to be bossed by a Superdepartment.[18]

There appears to have been no clear deliberation or agreement on what planning was about: was it to provide strategic direction or was it about planning specific projects? A scientific and industrial research system integrated into centralized planning for development of the new country, it appeared, was not going to work. Another attempt at renewal of this idea would not be taken up for another two and a half decades.

In the meanwhile, the institutional and research infrastructure for science and engineering education, as well as research, grew exponentially in India after Independence. Under the Nehru regime, the CSIR grew into a national laboratory system with Bhatnagar at the helm for the first ten years. The number of laboratories grew from four to sixteen.[19] The government employed a 'large majority' of scientists and engineers in the country.[20] By the

14 Meghnad Saha, 'Experience as a member of the Indian Scientific Mission – 1946', in *Collected Works of Meghnad Saha*, vol. 4 (ed. Santimay Chatterjee), Delhi: Orient Longman, 1993, pp. 489–504, 496.

15 Meghnad Saha, 'Department of Scientific Research' (1948), *Science and Culture* (1993) 14, p. 155. See also Editorial, *Journal of Scientific and Industrial Research* (1947) 6(12), p. 1.

16 A Scientific Consultative Committee was also established (December 1944) to advise the department and the government on matters of science policy. See Editorial, 'A central organisation for scientific research', *Journal of Scientific and Industrial Research* (1945) 3(9), pp. 382–383.

17 Four laboratories were recommended: the National Physical Laboratory, the National Chemical Laboratory, the National Metallurgical Laboratory and the Central Glass and Ceramic Institute. In addition, a National Trust for Patents and a Bureau of Standards and Specifications were also established.

18 Editorial, 'National Research Council', *Science and Culture* (1947) 13, p. 123.

19 M.S. Thacker took over following Bhatnagar's death in 1956; he left for the Planning Commission in 1962 and was in turn was succeeded by Hussain Zaheer. This close nexus with the Planning Commission would continue until the mid-1970s.

20 Baldev Raj Nayar, *India's Quest for Technological Independence*, vol. 1: *Policy Foundation and Policy Change*, New Delhi: Lancers, 1983, p. 439.

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mid-1960s, the CSIR was under the Ministry of Education.[21] In keeping with the logic of centralization, other departments governing science and engineering also emerged. A Department of Atomic Energy (DAE) was set up on 3 August 1954 under the direct charge of the prime minister through a presidential order. The physicist Homi Jehangir Bhabha was appointed secretary of the DAE.[22]

Only a year later, two international meetings showcased the relationship between China and India: Atoms for Peace at Geneva and the first meeting of the Non-aligned Movement in Bandung. In February 1955 the Soviet Union had accepted an Indian foreign policy of non-alignment, Indian foreign policy was supportive of Communist China, and the Bandung Conference was planned for later that year. Jawaharlal Nehru and Homi Bhabha came to be seen as the politically acceptable face of Asia.[23] The PRC was important to them both but this was short-lived. Following the announcement of the Bandung conference,

> India's Jawaharlal Nehru was the busiest man in London last week. Britain's Anthony Eden wooed him, Burmese and Indonesian envoys sought him out. Communist China's chief representative conferred with him twice. So did U.S. Ambassador Winthrop Aldrich, who got the full treatment on the 'Asian' view of Formosa, featuring Red China's indisputable right to Formosa and the U.S.'s 'interference' in Asia's affairs … By default all hopes centred on Jawaharlal Nehru. The question was whether his intervention would do more harm than good. He was insisting that Red China's ultimate right to Formosa must be recognised first …[24]

The PRC was provided its first international forum and the first regional endorsement of its legitimate statehood in Indonesia, at the Bandung Conference in April and May 1955. The Atoms for Peace conference took place in Geneva three months later. Homi Bhabha was invited to preside over the meeting. His choice as president of the meeting could also be seen as a reflection of taking Nehru's India seriously. Bhabha's presidential address to the conference contained two unexpected statements that caused surprise. One concerned nuclear fusion. In the other, Bhabha regretted, on Nehru's behalf, the exclusion of Communist China: 'It is a matter of regret', he said, 'that there are several areas of the world which are not directly represented at this Conference'.[25]

21 It was not always the case that the CSIR fell under the Ministry of Education. Its location moved thus: under the Department of Scientific Research established in 1948; in 1951 this became the Ministry of Natural Resources and Scientific Research; in 1957 the ministry was merged to form a Ministry of Education and Scientific Research, which within a year led to a Ministry of Scientific Research and Cultural Affairs (1958). In five years this too was merged into the Ministry of Education, with a further dissolution of the Department of Scientific Research. This was the state of affairs in 1970.

22 As chair of the Atomic Energy Commission of India (AECI), and secretary (DAE), Bhabha was responsible for the following institutions: the Tata Institute of Fundamental Research, the Rare Minerals Survey Unit and Indian Rare Earths Limited, and finally also for reactors built and purchased by the AECI. See Anderson, op. cit. (5), Chapters 11 and 14; Phalkey, op. cit. (6), Chapter 5.

23 On 8 February 1955, Foreign Minister Molotov of the USSR accepted Nehru's (and Zhou Enlai's) *Panch Sheel* – the five principles of non-alignment to be followed in Indian foreign policy. See Zachariah, op. cit. (5), pp. 214–252, esp. 216.

24 'The man between', *Time* magazine, 14 February 1955 available at www.time.com/time/magazine/article/0,9171,807012,00.html, accessed 6 April 2016.

25 For an analysis of Bhabha's speech see Itty Abraham, *The Making of the Indian Atomic Bomb: Science, Secrecy and the Postcolonial State*, New Delhi: Orient Longman, 1998, pp. 98–106.

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The ties between the two countries were, however, not those of strong allies. There was an uneven exchange of ideas and personnel with an inbuilt sense of competition and, therefore, a considered lack of trust.[26] The physicist–statistician Prasanta Chandra Mahalanobis was one of the main architects of India's Second Five Year Plan; he and his colleagues became aware of a Chinese science and technology plan – to which we will return later. Only two years after Geneva and Bandung, Mahalanobis asked to see the science and technology plan on a visit to China in 1957. The Chinese held that statistical data and the plan, apart from its most general announcement, were secret. He was denied access.[27]

In the same year that the Chinese science and technology plan was formulated, an Industrial Policy Resolution (April 1956) was launched in India. The Industrial Policy Resolution (IPR) was aligned closely to the Directive Principles of State Policy – a section of the Indian Constitution that articulates the moral duties of the Indian state towards its citizens: 'The State shall strive to promote the welfare of the people by securing and protecting as effectively as it may a social order in which justice, social economic and political, shall inform all the institutions of national life.'[28] Planning was being pursued in India with great enthusiasm following the establishment of the Planning Commission of India (1951). Industrialization and agriculture took priority in turns, and science and engineering were integral to the plan. The IPR was drawn up in consultation with the Planning Commission, and brought the moral obligations of the Indian state together with the ideological commitments articulated in the first decade of independence:

> These basic principles were given a more precise direction when Parliament accepted in December 1954 the socialistic pattern of society as the objective of social and economic policy … In order to realise this objective, it is essential to accelerate the rate of economic growth and to speed up industrialisation and, in particular, to develop heavy industries and machine making industries, to expand the public sector, and to build up a large and growing cooperative sector … Accordingly, the State will progressively assume a predominant and direct responsibility for setting up new industrial undertakings …[29]

Two years later (March 1958), a Science Policy Resolution (SPR) was approved by Parliament. Scholars have claimed that Homi Bhabha wrote the document and persuaded Nehru to consider adopting it.[30] The SPR was first discussed by the Scientific Advisory Committee to the Cabinet (SACC) and among its members was Mahalanobis – who was aware of the Chinese plan.[31] However, it is difficult to say if

26 See Arunabh Ghosh, 'Accepting difference, seeking common ground: Sino-Indian statistical exchanges 1951–1959', in this volume.

27 Arunabh Ghosh, 'Making it count: statistics and state–society relations in the early People's Republic of China, 1949–1959', PhD dissertation, Columbia University, 2014, p. 314.

28 Industrial Policy Resolution, 30 April 1956, at http://eaindustry.nic.in/handbk/chap001.pdf, accessed March 2016.

29 Industrial Policy Resolution 30 April 1956, at http://eaindustry.nic.in/handbk/chap001.pdf, accessed March 2016.

30 Anderson, op. cit. (5), pp. 254–257.

31 The other members of this newly constituted committee were the physicist K.S. Krishnan, director of the National Physical Laboratory; the electrical engineer M.S. Thacker, who succeeded Bhatnagar as director of the

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this was even marginally triggered by the launch of the Chinese plan. The resolution was a brief document and not a substantial one that resonated ideas already expressed in the IPR: 'the wealth and prosperity of a nation depended on the effective utilisation of its human and material resources through industrialisation'.[32] This effective utilization called for education in science and training in technical skills; 'Science and technology can make up for the deficiencies in raw materials by providing substitutes, or, indeed, by providing skills which can be exported in return for raw materials.'[33]

While the IPR was expected to help launch a robust industrial public sector, the SPR could shape education and teaching in science and engineering. As a result, political leadership and SACC called for the First Conference of Scientists to address the growing gap between state-funded scientific research in the national laboratories and the universities. The conference, Robert S. Anderson argues, was to build a constituency for the resolution's implementation – and, crucially, to discuss the objectives of the resolution also with cabinet ministers.[34] The most challenging of goals was to create a pool of trained scientists, engineers and technicians and to create jobs they could keep. Improved salaries and new textbooks were among the recommendations of the conference. While some expressed concern over the missing mention of 'technology' in the resolution's goals and rather a specific focus on science, the conference informed the establishment of regional engineering colleges and polytechnics alongside the rather well-funded Indian institutes of technology. A comparable crop of institutions dedicated to science education was not to be seen until well into the twenty-first century.

As the decade grew to a close, the Chinese had begun distancing themselves from the Soviet Union. India's engagement with the Soviet Union, on the other hand, was growing.[35] The Indian relationship with China, though, took a nosedive as they went to war over territory in the Himalayas (1962). Nehru was not prepared for this attack, although his surprise was not convincing to his colleagues; nor is it to scholars today.[36] The physicist S. Bhagavantam, science adviser to the Defence Research and

CSIR; the physicist Daulat Singh Kothari, who chaired the Defence Research and Development Organisation; B.P. Pal of the Indian Council of Agricultural Research; and the physician C.G. Pandit of the Indian Council for Medical Research.

32 'Science Policy Resolution', op. cit. (2).

33 'Science Policy Resolution', op. cit. (2).

34 Anderson, op. cit. (5), p. 256.

35 The Indian delegation was invited to visit the Soviet Union at the Atoms for Peace meeting in Geneva. Khrushchev and Bulganin visited India in February 1960, and were given a tour of the Tata Institute of Fundamental Research. Bhabha also led an Indian delegation to the Soviet Union in the summer of 1960. In February 1961, Bhabha announced that the Soviet Union had agreed to build a reactor for India. In a public statement, Bhabha mentioned inspections required by the IAEA for reactors coming in from the USA as an 'infringement upon Indian sovereignty'. Since the Soviet Union was not a member of the IAEA and 'hailed the opposition of India and other non-aligned Afro-Asian nations to IAEA controls over their nuclear development programs', not going to the Americans, Bhabha claimed, appeared agreeable to both the Indians and the Soviet Union. An Indo-Soviet agreement was signed on 7 October 1961. *The Hindu*, 3 February 1961; *The Statesman*, 7 October 1961, quoted in Arthur Stein, *India and the Soviet Union: The Nehru Era*, Chicago: The University of Chicago Press, 1969, pp. 180–182.

36 Srinath Raghavan, 'The fifty year crisis: India and China since 1962' in 'India 2012', *Seminar* (January 2013) 641, at www.india-seminar.com/2013/641/641_srinath_raghavan.htm.

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Development Organisation (established 1948), was worried that 'defence is mentioned only once in the Science Policy Resolution … and such an imbalance should be corrected. We cannot separate scientific output into water-tight compartments, separating defence laboratories from universities and civilian laboratories'.[37] Within two years, the Chinese had conducted their nuclear tests (1964). Exactly ten years after John Desmond Bernal concluded that the Chinese were ahead of the Indians, Patrick Maynard Stuart Blackett, science and defence adviser to Jawaharlal Nehru, informed Hussain Zaheer, director of CSIR, that the Chinese were far advanced in electronics.[38] Zaheer agreed with Blackett. However, the problem lay not in the underdevelopment of the electronics laboratories: 'The bigger issue at stake was not simply electronic instruments for researchers or electronic engineering for military systems, or even consumer electronics; the bigger issue was the supply and delivery of electricity itself.'[39]

At the same time as scientists were struggling to isolate bottlenecks and problems of development, these events opened the question of nuclear capability to public debate for the first time in India. The following circumstances were important to the terms of the debate: Nehru died the same year as the Chinese nuclear tests. Only a year later, India and Pakistan went to war (1965). The key scientist–administrator of matters nuclear in India, Homi Bhabha, died in the year Indira Gandhi assumed political leadership of the country (1966). India, at the launch of Indira's regime, faced a near complete change of guard. Her thinking on science policy was inextricable from the debate on the place and purpose of science and engineering in India following the two wars and the Chinese nuclear tests.[40] If defence and economic growth were a priority, the infrastructure for their delivery was fundamental. Her broader vision, however, remained entwined and substantially engaged with that of her father, as articulated in the Science Policy Resolution. Her government questioned the uneven and lagging implementation of the SPR: that discussion would eventually lead to the one and only science and technology plan of India.

A science and technology plan for India

Indira Gandhi became the prime minister of India in 1966. After nearly two decades of her father's regime (with a two-year interlude), it was under her regime that the first science and technology plan of India was designed. Many people whom Jawaharlal Nehru worked with, scientists as well as bureaucrats, were no more. The CSIR held oversight on the allocation of funding for scientific and industrial research through a national laboratory system reporting directly to the prime minister. Scientific and industrial research was completely decoupled from planning by the early 1950s, leaving no direct

37 Quoted in Anderson, op. cit. (5), p. 265.

38 Robert S. Anderson, 'Patrick Blackett in India: military consultant and scientific intervenor, 1947–72, Part II', *Notes and Records of the Royal Society of London* (1999) 55, pp. 345–359; Anderson, 'Patrick Blackett in India: military consultant and scientific intervenor, 1947–72, Part I', *Notes and Records of the Royal Society of London* (1999) 53, pp. 253–273.

39 Anderson, op. cit. (5), p. 273.

40 Srinath Raghavan, 'Indira Gandhi: India and the world in transition', in Ramachandra Guha (ed.), *Makers of Modern Asia*, Cambridge MA: Harvard University Press, 2014, pp. 215–243.

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mechanism for oversight, dialogue or advice between these two sets of institutions, if that were ever thought desirable. This was further consolidated with the establishment of a separate department of atomic energy reporting, again, directly to the prime minister. There was little or no coordination between these institutions.[41] Moreover, they were all removed from university-based research and advanced education. A range of new institutions of 'national importance', including the five Indian institutes of technology, emerged at this time. However, within the emerging science and technology establishment, the link between research and teaching appears to have been broken irreversibly, even if not without regret.[42]

Indira Gandhi inherited, the political scientist R. Natarajan argues, a collection of state-funded laboratories and research institutions that were not linked into industry – public or private; industry, both public and private, heavily depended on imported technology; there were no administrative mechanisms to cost-balance or judge the appropriateness of imported technology; and finally, as we saw above, insufficient numbers of engineers and technicians were able adapt new technologies or to generate them at home. And this is only as far as engineering and technology are concerned – not science. Gandhi addressed what her regime saw as problems by creating new institutions for research and science administration, with scientists and engineers in decision-making positions through expansion of funding for research, including reallocation in some cases; oversight on import of technology and encouragement of R & D in the private sector; and finally the formulation of an explicit technology policy to align economic production with research and development.[43] It is in this context that we can understand the science and technology plan launched in August 1973.

The long 1970s in India witnessed two interlinked crises: a crisis of domestic politics and a global crisis of development. At home, a severe drought in 1966 saw significant reallocation of research budgets to the Indian Council for Agricultural Research (ICAR). This marked the beginning of the state-led efforts towards the Green Revolution: 'Recent events have compelled us to explore the fullest possibilities of technological reliance', said Gandhi.[44]

> It is now our endeavour to rationalize the structure of Indian science and to relate it more closely with the process of planning and development … Growth cannot be sustained on

41 For a comprehensive view on science policy and science institutions see Balwant Bhaneja, *Science and Government, the Nehru Era: Accountability of Science Policy in India*, New Delhi: National Publishing House, 1992; and Ward Morehouse, 'Sarkar and Vigyan: problems and prospects of government and science in India', unpublished manuscript, 1967.

42 Dhruv Raina and Ashok Jain, 'Big Science and the university in India', in John Krige and Dominique Pestre (eds.), *Science in the Twentieth Century*, Amsterdam: Harwood Academic Publishers, 1997, pp. 859–878; Homi J. Bhabha, 'Science and the problems of development', *Science* (1966) 51, pp. 541–548.

43 R. Natarajan, 'Science, technology and Mrs Gandhi', *Journal of Asian and African Studies* (1987) 22, pp. 3–4, 98–115, 99–100. Natarajan finds that the Indian science and technology plan compares globally only to the design reform campaign by the Central Committee of the Communist Party of China (1964). See also Mahesh Rangarajan, 'Striving for a balance: nature, power, science and India's Indira Gandhi', *Conservation and Society* (2009) 7, pp. 299–312.

44 Indira Gandhi, *Selected Speeches of Indira Gandhi: January 1966–August 1969*, New Delhi: Publications Division, 1971, p. 5.

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> borrowed or even adapted technology. True self-reliance can come only as we develop the ability to solve our technological problems.[45]

Technological self-reliance was evoked in the Congress Party Manifesto (1967) and they took it one step further when the party approved a Resolution on Science and Technology (1969) calling for 1 per cent of gross national product (GNP) to be dedicated to research and development. The resolution also suggested making R & D budgets mandatory for the public and private sectors, alongside an increase in the number of scientists and engineers in decision-making positions. Most significantly, the Congress Party resolution called for the establishment of a Ministry of Science and Technology.[46]

Indira Gandhi and the Congress were reasserting their faith in technology to solve India's pressing problems in a language of Cold War geopolitics: technical assistance was available from both the United States and the Soviet Union, as well as the United Nations. At this moment, the student movement worldwide raised morally charged questions about the legitimacy of political conduct, progress and warfare in and around 1968. A strong student movement in India also began to question the government's commitment to ideas of development, progress and modernization as they had failed to deliver on their liberating potential through access to education and employment.[47] General discontent, combined with a crisis of leadership even within the Indian National Congress, led to the first split in the party (1969). The war that created Bangladesh (1971) and the subsequent meltdown of relations with the United States only strengthened Gandhi's election slogan 'Garibi hatao' ('Eradicate poverty' in Hindi) – the campaign emphatically pressed for self-reliance. The making of the science and technology plan as a response to political and institutional crisis: worried about the fragmenting nature of state power amidst growing political unrest, Indira Gandhi and her regime took to restructuring and centralizing in order to bring the diverse agents responsible for a policy area, science and technology included, to speak to a united and systematic agenda.

Government policy on science and technology was also questioned. The majority of India's scientists and engineers were employed by the state and there was internal discontent: Yelavarthy Nayudamma, then director of the Council for Scientific and Industrial Research (1971–1977), described it thus: 'the scientific scene presented an arena of intense controversy, appointment of committees over committees, questioning introspection, discussions, sometimes acrimonious, in and outside the press and Parliament and in

45 Indira Gandhi Abhinandan Samiti, *The Spirit of India*, vol. 1, Bombay: Asia Publishing House, 1975, pp. 205–206.

46 R. Chandidas, Ward Morehouse, Leon Clark and Richard Fontera, *India Votes*, New York: Humanities Press, 1968, p. 7. Incidentally, the United States advised Taiwan, around the same time, to invest 1 per cent of GDP in research and development.

47 Nagindas Sanghavi, 'From Navnirman to the anti-Mandal riots: the political trajectory of Gujarat (1974–1985)', *South Asian History and Culture* (2010) 1, pp. 480–493; Pravin N. Sheth, *Nav Nirman and Political Change in India: From Gujarat 1974 to New Delhi 1977*, Bombay: Vora, 1977; David Hardiman, 'Tribute to Kanu Bhavsar: activist, researcher, therapist', *Economic and Political Weekly* (21 February 2015) 50(8), available at www.epw.in/journal/2015/8/web-exclusives/tribute-kanu-bhavsar-activist-researcher-therapist.html.

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scientific forums on the strategy, organisation and planning of scientific and industrial R & D'.[48] The growth of science in India, Aqueil Ahmad of the Administrative Staff College of India argued, was essentially a 'management problem':[49]

> The initial mistake after Independence was organisational. We started adding large, complex organisations to the existing bureaucratic structure, thus making it even more centralised and complex instead of creating small, homogenous, autonomous, goal-oriented research departments or laboratories where management would have been simpler and the objectives easily identified and readily achievable.[50]

In this climate of self-diagnosed malaise, the existing Scientific Advisory Committee to the Cabinet (SACC) – with advisory oversight but no powers or machinery to address the discontent, or, more immediately, to judge the appropriateness of imported technology – appeared inadequate.[51] In line with the new government's mood to restructure, SACC was dissolved to establish a new Committee on Science and Technology (COST). The new committee had an advisory function, but was also charged with drawing up R & D priorities in consultation with various ministries of the government. In this capacity, COST called for a round table of scientists and technologists (1970); they were far from satisfied with the implementation of the Science Policy Resolution. As a way of addressing that problem, they called for a comprehensive science and technology plan.[52] A new Department of Science and Technology was created under which COST was dissolved to make way for a new National Committee on Science and Technology (NCST) comprising fifteen members and a chair who would also function as the science adviser to the prime minister. The NCST's explicit mandate was to

48 Yelavarthy Nayudamma, 'Developing patterns of industrial R & D culture', *Journal of Scientific and Industrial Research* (1973) 32, p. 271.

49 Aqueil Ahmad, 'Science as a management problem', *Economic and Political Weekly*, 3 August 1968, pp. 1214–1217.

50 Ahmad, op. cit. (49), p. 1214.

51 The inadequacy was highlighted in the third Science Round Table (1970) when Gandhi met with leading scientists and engineers (the previous meetings were held in 1958 and 1963). The Round Table recommended the creation of an additional National Council for Scientific Research as well as the establishment of a dedicated Ministry of Science and Technology. The Administrative Reforms Committee, in the very same year, made equally pointed and controversial suggestions for the reorganization of science administration.

52 Natarajan, op. cit. (43), p. 239. COST proceedings were not without controversy. Two notes of dissent on COST assessment of where R & D in India fell short of implementing goals stated in the Science Policy Resolution were submitted by Homi Sethna of the Bhabha Atomic Research Centre and Kakkadan Nandanath Raj of the *Economic Weekly*; and another by Vikram Sarabhai, chair of the Atomic Energy Commission. Sethna and Raj recalled, 'An earlier draft of the Report had referred to feudalism in this sphere: this to our mind, is the correct description of the values and methods of decision making in evidence in most of these institutions … We believe that unless this issue is directly faced and resolved, much progress cannot be made in the near future.' Sarabhai was brutal: 'Behaviourly [*sic*] our performance clearly indicates that the policy makers at the top, responsible for organisation and commitment of resources for development, do not have an appropriate understanding of the purpose and content of the Science Policy Resolution (1958) and the investments that are required in order to derive returns from the effort … The failure of the Planning Commission in not recognising the meaningful applications of science and technology as investments for national development and for not according appropriate priority for undertaking these tasks.' See 'Proceedings of the Third National Conference of Scientists, Technologists and Educationists', New Delhi, 1971, pp. 261–279.

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recouple science and industrial research with economic development in creating direct links with the Fifth Five Year Plan (1974–1979). Around the same time, at the dedication of the Tarapur Atomic Power Station, Gandhi warned, 'We feel that a country as large as ours, with its rich and variegated technical talent, should work progressively towards self-reliance. Our past experience has been that aid can be stopped at crucial moments.'[53]

What was the science and technology plan of 1974 to 1979? The National Committee on Science and Technology (NCST) was mandated to direct technological change and to ensure that the priorities of development, resource allocation and research were aligned with each other. In order to accomplish this, they were to build strong links to the Planning Commission and the Fifth Five Year Plan on the one hand, and to various ministerial departments, or user ministries, as they were called, on the other. This included the newly created departments of science and technology, of space, and of electronics. Science and Technology, in the spirit of the emerging managerialism of the time, was also a 'management problem'.

Already at inception, there were differences on the purpose of the science and technology plan. Parmeshwar Narayan Haksar, principal secretary to the prime minister (and later deputy chair, Planning Commission) was the voice of those who thought that the government should focus its efforts on key sectors, which should eventually lead to overall improvement (and economic growth). On the other hand, Ashok Parthasarathi, special assistant for science in the prime minister's secretariat, voiced those who argued that science and technology had to be strengthened comprehensively and not selectively. What was clear to both camps was the following: that in the two decades after Independence, a significant expansion of science and technology institutions under various ministries and departments had not led to a system at the national level, a problem that Bernal had identified in 1954. By the early 1970s, this came to be seen as a problem articulated through various claims: that the lack of systematic investment had led to uneven returns; that the lack of system made it difficult to establish funding priorities; and even more so that the lack of system made these institutions difficult to govern, which was untenable in a climate where state power was fragmenting, political leadership faced a crisis of legitimacy, ideas of progress as well as the ability of the state to deliver were in question, and the science establishment was itself in turmoil.

The NCST pulled together a range of institutions and individuals, and with more than 1,800 participating scientists and engineers formulated the plan in less than two years.[54] A draft was opened to public discussion in January 1973 with the publication of the 'Approach to the Science and Technology Plan'. The final plan was released a year later.[55] Twenty-four sectors in science and technology were targeted for their ability to address the 'total overview of the nation's scientific and technological

53 This was also the time when there was tremendous pressure from the United States for the Indians to sign the Non-proliferation Treaty; Indira Gandhi, *The Years of Endeavour: Selected Speeches of Indira Gandhi*, New Delhi: Publications Division, 1975, p. 422.

54 See Balwant Bhaneja, 'India's science and technology plan, 1974–79', *Social Studies of Science* (1976) 6, pp. 99–104.

55 The budget for research and development over five years was estimated at Rs 1725.61 crore and the plan was expected to generate employment for 120,000 scientists and technologists. A crore is a unit in the Indian numbering system equal to ten million.

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needs'.[56] Each sector had a dedicated panel assisted by several working groups; the working groups were primarily responsible for drawing up the specific research and development projects in consultation with user ministries. All effort was directed at synchronizing with the two main stated goals of the Fifth Five Year Plan: to meet the basic needs of the population, and self-reliance. The approach document outlined a third: that of rationalizing policies towards the import of technology.[57]

The NCST sought detailed research proposals from national laboratories and other state-funded research institutions. The projects were to be justified for 'socio-economic impact', 'status of the technology (to be developed or used)', 'requirement for scientific personnel', '(end) users of technology', and finally 'importance of the project'. The working groups, with representative members from the ministries, assessed these projects and the panel eventually decided on projects to be recommended for inclusion in the plan and, therefore, for funding by the Planning Commission. The process, it turns out, was not easy: the Planning Commission, at least according to one contemporary observer, was difficult to please. Apart from suggesting that the NCST had plagiarized the commission's own approach paper to the Fifth Five Year Plan, they also suggested that the science and technology plan itself was a 'large-scale reproduction of another science plan document conceived abroad'.[58] The accusation of plagiarism is not sustained but it is hardly surprising that inter-departmental rivalry and competition for turf between various institutions is exacerbated in the context of systematization, centralization and management from above.

The 'plan conceived abroad' was the World Plan of Action for the Application of Science and Technology to Development released by the United Nations Advisory Committee on Science and Technology in Addis Ababa (3–14 February 1969).[59] This

56 Twenty-seven dedicated panels with 233 working groups were assigned to each of the twenty-four sectors, which included agriculture, heavy engineering, natural resources, marine resources, chemical industries, consumer industries, village and Khadi industries, housing, health, transport, fuel, power etc. The number of working groups varied: heavy engineering had fourteen working groups and village and Khadi industries had only two.

57 In the period leading up to the science and technology plan, foreign exchange was scarce. Three committees reviewed the import of technology between 1966 and 1971, and as a result a Foreign Investment Board was set up (1973) to evaluate the appropriateness of foreign collaborations and imports. See Ghayur Alam, 'India's technology policy and its influence on technology imports and technology development', *Economic and Political Weekly* (1985) 20(45–47), pp. 2073–2080.

58 Bhaneja, op. cit. (54), p. 101. For an overview see 'Science in underdeveloped countries: world plan of action for the application of science and technology to development', report of the Advisory Committee on the Application of Science and Technology to Development, 24 November–5 December 1969. The advisory committee were consultants to the UN and otherwise located at the Institute for Development Studies and Science Policy Research Unit, Sussex (a topic well deserving of its own history). The regional plans set goals for the following development sectors: science policy and planning (creation and expansion of infrastructure for research and development); natural resources; food and agriculture; industry, transport and telecommunications; housing and urban planning; health; education and population. There appears to be no significant resemblance between the two documents – the Indian document carries detailed project plans drawn up by various national laboratories.

59 Vladislav P. Kotchetkov, 'Science and technology policy in the United Nations system: a historical overview', in P. Lorenzano, H.-J. Rheinberger, E. Ortiz and C. Galles (eds.), *History and Philosophy of Science and Technology*, vol. 4, Oxford: EOLSS Publishers Co. Ltd, 2010, pp. 208–232.

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plan began with the Economic and Social Council-organized first United Nations Conference on Science and Technology for the Benefit of Less-Developed Areas in Geneva (1963). An Advisory Committee on the Application of Science and Technology for Development (ACAST) continued the work and released, in 1971, the World Plan of Action. Of the two parts of the plan, the first dealt with areas in which member states felt that science and technology could make a resounding impact. The second was dedicated to science policy, and institutional and educational matters, with greater stress on effective science policy. ACAST, being an advisory body only, was dissolved to make way for a Committee on Science and Technology for Development (CSTD) as a forum to discuss science policy. A further Office of Science and Technology was created within the UN system to plan for the implementation of CSTD recommendations. Three regional plans for Africa, Asia and Latin America set the targets and a number of programmes specifically for each region.

The Indian science and technology plan was thus a product also of an emerging global consensus on the purposeful harnessing of science and technology for development. If the discussions of the 1940s, which included Bernal, who spoke to both the Chinese and the Indian conditions, were focused on science and society, on the social responsibilities of the scientist, then the discussions of the 1970s had taken on board the post-war language of modernization and development and the responsibilities of the state. And this language was specific: if the world had not yet congealed into three tiers in the late 1940s, it was resolutely the case by the 1970s. If the Indian science and technology plan was a response to interlinked domestic and global crises, then those crises were produced by the projects and expectations of development promoted and pursued through Cold War geopolitics. The science and technology plan was both a result of and a response to the very same processes and anxieties.

The anxieties sometimes played out as turf wars and at other times simply made apparent that the mechanisms of coordination were missing for what were assumed to be institutions bound to each other through goals and purposes: the dialogue between temporary planning units set up in ministries proved difficult as the status of these units in relation to the NCST was not clear. Were they partners, service units, subordinate or autonomous (in relation to the NCST) in order to establish research and development priorities for their respective ministries?[60] At the end of the two-year process of drawing up the plan, the Planning Commission still held the authority to allocate resources. It is no wonder that writing the plan was contentious as this was about securing resources and not only about establishing research priorities.

The autonomy given the science and engineering community to determine research priorities was appreciated.[61] However, as Balwant Bhaneja, a political scientist writing at the time, noted, the plan assumed a 'total science and technology system … [with] resources for investment, technology, and managerial efficiency. In a developing country all of these three are either scarce or underutilized'. In 'channelling standardized information into a central body like the NCST, [the plan] has tended to reduce the number of implicit

60 Bhaneja, op. cit. (54), p. 101.
61 Bhaneja, op. cit. (54), p. 100.

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assumptions on which many of the institutions earlier functioned … and provided a lead by introducing a more explicit method of preparation of departmental estimates'.[62] In sum, the political scientist Baldev Raj Nayar argued, the plan was an aggregate of projects 'rather than a product of rigorous and integrated planning'.[63] It was also a partial plan in that the bulk of the focus was on the Council for Scientific and Industrial Research, the Indian Council for Medical Research, and public-sector industrial units. No detailed consideration was given to agriculture, atomic energy (half a page), defence, electronics and space. Many of these fiercely guarded their autonomy from the planning exercise.[64]

As a result of the planning process, if not the plan itself, there was a significant increase in the bureaucracy for science and technology administration and a formalization of decision making on research and development. Moreover, the exercise was also not about the future in a direct way; it was about taking stock of existing infrastructure to reorganize and reorient rather than to plan for what might else be required in the future. The Planning Commission significantly reduced the allocations requested; nonetheless, the mechanisms for the pursuit of purposeful engagement between various state institutions were now in place: 'the paradigm was neo-Keynesian, the theme was self-reliance, the solutions proposed were managerial'.[65]

At the same time, the budget allocation by the NCST appeared to be quite similar to pre-plan allocation, the only difference being that all programmes now had a high applied component.[66] To some, this would appear a success of the plan's conceptualization. A critique of the plan that remained unaddressed was the inability of its leaders to conceptualize how the basic needs of the population were to be met by import substitution and development of technologies in-country, apart from implying that planning could create jobs and save foreign exchange. Could R & D create state capacity to eventually meet the basic requirements of its citizens?

The citizens had, in the meanwhile, run out of patience. Protests against rising prices, unemployment, corruption and inflation had citizens marching all over the country. Students took the helm alongside trade unions and political opposition, leading to clashes with the police. In the middle of a twenty-day countrywide strike (8–27 May 1974) drawing in over 170,000 railway workers asking for fair wages, Indira Gandhi and her government allowed the country's first peaceful nuclear experiments, as they were called, to proceed on 18 May 1974. The strike was brutally supressed, by all accounts,[67] but that was not

62 Bhaneja, op. cit. (54), p. 103.

63 Nayar, op. cit. (20), p. 463.

64 Ashok Parthasarathi suggests that the NCST did manage to rein in the Department of Atomic Energy by asking for a revision of their 'non-nuclear' research projects and asking them to take an allocation cut. See Ashok Parthasarathi, *Technology at the Core: Science and Technology with Indira Gandhi*, New Delhi: Pearson Education, 2007, pp. 54–57.

65 V. Siddhartha, 'Private science and public policy', in K.D. Sharma and M.A. Qureishi (eds.), *Science, Technology and Development: Essays in Honour of A. Rahman*, New Delhi: Sterling Publishers, 1978, pp. 68–87, 73.

66 Bhaneja, op. cit. (54), p. 102.

67 Stephen Sherlock, 'Railway workers and their unions: origins of 1974 Indian railways strike', *Economic and Political Weekly* (1989) 24(41), pp. 2311–2322; V.P. Dutt, 'The emergency in India: background and rationale', *Asian Survey* (1976) 16(12), pp. 1124–1138.

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the end. On 5 June 1974, the socialist leader Jayaprakash Narayan (1902–1979) called for a total revolution: 'Educational institutions are corrupt. Thousands of youth face a bleak future. Unemployment goes on increasing. The poor get less and less work. Land ceiling laws are passed but the number of landless people is increasing. Small farmers have lost their lands.'[68] It was the return of a radical Gandhian critique energized by student politics.[69] In a year's time – and a year into the implementation of the science and technology plan – citing internal and external threats to national security after another war with Pakistan (that led to the creation of Bangladesh, in 1971), the oil crisis, and internal student and trade union agitations, Indira Gandhi, in agreement with the president of India, Fakhruddin Ahmed, declared an emergency (25 June 1975–21 March 1977).[70] Just two months prior to this announcement, the first Indian satellite, *Aryabhatta*, had been launched into space from a Russian space station on 19 April 1975.[71]

A controversial Constitution (Forty-Second Amendment) Act, 1976, was ratified during the emergency. The amendment introduced wide-ranging changes to the Constitution of India. In the Preamble, India went from being called a 'sovereign democratic republic' to a 'sovereign, socialist secular democratic republic'. Most interesting to us was the introduction of a new Part IV(a): 'It shall be the duty of every citizen of India … to develop the scientific temper, humanism and the spirit of inquiry and reform.'[72] In the year that the science and technology plan began to take shape, Daniel Bell in his new

68 Jayaprakash Narayan, 'Towards total revolution, Patna, 5 June 1974', in *Jayaprakash Narayan: Selected Works*, ed. Bimal Prasad, vol. 10 (2009), New Delhi: Nehru Memorial Museum and Library and Manohar Publications, pp. 286–294; and 'Gist of J.P.'s speech in Hindi at a mass rally at Patna on 5 June 1974', *Everyman's*, 22 June 1974. See also Chandan Gowda, 'The idea of "total revolution"', *Bangalore Mirror*, 16 October 2015, available at www.bangaloremirror.com/columns/views/The-Idea-of-Total-Revolution/articleshow/49422574.cms, accessed April 2016.

69 For the Gandhian vision of development in the context of arguments for science-led industrialization see Zachariah, op. cit. (5), Chapter 4, 'The debate on Gandhian Ideas', pp. 156–210; Prakash, op. cit. (5), Chapter 7, 'A different modernity', pp. 201–226; and Partha Chatterjee, *Nationalist Thought and the Colonial World: A Derivative Discourse*, London: Zed Books, 1986, particularly Chapter 4, 'The moment of manoeuvre: Gandhi and the critique of civil society', pp. 85–130.

70 The emergency was a twenty-one-month period when Indira Gandhi held power of rule by decree. Parliament was suspended, as were civil liberties and freedom of the press, all on grounds that 'national security was threatened by internal disturbance'. This came even as the emergency on grounds of external threat to national security during and following the war leading to the formation of Bangladesh (1971) was yet to be lifted. See, among others, Emma Tarlo, *Unsettling Memories: Narratives of India's 'Emergency'*, London: Hurst, 2003; M.R. Masani, 'India's second revolution', *Asian Affairs* (1977) 5, pp. 19–38; Mary E. John, 'The Emergency in India: some reflections on the legibility of the political', *Inter-Asia Cultural Studies* (2014) 15, pp. 625–637; Rebecca Williams, 'Storming the citadels of poverty: family planning under the Emergency in India, 1975–1977', *Journal of Asian Studies* (2014) 73, pp. 471–491; Patrick Clibbens, '"The destiny of this city is to be the spiritual workshop of the nation": clearing cities and making citizens during the Indian Emergency, 1975–1977', *Contemporary South Asia* (2014) 22, pp. 51–66; Arvind Rajagopal, 'The Emergency as prehistory of the new Indian middle class', *Modern Asian Studies* (2011) 45, pp. 1003–1049.

71 U.R. Rao, 'An overview of the "Aryabhata" Project', *Proceedings of the Indian Academy of Sciences Section C: Engineering Sciences* (1978) 1(2), pp. 117–133, available at www.isro.gov.in/Spacecraft/aryabhata-1. On the Chinese and Indian space programmes, also see the Asif Siddiqi article in this volume.

72 Granville Austin, *Working a Democratic Constitution: A History of the Indian Experience*, New York: Oxford University Press, 2003, Chapter 17.

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publication *The Post-industrial Society* argued that the society of the near future 'would be organised around knowledge for the purpose of social control and the directing of innovation and change'.[73] Indira's government was determinedly both pursuing social control and directing technological change.

The Fifth Five Year Plan, as well as the Science and Technology Plan, took off less than a year before the declaration of the emergency. The short history of the plans' realization, however partial, should be explored. Given the near complete control over bureaucracy during the following twenty-one months, one might expect that both plans were executed with great vigour. The citizens appear not impressed by the nuclear tests or the launch of a satellite: Indira Gandhi lost elections following the withdrawal of the emergency in 1977, and the incoming government certainly did not see merit in continuing implementation of the science and technology plan. In that we are likely to find important stories on science and government in India, and more specifically the plan's links to at least three crises: the crisis of development, the crisis of institutions and the crisis within the scientific establishment as they renegotiated their autonomy and purpose in a climate of unstable politics, fluctuating priorities, war and resource scarcity.

Planning for science and technology in Cold War China

As in India, science and technology have played a key role in the modern history of China, but along a path and in a social and political context that presented interesting similarities and differences in comparison to its Asian neighbour and other countries. Some of the factors that drove the development of science and technology in modern India, such as national independence and developmental aspirations, were also, in various forms, present in modern China, but others, such as ideology and international geopolitics, seem to have exerted a stronger influence in China than in India or indeed elsewhere.

Like Nehru, the Chinese Communist Party state's leaders under Mao Zedong placed science and technology high in their rhetoric from the founding of the People's Republic of China in 1949 but did little to foster their indigenous development until 1955 or 1956, when a combination of factors led to the making of a major, comprehensive, long-term plan for science and technology.[74] Initially, the party state's leaders felt that they could rely on Soviet technical assistance to wage the war in Korea and lay a foundation for industrialization, especially in the form of more than 150 major Soviet-aided projects. With some exceptions, politically they also distrusted Western-trained Chinese scientists and engineers whom they had inherited from the Nationalist government which they had just defeated and driven to Taiwan. The new government had established the Chinese Academy of Sciences in November 1949, only one month after the founding of the PRC, based mainly on institutes of the Nationalists' Academia Sinica (whose headquarters and a few of its institutes left with the Nationalists for Taiwan). But the academy was

73 Daniel Bell, *The Coming of Post-industrial Society: A Venture in Social Forecasting*, New York: Basic Books, 1973, p. 20.

74 For more details on science and politics surrounding the making of China's twelve-year science and technology plan see Zuoyue Wang, 'The Chinese developmental state during the Cold War: the making of the 1956 Twelve-Year Science and Technology Plan', *History and Technology* (2015) 31(3), pp. 180–205.

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given few mandates or resources during its early years, and was asked mainly to solve problems arising from production and to help with ideological 'remoulding' of scientists.[75]

Thus when Mao made his historic visit to the Soviet Union in late 1949 and early 1950, he doggedly pursued a strategic partnership with the Soviet Union that would help him to meet two most urgent challenges: national security and economic development. The Sino-Soviet friendship treaty signed during his visit would, as he told a group of officials in north-east China on his way back to Beijing, not only help unify the Chinese people under the new government, and deter Western intervention with the promised Soviet nuclear umbrella, but also help establish 'economic mutual assistance' between the two countries, referring implicitly to promised Soviet loans and technical assistance. Above all, Mao made a special point of his tours of Soviet factories. Their rapid growth showed Mao that 'we can also start from small factories capable only of repairing automobiles and airplanes to big ones capable of making them'.[76]

While most of the existing historical studies highlight the national security objective of Mao's Soviet trip, it can be argued that development was not an insignificant part of Mao's motivation in making the trip and even in formulating the famous 'Leaning to One Side' policy of siding with the Soviet camp during this early stage of the Cold War. As Mao had already made clear in an article published in the *People's Daily* on 1 July 1949, China had to lean to the Soviet side because the West, whose 'rulers are still imperialists', would never give assistance to this 'people's country' and 'we belong to the Soviet-led anti-imperialist unified front and we can only seek truly friendly assistance from this side'.[77] In February 1957, several years after his first Soviet trip, Mao once again lectured on the merits of leaning on and learning from the Soviet Union:

> Let's see who has helped us design and equip so many important factories. Did America do this for us? Did Great Britain do this for us? Neither did. Only the Soviet Union was willing to do so because it is a socialist country and because it is our ally.[78]

So, at least initially, the availability of Soviet technical assistance seemed to lessen the Chinese government's perceived need for its own domestic scientific and technological resources. But the fortunes of Chinese scientists and the academy would improve when the Chinese party state's leadership moved gradually toward a nuclear decision in the mid-1950s, just as had happened to Soviet scientists when Stalin decided to accelerate his nuclear programme in the 1940s.[79]

There is evidence indicating that as early as spring of 1952 Chinese leaders had begun to consider seriously the possibility of pursing nuclear weapons. On 27 March 1952, Premier Zhou Enlai sent two assistants to see Zhu Kezhen, meteorologist and vice

75 Wang, op. cit. (74).

76 Entry on 3 March 1950, in Pang Xianzhi and Feng Hui (eds. in chief), *Mao Zedong nianpu* (Chronicles of Mao Zedong), Beijing: Central Documentation Press, 2013, pp. 98–99.

77 Mao Zedong, 'On the people's democratic dictatorship', *People's Daily*, 1 July 1949.

78 Mao Zedong, 'On correctly dealing with internal contradictions within the people', based on a speech on 27 February 1957 and published in *People's Daily*, 19 June 1957, p. 1.

79 On scientists under Stalin see, for example, David Holloway, *Stalin and the Bomb: The Soviet Union and Atomic Energy, 1939–1956*, New Haven: Yale University Press, 1996.

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president of the academy, to inquire about necessary conditions for the making of atomic bombs. Zhu listed three: concentration of specialists from a variety of disciplines, importation of cutting-edge information and instruments, and investment much greater than that for conventional weapons. Zhu said that on the first condition, China had some specialists, such as the French-trained nuclear physicist Qian Sanqiang in the academy, but needed to recruit more, especially those Chinese scientists currently studying or working abroad. On the second, he suggested that it would be best to try to get information and instruments directly from the Soviet Union in the form of technical assistance or otherwise obtained via discrete purchases from abroad. Apparently Zhou followed up by, among other measures, talking to the Soviets about nuclear assistance in mid-1952 when he led a delegation to Moscow to discuss Chinese economic planning. But the Soviets responded that China was far from being ready to launch a nuclear programme and refused to provide nuclear information or specialists.[80]

The next time Soviet nuclear assistance came up was during the visit by the Soviet leader Nikita Khrushchev to Beijing, his first, in early October 1954 to celebrate the fifth anniversary of the PRC. At a meeting Khrushchev asked Mao what requests he wanted to make, and was caught by surprise when Mao responded that 'we are interested in atomic energy and nuclear weapons'. After a pause, Khrushchev told Mao, according to Mao's translator, that nuclear weapons were too expensive, that the Soviet nuclear umbrella should be adequate to cover the whole socialist family, and that China should focus on economic development first. 'If you want to make nuclear weapons at the present', Khrushchev said, 'it is hard to say whether all your electricity combined would be enough for this endeavour'. Nevertheless, as a concession, Khrushchev did agree to help China build a small nuclear reactor and train associated personnel.[81]

Mao, of course, knew Khrushchev was right in questioning China's industrial capabilities. A few days earlier he had admitted to the Indian politician Uma Nehru (a relative of Prime Minister Nehru also in Beijing for the festivities) that China lagged behind even India in industrialization 'as a result of suppression of China by imperialists'. He mentioned, for example, that India's total length of railway tracks was longer than China's, and the scale of its textile industry was twice that of China's.[82] Two weeks later, Mao reiterated the same points to Prime Minister Nehru himself when the latter came to visit. With Nehru, Mao first elaborated on the two countries' shared history of suffering at the hands of Western imperialists:

80 Fan Hongye, 'Zhu Kezhen riji tanmi: Yuanzidan de gushi ying cong 1952 nian jiangqi' (Secrets from Zhu Kezhen's diaries: the story of the [Chinese] atomic bomb should start from 1952), *Zhonghua dushubao* (A Chinese Newspaper for Readers), 30 December 2004, available at http://news.sina.com.cn/cul/2004-12-30/2667.html, accessed April 2016.

81 Shi Zhe, *Zai lishi juren shenbian* (At the Sides of Historical Giants), Beijing: China Central Documentation Press, 1991, pp. 572–573.

82 Entry for 30 September 1954, in Pang Xianzhi and Feng Hui, *Mao Zedong nianpu* (Chronicle of Mao Zedong's Life), 6 vols., Beijing: Chinese Communist Party Central Committee Documentation Research Office, 2013, vol. 2, p. 289.

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> Even though we differ in ideology and social system, we have a major point of convergence, i.e. we both need to deal with imperialists. Prime Minister Nehru, you should not think that China is completely independent and free of problems. We still have one big problem: Taiwan is still in the hands of the United States and Jiang Jieshi.

He then emphasized their mutual desire and need for industrialization:

> Our country is still not an industrial country, but an agricultural country. Our level of industrialization is lower even than India's. We need to work hard for ten to twenty years in order to gain some achievements. Imperialists still look down on us now. Our two countries are in similar situations, as are all countries in the east.[83]

Mao's assessment was echoed by other Chinese leaders such as Premier Zhou Enlai, who told a British delegation on 21 October 1954 that 'we are making efforts toward progress in order to industrialize and lift our culture'.[84]

In retrospect, the October 1954 meeting with Khrushchev must have alerted Mao, Zhou and other Chinese leaders that China could not depend on Soviet assistance to build its atomic bombs and other hi-tech weaponry or modernization in general. Instead it would eventually need to rely on its own scientists and engineers for such endeavours while taking as much advantage as possible, for as long as possible, of any Soviet assistance. Stung by the continued American threats to use nuclear weapons against China, including that during the Jinmen (Quemoy) incident in the Taiwan Strait in September 1954, and buoyed by the discovery of a uranium mine in Guangxi in 1954, Mao and other leaders of the party state made the decision to launch China's own nuclear weapons programme at a high-level briefing by the nuclear physicist Qian and the geologist Li Siguang on 15 January 1955. Remembering Khrushchev's earlier limited nuclear offer, Mao declared at the meeting that 'now with the Soviet assistance, we should certainly make it work. Even if we have to do it on our own, we can also certainly get it to work'.[85]

In conjunction with the nuclear decision, the party state soon also undertook a number of measures in 1955–1956 to strengthen Chinese science and technology, especially by rehabilitating scientists and other intellectuals and by increasing investments. For example, the government approved the establishment, in mid-1955, of the prestigious academic divisions of the Chinese Academy of Sciences whose membership represented the highest scholarly honour in the country.[86] Then, at the initiative of Premier

83 Entry for 19 October 1954, in Pang and Feng, op. cit. (82), vol. 2, p. 302.

84 Entry for 21 October 1954, in Li Ping and Ma Zhisun (eds.), *Zhou Enlai nianpu 1949–1976* (A Chronicle of Zhou Enlai 1949–1976), 3 vols., Beijing: Central Documentation Press, 1997, vol. 1, pp. 421–422, 422.

85 See entries for 14 and 15 January 1955, in Ge Nengquan (ed.), *Qian Sanqiang nianpu changbian* (A Detailed Chronicle of Qian Sanqiang), Beijing: Science Press, 2013, pp. 249–252. See also Zuoyue Wang, 'Physics in China in the context of the Cold War, 1949–1976', in Helmuth Trischler and Mark Walker (eds.), *Physics and Politics*, Berlin: Franz Steiner Verlag, 2010, pp. 251–276; and John Lewis and Xue Litai, *China Builds the Bomb*, Stanford, CA: Stanford University Press, 1991, pp. 38–39.

86 See Guo Jinhai, *Yuanshi zhidu zai zhongguo de chuangli yu chongjian* (The Establishment and Reconstruction of the Academician System in China), Shanghai: Shanghai Jiaotong University Press, 2014, pp. 295–334.

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Zhou Enlai, who was more sympathetic to the scientists than was Mao, the Party held a major Conference on the Issue of Intellectuals in January 1956 to enhance and improve the political, professional and material status of intellectuals in general and scientists in particular. It also launched a nationwide March on Science movement.[87]

For Chinese science policy, the single most important specific measure to emerge out of the conference on intellectuals was Zhou's announcement of the making of a twelve-year (1956–1967) plan for science and technology. The original idea of a long-term national science plan had come from V.A. Kovda, chief Soviet adviser at the academy, in January 1955, and it was soon embraced by the academy, the State Planning Commission, and, by the end of the year, influential members of the ruling Politburo, including Zhou Enlai and Liu Shaoqi. On his part, Mao Zedong endorsed both the conference on intellectuals and the science plan because he saw them as necessary steps towards a far faster pace of economic development, for which he had been advocating against resistance by Zhou Enlai and Liu Shaoqi, and towards exercising the party's political control of science and technology policy via planning.[88]

The making of the science plan in 1955–1956 involved the participation of hundreds of Chinese scientists, especially those who had recently returned to China from the United States, and dozens of Soviet resident advisers and visiting scientists. Zhou Enlai was the overall leader of the effort and he was assisted by a group of mostly non-scientist but politically moderate science administrators, in consultation with top scientists. Together they came up with two organizing principles for the making of the plan. The first one set the strategic objectives of the plan as 'select important developments and catch up from behind'. It meant that China, given its 'backward' condition, rapid developments in the world and the availability of Soviet assistance, had to focus on key areas first and take short cuts whenever possible to achieve rapid development. Such objectives were to be realized through a second principle formulated under the slogan 'let the tasks lead disciplines', which meant that the plan would be organized by key, practical state mandates which planned scientific advances would serve. This way the organizers came up with a comprehensive list of fifty-five 'major tasks', ranging from natural resources to defence technology. Upon protest by some scientists, a separate category of basic scientific developments was added to the plan (as well as one on scientific information) with Zhou's endorsement, but the overall thrust of the plan was on applied development.[89]

The 1956 plan had a profound impact on Chinese science and science policy. Perhaps the most prominent result of the 1956 plan was the identification of six 'emergency measures' that China needed to undertake right away both because it was deficient in these areas and because of their newly recognized centrality in modern science and technology: atomic energy, rockets, electronics, automation, semiconductors and computers. Institutionally, new research units were soon established for these fields, with Soviet assistance, especially within the Chinese Academy of Sciences. The making of the plan led

87 Wang, op. cit. (74).
88 Wang, op. cit. (74).
89 Wang, op. cit. (74).

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to a major step in state formation with the establishment of the Science Planning Commission under Marshall Chen Yi, and soon its successor the State Science and Technology Commission under Marshall Nie Rongzhen, who also headed the nuclear weapons programmes. The Chinese Academy of Sciences also underwent dramatic transformation as it moved closer to the national security system and engaged in 'applied basic research'. Finally, the close Soviet involvement in the making of the plan, including a massive effort to review and revise it in Moscow in 1957, helped facilitate another surge of Soviet technical assistance to China, including an agreement on 'new defence technologies' (atomic bombs and missiles) and another one covering 122 projects.[90] In many ways the 1956 plan, whose implementation suffered from but survived the Anti-rightist campaign against intellectual dissidents in mid-1957, paved the way for the successes in fission and fusion bombs, missiles and satellites in the next decade and half in China.[91]

But the plan, which was supposed to enable China to catch up with cutting-edge science and technology in the world by 1967, also contained in it the spirit of what soon became known as the Great Leap Forward, a rash industrialization and collectivization drive with devastating consequences for China and its scientific and technological developments. Increasingly impatient with what he perceived as the Soviet-style technocratic approach to economic development advocated by Liu Shaoqi and Zhou Enlai, Mao launched the Leap in 1958 after a trip, his second, to the Soviet Union. On 18 November 1957 he declared in Moscow, at an international conference of Communist Party delegations to mark the fortieth anniversary of the Soviet Communist revolution, that 'the Western world has been outpaced by us', citing as evidence the recent launchings of the two Soviet satellites. Before these achievements, the socialist camp already boasted a bigger population than the capitalists, Mao said, implicitly crediting his own revolution in China in 1949. Now, after these launchings, the socialist countries 'enjoyed overwhelming advantages in the most important scientific and technological sectors' as well. 'Comrade Khrushchev has told us that the Soviet Union would surpass the United States in fifteen years', Mao continued. 'I can also tell you that we could catch up or surpass Great Britain in fifteen years'.[92]

What was Mao's measurement of the China–UK competition? It was expected national production of steel. And his basis for confidence? Conversations he had at the Moscow conference with Harry Pollitt and John Gollan, leaders of the Communist Party of Great Britain, who told him that they expected the output of British steel to grow from 20 million tons in 1957 to 30 million tons in fifteen years. By his own

90 Zhang Baichun, Yao Fang, Zhang Jiuchun and Jiang Long, *Sulian jishu xiang zhongguo de zhuanyi 1949–1966* (Technology Transfer from the Soviet Union to China, 1949–1966), Jinan: Shandong Education Press, 2004, pp. 181–204.

91 Wang, op. cit. (74).

92 Mao Zedong, 'Zai mosike gongchandang he gongrendang daibiao huiyi shang de jianghua' (Speeches at the conferences of delegates of communist and labour parties in Moscow), 14, 16 and 18 November 1957, in Mao Zedong, *Jianguo yilai Mao Zedong wengao* (Mao Zedong's Writings since the Founding of the People's Republic of China), 13 vols., Beijing: China Central Documentation Press, 1992, vol. 6, pp. 625–647, 635.

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calculations, Mao believed that China could produce 40 million tons of steel by then (its 1957 output was 5.2 million tons).[93]

Upon his return home, Mao, silencing opposition from Zhou Enlai and Liu Shaoqi and breaking collective leadership, first made 'Catching Britain' through a 'technological revolution' a national priority. By early 1958, he had further launched the country into a massive Great Leap Forward movement with a singular focus on steel, touching off a nationwide frenzy of backyard steel making (mostly primitive ironworking).[94] At one point, he believed that China could now actually catch up with Britain in two years.[95] In science and technology, correspondingly, the objectives of the twelve-year science plan were predicted to be completed 'ahead of schedule' in 1962, although in fact many projects and institutions, except for those related to nuclear weapons and missiles, were negatively affected by the Leap.[96] Soon enough, wasteful steelmaking was joined by forced agricultural collectivization, which together brought about one of the worst famines in world history. The Leap also played a role in intensifying Sino-Soviet tension to the point where Khrushchev withdrew most Soviet specialists from China by 1960.[97]

By 1962, the reality of the famine and economic difficulties forced the party state to halt the Leap and Mao to make a public 'self-criticism' within the party, acknowledging, 'I don't know much about industry and business' and 'it looks to me impossible to catch up and surpass the most advanced of capitalist countries within about one hundred years'.[98] Taking advantage of the new 'readjustment' policy, Marshall Nie Rongzhen presided over the making in 1961 of 14 Points, a liberal Party directive on science that sought to rehabilitate scientists and other intellectuals politically, improve their working and living conditions and enhance their professional autonomy, including some protection of basic research.[99] The high point in this liberal campaign came in March 1962 when Premier Zhou Enlai and Marshal Chen Yi, in Guangzhou at conferences of scientists and playwrights, declared that intellectuals were no longer reactionary bourgeois but part of the working class. Ominously, however, Mao conspicuously

93 Mao, op. cit. (92), p. 635. Entry for 9 November 1957, in Pang and Feng, op. cit. (82), vol. 3, p. 241.

94 Pang Xianzhi, Jin Chongji and others, *Mao Zedong zhuan 1949–1976* (A Biography of Mao Zedong, 1949–1976), 2 vols., Beijing: Central Documentation Press, 2003, vol. 1, pp. 761–804, 815, 824.

95 Pang, Jin and others, op. cit. (94), vol. 1, p. 824.

96 Wu Heng, *Keji zhanxian wushinian* (Fifty Years on the Scientific and Technological Front), Beijing: Science and Technology Documentation Press, 1992, pp. 205–207; 'Zhonggong zhongyang dui guojia kewei dangzu "guanyu yijiu liuling nian kexue jishu fazhan jihua de baogao" de pishi' (Chinese Communist Party central instructions on the 'report on plans for scientific and technological development in 1960' by the party group of the State Science Commission), in *Jianguo yilai zhongyao wenxian xuanbian* (Selected Important Documents since the Founding of the People's Republic of China), 20 vols., Beijing: Central Documentation Press, 1992–1998, vol. 13, pp. 17–18.

97 Lorenz Luthi, *The Sino-Soviet Split: Cold War in the Communist World*, Princeton, NJ: Princeton University Press, 2008; Shen Zhihua, *Sulian zhuanjia zai zhongguo (1948–1960)* (Soviet Specialists in China, 1948–1960), Beijing: Xinhua Press, 2009.

98 Pang, Jin and others, op. cit. (94), vol. 2, pp. 1023–1024.

99 The text of the '14 Points', dated 20 June 1961, is reprinted in *Jianguo yilia zhongyao wenxian*, op. cit. (96), vol. 14, pp. 514–570.

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withheld his personal approval of the new designation, sowing seeds for a reversal later.[100]

In 1962–1963, Nie reaffirmed the claim of the Leap period that the objectives of the 1956 science plan were largely complete by 1962, but he did so with two caveats. First, such specific objectives had been projected for completion by 1962 in the 1956 plan in the first place (longer-term objectives were only vague and general) – so the achievement was on schedule, not ahead of schedule. Second, even those objectives that were completed by 1962 represented only the state of the art of the 1940s, not the 1960s. Thus the 1956 plan, even when completed and even though quite effective in many ways, did not achieve the goal of catching up to world standards.[101]

Nie then supervised the making of a new ten-year (1963–1972) science and technology plan in 1962–1963 in coordination with the making of a ten-year national economic plan. This time it involved the participation of about ten thousand specialists, and its topics included agriculture, industry, resource surveys, medicine and public health, technological sciences, and basic sciences. Reflecting the reality of isolation now from both the US and the Soviet Union, the plan focused on the need to utilize indigenous scientific research in solving practical problems encountered in defence and industrial projects. It led to the establishment of intermediate experimentation programmes to link basic and applied research and product developments.[102] In contrast to the 1956 plan, however, the 1963 plan did not include defence science and technology, although it provided for many technological advances, such as lasers, that would be relevant in this regard. It was no longer aimed at catching up to world standards of 1972, but more modestly and vaguely at reaching those of the 1960s, which it acknowledged might have already been too ambitious.[103]

On 16 December 1963, Nie briefed Mao and other top leaders on the new science plan. Mao expressed his strong support for the plan and for the development of science and technology in general as a key to economic progress, thereby fulfilling the purpose of the Chinese revolution. He was especially fascinated by the prospect of the military applications of lasers, directing Nie to organize a group of experts to 'focus on nothing but this besides their meals'.[104] Alas, the plan, though effective in some areas, would not be fully implemented because the advent of Mao's Cultural

100 Liao Xinwen, '1962 nian guangzhou huiyi de qianqian houhou' (Around the 1962 Guangzhou conferences), *Dang de wenxian* (Documents of the Party) (2002) 2, pp. 13–21. Chen's speeches are reprinted in the same issue, pp. 3–12. Zhou's speech is reprinted in Zhou Enlai, *Zhou Enlai xuanji* (Selected Works of Zhou Enlai), 2 vols., Beijing: People's Press, 1984, vol. 2, pp. 353–369.

101 See, for example, Nie Rongzhen, 'Guanyu guojia kewei jiguan gongzuo de jianghua' (A talk on the work of the State Science Commission staff offices), 23 December 1963, in Nie, *Nie Rongzhen keji wenxuan* (Selected Papers on Science and Technology by Nie Rongzhen), Beijing: National Defence Industrial Press, 1999, pp. 486–507, 487.

102 Wu Heng and Yang Jun (eds.), *Dangdai zhongguo de kexue jishu shiye* (The Scientific and Technological Enterprise of Contemporary China), Beijing: Contemporary China Press, 1991, pp. 114–119.

103 Nie's report on the plan and the top leadership's approval are included in *Jianguo yilai zhonyao wenxian*, op. cit. (96), vol. 17, pp. 497–515.

104 Mao Zedong, 'Zai tingqu Nie Rongzhen huibao shinian kexuejishu guihua shi de jianghua' (Statements while being briefed by Nie Rongzhen on the ten-year plan for science and technology), *Dang de wenxian* (1996) 1, pp. 34–35.

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Revolution in 1966 would disrupt most scientific and technological work except for nuclear weapons and other top defence projects. The planning for the latter was put under a high-ranking central special commission (*zhongyang zhuanwei*) headed by Zhou Enlai himself, established in November 1962.[105]

Yet amidst political and ideological tightening on the eve of the Cultural Revolution, there were signs that the dramatic revolution in electronics, marked especially by the introduction of integrated circuits in the United States in the early 1960s, created transnational waves across the Iron Curtain and into China. For example, in 1964–1966, Chen Boda, one of Mao's secretaries and a vice president of the Chinese Academy of Sciences, repeatedly called on the academy and others to pay attention to electronic technology as a possible engine of a new industrial revolution. Chen said that he had been alerted to the importance of electronics from reports out of Japan and East and West Germany. 'If we develop electronic technology with intention and planning', he declared, 'the second industrial revolution could first be realized in China'.[106]

During the Cultural Revolution, while defence science and technology programmes received some protection and largely continued, their civilian counterparts faced disruption and often catastrophic ruin. The Beijing Botanic Garden of the Chinese Academy of Sciences, for example, was shut down in 1969 on the ground that studying 'flowers and grasses' was the doing of reactionary 'feudalists, bourgeoisie and revisionists'. Much of its collection of valuable plants and seeds was destroyed or lost.[107] By the early 1970s, when the worst of the chaos was over, there were efforts undertaken by Zhou Enlai and other moderate leaders to resume scientific research during another short period of political liberalization. It was against this background that a national conference on scientific and technological work was held in Beijing in August and September 1972 to discuss, among other agenda items, the making of a new long-term scientific and technological plan. The academy, now institutionally much reduced, helped organize the conference and set its tone with a major report titled 'Work on basic scientific theoretical research must be greatly strengthened'. But the conference and planning went nowhere as Mao saw the liberalization drive as a rebuke of his Cultural Revolution and turned against its advocates Zhou Enlai and Deng Xiaoping.[108]

105 Xie Guang and others (eds.), *Dangdai zhongguo de guofang keji shiye* (National Defence Science and Technology Enterprise of Contemporary China), 2 vols., Beijing: Contemporary China Press, 1992, vol. 1, pp. 46–51.

106 'Chen Boda tongzhi canguan beijing shi wuxiandian qijian yanjiusuo hou suozuo de zhishi' (Directives from Comrade Chen Boda while touring Beijing Institute of Radio Electronics Instrumentation), 21 April 1965, in *Kexue geming* (Scientific Revolution: A Magazine Published by the Revolutionary Rebels Alliance of the Chinese Academy of Sciences), initial issue date 25 June 1967, p. 32. See pp. 23–36 for various speeches and letters of Chen on the issue in 1964–1966. Chen became the head of the powerful Central Cultural Revolution Group during the early years of the Cultural Revolution in 1966–1969 before losing Mao's favour in 1970. See Ye Yonglie, *Chen Boda zhuan* (A Biography of Chen Boda), Beijing: Writers' Press, 1993.

107 Fan Hongye, *Zhongguo kexueyuan biannianshi* (A Chronological History of the Chinese Academy of Sciences), Shanghai: Shanghai Science and Technology Education Press, 1999, pp. 199–200.

108 Qian Linzhao and Gu Yu (chief eds.), *Zhongguo kexueyuan* (The Chinese Academy of Sciences), 3 vols., Beijing: Contemporary China Press, 1994, vol. 1, pp. 141–167.

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Mao's death and with it the end of the Cultural Revolution in 1976 marked the beginning of the reform era under Deng Xiaoping when economic development was given priority and science and technology were held to be key to the Four Modernizations (agriculture, industry, defence, and science and technology) drive. The new science policy pushed Chinese science in general, and the Chinese Academy of Sciences in particular, in a utilitarian and applied direction against resistance by many of the leading scientists who complained there was too little, not too much, emphasis on basic research (even in the academy it counted for only about 15 per cent).[109] Thus even though general political and ideological pressure on scientists and other intellectuals dramatically decreased in the reform era, the tension between the state and the scientific elite over basic research continued. And, ironically, reliance on foreign, mostly Western, science and technology now was, as in the early 1950s with the Soviets, used to reduce the perceived importance of indigenous basic research. In March 1985, the Party leadership issued a formal Resolution by the Central Committee of the Chinese Communist Party on Reforms of the Scientific and Technological System which launched a new era of market-driven Chinese science and technology policy where dynamics involving basic versus applied research, and self-reliance versus foreign influences, would both continue and exhibit new forms.[110]

After comparison

The science and technology plans in China and India are products of two quite distinct historical moments. What are we to gain from looking at them together for the history of China and India respectively, and for the history of science and technology more broadly? The political scientist and management studies scholar Aqueil Ahmad undertook a similar exercise over forty years ago; in terms of availability of archives, we do not seem to have come very far since then.[111]

If the Chinese plan is a product of the early Cold War and bears marked Soviet influence, the Indian plan is a product of the early years of détente which saw India's growing distance from the United States and growing ties with the Soviet Union. The language of modernization was in the making when the Chinese plan was written; alongside managerialism, development was the idiom of the times for the Indian plan. Indira's India laid strong claims to socialism but was, by then, adept at managing international negotiations through the stance of non-alignment. Given the distinct contexts and the fact that there was a generational turnover of leadership, it is quite remarkable – at the

109 On this debate see Wang Lina, 'Gaige kaifang chuqi zhongguo kexueyuan "banyuan fangzhen" zhizheng' (The debate over the mission statement of the Chinese Academy of Sciences during the early years of the era of reform and opening up), *Kexue wenhua pinglun* (Science and Culture Review) (2010) 7(6), pp. 5–22.

110 'Zhonggong zhongyang guanyu kexue jishu tizhi gaige de jueding' (Resolution by the Central Committee of the Chinese Communist Party on reforms of the scientific and technological system), in Zhonggong zhongyang wenxian yanjiushi (ed.), *Xin shiqi kexue*, available at http://cpc.people.com.cn/GB/64184/64186/66700/4495269.html, accessed December 2015.

111 Aqueil Ahmad, 'Science and technology in development: policy options for India and China', *Economic and Political Weekly* (1978) 13(51–52), pp. 2079–2089.

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thin level at which they can be compared (the Chinese plan document remains mostly closed) – that the two plans are quite similar to each other.

We find that looking at the histories of science and technology planning in India and China illuminates, first and foremost, the specific yet overlapping concerns of two countries that embarked on the struggle to make the political formation of a nation state work for their populations in the middle decades of the twentieth century. We also notice that historical actors at all levels in China and India are aware of each other and refer to each other.[112] Tenuous attempts at sharing with and learning from each other sometimes met with success, and at other times did not. In this, the two countries are not remarkable. What is remarkable is the intensity of effort in the planning process; the faith in the practice of science and technology as a powerful instrument of social change to deliver progress, to retrieve greatness; and the aspiration to shape circumstances under which China and India could each claim their 'rightful place in international politics'.[113]

The Indian Science Policy Resolution of 1958 and the Chinese science and technology plan of 1956 called for modernization of science, technology and education, but the Chinese plan emphasized practical and national defence-related high-technological developments, while the SPR was a much more philosophical statement on science's cultural and spiritual values as well as its industrial applications. The difference also showed up in the call for urgent implementation of the former and the rather slow process in carrying out the latter.[114] The process of implementing the science and technology plan of 1974–1979 might be a more appropriate comparison with the Chinese plan. But the archives for this period are only just beginning to open. India certainly did not witness the tragedies that befell many Chinese scientists who were attacked as enemies of the state for not following closely enough the state's plans in science and technology. That kind of ideological coherence, the discipline required to sustain it and the international alliances that it entailed (or did not) were not seen in India. What distinguishes the Indian case most significantly for this time period is that the studied and restrained policy of non-alignment, ironically drawn up in a conversation between Jawaharlal Nehru and Zhou Enlai, was followed more rigorously by India during the Cold War – also in negotiating technical assistance.

Alongside the specificities, the two archives renew the discussion on two key concepts in twentieth-century history of science and technology: 'self-reliance' and 'the linear model'. Self-reliance has globally served as a mobilizing concept for resources especially since the Second World War. Its synonyms have been, among others, *swadeshi* (in India), self-sufficiency, technological self-reliance, technological self-sufficiency, economic self-reliance, import substitution and economic independence (in an interdependent world). Its meanings travel from rhetorical claims to isolation to bargaining capability in importing technology. Shades of all of these are found in the discussions in China and India. Each of these is mobilized in India by different groups around the plan to

112 Arunabh Ghosh, 'Before 1962: the case for 1950s Sino-Indian history', unpublished manuscript.

113 George Perkovich, 'The measure of India: what makes greatness?', *Seminar Magazine* (September 2003) 529, at www.india-seminar.com/2003/529.htm, accessed 27 July 2015.

114 Dhirendra Sharma, 'Growth and failures of Indian science policy', *Economic and Political Weekly* (1976) 11(51), pp. 1969–1971.

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address concerns arising from increasing unemployment of scientists and engineers, foreign-exchange shortage, drought, war, Cold War geopolitics and foreign aid, domestic politics, and the rise of student politics in the 1970s. Self-reliance became an argument that allowed all the problems named above to be resolved in the managerial or technical realm. Even if the implementation of the science and technology plans in both cases was incomplete, the mechanisms of problem solving across ministries with institutions created for government oversight became standard practice. In the Chinese case the Sino-Soviet tension played out in both international geopolitics and domestic technology policy, forcing the Communist Party state to rely on its mostly Western-trained scientific and technological elite to build its nuclear weapons.

Historians of technology have visited, revisited and rescinded 'the linear model' on several occasions in the last two decades.[115] The linear model, briefly put, is a claim about the useful translation of basic or fundamental research to applied or industrial and commercial purposes leading to economic growth, in which basic science begets applied science, which begets useful technology. In sum, the claim would be that basic or fundamental science is (eventually) foundational to economic growth which would justify the funding of scientific research to the largest extent possible in a growing economy. The model has been discredited by many historians for unproblematically coupling basic science and technology, and to a lesser extent for coupling technology to economic growth. Nathan Rosenberg has argued, for instance, that 'technology is not the mechanical "application of science" to production; it is a field of knowledge by itself, quite different in its incentives, its modes of transmission and its culture. It is affected by science, but in turn provides "pure research" with its instruments and much of its agenda'.[116] David Edgerton has argued that the model has never quite existed and gained currency in the much later part of the twentieth century.[117]

Leadership in both China and India claimed and continues to claim, 'Modernization cannot be imported. It has to grow out of our own soil in order to take root. That alone is real transformation.'[118] North America and the Soviet Union were offered and to a significant extent accepted as the benchmark of development by the political leadership in both China and India in the later twentieth century. What was that history of Soviet or American modernization? More often than not, it was a narrative of scientific research leading to industrialization and economic growth, seamlessly interconnected. Consider the very first paragraph of the Indian Science Policy Resolution:

115 Among others see Sabine Clarke, 'Pure science with a practical aim: the meanings of fundamental research in Britain, *c*.1916–1950', *Isis* (2010) 101, pp. 285–311. Benoit Godin, 'The linear model of innovation: the historical construction of an analytical framework', Project on the History and Sociology of S&T Statistics Working Paper 30, 2005.

116 Nathan Rosenberg, *Inside the Black Box: Technology and Economics*, Cambridge: Cambridge University Press, 1983, esp. Chapter 7, 'How exogenous is science?'.

117 David Edgerton, '"The linear model" did not exist: reflections on the history and historiography of science and research in industry in the twentieth century', in Karl Grandin, Nina Wormbs and Sven Widmalm (eds.), *The Science–Industry Nexus: History, Policy, Implications*, New York: Watson, 2005, pp. 31–57; David Hounshell, 'Industrial research: a commentary', in Grandin, Wormbs and Widmalm, op. cit., pp. 59–65.

118 Gandhi, op. cit. (53), p. 427.

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> The key to national prosperity, apart from the spirit of the people, lies, in the modern age, in the effective combination of the three factors, technology, raw materials and capital, of which the first is perhaps the most important since the creation and adoption of new scientific techniques can, in fact, make up for a deficiency in natural resources, and reduce the demands on capital. But technology can only grow out of the study of science and its applications.[119]

In the case of Maoist China, especially during times of highly ideological political campaigns such as the Anti-rightist campaigns, the Great Leap Forward and the Cultural Revolution, basic research carried, for scientists, much more political risk than work on more applied subjects. But even Mao and his radical followers recognized, as had Joseph Stalin before them, that scientists needed relative freedom in defining the relationship between basic and applied research in national security and other areas where real achievements were of critical importance to the regime.[120]

For a significant majority of the global population in the twentieth century, the relationship between science and technology holds no particular value. If modernization is desired, it is to maintain sovereignty and the integrity of the nation state. Many Chinese scientists under persecution in Maoist China or those adversely affected by the political chaos in India in the 1970s would accept the primacy of the nation state. Security and development were never separate questions with different solutions: it is this experience that we have only begun to explore through a minor and incomplete archive in context.

We could only hope for historical studies of the implementation of the two plans to allow for a robust comparison – and to draw wider lessons from it. In 1978 the Indian political scientist Aqueil Ahmad argued, 'While science in China has evolved out of and for production needs, science in India has emerged as a grand abstraction out of the "limbo effect" of national development where people, systems, activities could easily acquire a ghostlike characteristic of being there without their feet on the ground.'[121] While his assessment may have been appropriately self-critical in regard to India's science policy and certainly echoed Bernal's 1954 China–India comparison, we need also to explore the human and political costs that accompanied the perceived Chinese success of centralization and utilitarianism. Nevertheless, one may claim that both developmental visions mentioned at the beginning of this paper did, in a way, come true in the twenty-first century: India exports skills especially in information technology while China has emerged as the manufacturing base of the world. So were those first science policy statements prophetic after all?

119 'Science Policy Resolution', op. cit. (2).
120 See Wang, op. cit. (85).
121 Ahmad, op. cit. (111), p. 2085.

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