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The IT Revolution's Implications for the Japanese Economy

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Why hasn't the Japanese economy benefited from the information technology (IT) revolution? Japanese firms were dominant suppliers of semiconductors and other electronic goods into the 1980s. But during the IT revolution of the 1990s, when IT was being hailed as the proximate cause of dramatic changes in business models, processes, and activities in user industries, Japan was in an economic downturn. Moreover, Japan's electronics industry was losing competitiveness relative to firms in the Republic of Korea; Taiwan, China; and elsewhere in East Asia. Aided by investment by foreign enterprises, China now commands the top share in production of many consumer electronic items.

The economic implications of the IT revolution on IT users are investigated in this chapter. First, the relationship between IT and productivity growth is analyzed in Japan and benchmarked against the United States. In the 1990s, a strong growth pattern can be found in the United States, in contrast to Japan's situation.

A growth-accounting exercise comparing Japan and the United States from 1975 to 2000 is provided to show the impact of IT on economic growth and productivity at the macro level. A substantial portion of the growth resurgence of the U.S. economy after 1995 can be attributed to advances in IT (Jorgenson 2002). Moreover, the rapid growth in U.S. labor productivity during the economic slowdown that began in 2001 suggests that prospects for potential growth of the U.S. economy have been considerably enhanced (Jorgenson, Ho, and Stiroh 2002).

The macro view is supplemented by industry and firm-level analysis. IT is a typical general purpose technology, which means it diffuses widely into an economy and has heterogeneous effects on the various aspects of firm activities. IT changes business practices and decision-making systems, as well as relationships between suppliers and customers. Thus, it is important to look at what is going on at the firm level to achieve deeper understanding of the economic impact of the IT revolution.

The implications of IT and digital revolutions are then discussed in relation to the "Japanese management system" or "Japanese model" as an economic institution. Due to the wide diffusion of IT networks, the role of external and explicit information becomes important in the knowledge creation process. This shift in the comparative importance of explicit knowledge may benefits U.S. firms more than Japanese firms, which have had an advantage in their handling of implicit knowledge. In addition, modularization of product architecture, particularly found in the electronics industry, raises innovation speeds. This means quick business decisions and adjustments using external markets are required more than was the case.

The policy implications of this context are then provided. In short, it is imperative that Japanese firms focus on quality rather than price for their competitiveness.

This means that building a national innovation system capable of maximizing knowledge creation in Japan as a whole has become a priority policy item. Effective use of IT is a critical component in such an economy. The incumbent innovation system, which has relied heavily on in-house research and development (R&D), must shift toward a network system using external collaborations.

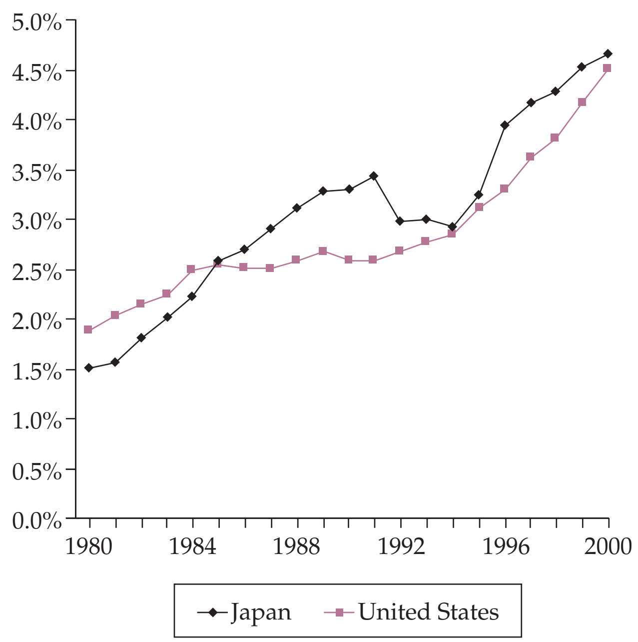
IT and Economic Growth at the Macro Level

As a determinant of productivity, use of IT has been extensively examined. An IT revolution, with rapid technological progress in computers and the spread of the Internet in the 1990s, coincides with a kink in the trend line of U.S. labor productivity. That is, after a slowdown in the 1980s, it regained speed in the late 1990s. Oliner and Sichel (2000) show that about two-thirds of the 1.5% annual productivity revival after 1995 can be attributed to the growth in IT investment. Even after the so-called IT bubble burst in 2001, U.S. labor productivity as measured by the U.S. Bureau of Labor Statistics (BLS) shows strong performance. Thus, it is fair to say that the IT investment surge can explain a significant portion of the U.S. productivity revival after the mid-1990s (Bailiy 2002).

Jorgenson and Motohashi (2005) extend such analysis to Japan and compare the role of IT in economic growth in the two countries. The growth rate can be decomposed into contributions from factor inputs: labor, capital, and total factor productivity (TFP). Capital inputs can be decomposed into IT capital and non-IT capital.

Figure 6.1 shows the ratio of IT investment to gross domestic product (GDP) in Japan and the United States. Due to active IT investment in the 1980s, the IT ratio in Japan surpassed that of the United States in the mid-1980s. After the resurgence of

Figure 6.1. *IT Investment as a Percentage of Nominal GDP, Japan and United States, 1980–2000*



IT investment includes computer, software, and communications equipment.

Source: Author's calculations using various statistical sources.

the U.S. economy in the 1990s, U.S. firms accelerated IT investment and caught up with Japan in 2000. The basic message from this graph is that the IT investment boom is not a phenomenon special to the United States: Japanese firms also invested heavily in IT.

In this sense, the result in Table 6.1, the growth decomposition computed by Jorgenson and Motohashi (2005), is not strange. A major source of Japanese economic growth in the late 1990s is the surge in the contribution of capital services from IT equipment and software. (Capital services refers to services from capital stock, as a contribution to value added growth.)

In Japan, the contribution of IT capital services declined during the first half of the 1990s, then rebounded strongly after 1995. However, the increase is not as large as for the United States. The IT contribution in the United States rose steadily between 1973 and 2003.

Until the mid-1990s, relative to United States, TPF grew faster in Japan, but progressively less so, and the share of GDP growth attributable to TFP was greater.

Table 6.1. *IT's Contribution to Growth in Japan and the United States, 1973–2003 (Annual Growth Rates, in Percents)*

1973–90	*1990–95*	*1995–2003*	
Japan			
4.03	1.64	1.28	GDP
Contribution of:			
0.36	0.29	0.54	IT capital services
1.01	0.77	0.62	Non-IT capital services
1.09	–0.22	–0.32	Labor services
1.57	0.80	0.45	TFP
IT capital services composed of:			
0.18	0.13	0.22	Computers
0.12	0.12	0.20	Software
0.07	0.04	0.11	Communications equipment
United States			
2.98	2.44	3.55	GDP
Contribution of:			
0.38	0.49	0.88	IT capital services
1.11	0.71	1.01	Non-IT capital services
1.18	0.93	0.67	Labor services
0.31	0.31	0.99	TFP
IT capital services composed of:			
0.20	0.22	0.49	Computers
0.07	0.16	0.22	Software
0.11	0.10	0.17	Communications equipment

These results are based on adjusted deflators of IT investments for Japan. The same calculation based on national deflators is also conducted, and the contribution of IT capital drops from 0.54% to 0.40% from 1995 to 2005. However, the TFP growth rate does not change, 0.45% for both estimates (Jorgenson and Motohashi 2005). Because of the price adjustment differences, the Japanese GDP growth rate here is different from that in official statistics. Detail may not add to totals because of rounding.

Source: Jorgenson and Motohashi (2005).

This reversed during the 1995–2003 period. The share of TFP in GDP growth has increased in the United States, from 10% in 1973–90, to 13% in 1990–95, to 28% in 1995–2003.

What explains the difference in growth rates between the two countries? Labor input made almost no contribution to growth in Japan throughout the 1990s. Production was becoming more efficient, but demand was not rising fast enough to absorb the available supply. By contrast, labor input growth in the United States far outstripped labor force growth, resulting in a decline in the unemployment rate and a rise in participation rates.

Another indication of slack demand in Japan is the anemic growth of non-IT capital input relative to the United States. The decline in per capita hours worked throughout the 1990s distinguishes Japan from other industrialized countries. This has been analyzed in detail by Hayashi and Prescott (2002) and can be attributed to the widespread adoption of a five-day work week and an increase in the number of national holidays. Demand-side factors in the labor market, such as the historically high unemployment rate, also are relevant.

Revival of TFP growth in the late 1990s can be attributed to acceleration of the IT revolution in terms of the relentless drop in the prices of processors and storage devices. Each successive generation of processors and storage devices was more powerful than the previous one, yet was the same or even less expensive. This meant not only that the constant quality price of hardware dropped, but that users could get a system that was both better and less expensive than the one it replaced. The staggering rate of technical progress in the IT-producing industries—semiconductors, computers, and telecommunications equipment—has led to substantial TFP growth in this sector. This, in turn, pushes up TFP at the macro level. Jorgenson and Motohashi (2005) estimated that the TFP growth rate from the IT sector explains about 80% of the overall Japanese rate.

TFP growth may come from various other factors, such as R&D investment and increasing market efficiency. Thus, growth decomposition by industry shows that a major portion in the 1990s was in service sectors (Fukao and Miyagawa 2003). Productivity growth in services during this period can be attributed to series of regulatory reforms conducted after 1990. A positive relationship between regulatory reform and productivity growth can be observed in industry-level studies in communication, retail, and financial services (CAO 2001). If one takes out contributions from all non-IT factors, a pure effect of IT on productivity in IT user sectors may become very small.

An Industry- and Firm-Level Look at IT and Productivity

The relationship between IT and productivity in user sectors is investigated in this section at the industry and firm levels. It is found that IT is not a sector-specific technology, and it diffuses widely across industries. The Ministry of Economy, Trade, and Industry (METI) IT survey conducted every year provides the amount of IT expenditure by industry. Note that IT expenditure and IT investment are different. For example, hardware rental costs are an IT expenditure, not an IT investment. Most computers are rented, so expenditure provides a more accurate picture of IT use on the user side. Table 6.2 shows the share of IT expenditure by industry in 2000.

In term of IT intensity, measured by the ratio of IT expenditure to total sales, the financial services sector scores (2.1%) much higher than manufacturing (0.9%).

Table 6.2. *Distribution of IT Expenditure by Industry, Japan, 2000 (in Percents)*

1	Primary industries
2	Construction
31	Manufacturing
6	Utilities
2	Transportation and communications
9	Retail and wholesale trade
20	Financial services
26	IT services
3	Other services

Total IT expenditure was 4.41 trillion yen (about $38 billion at 115 yen/dollar). Data are for fiscal years that ended during 2000. For large firms (and thus, most of the expenditure), this means years ending in March 2000. For small firms, data are mostly calendar year 2000.

The IT services industry includes software and information providing and processing services.

Source: METI, ICT Workplace Survey.

However, higher IT intensity does not always lead to higher productivity growth. Nishimura and Minetaki (2004) analyze the relationship between TFP growth and IT intensity, measured by the ratio of IT capital stock to total capital stock by industry. They cannot find any statistically significant effect on productivity from IT in a cross-industry regression. The same result is found for the United States (Stiroh 2002).

High IT intensity does not always suggest a higher degree of IT capital deepening at constant prices. Cross-industry analysis of the speed of computer downsizing shows that mainframe systems still dominate Japanese commercial banks, while client-server systems are diffused widely in other industries (Motohashi 2005). In general, the speed of technological progress and price decline is faster for smaller computers. Thus, high IT intensity in the financial services sector may simply reflect higher-priced systems.

Cross-industry differences in TFP growth comes from various factors other than IT investments. For example, market competition affects productivity growth (Nickel 1996). R&D is another driver of TFP.

In this context, Motohashi (2003) conducted a firm-level analysis of IT network use and productivity for the manufacturing and trade (retail and wholesale) sectors to separate IT from other contributors to TFP growth. A rich firm-level dataset for IT and performance collected by METI allows investigation of the nature of general purpose technology and its economic consequences. (A general purpose technology is one that can be used differently in different industries, and in various ways within an industry, as is shown in Motohashi (1997)). For example, flexible manufacturing systems and Internet banking are totally different applications of IT. Even within a firm, various IT applications—from financial accounting systems to inventory control systems—can be found.

METI's firm-level dataset includes information on the use of information networks by type of application. Comparing the economic impact by type of IT

Table 6.3. *Effect of Information Network Use on TFP Growth, Japan, 1997–2000 (Annual Percentage Rates)*

	1991–94	*1994–97*	*1997–2000*	
Intrafirm network				
	1.0	0.1	2.2	Manufacturing
	–0.6	3.7	4.3	Trade[1]
Interfirm network				
	3.1	0.7	1.8	Manufacturing
	–0.3	2.1	0.5	Trade[1]

Entries are the difference between a firm using the specified type of IT network and a firm not using IT. For example, the TFP growth rate between 1991 and 1994 of a manufacturing firm using an intrafirm network is 1.0% higher than that of a firm not using it. This productivity growth premium varies over periods, types of IT network, and industry.

Data are from Motohashi (2003). They are the results of estimating a production function including labor, IT capital, and non-IT capital as inputs.

1. Includes both retail and wholesale trade.

application provides useful information for understanding the relationship between IT and firm-level performance.

Table 6.3 shows the difference in the TFP growth rate of a firm using each type of IT network as compared to a non-IT user. The results of this sort of analysis suffer from errors in variables and model specifications. Still, it is possible to conclude that positive effects of network use on productivity are found in general.

The size of the productivity premium is very small. It is also found that variances in TFP growth within the network-use group and non-network-use group are very large. Statistical tests for the regression models show that only 1 of 12 coefficients is positive (different from zero) at a 10% significance level. Therefore, although a positive relationship can be found on average, it is only to a mild degree.

The same analysis is conducted for network use by type of business process, such as ordering, production, inventory, customer relations, human resource management, and the like, in Motohashi (2003). The results are almost the same, showing only small effects, and no particular patterns over type of process can be found. There are no comparable studies for the United States or European countries, but an effort to put together similar types of studies has been conducted by the OECD (2003).

Comparing Japan and the United States, increases in two measures of labor productivity related to network use have been calculated by Atrostic et al. (2004). They found that sales per employee in Japan were 12% higher with network use than without in 1997, and value added per employee was 5% higher. The 1999 differences for the United States were 28% for sales and 29% for value added.

Organizational Considerations

Underperformance of IT network users in Japanese firms can be explained by underinvestment in organizational capital complementary to IT. At the firm level, IT investment is not simply buying computers and software. Success requires co-invention by suppliers and users, including organizational innovation (Bresnahan and Greenstein 1997).

There are a significant number of studies addressing the importance of particular organization forms and work practices to make the most of IT investments. For example, innovative practices are captured by a firm-level survey, and their relationship with firm performance is tested, by Ichiniowski et al. (1996). Practices included work teams (quality circles, for example), employee stock ownership (ESOPs), and flexible job assignment. Their study shows that "high-performance work systems" lead to better performance.

The complementarity of IT and organizational assets is also shown by Bresnahan, Brynjolfsson, and Hitt (2002) using firm-level quantitative analysis. They stress that increased productivity requires both IT investment and innovative work practices. The value of intangible assets is addressed directly by Brynjolfsson, Hitt, and Yang (2002). They looked at the relationship between innovative work practices and the stock market valuation of firms and found a positive association between them.

Complementary assets of interfirm networks include a firm's ability to handle relationships with suppliers and customers. SCM (supply-chain management) and CRM (customer-relationship management) are straightforward examples for IT applications in this area. However, simply applying an SCM system does not automatically improve performance. If it did, Dell Inc.'s effective SCM could be imitated by others, and Dell would loose its competitive edge instantly. There must be some firm-specific and sticky intangible assets to explain the excellent performance of Dell's SCM.

All these studies suggest that introducing a new IT system should be paralleled by changes in internal work practices, incentive systems, supplier and customer relationships, and the like. As IT system prices have dropped dramatically, the cost of the organizational changes (investment in organizational capital) has become relatively large. However, there is a general agreement that without proper investment in organizational capital, the introduction of a new IT system does not work well, and it is difficult to achieve expected performance improvements.

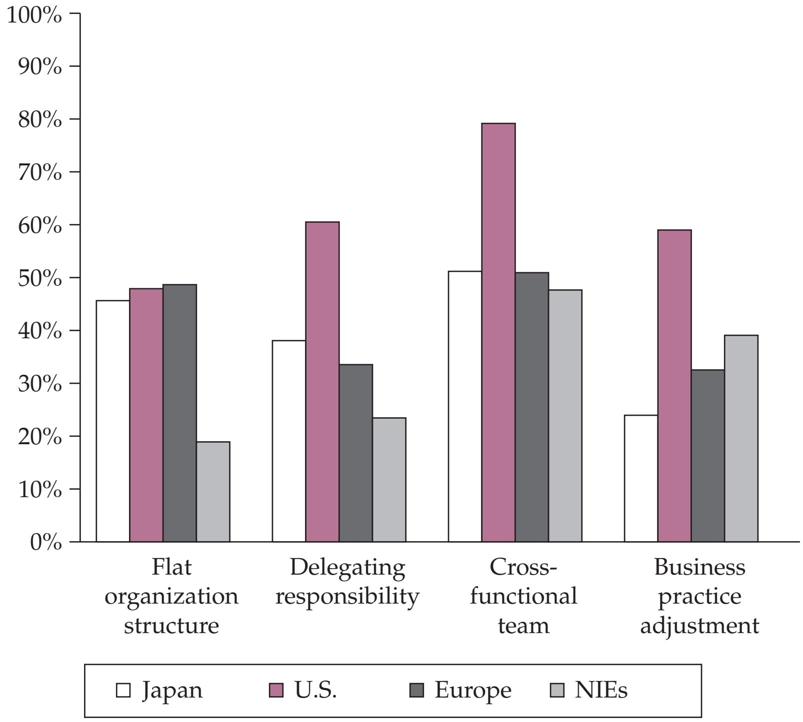
Japanese firms make fewer organizational changes when they introduce new IT systems. Figure 6.2 indicates the share of firms that conducted each type of organizational change in processes related to IT system adoption.

Labor Constraints

There is no evidence that Japanese firms underinvest in IT systems as compared to U.S. ones but, due to employment constraints, they cannot achieve the same level of performance. It is very difficult for firms to fire employees. A major reorganization of a firm's structure typically is accompanied by a reallocation of workers, which sometimes requires cuts in the total number. In Japan, organizational changes such as flattening the organization, integrating divisions, reduction of back-office staff, and the like, were indeed done when new IT systems were introduced. However, workforce redundancy associated with such changes was absorbed mainly within the firm by transferring staff, instead of using more part-time and temporary workers. (Motohashi 1999), using data are from a firm-level survey on technology adoption and organizational changes from 1991 to 1994 conducted by the Japan Productivity Center for Socio-Economic Development).

TFP growth in the late 1990s at the macro level can be—and was—achieved at the expense of labor inputs. In this process, large Japanese companies have conducted substantial restructuring of labor forces. However, reducing the labor force

Figure 6.2. *Organizational Change and IT Adoption*



Data are for 2000. NIEs new industrialized economies.
Source: METI, *White Paper on International Trade,* 2001.

has been done mainly by early retirement rather than terminating underperforming employees. Due to the lack of an active external labor market, the resource reallocation necessary to deal with the rapid shift in labor demand driven by the IT revolution cannot be expected. Sluggish economic performance after the burst of the economic bubble exacerbates this rigidity.

IT Management Style

Another factor in the underperformance of Japanese IT users is rooted in IT management style. In most cases it is fragmented by department or division, rather than an integrated system throughout the whole company. This reflects how enterprise IT systems were developed historically. In the past, systems addressed specific business needs, such as financial accounting, inventory control, and customer relations. Now, however, Enterprise Resource Planning (ERP) systems integrate various application into one package. ERP unifies all information in each division throughout a whole firm, and managers can access it for day-to-day decision making. Efficiency gains in individual sections of a company do not always lead to productivity increases in the whole, but ERP is a system enabling total optimization and timely information availability across a firm.

ERP is used extensively by U.S. firms, while diffusion in Japan has been relatively slow. Even when it is introduced, proper modifications of business practices are not conducted, and it does not contribute to business performance at all. Organizational rigidity regarding changes in work practices again hampers effective use of an IT system.

METI conducted a survey of about 500 listed companies regarding IT management and business performance (METI 2003). It found 66% of firms use information systems (IS) by department, while 19% had integrated IS.

METI also found that companies introducing firm-wide IT systems achieved better business performance in terms of managerial decision speed, business process re-engineering (BPR), differentiation of products and services, and response to globalization. The problem is the share of firms with firm-wide IS is only 19%, which indicates that, in general, Japanese companies are operated in a decentralized way, without strong top-down leadership.

The Japanese Model and IT User Performance

The foregoing discussion leads to the relationship between IT systems and the "Japanese model" as an economic institution. The term "Japanese model" is a comprehensive reference to a unique management style that has been practiced by Japanese corporations as the country's economy developed in the postwar period. With regard to business practices, it refers to the maintenance of long-term business relationships; with regard to human resources management, it refers to lifetime employment and reliance on seniority; in the financial sphere, it refers to a heavy reliance on indirect finance; and in corporate governance, it refers to the influence exercised by main banks. These institutions and business practices fly in the face of classical economic thinking, with its emphasis on the allocation of resources by labor markets, capital markets, product markets, and other such mechanisms. Of course, Western enterprises do not operate entirely on market principles either, but it remains true that Japanese enterprises rely more than their Western counterparts on nonmarket mechanisms.

Comparative institutional analysis (CIA) provides a useful tool for the analysis of the Japanese model (Aoki 2001). In neoclassical economics, a corporation is treated as a black box, but to analyze the Japanese model, there must be a framework that delves into the organizational structure of corporations. For example, a model has been put forward for decision making processes in managerial and operational divisions, and for coordination mechanisms between different operational divisions (Aoki and Okuno 1996). According to this model, where different operational divisions are highly complementary, the most advantageous institution is one in which the different divisions engage extensively in information sharing while devolving decision-making powers to the level of the shop floor. Where different operational divisions are *not* highly complementary, the most advantageous institution features centralized, top-down decision-making. It is said that lifetime employment, which is one feature of the Japanese model, tends to increase sharing of information within a firm, and that Japanese enterprises tend to stress decision-making at the shop-floor level.

Comparison of firm behavior and organizational structure is conducted in Kagono et al. (1983). Based on a firm-level survey, it is shown that Japanese firms are organized in a decentralized fashion in terms of their decision-making system and allocation of responsibility as compared to U.S. firms. In this sense, cross-functional coordination of Japanese firms is more active at the shop-floor level. In addition, such a bottom-up system, with team-based management, does not require a detailed job description for each employee. This is compatible with the long-term employer-employee relationship at Japanese firms. Fragmented IT systems, as found in Japanese firms, are consistent with bottom-up decision making, without top-down initiatives for IT investments.

IT systems are an effective communication tool throughout a firm, but their benefit to Japanese firms is relatively small. The first reason is that effective cross-functional communications had already been achieved before the IT revolution. In this sense, the marginal gain from IT systems is smaller for Japanese firms. Second, it is difficult to codify the business processes of Japanese firms in digital format. This is because they are not clearly articulated, and day-to-day decision making is done in a subtle and flexible way. Third, Japanese firms are strong in using tacit knowledge for innovation as compared to explicit knowledge (Nonaka and Takeuchi 1995). Explicit knowledge can be more easily handled by a computer than tacit knowledge. This point is investigated in more detail in the next chapter.

Table 6.4 summarizes the contrasts in management practices between stylized Japanese and U.S. firms, as well as the implications for IT use. Together, the points suggest that the firm-wide application of IT does not fit comfortably into the Japanese model.

Strengths and Weaknesses of Japanese Enterprises

Use of IT in the knowledge creation process is analyzed in this section, and the results of a survey on "organizational IQ" conducted by Research Institute of Economy, Trade, and Industries (RIETI; 2001) comparing Japanese and U.S. firms are presented.

Organizational IQ focuses on providing an overall measurement of a firm's sensitivity to external information, its ability to efficiently process in-house information, and the quality of its decision-making processes. The concept was introduced by Mendelson and Ziegler (1999). They conducted a questionnaire survey of firms in Silicon Valley and used the results to analyze the relationship between organizational IQ and corporate performance.

RIETI conducted a similar survey for Japanese firms. The organizational IQ of each firm was based for the most part on the following elements.

1. Grasp of external information: frequency of contact with customers; intake of information on competitors and technologies.
2. Flow of in-house information: access to information regarding competitors and markets, use of lateral teamwork.
3. Decision-making processes: degree of delegation (flat organization), internal flow of information.

Table 6.4. *U.S. Firms versus Japanese Firms*

	U.S. firms	*Japanese firms*	Implications for IT use
Cross-functional coordination	Inactive	Active	Comparative disadvantage in using IT tools
Job description and responsibility	Clear	Unclear	Dificulty in business process reengineering
Decision-making process	Top-down	Bottom-up	Fragmentation of IT system
Knowledge creation process	Explicit knowledge	Tacit knowledge	Ineffective use of digitalized information

4. Organizational focus: clarity of development processes, operational objectives, and evaluation criteria.
5. Creativity: activities aimed at creation of tacit knowledge, ability to carry through on ideas.

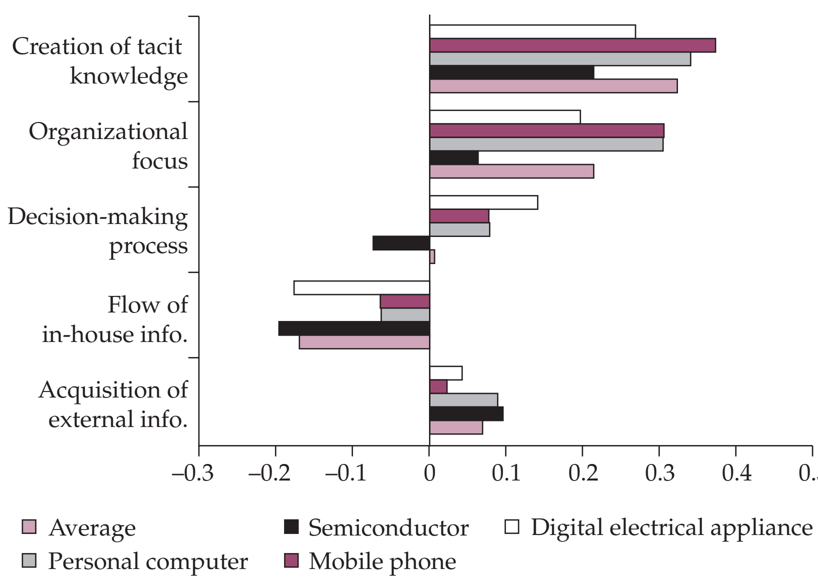
Figure 6.3 shows scores of Japanese firms compared to the U.S. firms in Mendelson and Ziegler. Positive values mean higher score for Japanese firms, and negative mean lower. The results must be interpreted with caution, as the questionnaire deals with subjective material.

Japanese firms scored higher than their Silicon Valley counterparts in many categories. However, Silicon Valley respondents on the whole gave more pessimistic responses, which lowered their overall score. Accordingly, any comparison should not treat the results as absolute scores. However, the U.S. scores can be used as a baseline for determining the categories in which Japanese firms were relatively strong or weak. Also, the results can be used to observe trends in relative scores.

Japanese firms in all sectors scored highest in "creation of tacit knowledge" and lowest in "flow of in-house information." To better understand these results it is helpful to use the Socialization Externalization Combination and Internalization (SECI) model of Nonaka and Takeuchi (1995). The model divides knowledge in a corporation into two types: tacit and formal. These serve as the basis for knowledge creation through the following four processes (the first letters of which are used to form the name of the model).

1. Socialization (creation of tacit knowledge from tacit knowledge);
2. Externalization (creation of formal knowledge from tacit knowledge);
3. Combination (creation of formal knowledge from formal knowledge); and
4. Internalization (creation of tacit knowledge from formal knowledge).

Figure 6.3. *Organizational IQ of Japanese Firms Relative to U.S. Firms*



Entries are the 2001 Japanese score from RIETI (2001) minus the U.S. score from Mendelson and Ziegler (1999).

The creation of tacit knowledge is a process of formalization whereby individual employees turn their tacit knowledge into concrete concepts and new products. Japanese firms can be said to be relatively good in the area of externalization.

The flow of in-house information, by contrast, involves internal circulation within the firm of tacit and formal knowledge. In other words, it involves socialization and combination. Looking at the individual items under the category "flow of in-house information," one finds that Japanese firms got low scores for access to information regarding competitors and markets, and for internal sharing of product specifications, both of which are concerned with formal knowledge. Accordingly, it could be said that Japanese firms are especially weak in the area of combination.

Progress in the field of IT has made it easier for corporate management to make use of external information, and an open-network model of management that focuses on collaboration with outside organizations has come to offer comparative advantage. This is a model that makes active use of formal knowledge. Japanese firms do not make effective use of formal knowledge from outside the company.

Japanese firms got extremely low scores for "management of product development in cooperation with outside organizations" and "selection of strategic development partners." Particularly in the electronics industry, where the pace of technological progress is quick and the business climate undergoes rapid change, a firm must stay well-informed of external developments. Exclusive reliance on in-house resources, such as personnel and information, is unlikely to be sufficient. Rather, as the firm seeks to correctly position itself within its business domain, it must aggressively pursue tie-ups with other entities.

The relative weakness of Japanese firms in handling explicit knowledge may weaken their competitive position, particularly in areas of rapid technological progress.

The IT Revolution and Modularization: Challenges to the Japanese Model

Thanks to decades of improvements in integrated circuit (IC) technology, computers have become of faster and smaller, and build-out of the Internet and other telecommunications infrastructure continues apace. These advances are prompting enterprises to invest in IS and are triggering changes in the structure of the economy. This IT revolution is being fueled by the vertiginous pace of progress in electrical engineering and material science.

Even after several decades, Moore's Law on increases in the capacity of computer chips and the level of integration of ICs continues to apply. In telecommunications, the fear of capacity constraints was shattered by fiber optics and digitalization. IT systems combining computing power and telecommunications have penetrated into the very fabric of society, to the point where economic activities can grind to a halt without them.

To understand the impact of the IT revolution on the economy, it is important to bear in mind the ongoing digitalization of information relating to business operations, products, and technology. In the form of the Internet, this has had particular impact on distribution, both between businesses and with final consumers.

The flow of publicly available information via the Internet is growing much faster than the flow of internal company information. (That is, information relating to unannounced products and technologies, for example, and know-how related to a company's unique management techniques.) The efficiency of exchange of confi-

Box 6.1. *Modular Architecture*

Modular architecture refers to the design of a product (mostly physical, but also some software) using standardized interfaces to allow interchangeability of various specific varieties of a component, and the combining of components into what can be complex systems. The PC is the most obvious illustration: many vendors supply many varieties of, for example, hard-disk drives, but any can be plugged into the computer.

With such an architecture, development of the separate modules can occur in parallel. Because competition takes place among the makers of each module, innovation in the product as a whole can proceed rapidly.

Modularization of product architecture leads to unbundling the supply chain, and dividing it among various kinds of players. Competitive advantage comes from innovative capacity in key components and the capability of maintaining supply-chain networks. This is a fundamental threat to the Japanese model, which is based on stable supplier-customer relationships and manufacturing technology and skills at the plant level, which cannot be codified and managed by IT systems.

dential information between enterprises is also notably higher thanks to improved information networks. This qualitative change in the nature of information makes it easier for corporate management to make use of external information, and it also encourages enterprises to exchange more information with specific outside entities. The result is a network-based model of management that creates win-win situations and offers comparative advantage.

Organization IQ tests show that Japanese firms are relatively weak in handing explicit knowledge, the importance of which has become greater because of IT. On the other hand, The Japanese model is effective in sectors where complementarity among divisions is strong and coordination is required. Therefore, the impact of the IT revolution varies across industries.

The electronics industry is in a particularly serious condition, because of the storm of modularization in product architecture (Ando and Motohashi 2002). In electronics, integrated manufacturers, producing final products as well as their components, have been losing competitive edge to overspecialized component companies due to the unbundling of production and supply-chain systems. This relates to the rise of "modular architecture," as explained in Box 6.1.

Conclusion

In this chapter, the impact of IT innovation in the Japanese economy is investigated using macro-level statistics, as well as micro findings at firms in terms of productivity and organizational effects. TFP growth in Japan has been comparable to that of the United States, and about half of it can be explained by the IT sector. A firm-level analysis suggests that the use and productivity of IT at IT-using firms is not so strong, and its impact is relativey smaller, in Japan than in the United States. New technology adoption always requires changes in work practices and management systems. There is no doubt that IT advancement leads to significant productivity growth in the IT industry, but organizational rigidity in user industries may hinder effective use of new IT systems.

In addition, the Japanese model is in a process of substantial changes, in part because of the digital revolution. In the fierce innovation competition due to the revolution, speed and collaboration are particularly important in managerial decision making. To achieve speed, a firm must rely on its core competencies and carefully consider its many options before choosing what is best, concentrating its resources in those areas. A strategic approach and leadership are needed. Western firms are aggressively pursuing cross-border merger and acquisition deals and tie-ups, and it has become accepted wisdom that firms with complementary core competencies must collaborate in order to achieve accelerated innovation and greater rates of return. The bottom-up approach to management and the "go-it-alone" business practice that afforded Japan competitive advantage for so many years will no longer meet the challenge of international competition.

To compete successfully in the ongoing IT revolution, it is necessary to formulate a corporate strategy that stresses speed and collaboration. Toward that end, it is important to reform entire systems, including their constituent institutions. As part of this, working within the analytical framework of a national innovation system, Japan needs to develop a "doctor's prescription" to strengthen complementarities between the mesh of institutions that support innovation, for example, product markets, intellectual property rights, financial markets, and labor markets.

Japan's innovation system is anchored by major corporations, and for many reasons the industrial community has not had strong linkages to universities or public research institutes. Based on the U.S. experience, it seems appropriate to create greater linkages with universities and research institutes to help spur corporate innovation.

National innovation systems evolve in each country on the basis of historic and institutional background, and it is not possible to make across-the-board statements about which type of system is best. Japan was able to achieve outstanding economic performance in the postwar years because its enterprises made effective use of in-house tacit knowledge, companies churned out new products on the strength of bottom-up initiatives, and new production systems, such as Toyota Motor Corp.'s, were developed.

Japan's innovation system appears to have worked quite well through the 1980s. Subsequently, amidst the wave of global competition that has erupted as a result of the IT revolution, comparative advantage in many industries has shifted to the U.S.-style network-based innovation system, especially in the electronics industry. Therefore, it is important to facilitate a shift in the Japanese innovation system toward a network-based, dynamic one. In a world of global competition for speed in innovation, in-house innovation systems do not work.

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