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TECHNOLOGY DEVELOPMENT FOR INDUSTRIALIZATION

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Introduction

There is certainly no need to expound on the various specific problems which plague most less developed countries (LDC's). Nor does anyone really need to be reminded that the vicious cycle of across the board underdevelopment is itself the most complex problem of all. It is generally agreed, of course, that science and technology are the most significant resources for breaking through this inertia of underdevelopment. Where differences of opinion and perspective arise is on matters such as how much and what kinds of science and technology should be employed to fuel development. However, to set a nation on the path toward development, these are the very questions that must be answered.

It has been asserted with some justification that industrialization is the principal avenue to economic development of a nation, particularly among the so-called LDC's. There are equally strong voices against such an idea on various grounds, be it the practicability of the idea or the optimality of resource allocation. Admittedly the development of a nation neither starts nor ends with economic development alone. It should emcompass a lot more than that, if it is both to bear and to enjoy the fruits of economic development. I do not intend here to dwell on the pros and cons of these conflicting views. Instead, it is intended to discuss the role of technology for the industrialization of a less developed country from a point of view of economic growth as the prime source of impetus for national development.

In discussing the role of technology in LDC's, there seem to be two conspicuous tendencies worth noting. The first of these is the tendency to advocate opti-

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mization of the factor endowment of given country which invariably results in favour of deploying less sophisticated, capital saving, labour intensive technology under various nomenclatures such as appropriate technology, intermediate technology, or frontier technology.

The second tendency is one which most often treats the subject at the local community, or business firm level as though they always represent the microcosmic characteristics at the national level. This, in my opinion, takes more for granted than can necessarily be true.

Some of the leading industrial sectors in a less developed country are geared primarily to breaking the inertia of underdevelopment of many kinds. They introduce technology quite advanced relative to their absorptive capacity, but feeder industries supporting the leader sectors do not necessarily require such advanced technology. It is, therefore, desirable to look at the issue from both the national and the local points of view so that is thought to be the ideal: "production by the masses" not "mass production", involving both leader and feeder industries, can be realized.

With these thoughts in mind I will try to relate the role of technology in development tasks by using as appropriate some of the experiences I have observed particularly in my own country. In so doing I shall be giving more attention to the role of technology at the national level for national development tasks, not because I believe in a highly centralized system but because of the impact the undertaking can have at the national level. The crucial point at the national level is what kind of role the national government is to play during the various stages of development with respect to that development and the choices of technology for the economy or for social needs. How to decide what role should be played when, seems the crux of the matter and does not lend itself to an easy solution based on traditional preconceived nations prevalent heretofore.

Approaches to Industrialization

For the past three decades since World War II, many countries have made many efforts, reflecting the aspirations of the people of a country, to industrialize their economies. Many have failed except for a few where special conditions of one kind or another prevailed or where they have been made to prevail. Each case is unique in that no all-purpose formula nor set of guidelines seems to exist for others to emulate. Inquiry into the development process from one point of view may not, however, be out of order.

Let us, first of all, look at the tasks which fall to most LDC's in their industrialization. The primary task should be setting the development wheel, from a static state, in motion on a path beset by obstacles of various kinds. The prospects for entering into modern industrialization by an LDC are not so obvious; nor can it be taken for granted that latecomers have the advantage. On the contrary, remedying the situation requires strenuous efforts to build up the capacity to remedy the situation so that industrialization can initially be embarked upon. The process of elimina-

tion of any obstacles to development must be a long-term operation, ideally preceding modern industrialization. If one were to try to accomplish it once and for all, the task would become formidable and could never be accomplished. Instead, there should be a gradual or modular approach to build up the capacity to maximize the advantages of the "latecomer in industrialization" as obstacles are being eliminated one by one, so that the development can take place through synchronization of building up capacity and elimination of obstacles to development.

Industrialization in most LDC's starts for political and economic reasons. By political, I mean the desire for self-reliance, which often transcends the economic reasons. Depending on the degree to which either reason is dwelt upon, the patterns of industrialization may vary markedly. One extreme is to achieve industrialization at all costs, while the other may be only to push industrialization as the economy dictates. The former is the case in which protection of domestic industry with non-economic barriers is essential for survival, while the latter allows the confrontation in economic terms of domestic industry with those of foreign countries. In general, the more the former is held to, the longer it takes to realize industrialization on a sustained basis. One way to look at approaches to industrialization in an LDC might be the degree of selectivity one would choose in terms of the fields and extent of industrialization. This decision for obvious reasons needs to be based on clear understanding of the potentials the country possesses and the constraints to which it is subjected. If it is richly endowed with natural resources for industrialization, the approach must be different from the case in which there are rich human resources but few natural resources.

To elaborate properly on how the path to industrialization should be charted requires treatises on numerous factors, socio-political, cultural, and economic. The case of Korea will be discussed here as an illustrative example.

Process of Industrialization and Role of Technology

The succcess of any industrialization effort hinges on the conditions existing prior to the industrialization, such as resources, technology, capital, markets and so on. These conditions are often referred to collectively by economists as factor endowments.

Korean industrialization began, for all practical purposes, in 1962 when the First Five Year Economic Development Plan was launched. To give some idea of what the initial conditions were in Korea, say from 1959 to 1961, here are some statistics: first, the GNP growth rate averaged 3.3 per cent per year while population growth was 2.9 per cent which leaves a 0.4 per cent net increase. The per capita GNP was under $ 100 so that altogether Korea offered a perfect example of an underdeveloped economy with accompanying stagnation. Second, a severe dichotomy existed within the economic structure: 65 per cent of the total employed were in primary industries while secondary industries (mining and manufacturing) employed only 6.9 per cent of the total. In terms of per capita output, primary industries represented 0.65 and secondary industries 2.60 when we use an index of 1 for all

industry. This means that a mere 7 per cent of the total employed were engaged in relatively productive sectors. Third, the domestic savings ratio to GNP was only 3 per cent and perhaps because of that, the Korean economy was from the beginning an open one vis a vis foreign countries for obtaining the necessary investments which accompanied the rise in the import of foreign goods and services, and also to some extent the rise in exports to pay for the imports.

What Korea opted for to begin with was development of light, labour-intensive industries by absorbing the labour force from the primary sector. The effective demand in the primary sector for industrial products was, however, all too slight so it was necessary to be outward looking in terms of capital, market, and technology. Korea, therefore, did not choose the import-substitution-followed-by-export type of industrialization for development but instead the two were undertaken almost simultaneously particularly when the first long range economic development plan went into effect. The apparent success of this bold approach can be attributed to several factors: 1) the amenability tn training or the absorptive capacity of the labour force in dealing with technologies which were relatively sophisticated, 2) close trade relations with the U.S. and Japan, both big markets, 3) full exploitation of the technical advantage of being late-comers in industrialization, 4) a capacity to adapt to the international economic environment which was actively supported by the government via the creating of a favourable investment climate for foreigners.

The most conspicuous constraints on the scheme for rapid industrialization progress were the deficiencies in the social overhead sectors: the infrastructure for industrial development was very poor so this was the area on which the government placed greatest emphasis for quick and decisive action to build up roads, ports, communications and the other essentials to development, including expanded educational facilities; particularly for technical education. About 50 per cent of the total induced foreign capital was spent in this area as well as over 70 per cent of the total public loan funds from overseas.

The First Five Year Economic Development Plan (1962–1966) embarked on selective industrialization on one hand and on the other the establishment of social infrastructures, to allow the economy to find a proper berth. Such industries as power, cement, fertilizer, and coal mining were among the targets which the government had much to do with. The light industries, such as textiles, plywood and consumer goods were largely evolved upon initiatives from private entrepreneures who saw the favourable domestic captive markets for such products.

This was the period when we witnessed the growth of industry centered around the then prevailing thrust of import substitutions. Thus, not only the size of the industry but the technology it required had little bearing on its competitiveness in international markets. While industry was plagued by its limited size because of limited domestic markets, the emergence of unforeseen industrialization imbued the government and public at large with some optimism for the country's economic future.

The Second Five Year Economic Development Plan (1967–1971) placed emphasis on initiating the lead sectors approach and pushed forward with the continued

expansion of the basic chemical industries and petro-chemicals as well as the iron and steel industry. What was attempted was the initiation of a growth momentum through these sectors so that a dynamism could make itself felt within Korean industry. These industries by their very nature are highly capital intensive and need a huge infrastructure which has to be supported by the government, not that they would develop sufficient linkage effects directly, but because they are essential to the foundation upon which the high linkage industries can be built.

In formulating the second five year plan we introduced a series of bold quantitative tools for formulating development models which were of the greatest importance in articulating our socio-economic goals so that we could identify the growth path we would travel to reach those goals along with identifying the major constraints and formulating investment programmes.

The idea behind this, along with the bold use of foreign experts, was to allow greater latitude for debate on the plan so that a defensible strategy would of necessity follow. Noteworthy is the fact that they often turned out to be too conservative at both the macro and micro planning levels. The dynamism of a developing country, if it ever does reach its momentum, is difficult for such experts to accept. The immensity of the job of catching up often provides an impetus which defies statistical prognostication. The problem can be acute when this happens in a key sector which can force the forward motion of the whole to a complete halt. Becoming overly optimistic can lead to the acquiring of a burden of non-productive capital tied up in excessive capacity which can then alow the forward momentum, and once lost it is extremely difficult to regain.

One pressing problem in developing these lead sector industries was whether or not they could be operated at full or at least near full capacity. It was found that the allowance was extremely small because of the fact that the cost of the capital for these industries, which mostly originated abroad, was very much higher than for the advanced countries. Recognition of this hard fact of life had much to do with the make-up of any industrial project.

The Third Five Year Economic Development Plan (1972–1976) followed later in more or less the same direction of industrialization with greater economy of scale along with agriculture and social services to maximise the advantages of the late-comers by capitalising on the experience of the advanced countries in earlier years and the improved capacity of the country itself. This orientation necessitated the introduction to industry of new, more and higher level technologies on an order of magnitude never experienced. It was an irreversible type decision so far as science and technology development were concerned. It was an issue of survival or extinction in ever stiffening international competition. Korea's experience in the past decade with particular reference to the relationship between commodity exports and royalty payments for induced foreign technologies indicate that there exists a high degree of correlation between the two which in turn leads us to believe that an adequate supply of proper technologies, often advanced because of our development stage, is the essential factor in enabling industry to produce the goods and services which can gain better access into international markets.

For this reason, one of two pillars of Korea's science and technology development policy hinges on developing a capacity for the proper selection, digestion and adaptation of imported technologies. Throughout the previous three five year development periods, foreign technologies were often mingled with the inflow of capital—statistics, therefore, tend to underestimate the amount of imported technology—stemming from the more strongly felt need for foreign capital rather than for technologies. In such cases the range of choice for technologies was often limited and it was treated as if these were only ancillary objects. The situation has, however changed and the explicit need for technologies, as clearly distinguished from capital, has been recognized. The idea of a so called comparative advantage, couched chiefly on low labour costs and making use of manual workers in the main, is not only untenable in the long term but is a path that should not be followed. The day for striking balance in the mix of manual and mental workers is not and should not be in the too distant future even for many less developed countries.

In retrospect, the three successive five year economic development plans culminated in success literally beyond our expectations. The GNP growth averaged 10 per cent per annum in real terms. The manufacturing sector alone attained, on the average, a 20 per cent growth rate per annum; exports which consist of 90 per cent manufactured goods, reached the level of U.S. $8 billion in 1976 from $55 million in 1962, representing an approximate 150 fold increase in 15 years.

Infrastructure for Technology Development

Depending on the host of problems such as the lack of institutional frameworks within which people can function, the lack of legal bases for providing incentives to develop technology, and most of all the lack of qualified people, one can devise various approaches, perhaps differing from country to country, in developing appropriate infrastructure conductive to the development of technology.

It has been said that developing technology in a less developed country is, for all practical purposes, out of the question, and many have treated the subject as though it were a playing field for intellectual exercises. They often assert that any need for sophisticated technologies could easily be met via the transfer of technology from developed countries as though it could just be picked off some shelf. This kind of thinking is undoubtedly not without some justification, but it is grossly over-simplified in such a way that it serves as a collective condemnation of what might be a noble, worthwhile and necessary initiative on the part of less developed countries. One Western author wrote "Research is of course no subsitute for wisdom". However, the pressing need to possess indigenous sources of technology development in tune with national requirements is widely felt in less developed countries. There are many approaches that would encompass more than technical considerations. What kind of technology one should aim at developing, is one of many formidable questions which must be answered.

The literature on appropriate technology is replete with elaborate treatises on the attributes of technology but there is less on the attributes of the development

tasks which cannot simply be translated into terms of employment or income distribution no matter how pivotal their importance.

It is not difficult to achieve a consensus among people of different backgrounds that the appropriateness of the technology depends to a great degree on needs and capabilities and we can go on to conclude that needs must be identified before formulating any plan for technological or, on an even broader scale, any national development plan. The pivotal problem is not deficiencies in perception but how to ascertain needs and how to assess latent capabilities so that they can be translated into development programs for implementation. What little experience we have had leads me to say that this is a task most difficult of accomplishment for most LDC's since such capabilities are often inadequate or even lacking in them. It is most especially here that international cooperation can play a supplementary and complementary role if any cogent progress is to be made.

The appropriateness of technology is often measured in terms of the labour-capital requirement ratio, the level of the requisite labour and the necessary material input. In a sense all these considerations stem from the implicit assumption that technology is to be chosen only after the tasks have been delineated. There is nothing wrong with this but it fails to take note of another vitally important role that technology should play, that is the proactive role through which tasks are to be defined. The mere assessment of the appropriateness of the technology using conventional yardsticks often fails to take various other important factors into consideration, as for instance absorptive capacity which depends on a myriad of factors such as the institutional, the legal, cultural, environmental and even ecological. The biggest problem facing less developed countries with respect to appropriate technology as I see it is the problem of establishing harmony between rising aspirations and slow but organic progress across the board. The degree of patience and the extent of opportunity cost—both political and economic—for not having skewed but fast growth in the lead sectors vary from country to country and how to reconcile them requires political will and sound leadership which goes beyond technical considerations.

For the institutional framework, the Korean approach was somewhat daring. It included, among others, the establishment of: 1) the Ministry of Science and Technology (MOST) in 1967 as the central planning, co-ordinating and promotional body in the government; 2) the Korea Institute of Science and Technology (KIST) by a special law in 1966 as an autonomous multidisciplinary industrial research institute chartered as a contract research organization; 3) the Korea Advanced Institute of Science (KAIS) in 1971, in addition to the many existing universities and colleges, as a mission oriented post-graduate school in selected applied sciences and engineering to begin with, and as a autonomous institution, with its support chiefly from the Ministry of Science and Technology, to educate high calibre scientists and engineers in number and of quality sufficient to meet the emerging needs of Korean industry; and 4) a huge number of vocational training institutes along with technical high schools to meet the rapidly rising, almost explosive demand for skilled workers and technicians.

The emergence of the Ministry of Science and Technology spearheaded the enactment of several very important laws for the development of science and technology. They include: 1) the Science and Technology Advancement Law of 1967 which defines the basic commitment of the government to support science and technology and to provide policy leadership; 2) the Law for the Promotion of Technology Development of 1972 to provide, among others, fiscal and financial incentives to private industries for technology development; 3) the Engineering Services Promotion Law of 1973 to promote local engineering firms by assuring markets on one hand and performance standards on the other; 4) the National Technical Qualification Law of 1973 which, through a system of examination and certification, promote the enhancement of status for professional in technical fields, particularly for those who practice skills; 5) the Assistance Law for Designated Research Organizations of 1973 which provides incentives in legal, financial and fiscal terms for research institute in specialised fields where the government and private industry place particular emphasis, such as shipbuilding, electronics, communication, mechanical and materials engineering, and energy and related area; and 6) the Law for the Korea Science and Engineering Foundation of 1976 which provides a legal basis for the establishment of the Foundation to act as prime agent for strengthening research in basic and applied sciences, as well as in engineering, centered chiefly around universities, and to facilitate more rapid application of science and engineering to national needs.

The Ministry is in charge of formulating and implementing, to some extent, plans for the development of science and technology as an integral part of the nation's five year economic development plans.

Education and Training of Manpower for National Development

Institutional Implications

No one can argue with the thesis that educated people constitute an essential prerequisite to national development. Education has been the subject of intensive treatises by social scientists for many year as the principal means of achieving human capital accumulation which some regard as the most valuable national investment. From the macroscopic viewpoint this has certainly been the case in Korea. Before 1945, when Korea was still occupied by the Japanese, less than 6 per cent of the total population was enrolled in formal educational institutions, but with the liberation of the country this percentage began to rise rapidly so that it had reached 26 per cent by 1974. Even during the Korean War from 1950–1953 more than 15 per cent of the population was enrolled in such institutions, and education was not enterrupted even during those perilous days of open hostilities.

Many people in development administration attribute Korean development in the following decades largely to the broad based education program.

Harbison and Myers[1] found a significant correlation between quantitative indicators of human resource development in seventy five countries and those which measure their economic development. According to their composite index,

the selected seventy-five countries were grouped into the following four categories: Level I, underdeveloped; Level II, partially developed; Level III, semi-advanced, and Level IV, advanced. Korea was listed under Level III as one of the semi-advanced countries even when the per capita GNP stood at only US $ 144 equivalent at the time of the study (1963). As they rightly pointed out, these quantitative indicators do not establish causal relationships. What would be much more relevant to causal relationships might depend very much on post-education arrangements. The cause and effect relationship becomes more apparent if we inspect the figures representing the between technical and nontechnical educational enrollments at the tertiary level. In balance the early 1960's technical education's share was well below that of nontechnical education, but by 1974 the situation had reversed itself so that the number of students in technical education was double the number of those in nontechnical education. These figures explain the degree of intensification of the industrialization that the country pursued.

Educated people can become the necessary manpower only when and if they are placed within proper institutional frameworks which can be made to function and in a favourable social milieu for them to function. If we look at the role of education in relation to national development from the microscopic view, it may be said that the educational system, in general, has not been dynamic enough in structuring its programs to be responsive in keeping pace with the development of the economic and the societal systems. It was on the whole slow in innovating educational programs and also in orienting the system toward development as a whole. It would be taking too much for granted to assume that a sheer increase in the educational base would prove sufficiently and efficiently productive. The truth might well be that the educational system has not really been able to produce what industrial society needed, but rather that society itself had so many tasks that they provided the opportunities for the educated to get involved in self-education and thus become useful.

As examples, the textile industry boom and the rapid emergence of the shipbuilding and steel industries have made it possible to enter into world markets with success not because schools were able to provide well-trained engineers, but because the extensive opportunities in the actual fields were such that the latent potential responded to the challenges. In this light, education is certainly important, but more important in a less developed country is whether or not society can provide the challenges which almost miraculously raise the capacities of the educated people not gradually but by great leaps.

Nonetheless, it would be far too lethargic an approach to depend on so slow an educational process, one that depends on the interfaces with the real world after formal schooling. Short term approaches which might best be adopted immediately could include:

1) establishing an institute which inherently bears a two facted functional responsibility, one to education and the other to industry itself—this could well be a multidisciplinary industrial research organization,

2) creating an educational institution from scratch—one that more than anything else can set the two standards of orientation. The result would be that either of these types of institution would establish a specific literacy in affairs both academic and industrial. At such time as these institutions are properly established and operated, they would exert a tremendous pressure in relation to the orientation of both sides: academic and industry.

In Korea, while recognizing the importance of innovation in education and programs across the board, we did not simply rely on realizing these goals since the development pace we had set for ourselves was simply too rapid for us to wait upon such obviously rational but far too slow solutions. We, therefore, established the Korea Institute of Science and Technology (KIST) and the Korea Scientific and Technological Information Center (KORSTIC) to cover the first aspect of the solution and Korea Advanced Institute of Science (KAIS), a graduate school in advanced science and engineering with principal support from the Ministry of Science and Technology, to cover the second. What this graduate institution tries to accomplish is the building up of a "center of relevance" to the nation's economic development rather than merely creating a "center of excellence" in academic pursuits. It furthermore is designed to accommodate a sufficient number of students and faculty in any given field so that they can act as a critical mass through interaction among themselves. By so doing, it is possible to justify the adequate eqiupping of such teaching and research facilities. They also have the responsibility of developing programs in teaching and research in such a way that they are relevant to the country's problems rather than having them delve into esoteric irrelevancies by working on programs merely out of intellectual inquisitiveness.

Role of Foreign Education: Relevance to Development of an LDC

The role of foreign education in the development of an LDC is, as in the case of technology transfer, a tough subject with two diametrically opposing views both in the LDC's themselves and in the advanced countries. The affirmative view on the contribution of foreign-educated people to the LDC is often a gross generalization stating that whatever knowledge is brought into the LDC will eventually be very useful in its development. This view does not take into consideration possible distortions or skewed concentrations of effort that may result. For instance, those trained in particle physics may well not want to convert their interest to solid state physics which would be relevant to the country's electronics industry. To provide them with the necessary conditions for the proper use of their own knowledge would not only be beyond the capacity of the nation, but it would also be an illusion to expect any meaningful scientific results.

Those who have gone abroad for advanced study have gone through the programs that the foreign country itself may require at some given time, and this of course changs from time to time as we have seen in the past decades. In Korea's case, we were able to locate many Korean scientists working abroad, who had extensive academic training, but not many in fields which the country could find immediately useful.

The other extreme view of foreign education is that it does not in itself contribute to the development of the LDC. For reasons just mentioned, this is of course an over-generalization which does not recognize the possibility of weaving such knowledge into the country's intellectual fabric. Obviously this process is a difficult one to accomplish, but with foresight and persistent persuasion, the conversion is possible to fill the gaps which would otherwise be difficult to fill from among only locally trained personnel. In the initial day of KIST's operation, I personally was involved in just such a conversion, for instance, from physical chemists to either lubricant technologists, or metallurgical engineers, through persistent persuasion. It can be highly successful, once the people involved can find values in achieving something that can be applied by industry rather than simply finding their gratifications in the sheer increasing bulk of the papers they would otherwise be turning out.

Some of the important potential contributions of scientists abroad, in addition to the cross-fertilization of knowledge with scientists at home, include the advantage of being able to use them either as resource people to supplement the scientific knowledge, as needed, or as referees for whatever scientific work we are involved in. One of the most difficult situations in the LDC so far as science is concerned is the lack of peer assessments simply because of the limited number of people in any given field. Candid evaluation should most often consist of critical evaluation, but such an evaluation of scientific work in an LDC environment can only offend so that assessing results becomes impossible.

We have not in Korea suffered from lack of understanding of the role of education in national development either by planners, economists, political leaders, or for that matter the public at large. What has been lacking so far is understanding of what is required to convert edcuated people into much needed manpower.

Supply of Skilled Workers

One of the most conspicuous bottlenecks that most LDC's face for their industrialization efforts has been the difficulty of ensuring the supply of necessary manpower, most particularly skilled workers. One of the reasons attributable to it is the social status accored to subprofessional people or those who practice skills. Producing a sufficient number of qualified people in the subprofessional category is a critical task to be achieved for the sake of economic development. Divising measures better to utilize them after training is much more important. Better remuneration can not alone solve this problem. Much more deep rooted tradition-bound value criteria need to be corrected somehow, be it through elevating their social status or improving financial factors or perhaps the two combined.

What Korea has done, directed toward this goal, includes legal, financial, and administrative measures. Several laws have been enacted to step up the training programs by the government on one hand and to obligate industrial firms above a certain size, on the other, to undertake in-plant training programs to help accelerate the production of needed manpower, exempt selected technicians who pass the national

examination for skill proficiency from obligatory military service—this is probably the most prized incentive the government can provide—and award scholarships to those who are still undergoing education and training.

The National Technical Qualification Law, promulgated in 1973, stipulates, among others, the enhancement of legal status, which it is hoped will filter down to the real world of those who practice skills in particular so that their status can be made equal to academicians and those who practice engineering after receiving academic degrees. The philosophy behind this law is to help bring about consensus building among the public so that young talented people may with high morale and pride choose skills as careers. Without this, the usual inclination of young people toward academic training can hardly be changed. If this were to continue to happen, it would not only drain a nation's all too scarce financial resources but more importantly, would make it difficult to fill the need for people in skill fields, which is the base upon which industrialization can be built.

Role of Technology Transfer

In addressing the subject of technology transfer, let me first say that a mystique seems to have attached itself to the subject, a mystique which can be either affirmative or negative. The affirmative view is that whatever is developed—mostly in the advanced countries—can be transferred intact to a less developed country thus obviating the necessity for R & D in the LDC. Stages of development, or more properly intensifying industrialization, have been markedly spaced enough to lead many to the thought that such transfers can suit the needs of those who require the technology involved. The negative, on the other hand, holds that whatever is developed in a particular place and situation applies only to that specific, unique condition so that relying on such a development would be futile, and what is always required is self-development no matter the cost, the length of time, or the difficulties involved.

In my view there are both excessively biased attitudes, but there is some truth in each. What is needed is a combination of the two rather than a seeking for solutions on one side or the other. We take a mixed view in Korea, that is, while it encourages maximum domestic R & D, in equally or even more strongly emphasizes the timely introduction of technology from abroad so that industrialization in selected areas can proceed without incurring high opportunity costs. That is, first, industry must have a given necessary technology in time to make resulting products competitive on world markets.

Obviously, when we think about technology transfer, we must understand clearly where the technology exist and in what from: is it embedded in equipment, in human resources, or in literature? Regardless of the form in which it exists, we must give thought to the proper method of transfer which in turn depends on the state of its existence.

A first point in considering technology transfer is that it has been borne out by experience that the amount of technology imported has a proportionate positive

impact on the level of exports. This has certainly been the case with Japan and Korea in the last two decades. Based on this experience, we may conclude that in a developing economy, where exports provide the main impetus for economic development, the technology import amount has a direct relationship with the amount of exports, or in other words, technology supply is not only essential but is the key determinant in building up the capacity to produce competitive goods.

The next point to be considered is that transfer of proper technology can only be accelerated if and when viable domestic R & D exists. Technology transfer needs can best be identified if there are present the informed people to speak up for them and also to assist in the selection of those which are relevant.

The third point is the selection of the particular technology for transfer. This makes it all the more essential that the domestic R & D be viable so that options are based on good assessments made by technologically literate individuals. As mentioned earlier, technologies exist in various forms; some can be retrieved only with persistent questioning, particularly in the case of know-how where intelligent questions are essential in producing feedback. There is no automatic flow of know-how knowledge; only appropriate enquiries and question can start such a flow and keep it going.

Only a limited number of firms are capable of, or equipped for, the efficient use of imported technologies, and this is an even more acute problem in an LDC where industries begin quite literally from scratch and then must move into, for them, completely unknown areas. Nor are educational institutions in an LDC in a position to help solve such problems. To make the educational institutions capable, however, of responding to the requirements arising from inadequacies at the producer level is by itself a formidable task. Even if it could be tackled adequately, there would be the risk of paying high opportunity costs.

To achieve viable results from technology transfer, we have found every reason to conclude that it is basic that a corresponding effort be made to digest and adapt foreign technologies. The Law for Promotion of Technology Development stipulates that whenever technology is imported and in whatever form, the importer is encouraged to set aside a specific amount of money—usually an amount equivalent to the import cost—for just this purpose. For those who do follow this policy the government, through its fiscal policy, accepts for taxation purposes the amount set aside as a legitimate business expense, and also any capital investment in adaptation is eligible for investment credit.

Since the law's promulgation in 1972, we have had reports on the amounts involved, and they demonstrate a striking rise in such activities. The Ministry of Science and Technology comes into this picture in certifying that what has actually been done with such funds have actually gone into R & D activity hence guarding against abuse of the law solely for tax deduction purposes. In 1974 alone, seventy eight firms filed reports with the government that some US $7 million equivalent had been set aside for either the digestion of imported technology or other R & D.

Because the importation of technology into Korea has been, in most cases, packaged into much larger arrangements involving for foreign capital investment, it

has not been possible for the government to regulate technology import effectively. the Foreign Capital Inducement Law enacted in 1962 is directed towards both the control and the promotion of foreign investment. The Law specifically recognized the importance of monitoring technology import by requiring that any request to import technology be subject to prior government scrutiny and approval. Permission is granted on the basis of certain established criteria such as contributions to export or the use of indigenous resources. In Korea, administering such procedures has been under the purview of the Economic Planning Board by law, but it has been depending heavily on the technical evaluation of the Ministry of Science and Technology. In practice, it has often suffered from the rapidly changing requisite technical expertise within government administration. For this reason, the Ministry has engaged the independent intermediary R & D institute, the Korea Institute of Science and Technology, where appropriate, to look into the appropriateness of a particular technology under consideration for transfer from foreign sources. In this sense, the R & D establishment in Korea has assumed a pivotal role in assuring the effectiveness of technology transfer.

Approaches to Industrial Research: Organization and Management

There are several important aspects in devising the proper approach to industrial research, particularly when the host of problems besetting most LDC's is recognized. Proper approaches can vary from country to country yet surely there are enough common elements to justify efforts to exchange experiences and information.

The Korean approach has been first to establish an independent multidisciplinary industrial research institute, the Korea Institute of Science and Technology. The second was the reinforcement of the information clearing house for industrial research. The third, the establishment of quality control and instrument calibration service centers as short-term measures in selected fields of industry to meet its immediate needs; as a long-term measure, the National Standardization Institute is being reorganized and reinforced, both in terms of physical and intellectural facilities to support industry. The fourth was the promulgation of a law for the promotion of industrial research as mentioned.

Most LDC research institutes have been directly under the jurisdiction of governments and, as part of government systems, these institutes have failed in many instances to recognize their obligation to produce for users. Potential users, particularly industry, have not taken interest in whatever development have come from these institutes simply because they are made available free. The situation might be explained thus: unless the users have to pay out of their own pockets for research and development, they are less likely to exploit them. This is one reason that we have made the Korea Institute of Science and Technology a contract research organization so that marketing principles prevail even in the realm of R & D.

Since it is a contract research organization, it was necessary to adopt several systems which most government institutes do not employ. These were: first, establishing a Project Development Department as the vehicle for selling the concept of

scientific research as a way of solving the ploblems of industry and as a means of assisting industry to formulate questions to be asked of the Institute; second, adopting a cost accounting systems for R & D activities to gauge input as compared with performance, including logging use rates on equipment, space, and utilities; third, adopting a multidisciplinary approach by eliminating the rigidity inherent in departmentalization. One foreseen potential drawback was the possibility that the institute might be so heavily preoccupied with contract research from various origins that the congruence of its program orientation might be difficult to establish, and further that it might leave little room for consistent and sustained buildups of capabilities. To guard against this, a large endowment fund was established to enable the institute to undertake research in long-term or overlapping interest areas for which particular clients cannot be clearly identified.

The Korea Institute of Science and Technology incorporates within its framework a self-perpetuating board of trustees of which three members out of the total eleven represent various government ministries so that, while it can serve the needs of both government and industry, it is under the control of neither and is allowed the maximum possible autonomy. Furthermore, the institute was made non-profit although all its work is on a contract basis. While it was reckoned that it would be almost impossible to expect industry to commission contract research in sufficient volume, it was also thought crucial to inculcate the concept of contract research to induce industry's involvement by attracting financial commitments on the one hand and by obligating research workers on the other to commit themselves to producing something relevant to industry's needs by their being supported financially by industry.

The following services, in addition to its major activities in R & D, which KIST has been providing to industry may deserve special mention: first, general engineering services rendered on both a periodic and an ad-hoc crash basis in an effort to diagnose the operations and provide assistance as necessary; second, assistance with adapting imported technologies to commercial production; third, the undertaking of package deal contracts for small and medium industries in selected fields; fourth, the production of prototype products or the operation of pilot-scale plants to demonstrate the feasibility of the commercial application of research results; fifth, the operation of information analysis services for industries to keep them abreast of technology developments in their fields.

In developing KIST's initial programs, the following thoughts were taken into consideration. First was the determination to insure that the first project be of great significance to make industry aware of the value and that it have a high probability of success with an all-out utilization of all available resources. To accomplish this, a techno-economic appraisal of each proposed project was made.

In addition to setting up the management philosophy, the initial program KIST undertook was a detailed techno-economic survey and study of Korean industry in an effort to place the KIST program in its proper perspective. The study, involving more than 600 industrial plants and related organizations, was made over a period of 8 months with about 80 specialists, including 23 from overseas in 25 different industrial sectors. This survey helped to formulate the main areas of the KIST operation for the initial period. They were:

1. materials and metallurgical engineering
2. food technology
3. chemistry and chemical engineering
4. electronics
5. mechanical engineering
6. industrial economics and management

Based upon these selected areas of endeavor, such important decisions as staffing, equipment, and facilities were made to ensure that the Institute would be properly equipped to solve both industry's current and emerging problems. Such studies are carried out periodically to cope with industry's changing requirements and to maintain the Institute's capability to solve them.

As industry grows by leaps and bounds, the technological requirements rise accordingly in level and diversity; laboratories in areas of particular industries such as shipbuilding, petrochemicals, mechanical, electronics and telecommunications which existed as integral parts of the institute, no longer find it feasible to render necessary technical support to industries growing so rapidly. This necessitated the establishment of a much broader based laboratory specific to each individual industry. To create such from scratch would become a formidable task. Instead, we make use of the existing small laboratories at KIST as the seed and spin them off their mother institute so that they not only inherit what has been accumulated there but also inherit a management philosophy which often is lacking or is in an amorphous state in a new organization.

The breadth of the importance of industrial research had only recently been recognized, although it not only provides support for economic development, but perhaps even more importantly for framing the plans for formulating economic development strategies. Industrial research is essential to the realisation of a nation's industrialization goal within the context of the global and regional economy, and if it is properly carried out, it can help in setting reasonable, feasible goals.

In striving toward these goals Korea has made substantial achievements, through numbers of trials and errors, in improving national scientific and technical capabilities, in innovating the administration and support systems, and in increasing as well as orienting R & D investment. The total science and technology effort was intended to effect a structural change in the economy from a simple labour-intensive to a more viable technology-intensive structure and later to development of a brain-intensive structure. In other words, these efforts were directed toward accelerating the transition of sciene and technology's role from supporting national economic development to one leading such development on a foundation of a technologically self-reliant economy which is planned for the near future.

Promoting Development through Focussing on Strategically Specialized Industries

Considering that industrialization had to be begun almost from scratch, a huge stimulus was needed to normalize the process. Accordingly, a leader sector was established to provide the boost needed to get industrialization off the ground and rapid

economic growth was achieved through concentrating support in this sector. I have already noted the industries making up this leader sector in the course of discussing the effects of long-range economic planning in Korea. It will be recalled that most of these industries are of the type requiring capital intensive huge facilities to turn out products which are generally raw materials or else semi-processed raw materials with comparatively low added value.

Relying on a leader sector of this kind makes it necessary to attach great importance to the economic unit. That is, not only from the economic but even from the technical piont of view, it becomes necessary to think in terms of economies of scale. Therefore, once these industries came to have great relative importance within the industrial structure, high-level growth came to hinge on stressing the expansion of their scale. The problem is that this leads to a vicious spiral of ever-expanding scale as the condition for maintaining the industrial system and its high-level growth. It becomes problematic whether this momentum can be kept up endlessly, and in any case this kind of growth has many unwanted side-effects.

The obstacles to continuing to pursue this type of development are formidable. In the first place, it ultimately demands a very large-scale industrial system which could only be maintained at the cost of chronic instability, considering the nearly total dependence on foreign countries for the needed raw materials and energy. This demand in turn implies many serious problems related to the tremendous infrastructure needed, the building of transportation networks, evironmental management and the resultant unnecessary competition in the international markets. Japan is a clear example of development models of this sort in which growth is achieved through placing priority on expanding the scale of all industrial fields. The increasingly apparent problems Japan is facing in adhering to this strategy suggest that, rather than simply following the Japaneses experience, an alternative strategy should be develped for promoting industrialization. Of course, I do not believe that there is any one unique formula for devising strategies to promote the industrialization process. We should not simply follow the example of the U.S. which is rich in natural resources but has a shortage of manpower, nor that of Japan, which has a superior labour force to compensate for its lack of natural resources. Actually, there are many small countries in Western Europe which are numbered among the developed countries and enjoy a stable prosperity even though they lack natural resources and even have a shortage of manpower. It is necessary to pay closer attention to the industrial structures of these countries and to the directions their industrialization has taken. Once a country has reached the take–off stage in its development, some kind of boost may be necessary to ensure that the momentum of development is maintained, but it is equally imperative that the industrialization process be put back on a normal track as soon as possible. To this end, unique industrial structure and direction for the industrialization process must be established on the basis of the actual conditions in a given country.

Reflecting on the actual conditions in the Korean case, it would seem that what is needed is not the blind pursuit of an ever-increasing scale but the transformation of an industrial structure which stresses the manufacturing of products with a high added value stemming from the asset of a high quality labour force combined with a sparing use of natural resources and energy. In this way it will be possible to

develop strategically specialized industries which emphasize technology and brainpower and do not need to follow the lead of other countries, even though they are small in scale, rather than becoming bogged down in establishing industries requiring huge infrastructures which in turn require immense capital investments. Thus it should be possible to achieve a stable prosperity while avoiding unnecessary competition from the viewpoint of the international division of labour.

In making this argument it is not my intention to minimize the significance of large-scale industries. Rather, my point is that the development of these basic industries should be kept within bounds of what is needed to support the minimum demands of the more specialized industries which produce high added value products. After all, ensuring a stable supply of the major raw materials and semi-processed intermediate products is the essential prerequisite for a final product which will successfully compete in international markets. In other words, basic industries must be developed as a foundation for industrialization but the scale of these industries has to be determined in terms of what is appropriate at a given stage and for the goals being pursued. Moreover, it is necessary to achieve a balance between quantitative and qualitative production as well as between installations and technology.

It is, therefore, quite obvious that in a country like Korea with its limited territory, few natural resources and high population density, it is skill and brainpower which provide the base for national development. So while we are laboring to foster the needed manpower we must also search for a technological development strategy which will employ this superior manpower within an industrial structure which makes the most of technology and brainpower. To place the emphasis exclusively on those industries which require a huge infrastructure would mean prevailing instability with the concomitant loss of the opportunity to join the ranks of the developed countries. Taking this perspective, it is elear that our efforts must be bent toward achieving that "small but tops" type of development which is exemplified by such European countries as Switzerland, Belgium, the Netherlands, Denmark and Sweden.

To realize the technology-intensive industrial structure, it is necessary to (1) foster the development of strategically specialized industries; (2) optimize social and industrial system; and (3) promote the quest for a high technology society. As was pointed out earlier, strategically specialized industries will have to be characterized by a propensity to economize resources and create employment opportunities while requiring minimal capital investments and producing little environmental pollution. In this respect, it has to minimize its spending on social overheads to compete successfully with the fully industrialized nations and resources-rich countries.

The industrialized nations of the present have all developed their industrial and social structures on a trial-and error basis. While they are obviously effective to one degree or another, these firmly established structures have a certain rigidity. In a LDC however, there is an opportunity to develop an optimal system by drawing on the lessons learned in the Western experience. In other words, LDC's are in a somewhat favourable position as far as social overhead spending is concerned.

For this reason, optimization of the social and industrial systems seems to be a very important strategic goal. The government will have to place a high priority

on technology development to achieve this goal. The renovation of backward technologies should be given special consideration. So should the introduction of advanced foreign technologies. But most importantly of all, LDC's will have to step up its efforts to develop their own technologies. Integral to the achievement of this goal are the efforts to train the needed research personnel and skilled workers while promoting a high level of interest in R & D activities within the industrial sector.

Concluding Remarks

In concluding, I wish to convey the following remarks from my own experience, observations and convictions.

First, for the LDC's which in most cases suffer from the vicious cycle of underdevelopment of many kinds but particularly economic, it is imperative to have some lead sectors pursued with a daring mix of technologies and entrepreneurship for breaking through the inertia of underdevelopment.

Second, planners in many LDC's have taken industrialization actually to mean "economic development". Less significance has, however, been placed upon the need for industrial research in the country where industrialization has been chosen as the economy's prime mover. The importance of industrial research has only very recently been recognized not only for its supportive role for economic development, but also—perhaps more importantly—for framing the plans for formulating the strategies for economic development.

Industrial research in developing countries is not only a feasible proposition but also an essential endeavor to help realize a nation's industrialization goal with the context of regional and global economics. In addition, industrial research, if properly carried out, can help in setting reasonable and feasible goals.

Industrial research can be extremely useful in developing technological rapport with changing pattern of industrial development and it can, over time, act as the catalyst in changing the attitudes of entities within the contact domain of industrial researchers to enable them to cope with ever changing situations. Sustained economic development in many of the LDC's absolutely depends on how soon, how much, and what kinds of industrial research they can manage to undertake.

Third, the massive effort to mobilise in-country talent and bring it to bear on the problems at the grass-roots level, be they agricultural or industrial, is not only desirable but essential to realize the national industrialization goals.

Fourth, the LDC's should not be swayed by the prevalent notion, held by some, that the generation of technology in the countries is not economic, if not impossible. On the contrary, there is a vast scope and an absolute need in LDC's for the generation of technologies by those countriest hemselves or perhaps in collaboration with countries where there are enlightened governments and people. To accomplish this requires the right people more than anything else as they are only ones who can change the methods and the milieu.

Lastly, I would like to emphasize that positive involvement of a chief executive of a nation in the development of science and technology for economic growth and social development, is not merely desirable, but essential for less developed countries, if they are to develop their science and technology and apply them efficiently to their development.

The development success stories we have seen evolving around us in the last century are distinctly limited in number and it behooves us to think of something daring and innovative in approach if we are to leap the gulf which separates the developed from the underdeveloped, the rich from the poor, the urban from the rural, industry from agriculture, and mental labour from manual.

Reference

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