Informatization in Japan and Its Impacts on Economic Growth

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Introduction

We are in the age of *informatization*. It was brought about by the development of new information technology embodied in computers, communication equipment, and information systems. Informatization has a profound impact on the functioning of all human organizations; it is transforming our daily lives, the business activity of firms, the structure of industries, and the operation of the whole economy. We also see its impact on international relations.

To economists, informatization means the growth of information industries. The impact of informatization, however, is so widespread that it is impossible to understand by simply expressing it as the increase in output from information industries. A more comprehensive approach is needed.

This chapter discusses the economic impact of informatization by using a framework that is called *interindustry analysis.* It is a method that explains a broad variety of economic activities by looking at the flow of goods and services among different sectors of the whole economy.

In the following section, we outline the process of informatization. A brief explanation of interindustry analysis follows. In the third section, we explain how to express information activities in input-output tables. Finally, the forth section presents some of the recent results that measure the impact of new information technology on the Japanese economy.

Informatization

Information is basic to human beings. Information activities include direct conversation with other people, consultation by means of telephone, watching television news and reading newspapers or books, and many others. The development of human society parallels with the development of information activities, so informatization is in no sense new. In fact, the inventions of information activities such as writing systems, paper, printing devices, radio and television have profoundly influenced the functioning of our society. In the economic arena, production and transactions of goods and services have long depended on information activities.

In the middle of the 1970s, technological breakthroughs were achieved in the United States that created large-scale integrated circuits (LSI) for electronic information processing; this greatly reduced the cost of information activities and became a major source of economic development. The invention of optical fibers and other information means, together with the development of software and computer systems, accelerated this trend. In this chapter, *informatization* means the rapid development of information technology since the middle of the 1970s and its widespread impacts on our society, ranging from its influence on an individual's life to corporate decisions to national and global activities.

Informatization takes two stages. The first is the development of the various means of information activities; the second is the development of information activities themselves by using new means of information. (See Table 11.1.)

The technological driving force of informatization was, as stated earlier, the invention of LSI. Information processing is a systematic manipulation of *bits,* a sequence of 0s (zeros) and 1s (ones), expressed by the presence or absence of electric charge or magnetic field. Bits are processed by transistors, each of which is nothing but a collection of tiny electric switches. Transistors can control bits by controlling electric currents. It became possible to produce a large number (nowadays millions) of switches on a small piece of semiconductor materials called silicon chips; electric circuits are printed optically on chips to generate switches. Thus, we have a microcomputer in a chip that can perform sophisticated information processing such as number calculation and machine control.

A large variety of electronic products has been created by using LSI. Today, we have chips in TV sets, telephone terminals, airconditioners, refrigerators, and automobiles. Manufacturing factories are operated by a variety of robots, each controlled by LSI. Computers are made of combined chips. Softwares can control chips and other devices so as to perform more sophisticated information tasks. To summarize, informatization was started by devices and systems performing information activities for human beings. Such devices and systems will, in this chapter, be called *information-related goods*. In addition, services given by information-related goods together with information-trained workers will be called *information-related services*. Thus, the basis of the first stage of informatization is the development of information-related goods and information-related services. (See Figure 11.1.)

The second stage of informatization is the advancement of information activities by using new information-related goods and new information-related services; it is the stage of informatization viewed from the users' side. For example, robots in automobile assembly factories help workers control machines and tools. A robot accepts the information about its environment, processes it, and takes appropriate actions. In a supermarket, bar-code readers help cashiers register the code of items of merchandises and their prices by reading the information on price tags and inputting it in the cash register. Furthermore, because of the emergence of personal computers, the efficiency of work in offices, schools, and research institutes has been greatly increased.

The development of information activities, of course, depends not only on the development of information-related goods and services, but also on the development of the ability of workers to use such new devices. Whenever new information devices become available, users must be trained. New information goods always demand that users be equipped with new abilities. Furthermore, the ability to evaluate and select information devices appropriate to the task to be performed is always needed. Without the advancement of technology on the users' side, no new information goods or systems will be useful. In fact, the human cost of using information goods and services is as great as the cost of new information devices or systems themselves.

Table 11.2 summarizes various impacts of informatization. They are broadly classified into three: the impact on information industries, the impact on individual users, and the impacts on the society as a whole.

It is easy to understand the impact on information industries; new information technology brought about new information-related goods and services, together with reduction in their prices. The growth of information industries since the middle of 1970s was remarkable in most advanced countries.

The second category related to users of information-related goods and services and to users of information. In factories and offices, because of informatization, the efficiency of production and management increased, reducing their costs. In households, as well, new information-related goods and new information provided benefits and conveniences. Companies increased their revenue and profits, and the standard of living of households.

The third category of the impacts of informatization contributed to the improvement of various socioeconomic systems. Human society is organized into groups of individuals; they compete and coordinate each other. Information activities--collection, transmission, and use of information for decision making--are needed by individuals working in social and economic organizations. Informatization improves the media for information activities; it may be regarded as an increase in the efficiency of society’s central nervous system. In the area of economic and business activities, informatization increases transaction opportunities between economic units, contributes to preventing disequilibrium or instability, and helps economic agents make correct decisions. In other areas, informatization also increases the efficiency of social systems. For example, transmission of political information through television networks may promote political democratization by increasing the efficiency in disseminating information and, consequently, in aggregating individual political opinions into a collective decision.

This is an intuitive summary of informatization. In the remaining part of this chapter, we use the framework of interindustry analysis for (a) clarifying concepts related to informatization, and (b) measuring quantitatively the contribution of informatization to economic development.

A brief introduction to interindustry analysis

Interindustry models (*input-output tables*) serve to trace the flow of goods and services between various sectors of the whole economy. In this section, we explain briefly what interindustry analysis is.

To begin with, the entire economy is divided into two large sectors: the *industrial sector*, engaging in production of goods and services, and the *exogenous sector*, sectors other than the industrial sector. The industrial sector is composed of industries; each industry is characterized by its product. In a large-scale input-output table, hundreds of industrial sectors are considered together with flows of goods and services between them. In order to explain the idea of interindustry analysis in a simple setting, we divide the industrial sector into Thirds: the primary sector (agriculture, forestry, and fishery), the secondary sector (mining, manufacturing, and construction), and the tertiary sector (services, public sectors, etc.). Figure 11.2 explains this. Industrial sectors are represented by a rectangle located at the upper-left corner of the figure. Arrows indicate the flow of goods and services between the three sectors (called *intermediate products*). For example, the petroleum refinery sector in the secondary industry sells oil to the electricity generation sector in the tertiary industry; the flow of oil is included in the arrow from the secondary sector to the tertiary sector.

Exogenous sectors are listed in a diagram of reversed L-shape that is identified at the lower right-hand corner of Figure 11.2. Exogenous sectors include the household sector, the government sector, the capital accounts, and the rest of the world. Exogenous sectors purchase goods and services from the three industrial sectors, as indicated by an arrow at the upper right part of the figure. Goods and services purchased by exogenous sectors are called the *final demand* for products, as distinct from intermediate products. In other words, all the products supplied by the industrial sector are divided into intermediate goods and the final demand. The final demand is consumed by the household sector, consumed by the government sector, exported to the rest of the world, or saved as an addition to the existing capital stock, which is investment.

On the other hand, exogenous sectors sell the service of productive factors, such as labor and capital, to industrial sectors. As shown in the lower left-hand portion of Figure 11.2, industrial sectors purchase labor and capital services from exogenous sectors, and import from the rest of the world.

Thus, interindustry analysis describes the flow of goods and services between the industrial and exogenous sectors and also among sectors within the industrial sectors. It is an overview of the activities of the whole economy allowing us to conduct a variety of economic analysis by using input-output tables. The objective of this chapter is to explain information activities in terms of the interindustry framework.

Information activities in interindustry analysis

A simple and straightforward way to express information activities in the framework of interindustry analysis is to pick up information industries, such as the computer industry, the software industry, the telecommunication industry, and others, and deal with them simultaneously with other manufacturing or service industries. Thus, according to this approach, informatization can be handled within the framework of input-output tables, because it is simply regarded as an increase in the output of information industries. This approach, however, does not capture the aspects of informatization we are interested in. Informatization is in fact more than an increase in the output of information industries.

To explain, let us begin with the increase in the production of information-related goods and services and the increase in the production of information. Figure 11.3 is obtained by making explicit from figure 11.2, the three-sectoral input-output framework, the production of information-related goods and information services, and the production of information.

Information-related goods are typically semiconductor materials, semiconductor chips, computers, and other electronic devices; most of them are produced in the secondary industry. Thus, the secondary industry is divided into the information-related good sector and the other sectors.

We next consider information-related services, which are typically computation services, telecommunications services, mail services, and others. These information-related services are produced in the tertiary industry. Further, the sectors producing and supplying information are also classified into tertiary sectors -- for example, broadcasting industry, the newspaper industry, and the publication industry all produce information. Research and development is mostly production of information, and education produces information to be embodied in human beings. All of these are considered to be information sectors. In Japan, these information sectors are sometimes called the *forth industry*, in contrast with the primary, the secondary, and the tertiary industries.

Table 11.3 exhibits value-added estimats in the information-related service sectors, the information sectors, the information-related good sectors, and noninformation sectors.[1] It can be seen from this table that, during the 10-year period from 1975 to 1985, the rate of growth of the value-added in information-related service sectors, the information sectors, and in the information-related good sectors was higher than in the noninformation sectors. This is a statistical evidence of informatization in Japan(Economic Planning Agency, 1966, Ministry of Post and Telecommunications, 1988).

There is, however, another aspect of informatization; it is the production of information within firms (or within households). For example, in the management department of large corporations, information about the corporation (such as accounting information and personnel information), and also information related to the business environment of the corporation (such as market information, customer information, and information on competitors), is produced, utilized, and stored. These kinds of information are not only collected or generated by the corporation itself, but they are also purchased, if so desired, from outside agents (such as database companies or research institutes). If information is produced by an outside agent and sold to the corporation, it is an interindustry transaction and constitutes a part of the flow from the tertiary sector to the corporation. If the corporation collects information by itself, it is an activity internal to that corporation; there is no interindustry transaction and no entry is made in the input-output table. Thus, interindustry analysis captures production of information transferred between sectors, but it does not capture the same activity performed within a single sector.

This problem was pointed out originally by Marc Porat in his doctoral thesis and published later, by the U.S. Department of Commerce(Porat, 1982). He called information transmitted between firms *primary information*, and information produced and used within a firm *secondary information*. (See Figure 11.4.) He estimated the cost of producing the primary information and that of the secondary information for the U.S. economy in the year of 1977. For the Japanese economy, statistics summarized in Table 11.4 gives such figures. It can be seen that the cost of the secondary information, that is, the cost of information produced within firms, exceeds the cost of producing the primary information(See Economic Planning Agency, 1986).

The effects of informatization on the growth of the Japanese economy

We now proceed to consider the effects of the development of information technology on the growth of the Japanese economy, that is, on the growth rate of the gross national products (GNP). In fact, as stated in the second section, the impact of informatization is not limited to GNP. For the purpose of simplification, we limit our attention to GNP.

The development of information technology increases production of information-related goods and services and production of information. From the economic viewpoint, the effects of the development of information technology are similar to the effects of the development in other technologies. Technological development brings about improvement in the quality of products and services (including emergence of new products and services) and/or reduction of their prices. Technological progress

[1]. In Table 3, however, the sum of the valued-added produced in information-related service sectors and that in information sectors is listed; the figure is not decomposed. Conceptually, we can distinguish information-related goods, information-related services, and information. Realistucally, however, it is not always possible to distinguish these three. For instance, the database sector and the VAN (value-added network) sector manipulate information to produce information with added values. Thus, these sectors produce both information-related services (in the sense it transports information from one party to another) and information (in the sense it creates additional information). Furthermore, it is frequently the case that production of information-related services and production of information is statistically indistinguishable. For instance, the newspaper industry produces information in the form of newspaper articles and at the same time produces a medium called newspaper and related services. The latter includes supplying printed paper, printing of newspaper articles, transportation, and delivery. However, data are only available for the newspaper industry as a whole, not for each of these goods or services. This is also true for the publication industry.

always implies the presence not only of quantitative changes, but also of qualitative changes. Interindustry analysis can be used to express qualitative changes, although input-output tables are expressed in terms of monetary units.

Let us consider an example of the price of an automobile. In particular, we intend to decompose the price into the components attributable to information activities and the components attributable to the other activities. As shown in Figure 11.5, the unit price of a car includes the cost of parts and materials; the cost of assembly and other services, the cost of design and testing, the cost of management, marketing and sales; and other costs including profits. The cost of LSI, which is attached to the motor of a car, is a part of the cost of the parts and materials. Similarly, the cost of using assembly robots is included in the cost of assembly and other services, and the cost of using CAD/CAM[2] is included in the cost of designing and testing. The cost of personal computers and the cost of subscription to a VAN paid by automobile dealers is included in the cost of management, marketing, and sales. Thus, within the price of an automobile represents costs incurred to information activities at various stages of the production and the sale of the automobile.

Let us focus on one of these costs, the cost of using assembly robots. We are interested in the components incurred from information activities. (See Figure 11.6.) First of all, the cost of using robots depends on the price of robots. The price of robots (like the price of an automobile) can be divided into many components. We consider, among them, the price of the software needed to operate the robots; the price of the software is a part of the price of the robots. Further, within the price of the software for operating the robots is included the cost of a workstation used to write the software. The cost of using the workstation, in turn, depends on the price of the workstation, which partly depends on the price of LSI in it. Thus, we trace backward the process of forming the price in the order of the automobile, robots, the software for robots, the workstation, LSI in the workstation, and so on. This means that, by examining each stage of production, we obtain the detailed composition of the price of the automobile. In particular, we can classify each component of the cost of the automobile into the cost incurred from information activities and the cost incurred from noninformation activities. By summing up all of these, we can divide the cost of the automobile into two components, the information component and the other component. The impact of informatization on the price of the automobile is included in the information part.

In order to estimate the impacts of new information technology on the price of commodities within a simple framework, we consider the Japanese economy to be composed of only two sectors: the *information sector* (the *H-sector*) and *the other sector* (the *Z-sector*) (for a detailed presentation of this, see Kuriyama & Oniki, 1989; Applied Research Institute, 1986a; and Economic Planning Agency, 1985). Since we are interested in informatization from the middle of the 1970s, we include in the H-sector only those industries that developed rapidly after the middle of the 1970s because of the new information technology. Typically, they are computers, telecommunications, and semiconductors. Other information, industries such as newspaper publishing, broadcasting, movies, and others, will be classified into the Z-industry.

To investigate the impacts of the technological progress in the H-sector, the price of the output in each of the H- and the Z-sectors is divided into two components, the *H-component* and the *Z-component*. One of the important sources of the H-component is research and development activities (R&D) in the H-sector; we can confidently assume that most of R&D in the H-sector is done to create new H-products. A similar assertion holds for R&D in the Z-sector. Thus, we postulate that the cost of R&D in the H-sector is solely composed of the H-component, and the cost in the Z-sector is solely composed of the Z-component.

Capital stock in each sector, on the other hand, reflects the history of investment during the preceding periods. Therefore, it is reasonable to assume that the composition of the price of capital stock in each sector is determined by the composition of the H- and Z-components of the investment made in the preceding periods. We assume, with regard to labor inputs, that the wage payment for the work that was intended to obtain capability for information activities is considered to be of the H-component, and the

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[2]. *CAD* means computer-aided design, and *CAM*, computer-aided manufacturing. Workstations are used as a device for CAD/CAM.

remaining wage payment to be of the Z-component. Thus, the cost of the productive factors purchased from the exogenous sector (i.e., the value-added) by each of the two sectors can be decomposed into the H- and the Z-components. (See Figure 11.7.)

From an input-output table of Japan, one can obtain the composition of the cost of each output from the data describing the value of the flow of goods and services between sectors and the data stating the H- and Z-components in the value-added in each sector(Applied Research Institute, 1986, 1986b; Ministry of International Trade and Industry, 1970, 1979, 1980). Thus, one can decompose the unit price of output from each of the H- and the Z-sectors into two components, the H-component and the Z-component. This analysis is called *the dual input-output analysis* or *the price-value-added analysis of input-output tables*. By this method, we can obtain a time series of the price of output from each of the two sectors decomposed into the H- and the Z-components. Since the middle of the 1970s, because of the progress of information technology, there has been a rapid reduction of the price of information goods and the rapid increase in the quality of information goods(Bank of Japan, 1974-1991). We have some advancement in the output from the Z-sector; the speed of the change in the Z-sector, however, is lower than in the H-sector. For each of the H- and Z-sectors, an index is formed by dividing the average price of output by the "average quality of output," which will be called the *quality-price index*.[3]

For the period from 1975 to 1985, we contructed a time series of labor and a time series of capital stock of the Japanese economy, divided into the H- and the Z-components, and deflated them by using the quality-price indices. We applied what is called *the total-factor productivity analysis* to the data thus obtained.[4] We then divide the growth rate of the Japanese GNP into four components, the H- and the Z-capital and the H- and the Z-labor, as shown in Figure 11.8.[5] It was found, from this calculation, that approximately 15% of the annual growth of the Japanese economy during the period from 1975 to 1985 could be attributed to the advancement of new information technology. If we assume, contrary to reality, that the speed of technical progress in the H-sector had been the same as that in the Z-sector, Japan's GNP in 1985 would have been lower by approximately 12% than the actual GNP.[6] This is a rough estimate of the contribution of new information technology to the growth of the Japanese economy. The magnitude of the estimate, that is, 12% of the GNP in 1985, however, indicates how significant the contribution of new information technology is.

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[3]. For the quality of information goods, an index was formed from certain attributes of computers. During the period from 1975 to 1985, the quality-price index of the H-sector in Japan fell by one-thirtieth.

[4]. This analysis gives a method to decompose an annual increase in GNP (i.e., the annual rate of growth of GNP) into parts each of which is attributed to the contribution of a productive factor such as labor and capital. For example, if an annual rate of growth of GNP is 5%, one may decompose it into 2%, which is the contribution of the increase in labor input, 2.5%, which is the contribution of the increase in capital equipment, and 0.5%, which is the unexplained part (the *residual*). A mathematical foundation for this may be given by the macroeconomic production function and its first-order derivative with respect to time. See, for example, Denison (1962), Jorgenson and Griliches (1967), and Solow (1957).

[5]. In Figure 11.8, the vertical axis measures the annual growth rate. The uppermost solid curve indicates changes in the growth rate of GNP from 1975 to 1985. The other four curves, dotted or dashed, indicate the contributions of the H-component and the Z-component in labor input or capital input. It is seen that while the contributions of the Z-labor and the Z-capital is still dominant, the contribution of the H-capital and the H-labor are not insignificant.

[6]. This figure (12%) is obtained from the difference between the real 1985 GNP and the 1985 GNP estimated for the case in which the H-sector was entirely replaced by the Z-sector from 1975 to 1985. The latter was computed by substituting the real value of the Z-component of GNP for the real value of the H-component of GNP (i.e., by using the quality-price index of the Z-sector for the quality-price index of the H-sector) for each year from 1975 to 1985. The estimated GNP means, therefore, the level of GNP that would have been obtained if in each year from 1975 to 1985 the H-sector had produced, contrary to the reality, the Z-product, not the H-product.

REFERENCES

Applied Research Institute (1986a). *A Report on the Change in Industrial Structures, economic growth, and indexation in relation to the informatization of Japan* [in Japanese]. Tokyo: Author.

Applied Research Institute (1986). *Conjunction tables of input-output relations of Japan* [in Japanese]. Tokyo: Author.

Bank of Japan. (1974 -1991). *Price indexes annual*. Tokyo: Author.

Denison, E. F. (1962). *The sources of economic growth in the U.S. and the alternatives before Us*. New York: Committee of Economic Development.

Economic Planning Agency . (1985). *A quantitative approach to informatization: Economic analysis and indexation of informatization of the Japanese economy* [in Japanese]. Tokyo: Bureau of Publications, Ministry of Finance.

Economic Planning Agency (1986). *Informatization of the Japanese economy--estimation and forecast of electronic information production by industries* [in Japanese]. Tokyo: Bureau of Publications, Ministry of Finance.

Jorgenson, D. W. & Griliches, Z.. (1967). "The explanation of productivity change," *Review of economic studies*, 34, 249-283.

Kuriyama, T., & Oniki, H. (1989 May). *New information technology and the growth of the Japanese economy*. Paper presented at the Conference on Asia's Experience in Informatization, Taipei, Taiwan. To be published in *Journal of Applied Input-Output Analysis*, vol. 1. no. 1 (forthcoming in 1992).

Ministry of International Trade and Industry (1970, 1975, 1980). *Input-Output tables of Japan* [in Japanese]. Tokyo: Author.

Ministry of Posts and Telecommunications, Institute of Research (1988). *A survey of informatization --a quantitative analysis of the information-communication economy and information transactions* [in Japanese]. Tokyo: Gyosei Publishing Company.

Porat, M. U. (1982). *The information economy*. Washington, DC: Office of Telecommunications, Department of Commerce.

Solow, R. M. (1957). Technical change and the aggregate production function," *Review of economics and statistics*, 39, 312-320.

Table 11.1: Factors of Informatization

Technical progress for production of information-related goods	Technical progress for production of information (Progress of using information-related goods)
Materials, chips Parts, computers Softwares Systems	Factories Stores, offices Social systems (transportation, communication, finance, etc.) Schools, research institutes Households

Table 11.2: Impacts of Informatization

1. Information industries	Firms	Production of information and information related goods Increase in sales, increase in income and profits Expansion of investment, growth of industry
2. Impacts on individual users	Factories	Automation and labor saving through microelectronics Cost saving Production of sophisticated goods Improvement of managerial capacity Saving of materials inventory, saving of product stocks Better management of workers
	Offices	Electronic processing of data and documents Automation of information processing and transmission
	Household	Home automation Saving of consumption and transactions costs
3. Impacts on the society as a whole	Economic impacts	Increase in efficiency in market transactions Timely supply of services Decreased mismatches Increase in the opportunity for transactions Decrease in erroneous decisions Decrease in erroneous expectations (decrease in uncertainty) Decrease in bankruptcy, disequilibrium Support of making correct decisions on investment, employment, research and development Prevention of macroeconomic instability (business fluctuations) Expansion of markets--geographical and overtime (Increase in trade, international investment, futures and forward transactions)
	Other impacts	Increased supply of information in culture, education, welfare, etc. Increased level of standard of living Increased supply of political information Political stability

Table 11.3: Value-added, Japan: 1975, 1985

Value-added (trillion yen)	1975	1985
Information-related service sectors and information sectors, total	15	38
Information-related good sectors	5	14
Noninformation sectors (total of primary, secondary, and tertiary sectors)	132	270
Total	152	322

Table 11.4: Value-added Decomposed into Information and Noninformation Production, Japan: 1985

Value-added (trillion yen)	1985
Information-related service sectors and information sectors total (Production of primary information)	38
Information-related good sectors	14
(Noninformation production)	(9)
(Secondary information production)	(5)
Noninformation sectors (total of primary, secondary, tertiary sectors)	270
(Noninformation production)	(190)
(Secondary information production)	(80)
Total	322
(Noninformation production)	(199)
(Secondary information production)	(85)