10

Structure of Development in a Smart Society: An Application of Input–Output Analysis

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Abstract

The construction of a smart society utilizing information and communication technology (ICT) is attracting attention to simultaneously achieve various Sustainable Development Goals (SDGs). Using input–output analysis, this chapter elucidates the economic structure of a smart society. This content is an extension of Leontief's "Structure of Development" study of the 20th-century industrial society. Here, a smart society enables waste to be eliminated and the utility of people to be increased by strengthening management in all fields of society using ICT. It is shown that a smart society will achieve an industrial structure with a lighter environmental load and sustain moderate economic growth. Therefore, the movement aiming to build a smart society in Asia and other regions of the world is deemed beneficial and expected to contribute to achieving the SDGs. Additionally, Japan is a developed country with advanced ICT in Asia, and improving the efficiency of Japan's ICT has been found to profoundly affect the entire Asian region. Japan plays a key role in building a smart society in the Asian region. This chapter is not only directly related to SDG9, but also to SDGs2, 5, 7, 8, 11, 12, and 13.

Keywords

Input–output table · Smart society · Information and communication technology · Structure of development

10.1 Introduction

In his (1994) book, *The Digital Economy*, Tapscott states that information technology brings new social norms for wealth creation and social development. This suggests that economic development in the information society requires an analytical perspective that is different from the conventional economic growth theory. Furthermore, Jorgenson and Vu (2016) report that a wide range of policy considerations are needed to guide economic growth through the information and communications technology (ICT) revolution. Jorgenson and Vu (2016) measure the contribution of ICT investment to economic growth and show that China and India are driving the world economy. On the one hand, Kooshki and Ismail (2011) empirically show that

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ICT investment has a positive impact on economic growth in newly industrialized countries in Asia. On the other hand, Pradhan et al. (2015) state that the construction of ICT infrastructure alone does not guarantee economic growth and must be accompanied by financial development. Vu (2013) also states that ICT use contributes to economic growth, while the contribution of ICT manufacturing to economic growth is limited (in the presence of China and India) based on empirical research on economic growth in Singapore. To clarify the effects of the spread of ICT on economic growth, these previous studies show that it is insufficient to investigate the effects of physical production and investment in ICT devices.

To verify the effects of ICT use, it is necessary to study the effects of services that utilize ICT. Toh and Thangavelu (2013) analyze the impact of the information sector on Singapore's economy using an input–output approach, which provides them with a framework for analyzing the linkage between the manufacturing and service sectors. A recent study (Tripathi and Inani 2020; Usman et al. 2021; Murshed 2020) has reported that informatization also contributes to economic growth in South Asia, and the effect of informatization is widespread throughout Asia, thereby suggesting expansion. Moreover, several studies (Usman et al. 2021; Murshed 2020; Lu 2018) argue that ICT contributes not only to economic growth but also to the mitigation of global warming.

Based on the aforementioned points, the following submissions are made: (1) research on the effects of introducing ICT requires an analytical framework that integrates various sectors and regions, (2) the effect of introducing ICT is greater when it is used than when producing ICT devices or investing in ICT infrastructure, and (3) it is necessary to grasp the value of ICT use that exceeds the economic value captured by conventional statistical indicators. Regarding point (1), the input–output framework used by Toh and Thangavelu (2013) is considered to be an appropriate analytical approach for analyzing the effects of ICT introduction. Notably, the framework for international input–output analysis, e.g., World Input–output Database (WIOD),[1] enables the evaluation of interdependencies between regions as well as sectors. At that time, in relation to point (2), it is necessary to consider how to describe the economic activity of ICT use within the framework of input–output analysis. In relation to point (3), it is necessary to expand the sector classification of the conventional input–output database. As Watanabe et al. (2018) indicate, ICT contributes beyond conventional economic values, thereby resulting in uncaptured gross domestic product.

In Japan, a new society that makes advanced use of ICT is referred to as a smart society, and the Japanese government has set the building of a smart society as one of its policy goals.[2] Currently, the building of smart societies is ongoing in other Asian countries. A theoretical understanding of the effects of building a smart society on the economy and how it contributes to regional economic development is an important issue in Asian development studies. Thus, directly related to SDG9, this chapter aims to explain the structure of development in a smart society that utilizes ICT using the input–output analysis framework.

The structure of this chapter is as follows: Sect. 10.2 explains the framework of the input–output analysis. Section 10.3 describes the structure of development theory using the input–output framework proposed by two representative input–output researchers (Professors Leontief and Ozaki), while Sect. 10.4 considers how their theory can be extended to explain the structure of the development of smart societies that utilize ICT. Section 10.5 uses the WIOD to provide an overview of the current state of interdependence between regions and sectors in Asia, including the relationship between the ICT manufacturing and ICT use sectors. Finally, a summary of the chapter is presented in Sect. 10.6.

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[1] World Input–output Database, http://www.wiod.org/home.

[2] Cabinet Office, Government of Japan, "Society5.0", https://www8.cao.go.jp/cstp/society5_0/.

10.2 Input–Output Framework[3]

Figure 10.1 is a conceptual diagram of the input–output table used for the analysis. It was originally developed by Prof. Wassily Leontief in the 1930s (see Leontief 1986). This table is a matrix that summarizes the annual transactions between sectors within an economy. The vertical columns show how each sector obtains the required inputs from others. Conversely, the horizontal rows show how the output of each sector of the economy is distributed among the others. This input–output table that describes the relationship between the product of one sector and the input of another sector reveals the interdependence in the economic sectors. In recent years, input–output tables[4] have been used to analyze the effects of sustainable economic structures using renewable energy on the economy and the environment (Washizu and Nakano 2021a).

In this figure, x_{ij} is the component of the intermediate transaction matrix, $\mathbf{X}$, and represents the monetary amount of the ith good consumed by activity j; $\sum_i x_{ij} + v_j = x_j$ is the sum of x_{ij} in terms of the ith good and the value-added, v_j, and it represents the total output for activity j; the ratio of x_{ij} to x_j, $a_{ij} = x_{ij}/x_j$, is called the input or technical coefficient; and the set of input coefficients of activity j, i.e.,

$$\boldsymbol{a}_j = \begin{pmatrix} a_{1j} \\ a_{2j} \\ a_{3j} \\ \vdots \\ a_{mj} \end{pmatrix} \qquad (10.1)$$

is called the activity vector of activity j. Leontief defines vector Eq. (10.1) as the representation of the production technology of activity j. A full set of input coefficients of all sectors is described by the symbol $\mathbf{A}$ and is called the input coefficient matrix. Using an input coefficient matrix, we can express the demand and supply balance as follows (the LHS of Eq. (10.2) is the sum of the intermediate and final demand):

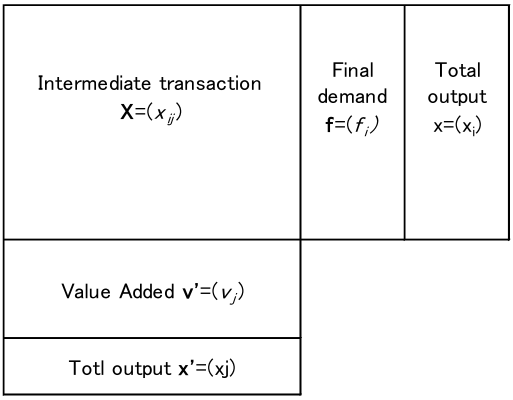

Fig. 10.1 Conceptual diagram of an input–output table

$$\underbrace{\mathbf{Ax}+\mathbf{f}}_{\text{demand}} = \underbrace{\mathbf{x}}_{\text{supply}} \qquad (10.2)$$

Here, $\mathbf{x}$ is the output vector (monetary units), $\mathbf{A}$ is the input coefficient matrix, and $\mathbf{f}$ is the vector of the final demand (monetary units).

Solving Eq. (10.2) for $\mathbf{x}$, we can obtain the Leontief inverse matrix $(\mathbf{I}-\mathbf{A})^{-\mathbf{1}}$. According to Eq. (10.3), we can see the direct and indirect effects induced by the given final demand vector. The effects contain all production amounts of goods and services directly and indirectly needed throughout the supply chain of goods and services included in the final demand vector.

$$\begin{aligned} \mathbf{x} &= (\mathbf{I}-\mathbf{A})^{-1}\mathbf{f} \\ &= \underbrace{\mathbf{If}}_{\textit{direct}} + \underbrace{\left(\mathbf{A}+\mathbf{A}^2+\mathbf{A}^3+\cdots\right)\mathbf{f}}_{\textit{indirect}}, \end{aligned} \qquad (10.3)$$

where $\mathbf{I}$ denotes the unit matrix. Figure 10.2 is a conceptual diagram of the direct and indirect effects induced by the final demand of the automobile (the induced effect when the component of the $\mathbf{f}$ vector in Eq. (10.3) is only the

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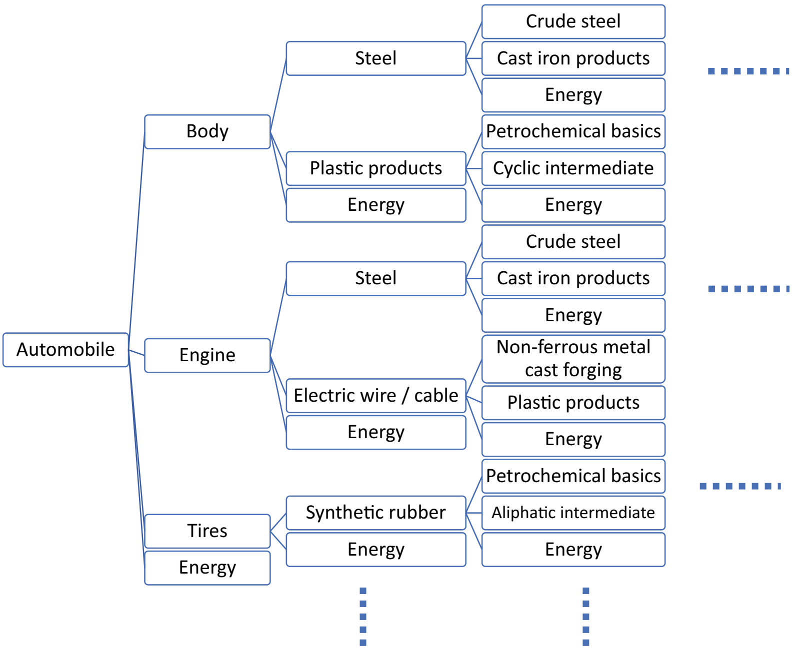
[3] See Nakano et al. (2015) in relation to this section.

[4] Institute for Economic Analysis of Next-generation Science and Technology, input-output table for analysis of next-generation energy system, http://www.f.waseda.jp/washizu/table.html.

Fig. 10.2 Conceptual diagram of the direct and indirect effects induced by the final demand of the automobile



automobile). Figure 10.2 can be interpreted as an illustration of the automobile supply chain.

The international input–output table analyzes the economic interdependence between sectors as well as between regions by combining the input–output tables of several countries. Figure 10.3 is a conceptual diagram of the international input–output table among three countries A, B, and C. Using this table, we can analyze the effect of the final demand by the people of Country A, for example, on the production activities of the sectors in Countries B and C through international intermediate transactions.

10.3 Structure of Development Theory

This chapter describes the mechanism of economic growth (led by manufacturing), which has been elucidated in previous studies under the framework of input–output analysis. It explains the structure of the development theory proposed in the past by two representative input–output researchers (Professors Leontief and Ozaki).

10.3.1 Leontief's Structure of Development Model[5]

Wassily Leontief is the founder of the input–output table and has been awarded the Nobel Prize in Economics for his work. He said, "It was the labor of computation that promoted the first systematic studies of the structural characteristics of an economy as they are displayed in an input–output table. (The members of US government's project) undertook to rearrange the rows and columns in a table of the US economy in such a way as to minimize the computation required to yield numerical solutions. Such rearrangement brought into sharper relief the inter-industry and intersectoral transactions that tie industries and sectors together in the subunits of the total structure of the economy" (Leontief 1986, p. 166).

According to Leontief, each sector does not have a uniform intermediate relationship with other sectors in the input–output table. Leontief submits that the input–output table can be organized in a form similar to Fig. 10.4 by

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[5] For the contents of this subsection, see Chap. 8 "Structure of Development" in Leontief (1986).

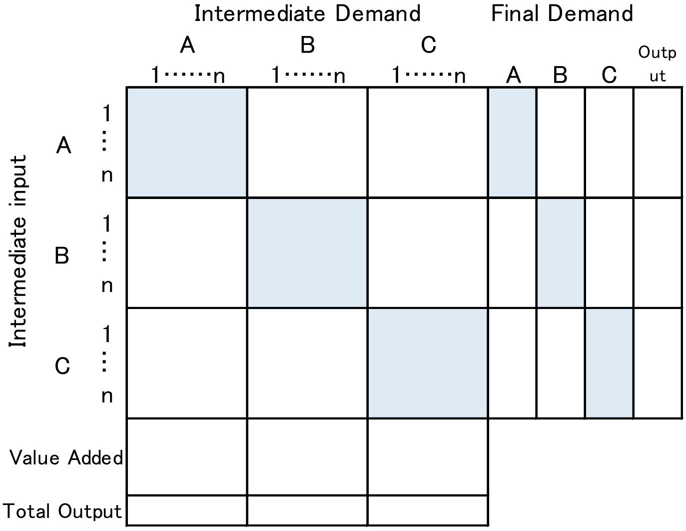

Fig. 10.3 Conceptual diagram of an international input–output table

rearranging the row and column sector array in the actual table because there are some parts where there are almost no intermediate transactions between sectors. He refers to such a structural feature in the input–output table as "triangularity."

Figure 10.4 shows the case where the structural relationships between sectors have the most complete hierarchical relationship. In Fig. 10.4, the first sector purchases inputs from all other sectors, while the tenth sector supplies inputs to all other sectors. The other sectors are arranged in the order of proximity to each role. The first sector, i.e., the automobile sector, produces complex goods with a large number of parts, and the tenth sector, i.e., the energy or corporate services sector produces general purpose and basic intermediate goods. Figure 10.4 illustrates the process whereby the intermediate goods of the sector at the bottom of the triangle are sequentially processed into the goods of the sector at the top of the triangle which are used for final consumption. The actual input–output table is composed of several blocks with a triangular structure shown in Fig. 10.4. For example, there is a machine block and a food block, and each block has a strong interdependence within itself, but the interdependence between blocks is relatively weak. Such a situation whereby the actual input–output table is composed of triangular blocks is called "block-triangularity" of the industrial structure.

According to Leontief, these structural features are discovered in the process of rearranging the order of sectors in the input–output table to simplify computer calculations.

10.3.2 Structure of Development During Japan's High Economic Miracle Period

Ozaki (2004) further extends Leontief's structure of development theory discussed in the previous section and clarifies the structure of development during Japan's high economic miracle period. This section describes Ozaki' s structure of development theory.

10.3.2.1 Rearrangement of Input–Output Sectors Based on Supply Chain

Ozaki (2004) initially considers the factors that cause block-triangularity in the industrial structure mentioned in the previous theory. Leontief (1986) does not explicitly discuss why the industrial structure has the block-triangularity properties. To explore the causes of block-triangularity, Ozaki (2004) assumes that manufacturing industries in each field need to build

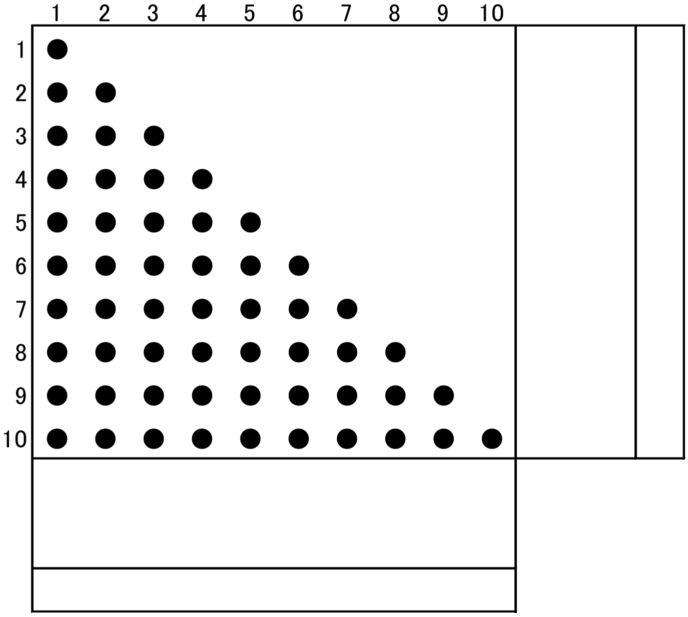

Fig. 10.4 Conceptual diagram of an input–output table with triangularity

their own efficient supply chains in order to establish economic growth through industrialization. He rearranged Japan's input–output table after a period of high economic miracles based on the following theoretical hypothesis:

> In an economic structure, there are several supply chains that connect and integrate multiple sectors. In the process of economic development, limited resources, labor, capital, etc. are sequentially invested along this chain, and one economic structure is formed.

As a result of this rearrangement, he discovers the nature of block-triangularity in the Japanese industrial structure. Ozaki's research process leading up to this discovery is presented as follows:

As a working hypothesis that embodies the aforementioned theoretical hypothesis, Ozaki assumes four supply chains based on the type of natural resource of their origin. They are supply chains from metal ores, natural crops, nonmetal minerals, and crude oil. In each supply chain, starting from the input of natural resources, related industries are ranked according to the processing stage of the product, leading to the final products. The more sophisticated the technology, the more diversified the sectors involved in one supply chain, but the number of main inputs for each final product is relatively limited. Leontief has established that the industrial structure is divided into blocks, and each block has triangularity. Ozaki extends Leontief's theory and clarifies that the blocks in the industrial structure are divided based on the type of raw material and that the triangularity of the industrial structure results from the rearrangement of the sectors according to the processing path of each supply chain. Generally, as technology becomes more sophisticated, the processing stage (supply chain) is extended, and more value-added is created. Therefore, if the technology becomes more sophisticated as the economy develops, the triangularity of the industrial structure will become clearer. At that time, the interdependence within one block will be strengthened, and the interdependence between blocks will simultaneously and gradually occur. For example, a food supply chain originating from agricultural products (natural crops) requires chemical fertilizers (products of the supply chain originating from nonmetallic minerals), and thus, interdependence will occur between a block originating from natural crops and that from nonmetallic minerals.

Based on the aforementioned working hypothesis, Ozaki closely tracks the supply chain originating from different raw materials found in Japan's 1965 input–output table and rearranges approximately 450 sectors therein.

Figure 10.5 shows a conceptual diagram of the sectoral rearrangement according to the supply chain. Starting from a certain raw material input (RM), products are sequentially processed in the order of the main material input (MM) according to the processing route of the supply chain, and the final product is produced. The sectors that support this mainstream concept include energy supply (E), auxiliary material input (Aux) (general-purpose goods and services used in the production of various industries), repair services (Rep), and various other services (S). The goods and services produced by these support sectors are introduced at all stages of the supply chain.

When the input–output sectors are rearranged according to the aforementioned hypothesis, the industrial structure shown in Fig. 10.6 is confirmed. The colored part in Fig. 10.6 shows that the intermediate transactions between sectors are solid, and the white part shows that virtually no transactions are found between the sectors. The six parts of the MM, RM, E, Aux, Rep, and S in Fig. 10.6 correspond to the rectangle of the same name in Fig. 10.5. In Fig. 10.6, the MM part is further divided into five subparts: machinery/metal, food, ceramic, textile, and chemical. Each subpart corresponds to one of the four supply chains (as shown in Fig. 10.5) originating from four types of RM inputs.[6] Figure 10.6 confirms the block-triangularity property. In other words, it has been confirmed that the industrial structure of Japan, which has been completed since the period of high economic miracle, has block-triangularity properties based on the supply chain originating from different raw materials.

Leontief discovers the block-triangularity nature of the industrial structure in the process of rearranging the sectors of the input–output table to simplify computer computation, while Ozaki establishes a similar block-triangularity property by rearranging the sectoral arrangements in the input–output table based on the theoretical hypothesis of the supply chain. Ozaki's work justifies Leontief's discovery.

10.3.2.2 Technology Classification of the Input–Output Sector

Following the rearrangement of the input–output sector, Ozaki measures the production functions of each input–output sector and classifies the sectors based on the measurement results, i.e., based on the nature of the technology.

The most basic production function traditionally used in microeconomics assumes that the factors of production can be flexibly substituted. For example, when the factors of production are labor and capital, if labor is relatively cheap, the technology of using a relatively significant amount of labor will be adopted (and vice versa). However, according to Ozaki, it is unlikely that the production function that allows flexible factor substitution is applicable to heavy industry, which has rapidly developed since the high economic miracle period. Heavy industries require large-scale capital equipment. For example, the steel industry requires the construction of large-scale blast furnaces, and even in countries where capital is scarce, labor cannot be substituted for capital. Moreover, once a capital facility, such as a blast furnace, is constructed, the relationship between the required factor input and production is fixed to some extent by the design value. When the demand is extremely low, it becomes difficult to reduce production according to the demand. Ozaki submits that capital equipment in the heavy industry has such a fixed production scale, and he refers to it as "plant indivisibleness."

Based on these, Ozaki measures the following two types of production functions for all sectors using microdata from industrial statistics.

1. $L = \alpha_L X^{\beta_L}, K = \alpha_K X^{\beta_K}$: Factor-limitational (Ozaki) production function
2. $X = \alpha L^{\gamma_L} K^{\gamma_K}$: Cobb–Douglas production function.

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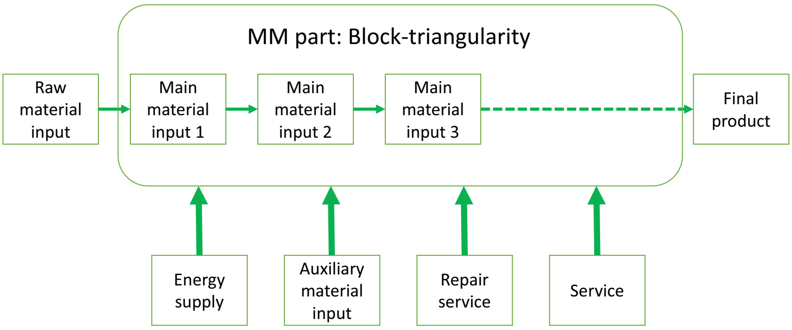
[6] The textile supply chain is an extension of the chemical supply chain originating from crude oil. Ozaki posits that during the period of high economic miracle, a material revolution occurred, and natural fibers used as textile raw materials were replaced by chemical types.

Fig. 10.5 Conceptual diagram of sectoral rearrangement according to the supply chain



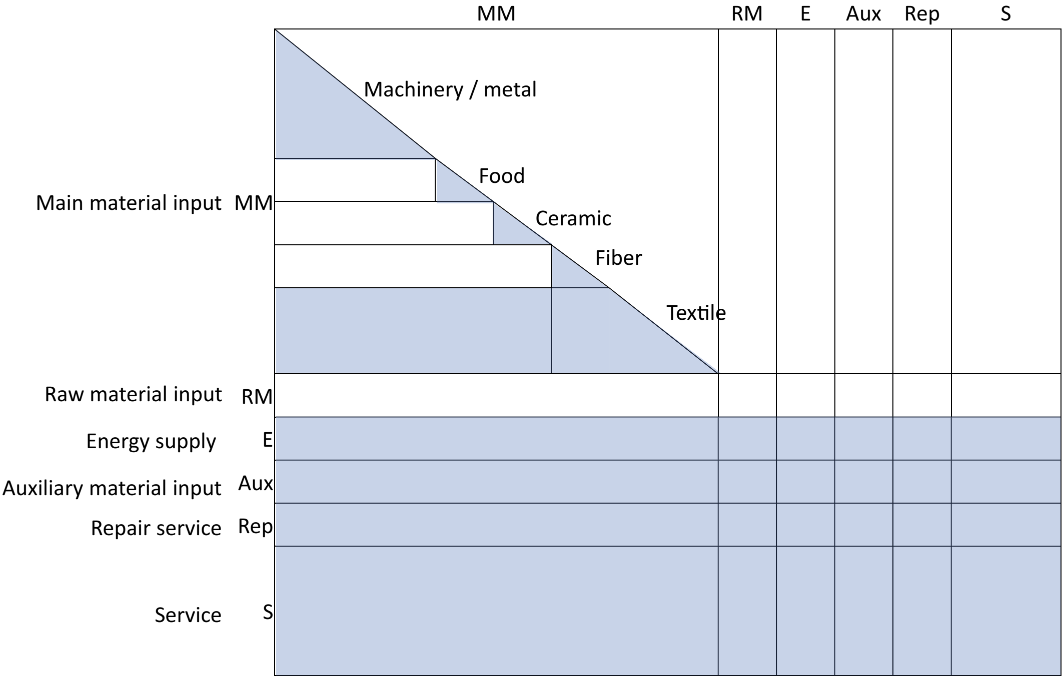


Fig. 10.6 Japan's industrial structure after the high economic miracle period

The factor-limitational production function is that whereby the input of labor and capital is determined independently according to the level of production, and no factor substitution is allowed between labor and capital. Furthermore, when β_L or $\beta_K < 1$, economies of scale work on labor or capital input. The Cobb–Douglas production function, which allows for factor substitution, is traditionally used in microeconomics. Ozaki empirically estimates the two aforementioned types of production functions for all input–output sectors and examines which production function is more applicable to each sector. He further evaluates the parameters of the estimated production function in detail and classifies all industrial sectors into five subgroups according to the estimated parameters of the production functions. He argues that such a classification is based on the "technical characteristics" of each sector. Table 10.1 shows the names given to the "technical characteristics" of each subgroup and a summary of each technical characteristic.

10.3.2.3 Mechanism of Japan's High Economic Growth

Ozaki's structure of development model can be summarized using the industrial structure diagram (Fig. 10.6), in which the order of the sectors is rearranged, and the technical characteristics of each sector (Table 10.1). Figure 10.7 shows a redrawn diagram of Fig. 10.6 for explanation. As mentioned previously, the filled parts in the figure indicate that there are many intermediate transactions. The block-by-block triangular-filled area shows the supply chain inside each block. The wide square-filled area below indicates that energy, auxiliary materials, etc., are universal inputs to various industries. Moreover, the rectangular filled area that extends to the left of the chemical block shows a material revolution, which is a characteristic technological change in the era of high economic growth. In other words, natural materials, such as natural fibers and wood, have been replaced by artificial materials, such as chemical fibers and resins. As a result of this replacement, chemical raw materials have become universal inputs to other sectors. Additionally, after high economic growth, the weight of the machinery and steel industries in the top block of the diagram significantly increases. Furthermore, from the 1970s to the 1980s, the weight of the assembly machinery industry (automobile, electronic/electrical machinery industry), which is located at the top of the top block, increases, and the industrial structure became more sophisticated.

Of the filled parts in Fig. 10.7, the dark-filled blocks are sectors with capital-intensive technical characteristics, in which economies of scale work strongly (sectors with K (I)-type technology). Figure 10.7 shows that the blocks with strong economies of scale are located at the top and bottom of the block-triangularity structure of the MM part. The blocks, such as the food and textile industries, sandwiched between them are a group of sectors with labor-intensive (L-type) technology. Focusing only on the machine-metal refining block located at the top of Fig. 10.7, the assembly machinery industry is located at the top of this block, while the metal refining industry is located at the bottom. These are the sectors with the K (I)-type technology defined by Ozaki. Sectors that produce mechanical parts are located in the middle of these sectors. Mechanical parts are often produced in small-town factories that have labor-intensive technical characteristics.[7]

To summarize the aforementioned, in Fig. 10.7, the capital-intensive sectors with economies of scale are located above and below the block-triangularity structure of the MM part, and the labor-intensive sectors are located between them. The same positional relationship applies to the internal structure of the machine-metal refining block that has driven the Japanese economy since the high economic miracle period.

The industrial structure diagram shown in Fig. 10.7 helps to explain the mechanism of the high economic miracle in Japan. A major feature of this period was the bullish and active investment motivation of companies that "investment calls for investment." The willingness to invest created a high demand for the assembly machinery industry, located at the top of the industrial structure. Large-scale production to meet this demand brought efficiency to the assembly machinery industry with the K (I-M)-type technology by pursuing economies of scale. The large-scale demand generated in the upper part of the block-triangularity structure returned to the supply chain and spread to the sectors in the lower part of the triangularity structure. In other words, the large-scale production of final products also caused the mass production of raw materials and intermediate parts. Consequently, mass production occurred even in the chemical block with the K (I-B)-type technology located at the bottom of the block-triangularity structure, and great economies of scale also occurred in that block. A similar spillover effect was true for the internal structure of the machinery–metal refining block,

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[7] Workers in these labor-intensive town factories producing mechanical parts possess sophisticated skills for delicate work. These skills are one factor which supported the international competitiveness of Japanese-made machines. It is desirable to digitize the professional skills of these workers to ensure they are passed on efficiently to future generations. This is also one of the purposes of a smart society described in a later chapter.

Table 10.1 Classification of the technical characteristics of sectors

Name of technical characteristics		Features of technical characteristics
Capital-intensive (K-type) technology	K(I-B) type	Large-capacity processing-type technology. This type of production function applies to sectors with strong economies of scale for labor input and high capital intensiveness, such as the petrochemical industry and steel industry, and electric power. B is an abbreviation for basic materials
	K(I-M) type	Large-scale assembly production type technology. Economies of scale work for labor input and capital intensity is high, but not as much as the K (I-B)-type technology. This type of technology applies mainly to the machinery industry. M is an abbreviation for machine
	K(II) type	Capital use type technology. Economies of scale work on labor input, but the non-economy of scale acts on capital input, and capital intensity is relatively high. This type of technology applies to traditional material production sectors, such as pulp, cement, inorganic chemistry, and coal products
Labor-intensive (L-type) technology	(L-K) type	This type of technology is characterized by constant returns to scale and factor substitutability. This type applies to primary industries, such as agriculture
	L(I) type	This type of technology is characterized by increasing returns to scale and factor substitutability. The capital intensity is low and the labor intensity is high. The L (I) type has a slightly larger scale effect
	L (II) type	

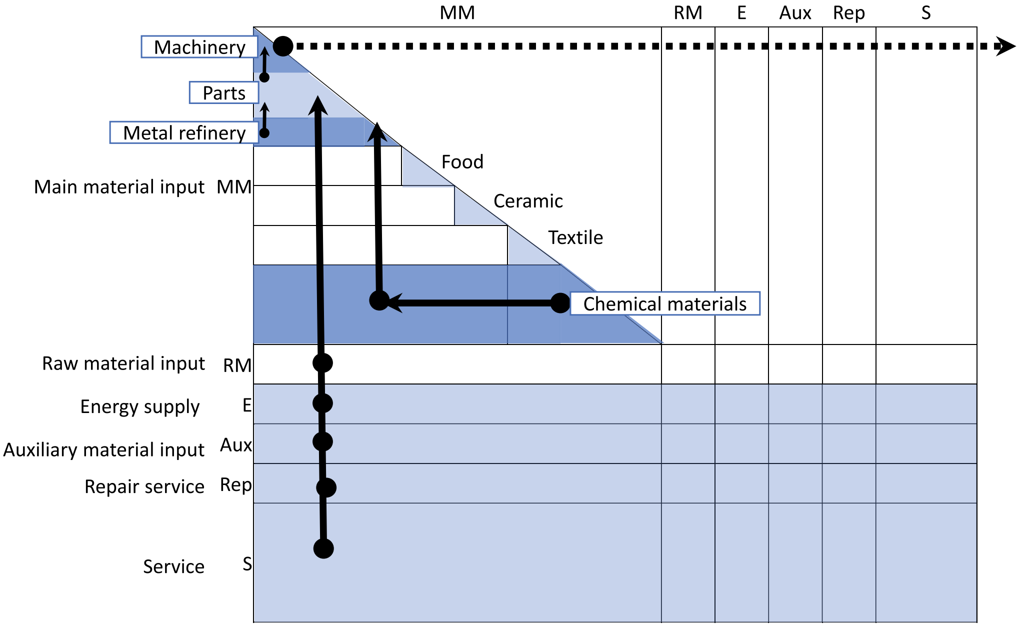

Fig. 10.7 Mechanism of high economic growth

which has been a major part of the Japanese economy during the high economic miracle period. In other words, the economies of scale of the assembly machinery industry at the top of the block triggered economies of scale in the metal refining industry at the bottom of the block.

However, the pursuit of economies of scale is essentially a labor-inhibiting phenomenon. In particular, a major feature of the K (I)-type technology is that economies of scale in labor input work strongly, and the larger the production scale of sectors with the K (I)-type technology, the more labor-saving progresses. When sectors with the K (I)-type technology mainly drive economic growth, it is not expected that labor demand will increase with economic development. In Fig. 10.7, it is important that a labor-intensive sector exists in the middle of the triangularity structure. This is because the spillover effect of large-scale demand generated in the upper part of the triangularity will surely extend to labor-intensive sectors. Large-scale labor absorption occurs in the middle block through the spillover effect from the triangularity upper sectors. An increase in labor demand will lead to an increase in consumer demand through an increase in employee income. In Japan, during the high economic miracle period, this consumption demand formed a large domestic market for products of assembly machinery industries. Certain terms, such as "three sacred treasures (electric refrigerator, electric washing machine, black and white TV)" and "3C (car, cooler, color TV) era," are slang terms that refer to the domestic market for home appliances formed in this way. Apparently, the formation of such a domestic market further strengthened the effect of the previously mentioned ripple mechanism. Similarly, a large-scale employment absorption effect occurred at a small machine parts factory located in the middle of the machine-metal refining block, which was a major part of the Japanese economy during the high economic miracle period.

To summarize, in the Japanese economy during the period of high economic miracle, the expansion of demand for the upper triangularity sectors spread to the lower triangularity sectors, and economies of scale were pursued in those sectors. Meanwhile, large-scale labor absorption occurred in the middle sectors of the triangularity. This mechanism has arisen technically through the transaction of intermediate goods along the supply chain, and thus, it can work in any country, not just Japan. However, in the case of Japan, this technical mechanism was reinforced by the institutional mechanism of affiliated relationships with *Keiretsu* between companies. In general, when discussing Japan's period of high economic miracle, the affiliation relationship between companies centered on banks, remaining from the prewar conglomerate, is emphasized. This affiliated relationship is the relationship between large enterprises and small and medium-sized enterprises (SMEs). The upper and lower sectors of the block-triangularity are dominated by large enterprises. Notably, SMEs dominate the middle sector of the triangularity. Accordingly, the affiliation relationship corresponds exactly to the block-triangularity of the input–output relationship. Therefore, in order to maintain this relationship properly, the Ministry of International Trade and Industry (MITI)[8] took measures to support SMEs as part of its industrial policy during the high economic miracle period. Thus, during the period of Japan's high economic growth, the efficient economic cycle mechanism functioned by mutually reinforcing the technical input–output relationships and institutional corporate relationships.

The key to this efficient economic cycle mechanism is the high final demand for the machinery sector located at the top of the triangularity structure. This stimulus of final demand generated an efficient cycle in the entire economic system through input–output relationships, and Japan's high economic growth was realized. However, when the high economic growth ended, domestic investment demand for machinery stagnated. Rather, from the late 1970s to the 1980s, the international competitiveness of Japan's machinery sector increased, and export demand replaced domestic investment demand, thereby driving the economy. However, in the 1990s, the catch-up of Asian countries reduced the international competitiveness of Japan's machinery sector, thus resulting in a decline in export demand for the upper sectors of the triangularity structure. Thereafter, the economic

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[8] The predecessor of the current Ministry of Economy, Trade and Industry (METI).

circulation mechanism malfunctioned, and the economy stagnated. This is one of the causes of the stagnation of the Japanese economy in the 1990s, which is referred to as the “lost decade.”

10.4 Structure of Development of a Smart Society

In the analysis of a modern economic society, wherein the weight of production activities in the service industry has increased, it is necessary to pay more attention to the input–output relationships between the service sectors located in the Aux, R, and S parts and to expand the discussion in Figs. 10.6 and 10.7 accordingly. Especially in recent years, with the development of ICT, new business services (information processing services, data provision services, etc.) that have never existed in the past are developing. Therefore, it is necessary to consider the role of ICT-related service sectors in the entire industrial structure. As mentioned in the introduction, it is important to focus on the economic activity of ICT use. Moreover, ICT will create unprecedentedly new economic values such that it may be necessary to expand the conventional input–output database. Section 10.4.1 explains how the structure of development theory presented in Sect. 10.3 is extended when focusing on the service industry of ICT use. Section 10.4.2 provides a perspective on how to expand the conventional input–output database for the analysis of a smart society.

10.4.1 Information Service Industry and Industrial Structure

Nakano and Washizu (2018) focus on the smart food industry and divide ICT-related industries into manufacturing sectors necessary for ICT infrastructural development and service sectors that utilize it. Furthermore, the latter is divided into sectors that provide general purpose and basic ICT services such as communication services, i.e., the primary information service (PIS) part, and sectors that provide ICT utilization services customized for each customer in detail according to user requests, i.e., the secondary information service (SIS) part.

Subsequently, Nakano and Washizu (2018) visualize the emergence of new input–output relationships between ICT-related (manufacturing and service) industries and food-providing sectors. In a smart society, it is expected that such new input–output relationships between ICT-related sectors and those that produce goods and general services are progressing in various industries other than the food industry. Figure 10.8 is a conceptual diagram of the input–output structure of such a smart society, which is created by extending Figs. 10.6 and 10.7. In Fig. 10.8, the service sectors at the bottom of Figs. 10.6 and 10.7 are expanded to the PIS, SIS, and general service sectors.

Here, the PIS sector refers to those that produce the basic information services necessary for the production of the SIS described below, such as the Internet, communication, broadcasting, as well as research and development. Secondary information services are sectors that produce application services customized for industry, such as wholesale/retail, finance, advertising, transportation, and legal/accounting services, which are produced by combining information goods and the PIS. The information goods sector is the manufacturing sector of MM parts that produces sensors and computer equipment. General services are other service sectors that are not included in the PIS and SIS sectors, and the quality of services provided can be improved by utilizing information goods as well as PIS and SIS. It can be thought of as a production sector for more highly customized services for end consumers, including households.

In the MM part, rearranging the sectors to trace back to the final goods production process shows a triangularity structure. Similarly, if we rearrange the service sectors in the order of general services → SIS → PIS, a triangularity structure will be shown in the service part as well. Furthermore, large IT companies, such as GAFA (Google, Apple, Facebook, and Amazon), are currently attracting attention. Our empirical study using the Basic Survey of Corporate

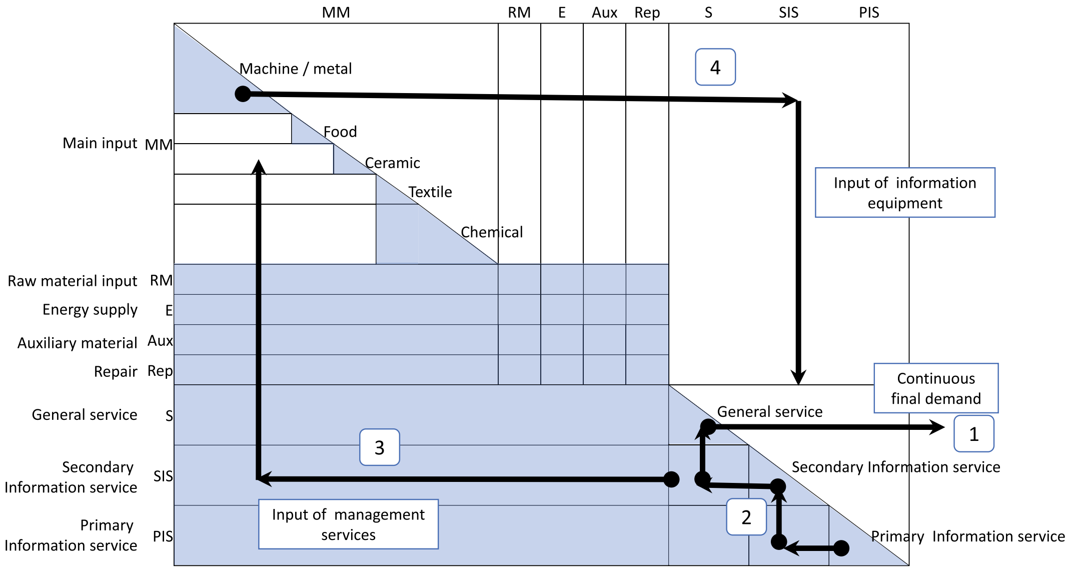

Fig. 10.8 Conceptual diagram of the input–output structure of a smart society

Activities in Japan suggests that the PIS sector, which provides the communications infrastructure (platform), is capital-intensive and is increasing returns to scale (Washizu and Nakano, 2021b). This property is similar to that found in large-scale equipment industries, such as the steel and chemical sectors in the MM part. Washizu and Nakano (2021b) also suggest that not only the information service sectors but also the general service sectors are shifting to a capital-intensive industry through the strengthening of equipment related to computerization.

The economic cycle in the industrial structure shown in Fig. 10.8 can be explained as follows: a variety of end services that are customized for individual service consumers have a continuous end demand (arrow 1). The final demand induces economies of scale for the PIS block below the triangle of the service part and increases the productivity of the block. Increased productivity of the PIS block located in the lower triangle will contribute to lower prices of general services in the upper triangle of the service part through the supply chain of the service part (arrow 2). According to Ozaki (2004), the service industry is a basic input in all industries, including the MM part sector (arrow 3), so the effect of increasing the efficiency in service sectors and lowering service price will bring cost reduction effects and productivity increase effects to the sectors in the MM part. The decrease in the price of information materials in the MM part increases the capital intensity of the service part, including the general service sectors, and activates the flow of information equipment input from the MM part to the service part (arrow 4). As the demand for general services is less likely to be saturated than the demand for goods and is considered to be continuous, the economic effects of the previously mentioned economic cycle are also expected to be continuous.

10.4.2 Toward the Input–Output Analysis of a Smart Society

Watanabe et al. (2018) report that ICT may create new economic values that cannot be captured by means of conventional economic indicators. Nakano and Washizu (2018) also attempt to capture such a new economic value. They define a smart society as that wherein management is highly sophisticated by utilizing ICT. They focus on “management activities” as economic activities that create new value using ICT. However, it can be difficult conceptually and statistically to estimate the actual size of those activities and values because they are not properly captured in conventional input–output tables, and they are often buried beneath the surface of an industry. Nakano and Washizu (2018) undertake this difficult task by referring to Porat (1977).

It is useful to review Porat (1977) when considering the estimation method of the actual size of information activities and those values that are buried beneath the surface of other industries and not captured at present. In the late 1960s, Porat set out to quantitatively measure what fraction of the gross national product (GNP) in the USA is related to information activities. He proposes a new definition for “information industry” and measures the amount of value-added by information industry, finding that these industries’ proportion of the overall GNP is 46%. According to Porat, information activities can be divided into two types: activities of primary information sectors already on the market and activities carried out in secondary information sectors within each industry. The GNP of primary information sectors can be measured by clarifying the definition of “information industry.” Meanwhile, a secondary information sector is buried inside an industry, and thus, it is more difficult to define and measure. Porat separates the internal information activities of each industry from the industry’s main business based on each industry’s occupation composition ratio. He defines “occupation to process information” and separated value-added as a result of information activities from value-added as a result of non-information activities according to the proportion of employees engaged in those occupations within each industry. For example, as a physician, in addition to the technical work of patient treatment, there are many tasks related to information activities, such as collecting patient information, conducting medical research, and processing patient accounts. Porat investigates the average time allocation of doctors’ daily tasks and estimates the allocation ratios for time related to technical work vs. time related to information work. Using these ratios, Porat separates the value-added by internal information activities from that of the medical industry as a whole.

Nakano and Washizu (2018) employ the same method as Porat to identify and isolate internal ICT-based management activities within an industry. They focus on the food industry and separate the internal management activities according to the proportion of occupation to process information in that sector. By applying the separation method developed by Nakano and Washizu (2018) to all sectors, internal management activities in all industries can be separated. These are economic activities that are not identified in the conventional input–output table. By explicitly separating these activities, it is possible to analyze the effects of management activities that utilize ICT, and eventually the effects of building a smart society. By separating the internal management activities of all sectors according to the proportion of occupation to process information in specific sectors and incorporating this into the service part in Fig. 10.8, the structure of the economic cycle indicated by arrows in this figure will become clearer. We will undertake this task in future research.

10.5 International Interdependence of Information Society in Asia

Figure 10.3 in Sect. 10.2 explains the international input–output table. Based on the discussions so far, this section attempts to analyze some of the international interdependencies in the modern Asian region that have been informatized. One international input–output table is the WIOD created by the University of Groningen. The WIOD (2016 Release) describes the transactions of goods and services between 43 countries and 56 sectors in 2014. In the table, six countries—China, Indonesia, India, Japan, South Korea, and Taiwan—are listed for Asia. Using the international input–output table, it is possible to calculate the amount of production and income (value-added) that the final demand of one

Table 10.2 Amount of production and value-added that the final demand of China and Japan has induced in their own country and others

Nation	Sector part	FD in China		FD in Japan	
		Induced production	Induced value-added	Induced production	Induced value-added
China	MM	33.46%	27.53%	2.79%	1.36%
	RM	8.98%	4.88%	1.79%	0.61%
	E	5.07%	2.94%	0.20%	0.10%
	Aux	13.63%	9.06%	0.21%	0.09%
	S	12.49%	20.50%	0.62%	0.68%
	SIS	8.33%	13.74%	0.19%	0.17%
	PIS	5.66%	7.58%	0.05%	0.04%
China Total		87.62%	86.22%	5.85%	3.05%
Japan	MM	0.35%	0.23%	12.87%	8.75%
	RM	0.31%	0.33%	4.18%	2.88%
	E	0.10%	0.08%	2.00%	1.16%
	Aux	0.03%	0.03%	9.37%	7.68%
	S	0.14%	0.24%	21.01%	24.34%
	SIS	0.04%	0.08%	19.02%	27.01%
	PIS	0.01%	0.01%	10.71%	13.25%
Japan total		0.98%	0.98%	79.15%	85.08%
Asia[a] total		90.50%	89.02%	86.95%	89.46%
Total inducement for world (trillions of US dollars)		28.3	9.7	8.8	4.5

MM: main material input, RM: raw material input, E: energy supply, Aux: auxiliary material input, S: general service, SIS: secondary information service, PIS: primary information service

[a] Asia: China, Indonesia, India, Japan, Korea, Taiwan

country has induced in the sectors of the country and other countries through the worldwide supply chain. Table 10.2 shows the results of calculating the amount of production and value-added that the final demand of China and Japan has induced in the industries of their own country and other countries using the WIOD in 2014.[9]

According to Table 10.2, the final demand in China induces a production of US$ 28.3 trillion worldwide, while the final demand in Japan induces a production of US$ 8.8 trillion, and the amount of added values generated by these induced productions is US$ 9.7 trillion and US$ 4.5 trillion, respectively. In China, the induced value-added is 34.2% of the induced production value, while in Japan it is 51.1%. Of the value-added induced by final demand, the domestic induction is 86.2% in China and 85.1% in Japan; that is, the former is slightly higher. The composition ratios of value-added by the sector part induced by the final demand of China and Japan significantly differ. The value-added induced for the MM part of the home country is 27.5% in China and 8.8% in Japan. However, the value-added induced for the domestic information service (SIS and PIS) parts is 21.3% in China and 40.3% in Japan. It is also interesting to compare the value-added composition ratio that the final demand of each country induces in the other country. The composition ratio that China's final

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[9] See the appendix for the specific calculation formula.

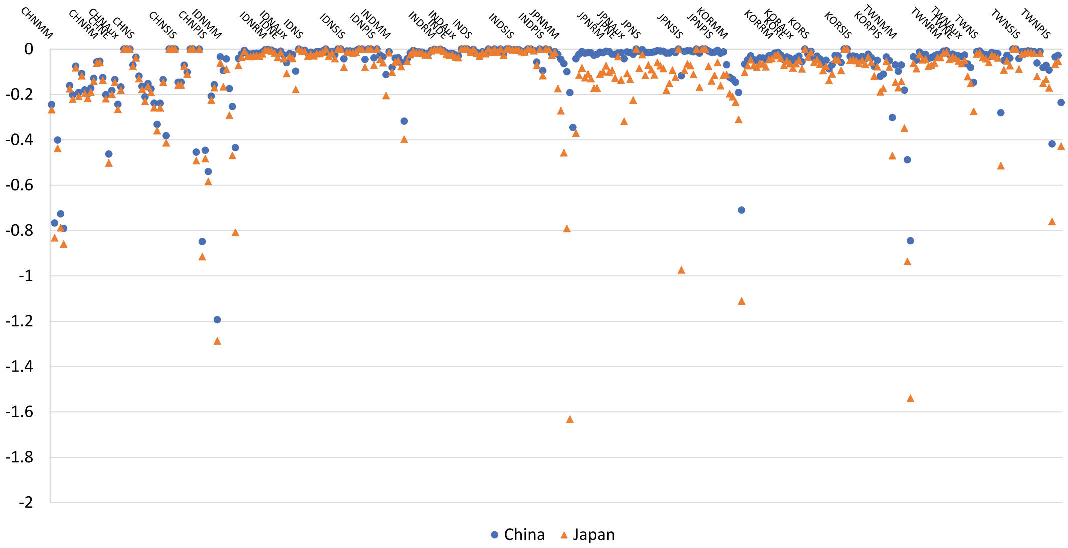

Fig. 10.9 Impacts of increased productivity in the "manufacture of computer, electronic, and optical products" sector in China and Japan on the manufacturing cost of each sector in other countries[10]

demand induces in Japan is only 0.98%, while the composition ratio that Japan's final demand induces in China is 3.1%. Upon considering the extent to which one country's production activity is affected by the final demand of another, it is observed that Japan's impact on China is higher than the other way around.

Figures 10.9 and 10.10 show the results of an analysis of the cost reduction effects of improved labor productivity in the information-related sectors of China and Japan on the production sectors of each country in the Asian region. Figure 10.9 shows how much the production cost of each sector in the Asian countries (China, Indonesia, India, Japan, Korea, and Taiwan) featured in the WIOD will decrease when labor productivity increases by 30% in the "manufacture of computer, electronic, and optical products" sector of the MM part in China and Japan. If a sector in a country has a "manufacture of computer, electronic, and optical products" sector in China or Japan involved in its supply chain, the production cost of that sector is expected to drop significantly. Figure 10.9 shows that the increase in labor productivity in the "manufacture of computer, electronic, and optical products" sector in Japan and China affects the manufacturing unit price of sectors of the information service part as well as sectors of the MM part in Asian countries. In particular, price declines in various sectors of China are significant. China's sectors are more affected by the productivity gains of Japan's "manufacture of computer, electronic, and optical products" sector than by the productivity gains of the same sector in China. This tendency is the same in other countries. It can be inferred that Japan's "manufacture of computer, electronic, and optical products" sector is deeply involved in the supply chains of many sectors in Asian countries.

Figure 10.10 shows how much the production cost of each sector of the Asian countries (China, Indonesia, India, Japan, Korea, and Taiwan) featured in the WIOD will decrease when labor

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[10] The abbreviations on the horizontal axis consist of country and sector part names. The abbreviations for country names are as follows: China (CHN), Indonesia (IDN), India (IND), Japan (JPN), Korea (KOR), and Taiwan (TWN). The abbreviations for sector part names are the same as those in Table 10.2.

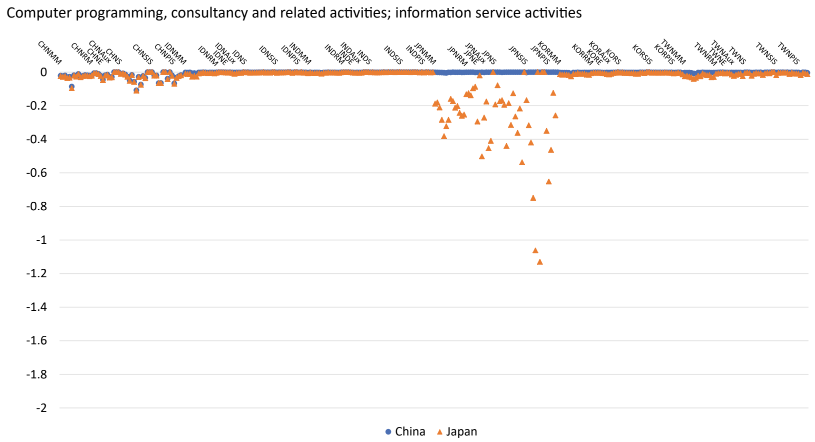

Fig. 10.10 Impacts of increased productivity in the "computer programming, consultancy, and related activities; information service activities" sector in China and Japan on the manufacturing cost of each sector in other countries[11]

productivity increases by 30% in the "computer programming, consultancy, and related activities; information service activities" sector of the PIS part in China and Japan. The increase in productivity in this sector in Japan has a considerable impact on the production prices of the service and manufacturing sectors in Japan. However, its impact on other Asian countries, including China, is not as high as in the case of increased productivity in the "manufacture of computer, electronic, and optical products" sector. Increasing labor productivity in the same sector in China has a minor impact on Asian countries. The impact of increased productivity in this sector in China on the production prices of each industry in China is approximately the same as the impact on them by this sector in Japan.

In short, Japan is more informatized than China. Japan's information goods manufacturing sector influences the supply chains of various Asian sectors. The productivity improvement of the information service sector in Japan will spread to the supply chains of Asian countries, but the extent will be minor compared to the effect of the information goods manufacturing sector. However, the scope of the production sector, which is affected by productivity improvements in the information service sector, seems to be broader.

10.6 Concluding Remarks

In this chapter, based on the recognition that the analysis of the effects of ICT use requires an analytical framework that integrates various sectors and regions, using the input–output framework, we explain the structure of development in a smart society utilizing ICT.

This chapter first clarified the structure of development theory of industrial society, developed by Leontief and extended by Ozaki. Subsequently, it was suggested that the structure of development mechanism of the industrialized society has major drawbacks: When the final demand for industrial products at the end of the supply chain disappears, it becomes dysfunctional.

Next, we considered how the structure of development theory would be extended in a smart society using ICT. Previous studies have pointed out that the effect of using ICT is greater than the effect of producing ICT materials and investing in ICT infrastructure, and that ICT creates values that exceed the economic value captured by means of conventional statistical indicators. Based on these points, we have rearranged the relationship between the information

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[11] The abbreviations on the horizontal axis are the same as in Fig. 10.9.

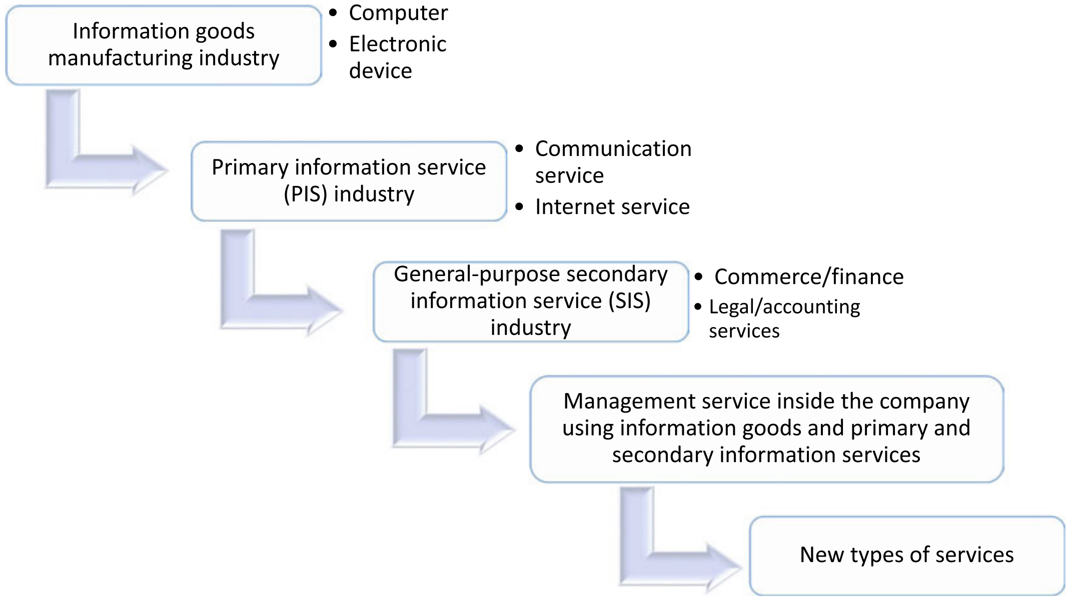

Fig. 10.11 Relationship between information goods manufacturing sector and information service sector

goods manufacturing sector and the information service sector, as shown in Fig. 10.11.

Specifically, the products produced in the information goods manufacturing sector of the MM part are input into the service industry of the PIS part that produces primary information services (e.g., communication services). At this time, economies of scale operate in the production process of the primary information services. Furthermore, the service industries in the SIS part use the primary information services produced in the PIS part to generate more customized secondary information services (e.g., legal and accounting services). The management department inside each industry (including the manufacturing industry of the MM part) creates efficient management services by combining information goods, primary information services, and secondary information services. The management service within each industry eliminates the waste in various supply chains and greatly contributes to improving the efficiency of the entire industrial structure. Furthermore, it creates new types of services (e.g., sharing services) which did not exist before the smart society and contributes to people's welfare.

Based on the inter-industry relationships in Fig. 10.11, we rearranged the input–output table and presented the structure of development mechanism of a smart society. Here, the continuous final demand for smart services makes it easier to maintain an economic cycle and avoid dysfunction.

Finally, using the WIOD, we analyze the current state of interdependence in the Asian region regarding the ICT material manufacturing sector and the ICT use sector. Consequently, it is shown that Japan is an informatized economy in the Asian region. Japan's information manufacturing sector has influenced the supply chains of various sectors in Asian countries. The productivity improvement of the information service sector in Japan also affects the supply chains of Asian countries, but the extent is minor compared to the effect of the information goods manufacturing sector. However, the range of production sectors affected by productivity improvements in the information service sector is wider.

This chapter analyzes the input–output effects of the smartening of society through technological innovations in ICT directly related to SDG9.

However, ICT advances have spillover effects that cannot be discussed under this topic alone. For example, it is necessary to build smart energy management systems to more efficiently utilize renewable energy sources, which are variable and decentralized. Therefore, this chapter is also related to SDG7. Similarly, advances in ICT have made it possible to strengthen the management of production systems and ensure improvements in resource efficiency (SDG8). They have also contributed to the realization of sustainable consumption by making it possible to replace the consumption of people's "things" with the consumption of "services" produced by things (sharing services, etc.) (SDG12). Advanced utilization of renewable energy, improvements in resource efficiency, and the construction of sustainable production and consumption systems are indispensable means of reducing greenhouse gas emissions (SDG13). Advances in ICT are also useful for solving various other social issues. For example, they can contribute to community development that is favorable for the elderly and people with disabilities through the provision of appropriate smart transportation services (SDG 11) and will streamline food production and contribute to addressing the problems of hunger and poverty through the development of smart agricultural machinery and precision agriculture technology (SDG2). Furthermore, it has been pointed out that improved ICT will increase employment opportunities for women and empower them, thereby contributing to gender equality (SDG5). Thus, this chapter is not only directly related to SDG9, but also to SDGs 2, 5, 7, 8, 11, 12, and 13.

Appendix

This appendix shows the formula for the analysis in Sect. 10.5 using the WIOD in 2014. The formula for Table 10.2 is as follows: Eq. (10.4) is for calculating the amount of production that the final demand in a specific region r induces in all regions. This formula calculates all the production inducements that individual goods in the final demand in region r cause worldwide through the supply chains.

$$\mathbf{x} = (\mathbf{I} - \mathbf{A})^{-1}\mathbf{F}^{\mathbf{r}} \qquad (10.4)$$

x: vector of the production induced in all sectors in all regions
$\mathbf{F}^{\mathbf{r}}$: vector of final demand in region $r(r = 1, \ldots, k)$
A: inter-regional input coefficients matrix of the WIOD

By using the calculation results of Eq. (10.4), the value-added (income) induced by the final demand in region r in all regions is calculated using Eq. (10.5).

$$\mathbf{VA} = \mathbf{v}'x \qquad (10.5)$$

VA: vector of the gross value-added induced in all sectors in all regions
$\mathbf{v}' = \left(v_j^r\right)'$: vector of the gross value-added ratio of all sectors in all regions
$v_j^r = {VA_j^r}\big/{X_j^r}$ VA_j^r: the gross value-added of sector j in region r in the WIOD
X_j^r: control total of sector j in region r in the WIOD

In Sect. 10.5, the case of r = China, Japan is calculated.

The method of calculating the cost reduction effect of improving labor productivity in the information-related sectors of China and Japan on the production sectors of Asian countries is presented as follows: The production unit price p by country/sector is calculated by the following Eq. (10.6) using the traditional equilibrium price model of input–output analysis:

$$\mathbf{p} = (\mathbf{I} - \mathbf{A}')^{-1}\mathbf{v} \qquad (10.6)$$

Here, **p** is the price vector by country/sector, **I** is the identity matrix, **A'** is the transposed matrix of the input coefficients matrix of WIOD, and **v** is the vector of gross value-added ratio by country/sector.

We assume that labor costs, which are components of value-added, will decrease and the value-added coefficient will decrease through the increase in labor productivity in the information goods manufacturing sector or information service sector in China or Japan. In the text, the analysis is performed based on the assumption that the rate of decrease in the value-added coefficient is 30%. That is, the value-added coefficient v of the information-related sector in China or Japan is reduced by 30%, and the change in manufacturing unit price p by country/sector is calculated.

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