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Conclusion: A Proposal for Future Research

Before coming to our proposal, I wish to reiterate that what I have introduced above does not represent all the work of my colleagues on this project. There is that of Otsuka Tsutomu and Kasama Aishi on food-processing technology; Nakagome Shozo on Western clothing manufacturing in Japan and traditional fabric recycling technology; and Namie Ken on farmers' development activities. Two other regional studies were planned, but were in the provisional stage when this book went to press; there is every reason to expect they will bear fruit.

Time and budget restrictions prevented us from publishing the results of the work of these scholars. Ironically, problems in "developing" these new areas of study were encountered. Although the work in these areas is of high practical and scholarly interest—indeed, because it is so—we find having to leave this work unfinished or unpublished particularly grievous.

We were also perhaps overly desirous of as wide an audience, as large a number of "dialogue" partners, as possible. This pushed our staff to the limits. But we did our best. Our respective places of employment all suffered, all bore the burden of this project. And all deserve a thankful mention here.

In conclusion, although we were not able to achieve all that we had hoped, we are satisfied that we have contributed in some measure to the narrowing of the gap between theory and practice. I fear only that I may have let down those working with me on the project.

The "Japanese experience" project was an attempt to analyse the process by which modern Japan passed from dependence on foreign technology to technological self-reliance as an example of a national experience with the development problem.

This perspective has heretofore not been found in Japanese studies, whether in Japan or abroad. As a result of our five-year study, we have developed our own theory concerning the components and stages of development. Here, in place of a conclusion, I would like to put forward a specific proposal regarding the problems of technology and technology policy and the course of future study. As stated throughout this book, what we desire is dialogue with third-world intellectuals and practitioners now actively engaged with the problems of development and of technology in the context of development. This proposal could serve as a basis for further dialogue towards a solution of these problems.

In exchanging actual experiences, specific examples, we participants in the dialogue can gain a clearer picture of development and its problems and identify common elements and possible solutions, and the proper priority or scale of the urgency of problems and how they might be linked. Through such a dialogue, I will doubtlessly be compelled to revise my position on certain aspects and go back to the shop-floor to provide my colleagues with the information that may be needed to give them a fuller understanding of the Japanese experience, to help them solve or provide them a way for tackling their particular development problems.

Specificity is desirable in the debates surrounding the problems of development and technology, especially reference in the debates to specific historical experiences. Without this specificity, there can be no approach to a solution. We cannot afford the privilege of leaving the solution of these problems to a third party. The problems require detailed inquiry. But detailed inquiry alone is not enough. Unless we converge specific cases to generalize, there can be no methodological basis for our dialogue. We cannot say, based on convergence from specific examples to theory, how far the dialogue we are urging will develop. We have, after all, only limited experience with such dialogues. Nevertheless, we must expect that our efforts will help to lift the discussion to a higher level for those who come later.

The Role of the State

1. This subject fits in anywhere in the dialogue. Looking at the Japanese experience, we find dramatic differences between the structure and the operation of the Japanese state between the time of initial industrialization and the period after World War II. The locus of sovereignty was also different. For these reasons, we must be cautious about simple or excessive generalization.

It is easier to discuss the role of the state if we confine ourselves to governments. The government played a major role in national development in Japan, which in a sense took place both at the initiative of the state authority and in the cause of its further development. That it was intended as protection of national sovereignty is obvious from the government's policy towards railroads and landholding patterns along rail lines. The government simply invoked its authority to acquire needed land resources.

At the same time, the government invoked its sovereign prerogative to build government factories and offices, for which it imported foreign technology and employed foreign engineers to bring needed technology into the country.

But the government did not do everything. It lacked customs autonomy and was unable to apply a policy of protection for infant industries. This was due in part to the small size of its tax base and thus of its budget. Because of budget difficulties and also the failure of government enterprises to prosper (not to mention the government's over-reliance on foreign engineers), many government-operated factories and mines were sold to private entrepreneurs. As a result, technology began to spread and management began to be rationalized.

The railroad enterprise, begun at government initiative, demonstrated its efficacy and profitability, leading to private rail development on the local and regional levels. The government example proved the efficacy of development.

Others learned from government failures. This was the case in the spinning industry, which was able to find a "rational" scale, in terms of technology and management, for proper operations after observing the government's mistakes. Here again, the government initiative performed a useful role and did not act to contain private activities.

In general, we can assert that, while the government bore the main burden in heavy industry, iron and steel, armaments, the main rail lines, and communications—industries requiring large capital outlays—it left the development of light industries to private entrepreneurs. By pursuing this kind of policy, it was able to foster the transplantation of the machine and chemical industries and to nourish the growth of a national technological network. This network had both public and private aspects, but the state was able simultaneously to minimize its own role and to maximize the efficacy of that role.

This did not lead to autarky in technology, but instead to a rapid and varied transformation of technology. If rational choices are made in the importation of basic technology it will be possible to integrate the imported technology into the pre-existing technological stock without creating too great a burden on the national economy. Japan's army and navy, contrarily, aimed at developing technology for "weapons independence," stressing functionality, with no regard to cost and linkage. Furthermore, it was not possible to apply such technology in the civilian economy, as the technology was developed with purely military purposes in mind.

In conclusion, we can say that the Japanese government lacked a firm policy on science and technology in the early period and began to develop one only after the outbreak of World War II. And, not until 11 years after the end of the war did the Japanese government establish its Ministry of Science and Technology, in 1956.

2. Japan's ability to develop technology, in spite of its slow response to the challenge, was due to the low level of the West's technological development in the mid-nineteenth century and to the technological gap between Japan

and the West being much narrower than what now exists between the North and the South. Japan was lucky.

World War I caused a structural change throughout the world in the relationships between politics and science and technology and also between science and technology and society. It also produced wider gaps between the West and Japan in certain sectors of production. Having achieved the minimum necessary level of scientific and technological autonomy, however, this period represented a challenge that Japan was able to meet. In time, and after persistent analysis, Japanese manufacturers were able to replicate the latest technological developments of the West and thus produce products that were competitive and narrow some of the sectoral gaps between Japan and the West.

Taking the latest technological developments as models, Japan copied the leading technologies, borrowing and replicating creatively. This approach, after the interval of World War II, provided a basis for Japan, once economic recovery began in earnest, to do what the scientific and technological leaders had done after World War I with national policy for science and technology. Japan's second stroke of luck was that this development came when the trading of scientific information and technology was freer than it had ever been.

The guiding principles of this Japanese experience can be represented by the following key words: the *feasibility* needed to realize technological goals in a relatively short period, the need to be *selective*, the *strategic planning* involved, the requirement for a clear establishment of *priorities*, and the desirability of *orderly* and *timely* application.

The effective application of these principles requires governments to secure adequate information about the five Ms discussed earlier and the five stages of development from imports to self-reliance.

Today, both science and technology in their most advanced areas have become heavily military in orientation and are very large in scale. A high degree of national and political prestige are involved, and efficiency and functionality have been realized to a degree far beyond the demands of mere economic rationality. Science and technology have thus become politicized, a part of the establishment, and in this sense, totally unrelated to the problem of development. Even if certain technologies derived thereby can be used for development, they will demand such economies of scale as are quite impossible for developing countries, handicapped by diseconomies of scale, to provide.

Further, contemporary technologies are, in a manner of speaking, black-box technologies in that they are not amenable to the kind of disassembly and study the nineteenth-century technologies were and not easily integrated with indigenous technologies, also often possible in the nineteenth century. For these reasons, if technologies are not borrowed selectively, their importation can easily lead to technological subordination and an end to hopes for autonomy.

In today's world, no country is autarkic in science and technology. And only a few have the ability to develop new technologies. If countries without this capacity choose technologies that worsen their technological subordination, these choices cannot be said to have been advantageous to the development of the nation-state.

3. Granted that development is a function of sovereignty and that technology is necessary for development, countries must nevertheless establish firm technological goals. Once these guide-posts are set up, the role of the state is reduced to monitoring how they are adhered to. Here again, administrative ability becomes important. This is something in which developing countries are often deficient. Data and information necessary for the establishment of guide-lines are not just neglected; they are left to rot in storage or appropriated for private use. These organizational weaknesses are compounded by poor monitoring, so that when something is really needed, it is not available. This last problem will probably be remedied when the latest information technology is employed.

From our dialogue, we have learned that there are countries with no industrial census, and that many of those that do have one restrict its use. A census must be taken, and proper methods for its use established. Unless the level of accuracy in industrial census data is raised, technological planning is impossible and guide-line monitoring ineffective.

Unification and standardization of units of measure, of rail track gauge, and of electric voltage and cycles are necessary, for example, to the developing nation. Countries lacking this unification face major obstacles in their pursuit of development. This may seem a minor point at first, but for countries that were kept divided regionally and culturally when they were colonies, such a logistical unification is often very difficult to achieve. Once these standards have been firmly established for technological development, however, enterprises can be set up fairly easily, and the newly urgent need to modernize outdated equipment and plants will spur national standardization.

As the record of village activity contained in Namie's (1981) work shows, one factor inhibiting the spread of knowledge of technology (and the application of that technology) is the use by techno-scientists and bureaucrats of terminology and units of measure that are unfamiliar or difficult to understand. This was true in Japan until the 1930s, especially concerning fertilizers, but generally evident in most books on agricultural technology. What we found from our surveys and dialogue was that there were surprisingly few basic technical manuals available, and the effort to provide charts, tapes, and slides for the illiterate farmer and to broadcast needed information for the spread of technology was noticeably lacking.

4. A technology and science policy has several aspects. First is the overall approach to development. The dicta "universal truths" and "science as the answer to everything" need to be carefully scrutinized to see just how applicable they are. Also, a policy on science and technology must include a persuasive response to those antiscientific and antitechnological elements in society that will resist its implementation. Taking the long perspective, which

involves a conviction of the efficacy of science and technology, developing nations must first take advantage of being late comers to industrialization. Next, developing nations must establish industries which are appropriate to their particular cultural conditions and seek competitive advantage in order to gain competitiveness in the international market.

Second, a policy of science and technology must be a policy of industrial technology. First designate the locomotive industries of the economy; then, based on their technology, develop linkages with related industries and supporting service industries.

At this phase, the problems directly encountered by a developing country vary widely from country to country. The technology for solving specific problems of development often does not exist anywhere, and each nation must develop its own. Technology transfer can only help to solve these problems; it cannot provide the basic solution. What is often called the latest technology is not necessarily applicable to the problems of all countries.

Reversing the explanation, we can say that the "alternative technology" is whatever technology can solve problems of development, be it new or old, domestic or foreign, acquired easily or developed with difficulty. The important thing is the creation of a national system for the use of alternative technologies. For self-reliance in technology, this must be created as rapidly as possible, at the minimum scale and standards required.

Third, countries wishing to develop a sound science and technology policy should plan for the training of scientists and engineers.

This comprises two basic strategies: (1) a long-term strategy for developing specific standards in elementary, middle, and high school education and (2) a short-term plan for meeting more immediate manpower needs. Both are related to the need for the creation of a cluster of engineers able to work with old and new, domestic and foreign technology to bridge the gaps in linked technological development.

Science may be universal, but technology is not. Native engineers must be the creators of solutions to problems of national development.

National Consensus and Basic Human Rights

Friction cannot be avoided in development. This is because there will inevitably be those who benefit and those who suffer. Even if it were possible to conceive of a situation in which this were not so, there is no historical precedent for development that preserved social relations and the social structure and that also brought about social and economic development that was both horizontal and vertical. Even when a proper balance is struck, there are bound to be differences in time or across regions or among different groups in society. If there are not too many people divided into opposing camps of beneficiaries and victims of development, the many who fall somewhere in between or who are neutral may act as mediators in the conflict.

Because development is intended to benefit a nation as a whole, when individual regions or groups do not share in the benefits, cries for fairer distribution can arise. The resulting tension and social unrest can have harmful consequences for modern technology. Because of the high density of interrelated technologies, paralysis or disorganization in one key sector (for example, in railroads or electric power) can have widespread and lasting effects.

A basic requirement of modern technology is political, economic, and social stability. At the same time, development and the proper use of technology promote stability. Meiji political leadership was remarkably stable and was therefore a basic condition of the domestication and development of modern technology in Japan.

However, it cannot be overemphasized that a national consensus supported the importation of modern technology for development. It was through the creation of this consensus that the social tension and friction resulting from the process of development based on imported technology were minimized. It was precisely because of this consensus that the accumulated experience and wisdom of the nation could be mobilized effectively and applied to the solution of problems of development.

A national consensus helps to absorb the shock of development, but it can also work the other way, as happened at the Ashio Copper Mine. The people living near the mine had their basic human rights and livelihood ignored and violently and forcibly suppressed. Tanaka Shozo, the leader and organizer of the protest movement against the pollution caused by the Ashio mine, was politically destroyed by the Meiji state and died in poverty.

Although not widely known internationally, the significance of Tanaka's work and thoughts is great indeed. He was not a modern thinker; yet, for that very reason, he was in a position to directly criticize the negative aspects of modern technology. Tanaka was not against technology or development *per se*, but to how modernization was carried out and how it affected people. Tanaka maintained that some groups in society were victimized, and that there was a need for the majority to respect the basic human rights of the minority. Tanaka's was a criticism from below of the national consensus for modernization that was initiated by the élite; it was a criticism of the inevitable disrespect for human rights by the authoritarian national statist ideology of the time.

To express it differently, we might say that, although a national consensus supporting development must be created, as long as it ignores the problem of human rights, it will never be free from the evil of state authoritarianism, that modern disease.

Because development is a matter of national prerogative, there can be no denying a country's right to it. Similarly, final responsibility for resolving the confusion and friction arising from development lies with the state. Government activity is legitimized by national consensus and regard for basic human rights. The basic human rights we speak of need no strict legal definition. They involve human dignity, the right of each individual to a decent life. There is a tendency for conflicts to arise between required technology and basic human needs, between human needs and those of the state. In times of political or economic hardship, the needs of the state tend to come first. It is the duty, and, if accomplished, the honour of politicians to co-ordinate a respect for and protection of basic human rights with the national interest.

The government imports and supervises technologies for social development and the establishment of a national economic base. There are also technologies that private individuals and groups use in the development of industry. When the two kinds are linked, they can be structurally co-ordinated, and the basis for an autonomous national technological infrastructure can be created. Once established, this autonomy can later be rapidly extended. The sign of a truly sovereign government is the early establishment of structural links between the technologies the government needs and those private industry demands. Many governments have asserted their sovereignty and tried to protect their economies, but few have thus proved sovereignty.

Formation of a National Technology Network

Modern technology is linked and accumulative. Its vertical and horizontal structural links, compared with those of pre-modern technology, guarantee less freedom of manœuvre, despite the normality of free transfer and sale of technology as a commodity. Without a variety of stable, fixed-scale service industries and a supporting infrastructrue, modern technology simply cannot operate.

This is the reason even technologies transferred for a specific productive purpose (for example, for import substitution) can quickly run aground.

Today, some technologies are transferred to meet government needs, and some are transferred for the needs of the populace at large. Hitherto, most technology developed in Europe and the United States has developed from the bottom up, over time, to meet the needs of civilian industries. Because the development was relatively slow, society had time to deal with the tension and friction arising from it. Although in Japan's case development was from above through government leadership, in contrast to the European pattern, and in this sense represents a case of late development, Japan also followed the classic pattern of first developing light industries as a domestic basis for the shift to a heavy industrial economy. Thus, Japan never faced the truly serious problems confronted today by developing nations; its situation was less complicated. This is not to say, however, that Japan had an easy time of it, that it could develop without bearing heavy burdens and without great suffering.

Because Japan experienced a combination of modernization and industrialization from above with technological accumulation and development from below, the stage of creation of a national technological infrastructure—the minimum necessary to sustain national autonomy—was largely finished more than 60 years ago.

Japan built up its primary technological infrastructure in 60 years. This was possible because it had the five Ms necessary for technological development and an accumulation of traditional technologies that, while only partly useful, were still transferred in part to the modern sector. This forging of organic links between old and new, foreign and domestic technologies made possible the achievement of technological autonomy, the creation of a national technology. Making full use of artisan skills and the accumulated wisdom of premodern society can make possible the copying of complicated machinery, especially when even vaguely similar types of technology have existed earlier. Examples of the role of these traditional technologies can be seen in Japanese clock-making, sword-making, and castle-building technologies. And yet, even if such skills prepared the way for creative copying, they alone were not sufficient to sustain modernization and industrialization.

It was Japan's engineers and creative entrepreneurs who were able to combine proper information and evaluation of latent skills and technologies with modern technology in a smooth course of development.

This makes clear the need—indeed, the duty—of a developing nation's engineers and its founding entrepreneurs to rediscover and to re-evaluate the value of that nation's traditional technology if a truly national technology is to be developed.

The promotion and orientation of research and development constitute an important aspect of this evaluation; unfortunately, in the cases known to us, no developing country has made a proper inventory of its native technology.

These latent links are most important for agricultural technology and its related technologies. The population and food problems have reached unprecedented proportions in many countries. It is easy to see the importance of developing agricultural technology, but the problem is complicated by the need for links between old and new and foreign and domestic technologies. Secondly, social and industrial development must be linked with agricultural technology, especially in the areas of fertilizers, water control, and the building of a national road network.

However, if the people living in the areas that will be affected do not participate in the planning for development, maintenance and supervision will be difficult and deterioration will soon begin. In Asian countries where the hydraulic facilities are more modern than Japan's but where the peasantry has no say in their maintenance and upkeep, repairs are inadequate and the systems have been ineffective in raising productivity.

In this area, villages and village leagues can profit from Japan's experience in establishing mechanisms for the regulation of water distribution and in group monitoring of joint activities. Local hydraulic planners emerged who had superior powers of persuasion and an ability to negotiate extremely effectively with bureaucrats. These local leaders were not necessarily rich peasants. Neither, of course, were they extremely poor peasants. They are impossible to characterize in class terms based on the size of their landholdings. There have been great changes in the past century in role, scope of activity, and social background of local rural leaders, but there has been a strong tendency for the same villages to continue producing leaders of ability while others consistently fail to do so.

Thus we may conclude that it is the national corps of engineers that is the primary resource of technological development, that alone can combine all the structural factors (the five Ms) required, that alone can bridge old and new and foreign and domestic technologies, and that alone can develop technological fields that make possible a convergence of public and private and light and heavy industrial technologies. A policy for technological autonomy is one that includes the training of engineers and that allows room for engineers to bring out the needed latent links in the nation's technology.

Formation of Native Engineers

The role played by the rural leaders in agricultural technology was assumed by Japan's engineers in the factory. Despite the differences between agriculture and industry, we can speak of a Japanese type of engineer in both. This engineer made the necessary connections between traditional and modern technologies in each case. Engineers performed two roles in introducing basically new and unknown industrial technologies. As work leaders at the point of production, they (1) provided needed assistance to skilled workers and (2) trained workers to create a body of skilled workers. This work represented an outlook of engineering rooted in Japanese society and culture. The workers respected these leaders' practical ability to solve problems and followed their lead in the acquisition of skills.

The basis of this evaluation by the workers was not the educational background of the engineers. In Japan, in general, engineers are expected first to achieve mastery in a special field, but then also to gain experience in related fields and thus help to raise the level of national engineering expertise. Thus there is no narrow division of engineering fields based on special areas of expertise, such as between design and operations engineers. Instead, engineers take turns working in both areas. High performance, safety, manageability, and durability are therefore built into designs from the start because designs are tested for these qualities by engineers who know what to look for.

This ability has paid some remarkable dividends recently as the technological revolution proceeds, creating new interpenetrations between preexisting fields.

In the developing countries, not only are there few engineers to begin with, there is what can only be called a legacy of colonialism, a tight and narrow specialization. There are many techno-scientists, but few engineers actually at work on the sites where they are needed. Here these countries have a problem.

It is important to raise the status and widen the scope of activity of practical engineers, but above all, their numbers must be increased. However, this cannot be done simply by instituting the necessary secondary education. Study must follow practical experience and lead to further study; quality must be raised. Engineers' backgrounds must be broadened. Engineers must be produced who fit their nations, who can discover the necessary links discussed above and who can lead their nations in the process of development.

The discovery of latent links in development is the job of native engineers and creative managers, or at times of what might be termed engineer-managers.

To create a corps of engineers across a broad span of industrial activity, the publication of basic texts in engineering and technology is required. A great many other things that have not been done need to be done; for example, the establishment of correspondence courses and practical and licence testing.

There is an ongoing debate about whether technical and scientific education should take place in the language of the nation in which it is being administered or in a foreign language. Here our position is clear. For the dissemination of engineering knowledge and the development of latent links, it is necessary to educate in the local language. The techno-scientists must decide on the translation of technical terms that will best aid the spread of the desired engineering knowledge. That this is especially important in agricultural technology is obvious from the Japanese experience.

The agricultural, fishery, and industrial experiment stations and pilot farms the government established throughout Japan could meet specific needs in these industries, acting also as aids to the establishment of necessary links between pre-existing technologies and industries and the needs of modernization.

Manning these stations is not difficult to effect. Staff need not be university-trained experts; if they know the technology and are able to keep records properly and handle ordinary questions but know when to refer more complicated questions to experts, this is sufficient. This work, in turn, serves engineers and scientists in carrying out their work.

Public Management of Technology

Management techniques can be taught, but education alone cannot create technology management. In any age, there are few truly creative managers. We discussed the Japanese style of management above, so we will not elaborate on it here. As we noted in our discussion of the Japanese style of engineer formation, there have been different types of technology management in each period and sector. We must repeat, however, that management is a decisive, vital factor in technology formation and development.

We wish to lay stress on the importance of technology management rather than the technology of business management. Until now, this theme has been almost completely absent in our dialogue.

In machine technology, for example, there is no piece of machinery and no factory in which operation will proceed according to the manual from the very beginning. All engineers know that machinery tends to be operated, over the long run, at less than its optimum capacity. Speeding its operation up to normal capacity and making this normal is the job of the engineer, especially the chief engineer.

Links with related technologies and supporting services are essential, but the core of technology management is the establishment of stable qualitative and quantitative standards for raw materials, processing these precisely, adding parts and seeing that the product is turned out on time and according to standards.

One factory encouraged its workers to "work rationally, save costs, and maintain quality," and this seems right on the mark. Nothing else helps prevent breakdown more than safe, stable, and proper operation. Securing a stable supply of materials and energy is a basic principle of economy, and a good standardized product is a sure sign of high quality-control standards. We call this principle of technology management SERQ: safety, economy, rationality, and quality.

When engineers and managers put SERQ thoroughly to work, they often change the very layout of a factory. This results in safer, more productive, more quality-controlled conditions. The manufacturing process becomes highly systematized, which produces changes in the mode of operation. Overall production can be improved and the chance of error reduced through the use of electronic machinery, but the basic concept remains in the hands of the manager or the design engineer. SERQ must be applied creatively.

In Japan, there is a dual structure in both the economy and technology; that is, a very large-scale sector and a sizable small-scale business sector. Both are well integrated into the national economy and technology network; both have their own potentials for technology innovation, and the small sector is capable of producing and developing its own technology, suited to its needs.

The rational breakdown and division of the manufacturing process is driven forward by the two forces of the need for a new approach to managing factory operations and the desire of skilled workers for autonomy. The two combine to bring about a dual structure in the economy and in technology. This dual structure originated from the needs of labour, business, and technology management; it is a consequence of the prevailing economic and technological conditions.

One-time farmers found a new identity as skilled factory hands and were then able to set themselves up independently as small-business men. How was this possible? One answer is that the Japanese farmer (whether freeholder or tenant) was an agricultural manager. Self-management was firmly rooted in the peasantry, and highly skilled people have the confidence to deal with technology. These two factors doubtless combined to produce this phenomenon.

Just as machinery must be well taken care of lest its performance drop and its life span shrink, so technology on the whole must be adjusted and managed to suit each manufacturing process, each factory, and each related field or it will not perform effectively. In most manufacturing industries, an unstable supply of electric power or other related services produces ill effects that increasingly worsen as the modern technology becomes more highly sophisticated and larger in scale. If the energy supply is unstable, industries are forced to produce and regulate their own electric power at high cost. Such costs can be avoided if there is adequate public supervision and maintenance of technology and its related services.

Energy control systems and related services should be established on a national level. This, in turn, would raise SERQ standards in each company and factory, and less investment would mean a more rapid division in the manufacturing processes.

Social stability and public welfare are better assured if technology management is operating effectively on a national scale. At the same time, this will act as a preventative against severe pollution problems.