SPECIAL REPORT

Japan's Industrial Society: Technical Innovation and Formation of a Network Society

By Ken'ichi Imai

The following is a summarized translation of the first chapter of the author's book *Japan's Industrial Society*, published in June by Chikuma Shobo. The book examines policy questions related to corporate strategy, industrial organization, regional policy, and an information-oriented society in respect to changes in Japan's industrial society. The author is studying the possibility of publishing a translation of the entire book.

In a nutshell, this thesis aims to show that Japan's industrial society is undergoing what should be regarded as an evolutionary paradigmatic change.

Central to this change is technical innovation. The word "evolutionary" is used in order to emphasize that the nature of this technical innovation is based on finely tuned cumulative learning and that it is essentially a process of evolution. The term "paradigm" is used in relation to the already proposed argument that the present technical innovation should be regarded as a paradigmatic change.

Since a paradigmatic change would include a change of some basic principles, it might seem to the reader that at a glance the phrase "evolutionary paradigmatic change" presents an inconsistency. However, I believe that it is rather more appropriate to regard the recent changes in Japan's industrial society as paradigmatic superimposed on an evolutionary change.

To give an easy-to-understand example, the computer functions only when both hardware and software come together. In Japan, however, the computer market at first was centered on hardware, and software was treated as incidental without much market value. However, as the importance of software began to be recognized, its value gradually rose. Today, as a matter of course, software is coming to be regarded as central and hardware as incidental. Through this evolutionary process, we are moving from a world of industry into a world where information is central.

However, this does not mean that industry is losing its pre-eminent role, as postulated by the post-industrial society theory, which flourished at one time. Rather, it means industry is evolving toward a more sophisticated level, moving into an industrial society in which the value of information is the basic axis. Consequently, values change bit by bit and corporate strategy also is changing imperceptibly in the direction of accumulating knowledge and information as the principal management resource.

A decade has elapsed since the first oil crisis of 1973, when this transformation is believed to have started. As a result of the changes accumulated over the decade, we are now able to observe what should be regarded as paradigmatic changes.

In the paragraphs that follow, the nature of these changes will be studied with respect to technical innovation and investment, division of labor and organization, and a network society, in that order. And on the basis of this study, I would like to advance my ideas on how we should cope with this change in the industrial society.

Technical innovations taking root

In Japan's industrial society there is no doubt that a strategic transformation of industry is taking place centered on technical innovation in the fields of information and communications. Some people are already calling this the "new industrial revolution." There is, however, much debate on how to evaluate it.

From the point of view of the technician who places importance on the original principles of technology, microelectronics is not particularly revolutionary because its principles were born in the 1930s. Therefore, in his view, the present stage is merely that of putting detailed finishing touches on technical innovations started in the 1930s. On the other hand, from the point of view of the economist, who attaches importance to technical innovation as the power to propel economic growth, the present stage is that of stagnation because the new technical innovation does not have the effect of creating big demand. It is just a small ripple.

However, if this technical innovation is, as I shall try to demonstrate later, something which qualitatively changes the system of the industrial society and whose character is such that it will in future permeate widely through society with a cumulative effect, I believe it is appropriate to position it as a new phase.

Industrial revolutions have changed the relationship between man and machine. In the present phase, we observe a qualitative change in which the machine is coming closer to man. But this transformation has just started in a small way. In future, under the impact of progress in the life-sciences, this transformation will advance further. Medical equipment, for example, is already moving in that direction. At the same time, as demonstrated by the progress made in the cerebral field, new machines will help to advance our understanding of man himself.

Lewis Mumford once said that a "bio-technic" era is the ideal in which biological science is freely applied to technology and in which technology aims to become the culture of life and achieve a humanistic balance. He said this was dimly visible on the horizon. The "bio-technic" era he talked of has already clearly emerged.

At the same time, the life-sciences themselves are opening up new possibilities in food production, which is essential to man. In addition, it is now believed the day will come sooner than expected when the recyclable energy of the solar system can be put to practical use.

When all these are taken together, one has to accept that the new technical inno-

Sunx Co., a typical Japanese venture business firm

vation will transform the very basis of industrial society.

As the recent studies of the process of technical innovation by R. Nelson and D. Sahal show, the technical innovation, which has become systematized in the contemporary era, should be regarded as a process of accumulating knowledge as a system.

A look at the process of recent technical innovation, including that of the computer, shows that numerous and diverse smaller innovations have to be made in the stage between the birth of the basic idea or designing and practical application. It is on the basis of accumulated smaller innovations that a major innovation, which can be called a breakthrough, is achieved.

The effective accumulation of these innovations is made possible through a systematized process of acquiring knowledge. Such a process covers diverse phases, from basic research to application, refinement to creation, designing to testing, and parts to assembly. When the appropriate linkage between these steps is achieved and information feedback is carried out, a process is formed for acquiring knowledge that can produce successive innovations.

This process naturally is not the ordinary straight line model that goes from basic research to the application of its results and then to practical use. Rather, it is an evolutionary model which includes many feedback stages necessitating the reorganization of basic research when a certain stage is reached.

In that area of the industrial system constituted principally by Japan's machinery industry, this kind of systematized learning process is taking shape. And this system is creating the cumulative process of technical innovation. This is the point which this thesis wishes to emphasize.

The fact that a system of this sort was formed in Japan was not because of any special characteristic of Japanese-style management or Japanese-style technology. It was due to the history of the system in Japan and the features of its organization.

Until now, in order to explain the reasons for the high quality and high productivity of Japan's manufacturing industries, attention has been drawn particularly to production line training aimed at lowering the incidence of defective products. This, no doubt, is one important factor. However, if only this point were to be emphasized, it would result in placing the focus only on the production effect resulting from the attainment of skill in a particular technique, and the learning process through which technology itself is improved step by step would be overlooked.

While it may appear on the surface that production plants in Japan rely simply on a specific technology, there has actually existed a system under which production technology is gradually improved in response to requests by users and in cooperation with machinery makers. Under this system, the feedback from users and machinery makers is used to make numerous small innovations in cumulative fashion.

This is not the age when an innovation emerges suddenly from the creative ingenuity of an individual. Rather it is brought about through an accumulation of wide-ranging knowledge and know-how in society. Even in the case where, as in a venture-type R&D company, an individual wields decisive influence, his creativeness is augmented by the accumulation of established knowledge and know-how.

The accumulation of know-how related to industrial technology is built up not only by the company which uses that technology to produce goods. It is built up also through feedback between the manufacturer and the machinery maker which engineers the technology into machines and devices, and through an extensive exchange of information with other related companies.

The users' views, too, are valuable sources of information on the points which require improvement. When all these are brought together into a network to form a system, the capability for continuous innovation is built up.

From the industrial standpoint, the results of Japan's high economic growth can be seen in the highly diversified machinery industry, which depends on private sector demand. In order to respond to the diverse forms of private demand, both direct and indirect, the machinery industry is flexibly and broadly constituted, embracing big, second-tier and small marginal enterprises.

Supported by diverse consumer demand and active private equipment investment, the machinery industry supplies a wide range of equipment and parts through cooperation and exchange of information with various sectors. It constitutes a technical group which has the ability to solve a great variety of problems.

When a company, standing on this broad foundation, wishes to seek technical innovation, it can regard the organization for pursuing development as a large system which reaches beyond its corporate walls and includes related machinery makers and users.

Since J. Schumpeter, the size of a company was one of the points taken into consideration when the efficiency of technical innovation was discussed. However, when regarded from the point of view outlined above, it becomes clear that the factor determining the effect of technical innovation is the size of the "system" related to the process of acquiring knowledge for the development. At the same time, the efficiency depends on how well know-how and information are transmitted and transferred.

If Japanese corporations are achieving relatively good results in the new phase of technical innovation, it is because of the scale and economy of their system in this context and the efficiency with which they transmit and transfer know-how and information.

Chain-reaction effect of division of labor

The impact which the above-explained trend of technical innovation has on Japan's industrial society will now be examined step by step. Attention is drawn first to the way the trend of technical innovation has diversified labor.

In order to explain this point, I would like to classify the kinds of multiplication of division of labor into "backward" and "forward breeding." "Backward breeding" signifies the related effects triggered by demand for a specific product, like the multiplying of parts-related division of

labor triggered by the demand for automobiles. "Forward breeding," on the other hand, is the form of multiplication in which a specific product creates a new use by the very fact that it has become available. This, in turn, accelerates the next stage in division of labor.

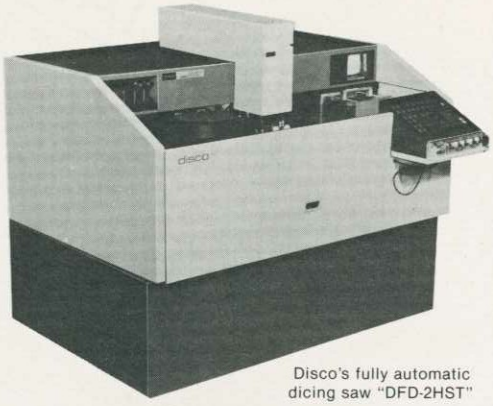
The division of labor which occurred during Japan's high economic growth era progressed mainly through "backward breeding." First, massive investment was made in the steel, chemicals and car assembly sectors. The ripple effects of demand for steel, chemicals and automobiles produced in newly constructed plants created new markets for raw materials, parts, and machinery, and gave birth to specialized industries.

Since the early days, Japan has had a system of division of labor within regional areas called "social division of labor," and a system of finely tuned division of labor incorporating medium and small enterprises has been established.

The "backward" division of labor means the division of the central work, which may be called the work of "the parent," into a vertical division of labor. During Japan's high economic growth era, the multiplication of division of labor progressed, supported by the growth of the "parent's work." This process of multiplication, however, came to an end when all the work of "the parent" had been completely segmented. This process had no mechanism which could generate further multiplication.

In the spread of "forward" division of labor, the process involves a mechanism which prompts a horizontal multiplication of division of labor seeking uses for newly developed products and technologies. For example, when LSIs (large-scale integrated circuits) were developed, machine tools, measuring instruments and medical equipment using LSIs mushroomed, giving birth to specialized makers in the respective markets. The work of these specialized makers was further segmented, leading to a new stage in the division of labor.

The case of ICs (integrated circuits), which form the nucleus of the technical innovation, will be taken up as an example in reference to the new phase of the



Disco's fully automatic dicing saw "DFD-2HST"

Takeda Riken K.K. specializes in inspection technology.

technical innovation mentioned earlier.

There are makers specializing in each of the technologies involved in the manufacture of ICs, for example, Disco specializing in the cutting of wafers, Shinkawa Co. specializing in bonding technology, and Takeda Riken K.K. specializing in inspection technology. These specialized makers are seeking further specialization in their finely-segmented respective markets, so as to keep ahead of their competitors.

Big enterprises, on the other hand, utilize the specialized technologies of these companies in order to mass-produce ICs. This is division of labor between element technology and assembly technology. If the process up to this point is regarded as division of labor done by "the parent," it is the same as the spread of "backward" division of labor. The multiplication of division of labor, however, does not end here in the case of the new technical innovation. Rather, this is where it really starts.

For example, the wafer cutting and sophisticated measuring technologies created by the development of ICs are now applied to the field of medicine. These technologies, together with ICs, are applied to medical equipment, giving birth to firms specializing in such equipment. Such medical equipment can be used more effectively, if it is linked with other facilities and if it is utilized by medical organizations on a mutual basis. For such linking, optical fibers are employed. Optical fibers for linking medical equipment or medical institutions are now being developed jointly by optical communications makers and medical equipment makers.

In addition to optical fibers, highly reliable software is essential to operate these systems, eventually necessitating the emergence of specialized software makers. In this manner, the division of labor becomes a chain reaction.

The simultaneous multiplication of division of labor among industrial organizations through horizontal chain reaction is one of the special features of the new phase of Japan's industrial society. In the process of chain-reaction multiplication of the division of labor in industrial organizations, the volume of interfacing to link different fields of work increases. Interfacing is another element of the multiplication of division of labor.

In order to link one sophisticated precision machine with another, new measuring and inspection machines are necessary. In order to link machines of different types (for example, computers of different models), software must be developed to make them compatible. In order to link man and machine, software which makes it easier for man to operate the machine is necessary.

In a country's economy, commerce performs the function of interfacing. For instance, distribution links producers and consumers, and financing serves as an intermediary to link the lender and the borrower, while transportation and communications perform the function of linking workplaces separated over a long distance. As the division of labor is further segmented, the volume of work to link a segmented work with a similarly segmented work increases. The methods of linking have been made efficient by the use of information and communications technology. This is the base on which a network society is formed.

Formation of new organizational links

In supplying goods and services in the industrial society, the two alternative methods of market and organization are used. How to mesh the market with the organization is one of the basic problems of the industrial society.

When we recall how technology was used in and after the first Industrial Revolution, we note that the achievements of the industrial society in the past were realized basically through mass production and mass marketing. In this context, organizational theories concentrate on achieving greater efficiency through the use of large-scale organizations. The success of large-scale organizations and vigorous research on management in the United States were manifestations of this.

During the process of Japan's economic growth after World War II, this American-style mass-production/mass-marketing method was adopted by leading manufacturing industries. Thus large-scale organizations became established in the fundamental sectors of our economy. In Japan, however, a large number of small organizations existed on the periphery of the large organization. Large enterprises and smaller enterprises and also the market and the organization combined in a mosaic pattern. This feature of Japan's industrial society is called a mutual penetration of the market and the organization.

The new phase of the technical innovation has brought out this distinctive feature of Japan's industrial society in greater relief, and an organizational relationship based on a new kind of linking has been formed.

First, attention is drawn to the fact that under the new situation of the technical innovation, the need for large-scale enterprises lies not in economy of technological scale but in the necessity for transactions aimed at linking the segmented work divisions.

In the conventional facility-based industry, the reason for largeness of scale lay in the need to build a continuous manufacturing process using big equipment and facilities. Even in that case, it probably was not impossible to segment the process. However, economy of scale and vertical integration were attained simultaneously by building up a continuous process and controlling it all under a single organization.

However, in the case of small-scale, segmented types of technology, the economy

of technological scale is small. Nor can the merit of large-scale organization be achieved merely by making work continuous. Organizing all processes within a single organization becomes profitable only when the linking of segmented work which cannot be undertaken appropriately in the market is undertaken within the organization more efficiently than in the market.

Consequently, whether in the case of the market or the organization, the point lies in how segmented work is linked. And, in both cases, the key to linking lies in "loose coupling."

Between corporations which conduct transactions in the market, a certain amount of continuous relationship is necessary in order to evaluate information and technology. In order to make the best use of the advantages of the market, that relationship should not be a rigid one but a loose linking. Within a corporation, too, the linking between the organizational units which go to make up the corporation should be loose. The corporation will demonstrate the greatest efficiency when it operates as a union of these organizational units.

The features of such a "loose coupling" type of organization can be summarized as follows.

First, because each organizational unit has autonomy and is capable of sensing and adapting itself finely even to a small change in the environment, the organization can promptly respond even to the slightest change in the environment. Moreover, because even a slight change in environment can be conveyed to other organizational units via diversified routes, the organization as a whole can react very sensitively to such environmental changes.

Secondly, because each organizational unit can adapt itself to environmental changes independently and on its own initiative, heterogeneity and originality can be preserved in the manner of adaptation, leaving the organization with the possibility that a creative solution may be found somewhere.

Thirdly, because the mutual work load on organizational units is lighter in a loosely linked organization than in a firmly linked organization, its vulnerability to unexpected changes in the environment is smaller.

On the other hand, there is the shortcoming that its adaptability to changes in the environment is limited and that plans which cover a wide field cannot be introduced.

The conclusion here is that under the economic environment which we have observed, the three advantages are far more important than the one shortcoming.

Formation of a network-type society advances

In Japan's industrial society, this organizational relationship is being realigned as a result of the impact of technical innovation in information/communications, and a new network-type society is being formed. It is believed that this trend has an important significance when we consider the future scenario of Japan's industrial society. Dividing the subject into a few fields, we shall summarize the main points below.

First comes the question of a network for technical development capability.

The feature of technical innovation in mechatronics in which information/communications are linked with machines is the subdivision or segmentation of labor of the manufacturing industry and the enhancement of the sophistication of each subdivision.

The division of labor therefore becomes even more segmented and breeds further division, as explained earlier. Simple segmentation or division of labor does not advance the economy. To advance the economy, the subdivided labor must become specialized, more efficient and more sophisticated. And, the point which I wish to stress in particular is that it is important that the improvement in efficiency and sophistication must be disseminated quickly throughout society to form a technology/information network.

Under the Japanese industrial system, the work that has been segmented in the process of division of labor is undertaken by small and medium enterprises which vigorously disseminate technology/information via the market in their effort to apply the new work method to various fields. Or, the technology developed by a big corporation is transferred to its affiliated small and medium enterprises, which refine and fine-tune the transferred technology for further dissemination. The reader's attention is drawn particularly to this process.

Through this process, division of labor multiplies and new work is created for linking the segmented work. The organizational relationship that results from this creates the learning system for innovation, as described in the first part of this thesis.

This ripple process of technology is fundamentally different from the ripple effects of the heavy and chemical industries during the high economic growth period. As stated earlier, division of labor breeds from the bottom up to create new work. In this process, therefore, entrepreneurial opportunities open for diverse types of business.

In this process, moreover, improvements are made at the place where the machinery is installed. Thus, work which is closely connected with the regional community increases, and local industries and small and medium regional enterprises become involved in the chain reaction process of division of labor. The concept, which is being pushed by the Ministry of International Trade and Industry, of achieving renewed progress in local industrialization with the Technopolis (technology-intensive cities) as the nucleus, is an attempt to form a new network society by taking advantage of the ripple process of technological innovation in this context and the multiplication process of division of labor.

Secondly, let us take a look at the formation of a network of social systems.

As stated above, it is the market and organization that fulfill the function of linking and unifying the segmented division of labor. In this area, too, it should be noted that large-scale enterprises are beginning to make moves for a new network. A case in point is housing, which is an aspect of life demanding improvement.

The housing problem is, in essence, a question of a network. People seek convenience in commuting to work, going to school, shopping, or exchanging visits

with friends, and therefore look for an appropriate location for their home. But the cost of housing in an appropriate location is high. Therefore, the key to the housing problem lies in where the place of work, school or shopping center is situated and in how the transportation/communications network can be utilized. If one's place of work is not located in a big city, one does not necessarily live there.

Information/communications technology has a big influence in the formation of a network.

I do not believe that the use of data communications will result in a general practice of people doing company work in their own homes, as some people predict. However, I would emphasize that information/communications technology would be very effective if used as a supplemental means.

Even when one is a regular employee of a company, it might be better to work at home one or two days a week, depending on the category of one's work. In the exchange of information, face-to-face contact between people is of basic importance. However, such direct contact could be limited to, say, once a month, and at other times contact can be effectively maintained through data communications. The same thing could be said of tele-shopping. The suggestion that information/communications technology would completely change the old ways of doing things has caused much misunderstanding. If such technology is taken as a powerful supplementary means, it can be said that the perception of living environment factors is beginning to undergo a big change.

If Japan's housing problem is continued to be viewed from the standpoint of how to check soaring land prices, no realistic solution can be expected as long as one relies on the present system.

As many experts have already pointed out, the housing problem is one that concerns large cities. In regional areas, good homes can be built at low cost. If the entire country should be reorganized into a new network and if the siting of places to live and work is considered on that basis, the possibilities of solving the housing problem are greatly increased.

Although space prevents an elaboration, I believe we are already just one step before a slow but fundamental change regarding these problems.

Thirdly, let us examine the relationship between a network and employment.

In the organizationally interrelated type of society, the work of linking individual organizations is important. In each organization, there will be an increase in the work of persons whose duties concern relationships with other organizations. Moreover, companies which specialized in the work of linking will assume an important function.

As stated earlier, distribution constitutes the work of linking producers to consumers or vice versa. Banking is work that links those who supply funds to those who need funds. In the conventional theory of the industrial society, little attention was paid, unjustifiably, to this broad role of commerce.

Commerce today not only earns commissions on distribution and makes profit on the margin of difference between interest rates but also fulfills a vital role as a medium between different types of work and organizations. We live in the age of a new commercialism in which commerce acts as the medium between man and man, between organization and organization, and between culture and culture. The thinking that the market cannot act as a medium between man and man is a narrow view. Japanese merchants have acted as a medium between man and man through distributing goods and services.

I wish to draw particular attention to the fact that this work of linking has now begun to involve the linking of differing systems.

The linking of man with machine is the interfacing technology of software. Because of the development of this technology, man is now able to give instructions to the machine by means of simple terminology. Similarly, in supplying goods and services to a country of a different culture, interfacing technology is necessary. In Japan's case, this function was fulfilled by the general trading houses (sogo shosha).

It should be possible to link, in a similar way, organizations of different dimensions, such as private and public organizations, or market and non-market organizations, or economic and non-economic organizations.

Let us examine this point further by continuing with the example of the housing problem.

As stated earlier, in its broad context this cannot be solved just by building new houses or by remodeling existing ones. A market is needed where people can exchange homes when they move from one region to another or when family composition undergoes a change. People's housing preferences change and with the passage of time they can become dissatisfied with the home they built earlier. In such a case, too, a well-developed market is necessary so that the people can market their unwanted house and plan a new one.

Transactions in housing touch on the basics of a person's way of life. The work of the intermediary in this case is to link people with people and people with organizations, paying due consideration to the question of neighbors, and what educational facilities and community groups there are.

It should be noted here that the performance of these linking tasks requires broad empirical knowledge, and therefore would suit persons of more advanced age. Technical innovations such as those relating to robots and computers are youth-oriented. When such technical innovations are adopted in the distribution and financial fields, it might seem that people of advanced age would be pushed out of their jobs. However, when the situation is viewed from the standpoint of the system of society as a whole, new work is created involving the linking of work to work, man to man, and organization to organization. It is possible therefore, that a new field of employment will open up for the aging society. ●

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