Section 2
DX and Changes in Human Resources and Jobs

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1. Introduction: Labor Productivity and Technology

The low labor productivity in Japan has been a longstanding issue. In 2022, Japan ranked 30th among 38 OECD member countries in terms of hourly labor productivity.[1)] A key challenge is how to enhance productivity to support the recovery of the Japanese economy.

From a longer-term perspective, however, Japan's postwar labor productivity has risen remarkably: in terms of GDP per capita, Japan's labor productivity in 2000 was six to nine times higher than in 1950.[2)] By contrast, in the U.S., GDP per hour worked in the non-farm sector nearly tripled over the 50 years from the 1950s to the 2000s (Acemoglu, Laibson, and List, 2021, pp. 562-563). Although these measures are not identical, this comparison suggests that Japan's productivity growth outpaced that of the U.S. over the half-century beginning in 1950.

Another indicator is Total Factor Productivity (TFP), which reflects the role of technology in improving production levels. Jorgenson, Nomura, and Samuels (2015) attempted a comparison of TFP between Japan and the U.S., pointing out that in both countries, TFP growth, rather than simply an increase in labor and capital input, has been a driving factor for economic growth. They also argue that from the period of high economic growth to the late 1980s, Japanese productivity increased at a rate that rapidly caught up with the U.S. level, but after the collapse of the bubble economy, the growth of TFP in Japan slowed down and the gap between the two widened.

Indeed, looking back at Japan's economic growth in modern times, it is clear that each of the industries that have become internationally competitive have been backed by innovative technology.

To begin with, the textile industry sustained Japan's economy from the prewar period through shortly after the war, and it is widely known that world-class, or even world-surpassing, production technology supported this industry. Koike (1997) explains that one of the reasons for the international competitiveness

1) Japan Productivity Center (2023).
2) According to Honkawa (2023), the increase is approximately tenfold, while Iwamoto (2023) estimates the figure at around six to sevenfold.

of the Japanese textile industry from the end of the 19th century was that "the machines used by British spinning mills were mule spinning machines. ...On the other hand, Japanese private spinning mills, led by Toyobo, used the most advanced machines of the time, ring spinning machines, almost from the beginning."

Furthermore, the introduction of advanced machinery significantly boosted productivity, forming the foundation of the industry's international competitiveness. For example, Japan's first powered loom, the Toyoda Power Loom, invented in 1896, "allowed one person to operate three to four machines, increasing productivity by up to 20 times compared to previous methods."[3)] Additionally, the non-stop shuttle-change Toyoda Automatic Loom (Model G), invented in 1924, enabled one operator to handle 20 to 30 machines, instantly raising productivity by over 20 times and dramatically improving fabric quality, achieving world-class performance.[4)]

In the early post-war period, Japan's economy relied heavily on the textile industry. Over time, however, the country's primary industries shifted to shipbuilding, iron and steel, machine tools, automobiles, and electronics. Japan's international competitiveness is often attributed to the diligence of its people and their long working hours, but in fact, each of these flourishing industries was underpinned by unique technologies not found in other countries.

In 1956, Japan became the world's number one shipbuilder in terms of ship launches, and for the next eight years it occupied the top position in the world. A key factor behind this competitiveness was Japan's unique construction method, the welded block construction technique (block method) (The Society for Industrial Studies, Japan, 1995).

Around the same time as shipbuilding, the steel industry began to emerge as a driving force in Japan's economy. Iron and steel production increased dramatically with the introduction of new technologies, particularly converter furnaces. From the 1960s onward, crude steel output grew rapidly, increasing productivity more than sixfold by its peak two decades later.[5)]

Following the iron and steel industry, the spread of machine tools gained momentum. At the same time, production management techniques like the Toyota Production System, along with such practices as small-group activities and QC circles, supported manufacturing industry by enabling the production

3) The Japan Society of Mechanical Engineers (2022b).
4) The Japan Society of Mechanical Engineers (2022a).
5) Labor productivity per worker, indexed at 100 in 1955, rose to 211 ten years later in 1965 and to 611 twenty years later in 1975 (Okishio and Ishida, 1981).

of high-quality products. Additionally, Japan's technological strength in the electronics industry attracted significant attention. Notably, in the semiconductor sector, Japan maintained the world's top market share from the late 1980s to the early 1990s.

However, when viewed from another perspective, Japan's economic growth and industrial shifts also raise some concerns. Over the approximately 40 years from the post-war period to the economic stagnation following the bubble collapse, five key export-driving industries—textiles, shipbuilding, iron and steel, automobiles, and electronics—successively replaced one another.[6)] This implies that no single industry sustained Japan's economic momentum for an extended period; rather, each major industry was able to dominate the global market with exceptionally high productivity for about a decade. It could be said that Japan maintained its competitiveness by continuously fostering new industries supported by unique technologies not available elsewhere in the world.

This also raises the question of whether Japan's prolonged economic stagnation after the bubble collapse could have been avoided if a new industry had emerged to take the place of electronics. Unfortunately, no new industry arose, and as a result, Japan found itself in a position where it had to rely once again on the automobile industry and machine tools.

The direction Japan could have taken in developing new industries can be seen in the example set by the U.S. During Japan's "lost 30 years," the U.S. saw the rise of the computer and software industries, with companies like Microsoft leading the way. More recently, the global dominance of GAFA (Google, Apple, Facebook [now Meta], and Amazon) has been dominating the world, especially the Internet world. In fact, most Japanese people now use GAFA services almost every day.

Table 4-2-1 shows statistics on global digital competitiveness, with the U.S. ranking first. In Asia, Singapore, South Korea, Taiwan, and Hong Kong are among the top 10, while Japan ranks 32nd. Additionally, Singapore, South Korea, and Taiwan each improved their rankings by one or two places from last year, whereas Japan dropped by three. The responses of neighboring South Korea and Taiwan to the COVID-19 pandemic, which effectively utilized digital technology, as well as the widespread adoption of foreign-made software for online meetings, have further highlighted Japan's lag in the digital field, both in

6) While the position of other industries in exports has shifted, machine tools continue to play a leading role in driving exports.

Table 4-2-1 IMD world digital competitiveness ranking (2023)

Ranking	Country / Region
1	U.S.
2	Netherlands
3	Singapore
4	Denmark
5	Switzerland
6	South Korea
7	Sweden
8	Finland
9	Taiwan
10	Hong Kong
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32	Japan

Source: IMD (2024)

business and social systems.[7)]

2. Changes in Work (Tasks)

(1) Japan-U.S. Comparison on Tasks and Skills

To consider what types of workers are needed for new technologies, such as information and communication technology (ICT), and data utilization, it is necessary to examine how these technologies have changed the nature of work: specifically in terms of the allocation of time and effort, and the knowledge, skills, and abilities required.

A recent representative study by the Japan Institute for Labour Policy and Training (2024) compared task and skill trends between Japan and the United States since the 1980s. The study found that both countries have experienced increases in "non-routine analytical tasks," which include activities such as analyzing information or data, thinking creatively, and explaining the meaning of information to others. Additionally, there has been a rise in "non-routine interactive tasks," encompassing building and maintaining interpersonal relationships, directing, instructing, and motivating subordinates, as well as coaching and developing others' abilities. However, the study also revealed a divergence in

7) Finan and Frey (1994) conducted interviews and literature research in Japan from the late 1980s, expressing concerns about the lack of awareness among Japanese corporate executives regarding the importance of program development and software use, as well as issues with the mindset of engineers.

"routine cognitive tasks," which involve repetitive tasks, precision and accuracy, and structured work. While these tasks have decreased in the U.S., they have increased in Japan.

Furthermore, occupations requiring computer skills, management skills, and creativity skills have been increasing in the U.S., whereas in Japan, the growth in occupations demanding computer and management skills stalled after the collapse of the bubble economy.

(2) Differences between Osaka and Tokyo Regarding Skill Change

The study also measured regional differences within Japan, comparing the Kinki region with the Tokyo metropolitan area. It indicated that, overall, the Kinki region may be lagging behind in adapting to technology compared to the Tokyo area.

From 1980 to 2020, occupations requiring analytical skills, creativity skills, and computer skills have notably increased in Tokyo, but not in the Kinki region. Additionally, while science and engineering skills have been in nationwide decline, Figure 4-2-1 shows that the distribution of science and engineering skills remains lower in Osaka compared to Tokyo.[8] Amid Japan's overall lag in the adoption and spread of digital-related technologies, it is possible that in the Kinki region, work is not shifting toward roles that require advanced knowledge and skills and that accelerate innovation.

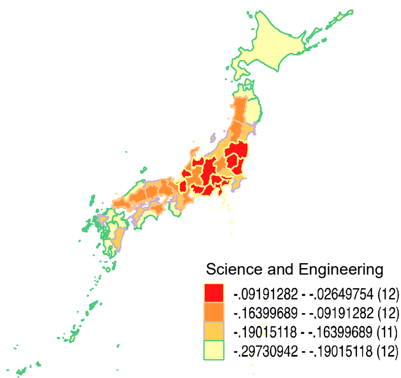

Figure 4-2-1 Distribution of Science and Engineering Skills (2020)

Source: The Japan Institute for Labour Policy and Training (2024), p. 53

8) Darker colors indicate higher distribution. The numbers represent standardized values for various skill levels. For more details, refer to the original source.

3. What Is the “Digital Transformation (DX)”?

To date, terms like IT, ICT, and digitalization have highlighted the use of information and communication technologies and related devices to improve production efficiency and labor productivity. With these technologies now widely implemented, if we are to use the term “DX” (digital transformation), it is essential to clarify what sets it apart from previous technologies and to identify the key areas of focus.

DX involves not only digitalization but also transformation. Specifically, it requires changes in employees’ tasks, work, skills, and work styles. Additionally, it suggests a shift in how work is conducted and even in the structure of the organization itself.

Furthermore, DX encompasses not just reducing time or labor in specific processes but also enabling instant and easy information sharing through digitalization. This, in turn, changes the number and composition of people involved in decision-making, impacting the way work is conducted and altering the organizational structure.

Using word processing software to digitize documents, reducing paper use, and moving files from binders to internal cloud storage represents mere digitalization. However, DX goes beyond this by standardizing information formats and ensuring easy access for employees, leading to continuous process improvements and quick, informed decision-making. In other words, one essential aspect of DX may be the creation of a structure that, like a nervous system, enhances efficiency and productivity through the constant utilization of digital technology.

4. Case Studies

(1) Perspectives on Technology Adoption and Diffusion

For new technology to take root within a company and produce visible effects, there are several stages: introduction, penetration, establishment, and improvement. Since DX is still in its early stages, current research can only focus on the initial stages of introduction and penetration.[9)]

As shown in Figure 4-2-2, plotting adoption rate on the vertical axis and time on the horizontal axis helps to understand the diffusion process. Early

9) Early studies addressing the adoption of new technologies and their diffusion throughout the economy include Griliches (1957), Mansfield (1961), Nelson and Phelps (1966), and Rogers (1983).

adopters, such as Company A, that quickly recognized the potential of new technology, contrast with non-adopters like Company B, leading to a time lag in their adoption curves. At this stage, entrepreneurial capability is key: the ability to recognize new opportunities and make the risky decision to adopt the technology is crucial.

Additionally, after the initial adoption, Company B, where the technology spread rapidly, differs from Company C, where diffusion took longer, resulting in a steeper adoption curve for Company B. This difference in the slope reflects a process known as absorption—the ability to assimilate, adapt, and embed the technology—where Company B outperformed Company C.

At this stage, the human capital of engineers and employees plays a crucial role. To understand, absorb, and effectively apply new technology in daily work, a company must have a sufficient number of personnel equipped with the necessary knowledge and skills to utilize it proficiently. In other words, both the quality and quantity (stock) of human capital are essential.

As mentioned earlier, DX has yet to fully permeate the entire economy, so it is not yet possible to analyze comprehensive statistics covering the entire process from introduction to diffusion and eventual saturation.[10] To understand the current situation, we must rely on case studies. Here, we would like to summarize the findings and implications derived from case studies highlighted in the Asia Pacific Institute of Research (2024) report.

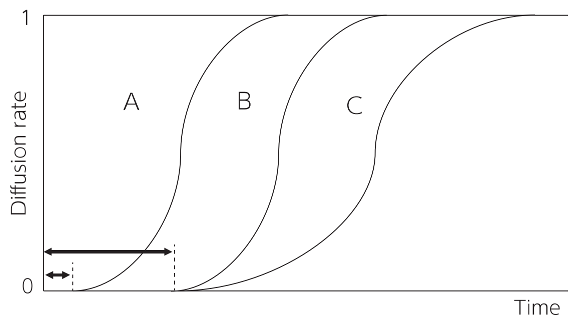

Figure 4-2-2 Time to introduce new technology and diffusion curve

10) Focusing on the introduction and diffusion process, Romeo (1975) demonstrated that the rate of adoption of numerically controlled machines is influenced by research and development expenditures. Similarly, Otani (2013) conducted one of the few empirical studies in Japan estimating the role of human capital in the diffusion of household appliances.

(2) Introducers, Promoters, Users

From a human resources perspective, each stage of this process has distinct focal points. First, it is essential to examine the characteristics of those who recognized the potential of the new technology, DX, and led its introduction. Next, understanding the characteristics, skills, and experience required of those who interpret the vision of these leaders and drive implementation within the company is critical. Finally, it is also important to track how tasks and skills have changed for those on the ground who utilize the introduced technology in their daily work.[11)]

The industries highlighted in the Asia Pacific Institute of Research (2024) report include nursing care services, lodging, and food manufacturing. All of these industries involve labor-intensive tasks and have high expectations for operational efficiency improvements through DX.

[1] Introducer

In all three industries, the DX initiative began with management recognizing both management and field needs for DX.

In the nursing care service industry, managers who had been out of the field took on the role of connoisseurs of digital tools based on both management and field needs, actively researching and leading the introduction of digital solutions through pilot tests at individual facilities (p. 35). In the lodging industry, ideas and advice from experts outside the field, such as CEOs with engineering backgrounds or external advisors who are alumni of ICT companies, have also served as a trigger (p. 66). In the food manufacturing industry, the key driver was a young, science-trained staff member, who kept abreast of external trends through marketing experience. In response to this trend, a science-trained representative Executive Managing Director in charge of corporate planning led the DX push.

[2] Promoter

To advance DX within the company, it is essential to appoint site managers who possess high expertise, extensive practical experience, and a positive attitude

11) Furthermore, implementing technology in production settings requires numerous modifications, adjustments, and improvements. During the introduction stage, in addition to engineers with technical knowledge, skilled workers who can adapt the technology to the worksite and help embed it are indispensable. For adoption across multiple sites, workers with sufficient knowledge and skills in manufacturing processes are necessary at each location. At the industry and economy-wide level, a significant number of engineers and skilled workers must be supplied. This highlights the critical role of a robust human capital base in the diffusion of technology.

toward new initiatives, as highlighted in interviews within the nursing care service industry (p. 35). This is a common requirement across all three industries.

The reason, as expressed by a lodging industry executive, is that customizing new technology is crucial for effective implementation. This requires coordination between the company's IT personnel and a "bridge" who understands both the operations and on-site needs (p. 67).

In the food manufacturing industry, the executive director who decided on the DX initiative established a new DX headquarters, gathering personnel with company-wide experience and perspective. These team members are 4 to 5 years younger than those in other departments and consist exclusively of university and graduate school graduates. Additionally, it is noteworthy that key positions within the department are filled by individuals with science backgrounds.

Employees with experience participating in DX-related training, study sessions, and meetings are being listed and assigned as liaison facilitators between the DX headquarters and various departments. According to personnel data, these individuals are also relatively young, with approximately 80% holding university or graduate degrees, indicating a high level of educational attainment (pp. 103–106).

[3] Users

The effect of DX for users is the reduction in time spent on indirect tasks such as paperwork, allowing them to dedicate more time and effort to their core duties, ultimately enhancing the quality of service provided to clients.

In the nursing care service industry, tasks such as creating shift handover notes, previously done by hand, have been standardized, allowing for more time to be allocated to core caregiving activities. Additionally, sharing digital data has streamlined communication among staff, resulting in increased time for interaction with clients (p. 46).

In the lodging industry, analog tasks such as reservations, check-in, and check-out at the front desk, as well as daily operational reports in the back office, have been eliminated or reduced (p. 68). This has allowed time and effort to be shifted toward core tasks such as customer service and cooking. Furthermore, information stored as online data enables real-time decision-making and increases the time available for managerial decision-making.

In addition, in the cases of the nursing care service and lodging industries, where DX implementation has advanced to a certain degree, minimal additional training was required for its use. Tasks are often performed on mobile devices, and it was explained that if employees can use a smartphone, they can easily operate the applications.

5. Conclusion

Even without tracing back to the Industrial Revolution, a review of modern Japan's international competitiveness reveals that much of its economic growth has been supported by the introduction and diffusion of new technologies. Had the Japanese economy, like the U.S. or neighboring Asian countries and regions, leveraged digital technology to transform its industrial structure, it might have avoided prolonged stagnation. The recently emphasized concept of DX raises the question of whether it could serve as a catalyst for economic revival and what types of talent are needed to achieve this.

In contrast to the U.S., the increase in "routine cognitive tasks" in Japan—comprising "repetition of identical tasks," "precision and accuracy," and "structuring work"—is a cause for concern. Additionally, compared to the Tokyo metropolitan area, the Kinki region may be lagging in adapting to technology, and the notable decline in science and engineering in Osaka, amid a nationwide downward trend, is also worrisome.

The case studies indicate that managerial decisions are crucial for DX implementation. Furthermore, successfully selecting appropriate technologies and embedding them within the organization requires personnel with a certain level of expertise in the relevant field, as well as broad experience and knowledge of internal operations.

There are often concerns that new technologies might displace many workers in labor-intensive industries. However, the case studies discussed here suggest the potential for DX to reduce workload and improve the quality of work by redirecting time and effort to core tasks. While these are only a few case studies and broad generalizations should be avoided, these findings are worth noting when considering the impact of DX on employment and the nature of work.

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