TRANSLATING AMERICAN MODELS OF THE TECHNICAL UNIVERSITY TO INDIA AND SOUTH KOREA

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Science, Technology and Development in India after Independence

Nehru's development strategy was based on his view that science-based industry was key to the West's prosperity, and that it was critical to India's future as well. As early as 1934 he stated:

I want to increase the wealth of India and the standards of the Indian people, and it seems to me that this can only be done by the application of science to industry, resulting in large-scale industrialization. (1)

When the Indian National Congress formed its National Planning Committee in 1938, it chose Nehru as its chairman. It was here that Nehru first formulated in a systematic way his view that modem technology lay at the base of future Indian development and that a self-sustaining scientific community was essential for it. Writing later of the work of the Committee, Nehru wrote:

The three fundamental requirements of India, if she is to develop industrially and otherwise are: a heavy engineering and machine-making industry, scientific research institutes and electric power. These must be the foundations of all planning and National Planning Committee laid the greatest emphasis on them. (2)

India would require scientific institutes and technical universities, and could not depend on market forces to produce them. But what should be the nature of these institutes? In a report which appeared in 1944, the famous British physiologist Professor A.V. Hill advocated not a British but an American model:

The future of Indian industrial and agricultural development must depend upon the supply of first-class technical brains, trained in an atmosphere both of original research and of practical experience. This requires not only that there should be facilities for technical training at all important centres in India, but that one or two institutes of the highest possible standing should be founded. (...) There is no institution as yet in the United Kingdom comparable in magnitude, in the quality of equipment and in excellence of teaching and research work, with the Massachusetts Institute of Technology at Cambridge. Mass. (3)

The call was taken up by Sir Ardeshir Dalal, Director of the Tata Iron and Steel Company who had recently been appointed to the Viceroy's Executive Council for the Department of Planning and Development. At his first press conference (September, 1944), he announced that the establishment of an Indian M.I.T. would receive the Department's highest priority (4).

A committee, under the chairmanship of Mr. N.R. Sarkar, was formed to explore and clarify the nature of the model to be followed.

During the following year, India was freed from colonial rule and Jawaharlal Nehru became independent India's first prime minister. As prime minister, Nehru moved quickly to implement strategies conceived before the war. He established the National Planning Commission, and reiterated his commitment to scientific and technical advance:

Today no country can advance in peace or war except with a full knowledge of modern science and technology... We have to absorb the spirit of science in India (5).

While the goal was intermediate and long-range scientific, technical and industrial independence, it was quickly seen by Nehru and his advisers, the scientists S.S. Bhatanagar and H.J. Bhabha, and the economist P.C. Mahalanobis (all three Fellows of the Royal Society) that in order to build the required infrastructure outside help was required (6).

Nehru's India stood between the West, led by the U.S., the U.K. and France, and the second world, under the hegemony of the Soviet Union. The plan would maintain this position, and not compromise India's role as a leader of the Third World. As such, the Government of India wished to *balance* the influence of East and West, and sought assistance from both sides of the Cold War and from international organizations.

Kanpur and the other Indian Institutes of Technology

The first Indian Institute of Technology was founded five years after the Sarkar Report. It was located in eastern India at Kharagpur. Assistance both financial and technical were sought from and received from international organizations, especially Unesco, from West Germany and from the United States. The first programs drew on the technical appendices of the Sarkar Report, and the 1950-1951 editions of the MIT and California Institute of Technology's bulletins (7). From 1951 to 1956 the Kharagpur experiment was closely watched and eventually its position was codified in the Indian Institute of Technology Act of 1956 which stated that the IIT was intended as the premier engineering institute of India; all new IITs were supposed to be modeled on it and that its own development was to be on the pattern of MIT of the United States (8).

This Act was part of a broad-front push towards industrialization and scientific agriculture. In May, 1956 Prime Minister Nehru introduced India's Second Five-Year plan which aimed at greatly expanding coal and steel outputs, increasing food production and doubling electric power (9).

As part of building India's technical base, four new Indian Institutes of Technology followed in the period 1958-1961. Whereas the first, experimental IIT at Kharagpur was established in close association with the West, the first new IIT was founded with the assistance of the Soviet Union. While the first formal request for aid from Unesco for the Bombay IIT mentioned that it was to be patterned after MIT, the memorandum of understanding that ultimately was produced between India and the U.S.S.R. understandably deleted the reference (10). The Soviet government, anxious to woo India in the Cold War context, gave a high priority to the effort. Scientists and engineers, equipment, textbooks, Russian-language instruction and 3.6 million rupees for additional equipment was provided by the Soviet govemment (11).

In the late 1950s, the administration of MIT was approached by the governments of India and the United States to assist in the development of the fourth IIT, to be located at Kanpur, an industrial city sometimes called the "Pittsburgh of India". For a variety of reasons including concern for the drain on MIT's domestic resources, MIT opted for a consortium approach; the consortium which would include the University of California, Purdue, Michigan, Ohio State, Princeton, Carnegie Tech and others, would however be led by MIT.

What was the American view of the terrain? Of course, the establishment of the Soviet-sponsored IIT at Bombay was duly noted in Washington, and India's neutral position in the Cold War made it imperative that the U.S. not lag behind in assisting India. U.S. agencies, such as the Agency for International Development, wished to ensure a «westem-based and western-oriented education» for Indian scientists and engineers, without, however, "alienating them from the real problems in their own country" (12) The goal was to "strengthen the umbilical cord" (13) However there is another dimension as well that must be carefully weighed.

Among American universities in this period, the missionary zeal to disseminate both American know-how and the lessons of U.S. democracy (both believed to be pillars of the American way of life) was widespread. This mental set accounts for the devotion of the faculty and administrations of many US institutions despite the lack of apparent immediate reward or even long-term return.

The following is an insightful representation of the American view by Prof. Robert Halfman, an MIT engineer who was a key figure in mounting the Kanpur program:

> *The Americans represented a new, rapidly changing society dedicated to growth and progress which were often expressed in materialistic terms. Although the fundamental drives toward useful and practical activity leading to salvation in finite time can be traced to religious roots, the technological revolution was characterized by the rational, scientific way of thinking and flowered profusely in the context of the democratic ideal. Particularly in the years around 1960 technology was ascendant, promising unlimited progress based on the ever more rapid revelation of natural truth through the sciences.* (14)

By 1960, an organizing team led by Dean Gordon Brown, and Professors Norman Dahl, C.H. Norris, and L.D. Smullin was formed and began conceptualizing "an MIT type" of institution for India.

What was the MIT model, which as they saw it, they wished to transplant to India? The MIT archives contain exceedingly revealing documents that illuminate this question:

> *Clearly the form and substance of MIT are as much a product (and a part) of its environment as, say, Oxford is of the English scene, and neither should or could*

be transplanted bodily. However, we think we can identify the major characteristic of MIT which has made it different from other institutions of technology, and we believe that this characteristic is an exportable quantity. We identify this essence of MIT as the intermixing of research, graduate training and undergraduate teaching in the same institution with the continual feedback which brings new research discoveries directly into the graduate teaching, where they are made more simple and better understood, and thence into the undergraduate teaching. (15)

Dean Gordon Brown and Professor Norman Dahl, the chief authors of this note, understood that MIT as described here is doing what any great university does. MIT did lay claim to pioneering such an environment for engineering and science. They continue:

[W]hat we have to offer is a spirit and a way of approaching technological education rather than a blueprint of specific curricula or recommended research topics. In other words, in aiding India we could... work with the Indians in an attempt to create an institution in which will exist the type of environment we have at MIT. (16)

The implementation of the MIT strategy began almost at once. The key line was to move ahead on all fronts – undergraduate education, graduate education, and research. The educational programs were based on the position, gaining ground in engineering education since the late 1950s, of basing the curriculum on extensive scientific training, that is, on the primacy of "engineering science". The point, of course, was to train engineers in fundamental science and its applications so that they would be able to participate and contribute to the new engineering directions of the future, rather than base their training on existing practices only. The criticism that this new curriculum met, i.e. that is was "too theoretical" was met by Norman Dahl, the MIT program leader, this way:

Do the students emerge from the curriculum with the idea that they can use their knowledge of the physical world to attack any problem or do they see themselves as able only to cope with that limited subset of problems which they have studied in some detail? Or to put the question another way, as they go into practice will the graduates look for the problems that need to be solved or the problems they think they can solve? (17)

Some specific points of departure regarding teaching included the "textbook system". Usually, at Indian institutions, students relied on lecture notes and on library reserve books; the MIT way included furnishing students textbooks which they could keep, as long-term tools. The examination system would also follow an American model. The usual Anglo-Indian practice of end-of-year and end-of-course external examinations would be replaced by internal examinations. The former have the disability of freezing curricula into "tight molds". The number of contact class hours would be almost halved to encourage individual work, and a complement of humanities and social science courses, as at MIT, would be introduced. (18)

Over the course of the next decade, the many successes of the Kanpur IIT are clear, depending of course on one's measure of success. The faculty became "Indianized" as the Americans gradually phased-out their role; the students were considered among the best in India and well-trained on a world-wide standard. By the 1970s, the other IITs began to converge in their curriculum and their research programs, generally following the American model delineated at Kanpur. However, there is one significant area which was a failure. The hopes for an MIT/Route 128 or Stanford/Silicon Valley type of university-industry relationship did not materialize. Local industry did not respond to the presence of this new resource in any way commensurable to the opportunity. As early as 1964, plans were launched to develop an "industrial research park" adjacent to the campus to stimulate academic-industrial links.(19) In 1966 discussions were initiated by IIT/K and the government of the state of Uttar Pradesh to establish such a park, specially targeted at electronics in conjunction with the Deparment of Electrical Engineering. Plans were proceeding well until the land designated for the park had been leased to a brick-making firm for five years; the matter disappeared into the bowels of the court system.

But more generally, the problem of "brain drain" persists. A former high-level Indian government scientists-administrator told the following story recently at the World Bank in Washington. "When a student is accepted to an IIT", he said, "he is said to have spiritually ascended to America; four years later his body follows".

One of the chief reasons for this leakage of talent is that Indian industry often does not utilize it in a timely and interesting way. Hopeful plans for university-industry cooperation has continued to founder on the shoals of university-industry mismatching.

Technical Education and South Korea's Economic Miracle

By 1960, American development experts had essentially written off South Korea as a "display window" for capitalism and democracy in Asia. Despite having received some $ 2 billion in US economic aid and another $ 1 billion in military assistance in the decade following the Korea War, South Korea still lagged behind the North industrially and economically. President Syngman Rhee's economic policy of "coercive deficiency" and foreign exchange manipulation may have kept US aid dollars flowing, but at the cost of complete political and economic dependence. From 1953-1960, American assistance accounted, on average, for a tenth of South Korea's gross national product, three-quarters of its imports, and half its government revenues. (20)

In May 1961, a military junta led by Park Chung Hee ended South Korea's brief experiment in democracy that had followed Rhee's ouster the year before. Park governed by decree until the nominal restoration of civilian government in 1963, then as president until his assassination in 1979. Unlike Rhee, Park was "a true believer in modern science", convinced that South Korea's future depended as much on its industrial as its military strength. He redefined the struggle with the North not only as a military and political contest, but also as «a competition in development, in construction, and in creativity" (21). His first five-year economic plan, begun in 1962, called for a national commitment to industrialization, with the goal of doubling exports, to $ 117 million a year, while cutting imports from $ 316 million to $ 41 million.(22)

Rejecting Rhee's policy of isolationism, and the import-substitution strategy that had sustained it, Park and his economic advisors aimed at achieving competitiveness in world markets. First, South Korea would capitalize on its comparative advantage in labor costs, and develop robust export sectors in textiles, footware, and otherlight assembly industries. Next it would build up steel, shipbuilding, and the heavy chemicals industry. Finally, drawing on the experience and financial resources gained from earlier leading sectors, it would begin competing in high technology industries such as as electronics and pharmaceuticals. At each stage, the government would provide leading sector firms with preferential access to bank credit and foreign capital, a highly protected domestic market, reduced tariffs on manufacturing equipment, lower taxes, and other incentives, while easing mature firms into the open market. In an effort to gain some of the advantages of scale enjoyed by global competitors, the government organized Korean firms into giant chaebol conglomerates, similar to Japanese zaibatsu, but with much more direct state investment and intervention (23).

Park and his advisors understood that to compete with foreign firms, Korean industry needed access to foreign know-how and capital. By 1961 South Korea had spent $ 100 million on foreign licensing, training, and fees, with little to show for it. Instead of simply buying technology, the Park government encouraged cooperative ventures with multinational firms, beginning with a joint US-Korean nylon plant in 1962.

Realizing that Japan could also provide a vital source of capital, technology, and experience, Park, at considerable political risk, normalized relations with Korea's former occupier in 1965. He dropped longstanding Korean demands for reparations in return for pledges of economic assistance totaling some $ 800 million (24). Japan rapidly supplanted the US as Korea's biggest trading partner, direct investor, and technology licenser, with 397 licenses by 1975, compared to 122 for the US.(25)

Direct foreign investment and licenses could provide Korean industry with know-how and an opening into export markets, but could also foster a new kind of dependency. Korean exports surpassed even the ambitious goals set by the first five-year plan, but foreign-owned or invested firms accounted for a third of the manufacturing exports, and a much higher share in such key industries as machinery and machine parts (94 %), metal products (89 %), and electric and electronic components (84 %) (26). Consequently, while exports grew rapidly, so did imports of the advanced technologies that Korean firms could not manufacture themselves. In industrial electronics and electronic components, for instance, South Korea continued to run substantial trade deficits (27).

In formulating the second five-year plan, for 1967-1971, South Korea's industrial planners determined to break this cycle of dependency. In some respects, they were starting from scratch. Korea was spending less than one half of one percent of its GNP on research and development, compared with about four percent for its most important trading partners (28) Even its biggest electronics and chemicals firms did almost no research and development of their own, aside from routine testing and quality control. South Korea's universities awarded several thousand undergraduate degrees in science and engineering a year, two-thirds of them in engineering. But the best students went abroad to complete their educations, and relatively few of these "lost brains", as they were called, ever returned, because there were no jobs for them back in Korea.

Strengthening Korea's technological infrastructure would therefore mean increasing the demand for research as well as increasing the supply of researchers. The Korea

Scientific and Technological Information Center (KORSTIC), established in 1962, was intended to help industry keep pace with foreign breakthroughs. But moving from a labor-intensive to a skilland knowledge-intensive economy, as South Korea's Economic Planning Board intended to do, would require developing greater self-sufficiency in research and development.

Korea's self-strengthening program found unexpected support from a US government under pressure to cut foreign aid programs to help pay for the escalating war in Vietnam. President Park's state visit to Washington in May 1965 marked a watershed in Korean-US relations. Instead of asking for the usual foreign aid package, Park negotiated for $ 150 million in development loans (29). In addition, Park and presidential science advisor Donald Hornig discussed a Korea Institute for Science and Technology (KIST) as a way of stimulating industrial development, reversing the "brain drain", and providing a prototype for other newly industrializing nations (30).

To evaluate the prospects for KIST, President Johnson sent a blue-ribbon technical mission to South Korea that July. Headed by Hornig, its members included such experienced industrial researchers as Bell Laboratories head James Fisk and Battelle Memorial Institute president Bertram Thomas. They returned convinced that KIST, properly conceived and supported, could have a decisive impact on Korean industry. The secret, they stressed, was keeping KIST focused on problems of direct interest to Korean companies. Rescarch institutes in developing nations too often chose projects of interest to their academic counterparts in the developing world, but irrelevant to local industrial needs (31).

Battelle Memorial Institute, under contract from the US Agency for International Development (USAID), sent its own team to Korea in the fall of 1965 to gauge support for KIST, and to draw up more detailed organizational plans. Its report recommended nothing less than a Korean version of Battelle, an independent, non-profit, multidisciplinary institute supported by industry and government contracts (32). The assumption was that contract research would ensure a closer coupling of scientific and industrial objectives than conventional government or university research institutes. Once Korean industry learned the advantages of contract research for itself, the planners argued, KIST would become self-supporting.

Impressed with the proposal, USAID awarded Battelle a followup contract to serve as a «sister institute» for KIST, to recruit and train its staff and to organize and launch its research program. The Korea government formally incorporated KIST in February 1966, backed by $ 9.2 million in grants and loans from USAID (including $ 3.1 million for Battelle), and $ 12.2 million from other US assistance programs. South Korea pledged $ 2.7 million of in-kind contributions, including a prime parcel of land northeast of Seoul (33).

KIST's first challenge was recruiting a qualified staff without depleting Korea's scant supply of industrial researchers, or competing for manpower with the universities. As president of KIST, Park tapped Hyung Sup Choi, an American-educated metallurgist who had previously headed Korea's atomic energy program. To fill out the senior ranks, Battelle targeted expatriate Korean scientists and engineers who, given the right incentives, might be interested in returning home. Battelle identified and screened 866

Koreans with advanced technical degrees living abroad. Choi interviewed the most promising, being careful to explain that KIST wanted researchers committed to solving industrial problems, not to winning Nobel Prizes (34). Altogether, he convinced 32 scientists and engineers, 23 from the US, and the rest from Gerrnany, Sweden, Australia, Japan, and Great Britain, to repatriate. Because these scientists came predominantly from universities and large corporate laboratories, few of them had any experience with the deadlines and bottom lines of contract research. To train them in the art of selling science to industry, Battelle assigned them as temporary research associates in its Columbus, Ohio laboratories (35).

Before setting the research agenda for KIST in any detail, Battelle conducted 16 extensive technology surveys, asking what Korean industrialists really wanted, and were willing to pay for. On the basis of these reports, KIST decided to concentrate on five broad technical areas – food technology, materials science, electronics, chemical engineering, and mechanical engineering. KIST organized itself into 31 independently managed laboratories, each expected to become financially self-supporting, covering the entire range of Korea exports, from Seafood Processing and Fishery Resources, to Shipbuilding and Ocean Engineering and Heavy Industrial Engineering, to Semiconductor Devices and Pharmaceutical Research (36).

KIST's mission was not basic research. Rather, it was intended as "the window through which the transfer of foreign technology to domestic industry can be made... It guides and counsels industries in selecting appropriate technologies for import and in modifying, improving, and adapting imported technology for application and dissemination. KIST is the bridge between domestic industry and advanced technologies of foreign countries" (37) It gave priority to those industries selected by the government as future export leaders – heavy industry, chemicals, electronics, and energy technology.

KIST confounded the skeptics, who doubted the willingness of Korean firms to pay for domestic research when they could buy foreign technology. KIST, with assistance from Battelle and the Korean government, promoted itself aggressively. It hosted technical symposiums and seminars for industry, and invited guest researchers to join KIST laboratories. Within two years it had lined up $ 1.2 million in industrial contracts, the largest for the engineering design for the new Pohang Steel Mill. The government also provided some crucial start-up support, funding major contracts for developing a computerized telephone system and for designing and building a pilot plant for freon production.(38) In the early years, the government picked up most of the cost. But by 1973, industry was already funding slightly more than half the total contracts, by value (39). KIST's focuses also shifted, from solving straight-forward manufacturing problems for smaller firms in the 1960s to "productivity improvement, cost reduction, domestic raw material development and imported technology improvement to serve large industrial firms which have accumulated considerable technological capability" in the 1970s (40).

Beyond its strictly scientific research, KIST also undertook several influential science and technology policy studies. One forecast future energy demands, recommending a major commitment to nuclear power. Another considered the future of Korean manufacturing, recommending that the government "encourage international cooperative programs aimed at export through tie-ups with outside firms that can supply product technology and are seeking an economic manufacturing source", a strategy that figured prominently in Korea's third five-year plan, beginning in 1972 (41).

Perhaps KIST's most lasting contribution was convincing Korean industry to fund its own research programs. By the mid-1970s, KIST had already registered 131 patents, introduced several commercial products, and completed $25 million in contracts (42). But with a professional staff of less than 200 (including 53 Ph.D.s), KIST could only do so much on its own. Perhaps its real impact was as a catalyst for industrial research. KIST's practical successes made Korean firms more willing to invest in-house research. Total Korean spending for science and technology as a proportion of gross national product rose sharply from .267 % in 1965 (about average for a developing country) to .867 % by 1980, and to 1.77 by 1985. Though still low by US or Japanese standards, that ranked at the top for developing countries. An even more impressive measure of industry's new-found confidence in research was the government's declining share of R&D spending, from 9 to 1 in 1965 to just 3 to 7 in 1985 (43). In targeted industries, Korea had nearly closed the R&D gap with its competitors, spending, for instance, 3.51 % of sales for R&D in electrical machinery, compared to 4.70 % for Japan and 5.19 % for the US, and 3.07 % for precision machinery, compared to 4.02 % for Japan and 5.98 % for the US (44).

KIST also provided the cornerstone for Korea's first "science park". Seeking to encourage greater interaction among its research institutions, the government relocated KORSTIC to a site adjoining KIST, and set up the new Korea Defense Research Institute nearby. Scientists could then share expensive library facilities, computer systems, and instrumentation, and more conveniently collaborate on projects of common interest (45).

KIST could increase the demand for research, but it could not increase the supply of researchers, for it did no graduate teaching. The closer Korean firms approached the research frontier, the more acutely they felt the lack of qualified scientists and engineers. Short of hiring expensive foreign talent, the only way Korea would be able to staff its expanding industrial laboratories would be to train its own industrial researchers. The government, convinced that Korea's conservative universities were not up to the job, especially at the graduate level, decided in 1970 to establish an entirely new institution of higher learning devoted exclusively to science and engineering, one, like KIST, closely coupled to industry.

Again, Korea turned to USAID for advice and financial assistance. To assess the proposal, USAID appointed a committee of American engineering educators led by Frederick Terman, widely acknowledged as the "father of Silicon Valley". As Stanford University electrical engineering professor, dean, and provost, Terman had pioneered any number of original schemes for bringing together industry and academia – an honors cooperative program, where corporate employees earned advanced degrees while working full-time on company projects; research exchanges that brought corporate researchers to university laboratories and classrooms, and professors to industrial laboratories; affiliate programs that offered members a sneak peak at university research and first pick of the best graduate students; the Stanford Industrial Park, where companies could set up advanced laboratories and manufacturing facilities close to campus, and to university consultants (46). Terman's innovations had helped make Silicon Valley synonymous with high technology. USAID and the Korean government hoped he could work similar miracles there.

What made the USAID project especially appealing to Terman was that in the years since his 1965 retirement he had been trying, without much success, to create just the kind of training center the Koreans seemed to have in mind. In 1966 a consortium of high technology companies in New Jersey, led by Bell Laboratories, had asked him to draw up plans for a new Institute of Science and Technology to help them compete with regions such as Silicon Valley and Route 128. Terman's bold blueprint called for a corporately funded and staffed institute, with training programs focused on the specific needs of consortium members. But when the participating corporations could not agree on who should pay how much for what, the consortium fell apart. Terman drafted a similar proposal for the SMU Foundation in Dallas, designed to build up Southern Methodist University as a corporate resource for Texas Instruments and other local high technology firms. That venture, led by Terman protege Thomas Martin, stumbled after TI reduced its support in the electronics slump of the late 1960s (47). Likewise, the Oregon Graduate Center, founded by former Stanford Research Institute staff member Donald Benedict, with backing from Textronix, failed to live up to its billing as the catalyst for Silicon Forest.

Terman's USAID mission, which included Martin and Benedict among its five members, came to Korea convinced that with the support of USAID and the Korean government, they could succeed abroad where they had failed at home. Terman's "Survey Report on the Establishment of the Korea Advanced Institute of Science", submitted to USAID in December, 1970, incorporated virtually every innovation he had perfected at Stanford or had intended for the proposed graduate centers in New Jersey and Dallas. Like the New Jersey plan, KAIS would be an independent, graduate-only institution, with perhaps 200 students at the master's level, and another 200 at the doctoral level. Rather than trying to cover the entire range of scientific disciplines, it would build steeples of excellence in fields of potential interest to corporate clients, a longtime Stanford strategy. Instead of structuring the curriculum around conventional departments, KAIS would combine interdisciplinary centers – electronic sciences or communications engineering – with more specialized subject offering – polymer technology or pharmaceutical chemistry.(48)

The really "distinctive feature of KAIS", Terman predicted, "will be extensive interactions with the technological activities of Korean industry" (49). To encourage close cooperation between KAIS and local industry, he proposed adopting a set of strategies that had already proved effective in linking Stanford to Silicon Valley. Following the example of the honors coop program, KAIS would recruit most of its students from industry. New employees would get a brief "tour of duties at the sponsoring firm and gain some practical views", before starting their educations, while experienced employees would return to school for advanced training while continuing to work full-time (50). A formal Industrial Visiting Committee would advise KAIS on curricula. Faculty would be encouraged to consult with industry, while industrial scientists would be invited to serve as adjunct professors at KAIS. Younger faculty members would be expected to see KAIS as a way station to industry. An interactive television network, an innovation introduced at Stanford and extended by Martin at SMU, would bring KAIS into the workplace. In each case, KAIS's goal would be "to bridge the gap existing between the background of BS students now trained by Korean universities, and the knowledge required to deal effectively with the problems in engineering and applied science with which Korean industry will be concerned in the years ahead" (51).

Like KIST, KAIS was intended to win markets, not Nobel Prizes. While research would be a vital part of its teaching program, especially at the doctoral level, its mission was "to satisfy the needs of Korean industry and Korean research establishments for highly trained and innovative specialists, rather than to add to the world's store of basic knowledge" (52). What Korean industry needed was not so much new knowledge, as means for applying existing knowledge in creative and appropriate ways. Ideally, KAIS would complement KIST and other scientific institutions, by supplying them with researchers attuned to the special challenges facing Korean industry. For that reason, it was given a place in the "science park", alongside KIST, KORSTIC, and the Korea Defense Research Institute.

Looking ahead, Terman offered a bold prediction. By the end of the century, KAIS would be enrolling 3000 students, and its graduates among the leaders of Korean industry and government. "Korea itself will have become a prosperous and modern albeit medium-sized nation, with a strong economy and a secure position in international trade. Its domestic prosperity, and its strength in international commerce will be based as much or more on merchandizing the products produced by trained minds as products representing the labor of trained hands. Above all else, Korea will have become an inspiration and a model of 'desire and expectation rolled into one' for all other developing nations."(53)

Astonishingly enough, all of Terman's predictions came true well before the turn of the century. KAIST (Technology was subsequently added to its official title) now enrolls 10,000 students, and its graduates have taken responsible positions throughout Korean industry and government research institutes. Korea's total R&D spending is approaching 3 % of GNP, and may well surpass Japan, Germany, and the US before the decade is out. Korean companies spend three times more on R&D than their counterparts in Taiwan, nineteen times more than India, and, as a percentage, only slightly less than Japan (54). Korea has become a major world competitor in virtually every heavy industry and high technology, and according to the World Bank, "is widely regarded... as a role model by other developing countries" (55).

But it is a model of paradoxes. If anything, Korea's massive R&D investment seems to have made it more dependent on foreign technology. Gold Star and Samsung can no longer count on licensing proven products from IBM, Fujitsu, or Hewlett-Packard, as they once did. Instead, they have to compete head to head, but with much smaller R&D budgets. As a percentage of sales, Korean electronics firms have nearly closed the gap with their American and Japanese competitors, but the biggest American computer maker still spends more for R&D than all of Korea's scientific institutions, public and private, combined. Consequently, the Korean electronics industry finds itself increasingly squeezed between the industrial giants on one hand, and the newly industrializing nations of Asia such as Indonesia, Malaysia, and China, with substantially lower wage rates than Korea, on the other. Keeping ahead of newly developing countries means training more scientists and engineers, to gain a comparative advantage in human capital. Competing with the Japanese and Americans means developing ever more sophisticated products, if only to use as bargaining chips to secure foreign licenses. That, in turn, means developing the basic research behind those products. A recent World Bank study suggests that "the Korean electronics industry has come to the point where the availability of skilled scientific, engineering and technical labor represents the single most critical potential constraint to its future development" (56). But what kind of scientists and engineers may turn out to matter more than sheer numbers. The question now facing Korea is whether models of research and technical education designed for a strategy of late industrialization, where adapting foreign ideas was enough, will adequately serve Korea's future needs.

Conclusion

When examining the *transfer* of technical models from the West to developing economies, it must be remembered that from an historian's point of view, the concept of transfer is not rich enough to control the complex phenomena with which we must deal. We suggest instead the concept of *translation* – how a particular model is reworked across cultural boundaries.

The post-World War II period, especially the quarter century from 1955-1980, was a great time of scientific and technical reconstruction in Europe, in Asia and in America as well. This tremendous effort was characterized in part by attempts to utilize what were perceived to be models "exported" from the United States. To understand this period will involve grasping the nature of the "translation" of the model in each national or cultural context. The Shah's "massachuseti" failed to understand that a successful translation of the American model requires a receptive social system in which it can flourish. High technology is a social process not a commodity.

Nehru, Bhatnagar, Homi Bhabha and others responsible for India's decision to build India's capacity for producing scientists and engineers had a much better grasp of this. Indeed, in producing well-trained engineers along American lines but firmly within an Indian context, India has done well. However, the goal of some of India's planners, that of stimulating Route 128's or Silicon Valleys, has not materialized. Owing in part to the nature of university-industry relationships in India, there has not been as much success on the *demand* side, i.e. there has not been an easy and fertile integration of IIT graduates into industry.

In Korea, the approach was quite different and has led to different results. The establishment and the evolution of KAIST was demand-driven. Korea's astonishing success with KIST and KAIST underscores the relevance of Frederick Terman's vision of a new type of academic institution, one more suited to close and fruitful interchange with industry. Now however, Korea has reached the point where basic research leading to new products and entire new industries is what is required to maintain competitiveness.Whether seeking markets rather than Nobel Prizes will, in the long run, prove more practical remains to be seen.

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AU XX^{e} SIÈCLE

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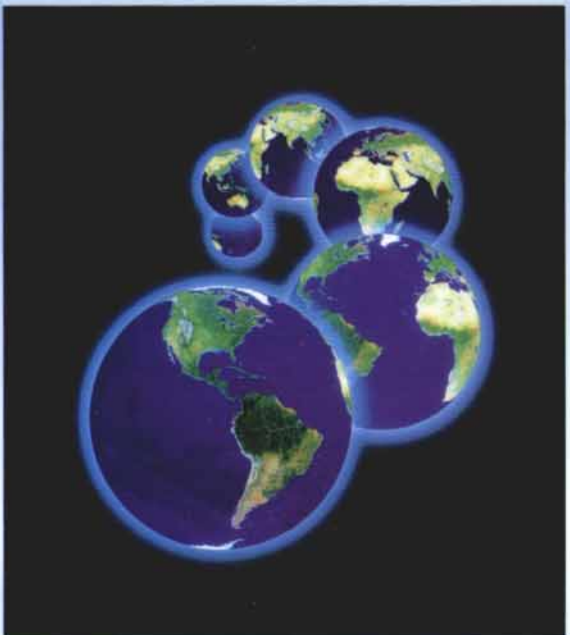

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