Various Capital Linkages in Inclusive Wealth [English translation]

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Abstract

This chapter put forward an outline of inclusive wealth (IW) and carried out its analysis mainly in terms of Japan based on the estimated values of the three facets of IW capital: produced capital (PC), human capital (HC), and natural capital (NC). As an analysis of its contents, there are three indexes of IW, which are the total amount, the per-capita index, and productivity (i.e., value added divided by IW). As for the specific contents, it verified a comparison between 1990 and 2014 for the whole world (Section 3), for the IW of Japan (Section 3), a comparison between Japan and G7 (Section 4), a look at the IW by prefecture (Section 5), and the relevance of IW to measuring the damage due to the Nankai Trough earthquake (NTE) (Section 6).

Keywords: Inclusive wealth; produced, human, and natural capitals; inclusive wealth productivity; total amount index, per-capita index, and productivity index; damage analysis of Nankai Trough earthquake.

JEL codes: E01, O11, O40, Q01

[Suggested citation]

Yagi, M., and Managi, S., 2020, Chapter 5. Various Capital Linkages in Inclusive Wealth: In Sato, M., Kitamura, Y., and Managi, S. (Eds.), ESD and Social Resilience in the SDGs Era, pp.121–154, Tsukuba-shobo, Tokyo. [Japanese]
ISBN: 978-4-8119-0571-6

[引用]

八木迪幸, 馬奈木俊介, 2020, 「第 5 章 新国富（Inclusive Wealth）における多様な資本の連関」, 佐藤真久, 北村友人, 馬奈木俊介(編), 『SDGs 時代の ESD と社会的レジリエンス』, pp.121–154, 筑波書房, 東京.
ISBN: 978-4-8119-0571-6

Creation date: April 28, 2020 (作成日: 2020 年 4 月 28 日)

1. Introduction

The purpose of this chapter is to introduce a recently developed indicator of sustainability, namely inclusive wealth (IW). This chapter intends to show the current state of the world and, in particular, Japan in a manner that is as simple as possible, while using the latest estimates of IW.

Since the adoption of the Sustainable Development Goals (SDGs) at the United Nations Sustainable Development Summit (UNSDS) in September 2015, global interest in sustainable development has been increasing. For economic development, it is necessary to measure the degree of economic growth (development), whereas a conventional development index takes gross domestic product (GDP) or GDP-per-capita to be important (Figure 5–1).

However, in conducting sustainable development, some economists have pointed out two major problems with using GDP (per-capita) (Section 2). First, the GDP only indicates the degree of the value added in a country and hence, it does not tell what amounts of the value added will remain in that country (i.e., the “flow” variable in economics). Therefore, if one is measuring the degree of economic growth, the value of remaining in the country (such as capital) would be more worth than measuring the value added (i.e., the “stock” variable in economics). Second, when thinking about sustainability, it is necessary to consider not only the economy but also other things, such as the natural environment. In other words, the GDP can increase even if depleted resources (e.g., fossil fuels) are used up. Therefore, it is argued that all other inclusive capitals are more appropriate to show sustainability than the mere economy.

IW is based on the belief that a measure of comprehensive capital (i.e., all stocks) would be a better indicator of sustainable development than GDP (i.e., the economic flow). The current IW (2018 version) is the sum of three types of capital: produced (or manufactured) capital (PC), human capital (HC), and natural capital (NC) (Figure 5–1). The IW that accounts for the benefits and losses due to exogenous (i.e., external) shocks is called the IW index (IWI) or the adjusted IW. The shocks currently consider carbon damage, capital gains due to oil prices, and the effect of total factor productivity (TFP).

As a characteristic of IW, because it is simply the sum of capital and if the data is available, it can be examined not only at the national level but also at the prefectural or municipal level, etc. This chapter analyzes and introduces Japan’s IW at the national and prefectural levels. The structure of this chapter is as follows. First, Section 2 presents a theoretical introduction to the IW. Section 3 introduces the IW relating to the world and Japan. Section 4 compares Japan and the G7 regarding IW-productivity. Section 5 compares the IW of each prefecture as of 2015. Taking an applied example of the analysis using the IW, Section 6 estimates the damage caused by the Nankai Trough earthquake (NTE) at the prefectural level. Section 7 summarizes the challenges and prospects for enhancing social resilience. Section 8 provides the conclusion.

2. About Inclusive Wealth

2.1 Problems with SDGs and GDP

The UNSDS held in September 2015 adopted the SDGs toward 2030 as an action plan for achieving the remaining issues of the Millennium Development Goals established in 2001 (United Nations, 2015 [Japanese translation]). Based on the SDGs, national and local governments are required to implement development programs that aim at sustainable development. Although the SDGs are an effort to be evaluated in terms of setting concrete goals, there is a technical problem, since there is no criteria to distinguish whether the development programs to be implemented are sustainable (Dasgupta et al., 2015).

For example, regarding public projects, there are analytical methods such as cost-benefit analysis and cost-effectiveness analysis. They enable us to compare costs and benefits (and effects) and to judge the execution of the project. Meanwhile, regarding SDGs, it is necessary to measure the benefit (and effect) of sustainability, but a problem is that the methodology is lacking as to how to measure it.

Sustainability is generally difficult to measure because it is a concept that spans a wide range and a long time. For example, if one is evaluating sustainability in Japan, it is necessary to first determine the scope of the analysis (e.g., forests) because it is difficult to measure sustainability as a whole (of Japan). Even if we decide on the analysis object, nevertheless, further problems arise. For example, the future values of benefits and effects need to be discounted in terms of present values. Also, because future matters are uncertain, problems arise such as how to consider this uncertainty.

The index commonly used today for measuring development is the GDP. According to the principle of three equivalences of national income, GDP is total of the value added (production), expenditures (consumption), and distribution (income). Thus, in terms of the GDP, production produces consumption and investment (Figure 5–1). The usefulness of GDP as a development indicator lies in the assumption that consumption and investment increase the people’s level of satisfaction (this satisfaction is called “utility” in economics). If the degree of satisfaction (i.e., total amount and/or per-capita) is high, economic growth or development is successful, but the degree of satisfaction itself is difficult to measure. Therefore, GDP, which is a substitution variable for consumption and investment that produces satisfaction, is effective to some extent as a development index. The method for calculating GDP has been established as national accounts (System of National Accounts [SNA]), which records resource flows such as consumption, investment, employment, and government expenditures, and measures GDP (which is the flow of income) (Dasgupta et al., 2015).

However, using the GDP has two problems. One is that the GDP is a flow and hence does not fully remain in the country. The other problem is that only the economic aspects are considered. That is, GDP can increase even as natural resources are exhausted.

2.2. Inclusive Wealth

The IW (called "*shinkokufu*" [Japanese]) discussed in this chapter refers just to "inclusive (*houkatsuteki* [Japanese])" "wealth (*tomi* [Japanese])" (originally called *houkatsuteki*-*tomi* [Japanese]). As mentioned above, production produces consumption and investment (Figure 5–1); however, the measure of this production and consumption (GDP) itself is a problem (i.e., as a development index) for two reasons: that it is a flow (variable) and that it considers only the economic aspects of an area. IW is the inclusive capital that can generate production and consumption (Figure 5–1). Therefore, because the measurement of production and consumption is a problem, the IW's approach measures all of the capital that produces wealth.

Note that the IW is not only used for production. First of all, the IW directly increases utility. This is an effect that people can feel wealthier by having buildings and a natural environment, etc. Then there is a feedback effect from investment (behavior) to capital. Due to this, when production is carried out using the IW, it leads to investments and hence an increase in the IW as feedback.

As a breakdown of IW, the 2018 version includes the following three forms of capital: PC (e.g., equipment and buildings), HC (e.g., educational capital and health capital), and NC (e.g., farmland and forests, fishery resources, fossil fuels, and minerals).

First, the PC is the so-called "capital stock" often used in economics, and it refers to facilities and buildings, etc. Regarding the capital stock, its depletion (consumption) is also considered as a fixed capital formation in GDP. The fixed capital formation consists of two components (Cabinet Office, 2007): the normal capital wear and tear (depreciation and amortization) and the normally expected amount of value loss due to accidents such as fires, storms, and floods (i.e., capital contingency loss). There are several methods for measuring capital stock, such as the benchmark-year method and the perpetual-inventory method (PIM). For example, the benchmark-year-method is used for the capital stock of private enterprises (93 SNA) (Cabinet Office, 2005). On the other hand, the PIM is used to estimate the IW, and it has some features such as that large amount of statistical data is unnecessary.

In addition to this ordinary capital, the IW considers two types of capital: HC and NC. HC is the sum of human worth. The 2018 edition of HC is divided into the capital relating to education and health. Educational capital is the value of an education provided to people, and health capital is the value of health (longevity). On the other hand, NC is the value of the natural environment used mainly in the primary industry. The 2018 edition of the NC considers agricultural land and forests (which are renewable resources), fishing resources, and fossil fuels and minerals (which are exhaustible resources).

HC and NC are often characterized by a lack of market prices. For example, the value of an education and agricultural land is difficult to measure if there is no market price. Therefore, we (usually) calculate the shadow price per unit. This is originally a marginal benefit of how much the utility per unit increases, but it is also an assumed cost per unit (marginal cost) to procure. We can calculate the value of capital by multiplying the shadow price by the amount of capital (e.g., education years and the amount of farmland).

In this way, the sum of PC, HC, and NC is equal to the IW. However, the welfare of people can be increased or decreased by the benefits and losses (external shock) that occur separately from these measures of capital. The IW that considers external shock is called the "IW index (IWI)" or "adjusted IW." In general, because the (exogenous) impact on the IWI is expected to be small, it may not be considered using a simple estimation. At present, three items, carbon damage, capital gains for crude oil, and TFP, are listed as adjustment items for external shocks. The carbon damage is the damage to each country due to climate change. Climate change is said to be generated in a human-induced way by greenhouse gases. However, the damage one gets from climate change is not always the same and often countries suffer as much damage or more as those countries that emit more greenhouse gases; the effect of climate change varies by geography and industrial composition. In this sense, the carbon damage is characterized as the amount of damage (i.e., as negative public goods in economics) that the whole globe is suffering from.

The capital gains for crude oil are referred to as the benefit/loss incurred by the increase/decrease of crude oil prices. Higher oil prices are beneficial for oil-producing countries and are a loss for oil-importing countries (i.e., the reverse is also true).

TFP is the productivity of all factors used in production. In the first place, productivity refers to the value added per production factor. For example, labor (capital) productivity is an indicator of how much value added is generated per working person (per capital stock). TFP is slightly different from labor and capital productivity and reflects the effects of some "unknown" capital rather than some capital effects. For example, we would like to assume that productivity is expressed by unknown residuals (i.e., the Solow residual) other than capital, labor, and the intermediate inputs in the Solow model in economics. Thus, the TFP can be altered by external shocks (e.g., by a disaster). A low TFP means that resources were not used well during the year, causing losses (the reverse is also true).

The larger the scale (e.g., population), the larger the IW (or IWI). Thus, similarly to GDP-per-capita, IW-per-capita (as an indicator) has been proposed as a new sustainable development indicator.

2.3 Revision of the Inclusive Wealth Report

The United Nations Environment Program (UNEP) and the United Nations University-International Human Dimensions Program on the Human and Social Aspects of Global Environmental Change (UNU-IHDP) have published the Inclusive Wealth Report (IWR) three times, in 2012, 2014, and 2018 (UNU-IHDP and UNEP, 2012, 2014; UNEP, 2018; Managi & Kumar, 2018). Though the classification of the three forms of capital (i.e., PC, HC, and NC) are the same, each revision has expanded the estimation object of HC and NC as well as the countries and years involved. Here, we would like to confirm how the IWR has been revised (Table 5–1).

First, the IWR2012 covers 20 countries from 1990 to 2008. The PC of IWR2012 is the usual "capital" in economics, estimated by the PIM (7% discount rate) based on King and Levine (1994).

The HC of IWR2012 is estimated from educational status (i.e., educational years) and the lifetime annual income from education based on Arrow et al. (2012). This calculation, the value of HC, which is based on the educational years and wages earned through employment training, is multiplied by the shadow price, which is the average labor wage per unit. The shadow price is calculated from the population, gender- and age-specific mortality rates for the workforce, etc. The interest rate for wages earned through employment training is assumed to be 8.5%.

As mentioned above, the NC of IWR2012 is mainly estimated from the following five sources: agricultural land (croplands and pastures), forest (wood and non-wood value), fossil fuels (mainly coal, oil, and natural gas), minerals (bauxite, copper, gold, iron, etc.), and fishery resources (only four countries). As the basic calculation method, each amount of capital is multiplied by the corresponding resource charge (i.e., the period-average market price per unit).

As for other adjustment items, the IWR2012 considers carbon damage, the capital gained by the change in crude oil prices, and the TFP, as mentioned above. The IWR2012 estimates health capital, which is an evaluation people's health as measured by capital, but it does not include this measure in the HC. That is, though the importance of health capital is recognized, the estimation of IWR2012 excluded the health value because it is much larger than the sum of three capitals (PC, HC, and NC). The health capital is calculated by multiplying the population by the value of statistical life (VSL) and converting it to the present value at a discount rate based on Arrow et al. (2012). Therefore, the health capital of IWR2012 is, so to speak, the value of longevity.

Next, the IWR2014 has changed the following items from the IWR2012. First, the target has been expanded to 140 countries from the years 1990 to 2010. The discount rate of PC was then set at 4%.

The HC of the IWR2014 is measured by the same method as Arrow et al. (2012); however, because this method depends almost exclusively on educational status (i.e., the number of education years), some have argued that there was a problem in estimating the population potential of a country. The newly proposed method is calculated from annual income per capita in the labor market (Jorgenson & Fraumeni, 1992). Using this method, the population is divided into three stages: 15 to 40 years old (education and employment), 41 to 64 years old (work only), and over 65 years old (after the mandatory retirement age). It calculates the annual income using the following information: age, gender, education level, and survival working rates (i.e., whether people are still working in the next year), etc.

Finally, the IWR2014 does not carry out the capital estimation on health but arranges the theory on health (capital). According to the proposed model, health affects people's welfare in the following three ways: direct welfare, productivity (GDP), and longevity. However, the former two ways are difficult to estimate due to a lack of data and empirical studies, therefore, the value of life expectancy is used for the main estimate of health capital. Note that the value is estimated to be about $10,000 per person per year in the United States.

In the IWR2018, the object country is the same in 140 countries, but the object years are expanded from 1990 to 2014. In HC, health capital is now added. The estimation of the HC changes how to calculate the shadow price of education and health, since it adopts the frontier approach. This method is based on data envelopment analysis, which a type of nonparametric approach, and estimates shadow prices from the frontier production function using GDP as the objective function (as output factor), three measures of capital (PC, HC, and NC), and health capital as explanatory variables (as input factors) (Färe et al., 2005; Tamaki et al., 2018).

Also, the IWR2018 adds fishery resources to the NC. Although the proportion of the fishery in the NC is small, the fishing stock tends to decrease over the years.

3. Overview of IWR2018

3.1 Inclusive Wealth in the World

We are going to introduce the results of the IWR2018 as in the previous section briefly. First, we compare the global results between 1990 and 2014 (the upside of Table 5–2). Regarding the total amount (the top of the table), the total annual GDP was $30.5 trillion in 1990 and $56.8 trillion in 2014, meaning that a simple growth rate was 86.1% (in terms of the real U.S. dollar in 2005). GDP increased (or stayed constant) in 136 out of 140 countries and decreased in only four countries. Thus, GDP growth has been successful in most countries.

Similarly, IW increased by 50.4% from $809 trillion in 1990 to $1,216 trillion in 2014. IW increased (or stayed constant) in 135 countries and decreased in only five. Therefore, we confirm that the IW is steadily increasing in addition to the GDP (however, the growth rate is smaller than the GDP). As a percentage, the IW is more than 20 times that of GDP (27 times in 1990 and 21 times in 2014). Conversely, if we set the IW at 100%, countries are likely to generate 4% in value per year as measured by GDP (3.8% in 1990 and 4.7% in 2014). As mentioned above, however, notice that the GDP is a flow variable and the IW is a stock variable.

Regarding the breakdown of the IW, in 1990 it was $89 trillion for PC, $615 trillion for HC, and $105 trillion for NC; in 2014 it was $195 trillion (+119.9%) for PC, $929 trillion (+51.1%) for HC, and $92 trillion (–12.6%) for NC. As a feature, the size of each capital is different: HC is by far the largest, and PC and NC have a similar size. PC has the largest growth rate, increasing over two times itself over 15 years. Meanwhile, when compared with the 1990s values, only the NC decreased among the three values. Regarding the increase and decrease for each country, the number of countries whose capital increased when compared with 1990 are 136 in PC and 133 in HC, but only 31 in NC. This decline in NC indicates that renewable and depletable resources are decreasing, and not enough are recovering.

Next, we check the per-capita indicator (the simple average for each country) (the lower part of Table 5–2). The population was 4.95 billion in 1990 but increased by 39.4% to 6.9 billion in 2014. GDP-per-capita was $8.2 thousand in 1990 and $11.9 thousand in 2014 (+45.5%), increasing in 128 countries and decreasing in 12 countries during this period. Therefore, it can be seen that GDP-per-capita is growing in many countries in addition to its GDP.

Next, IW-per-capita was $220.7 thousand in 1990 and $210.7 thousand in 2014 (–4.5%), which means it was decreasing slightly. It increased in 89 countries and decreased in 51 countries. Therefore, although IW-per-capita has increased in more than half of the countries, it has decreased in certain countries, suggesting that sustainable development is not being carried out. As for the breakdown, the reason for the decrease is that NC-per-capita has decreased so sharply in many countries such that it cannot be covered by increases in PC and HC. PC-per-capita has increased a large amount from $24.8 thousand to $40.8 thousand (+64.2%); HC-per-capita has increased slightly from $136.6 thousand to $139.1 thousand (+1.9%); NC-per-capita has decreased sharply from $59.3 thousand to $30.8 thousand (–48.0%). The number of countries that saw an increase during this period was 120 for PC-per-capita, 122 for HC-per-capita, and only 12 for NC-per-capita.

3.2 Inclusive Wealth in Japan

Subsequently, we can confirm the results for Japan (Table 5–3). First, regarding the total amount (at the top of the table), the annual GDP is $3.9 trillion (2nd out of 140 countries) in 1990 and $4.8 trillion (3rd) in 2014 (i.e., the growth rate is 24.1%, which is ranked at 128th). Meanwhile, the IW was $26 trillion (6th in the world) in 1990 and $36 trillion (5th) in 2014 (the growth rate is 37.5%, which is ranked at 88th). Regarding the ratio, if IW is set as 100%, it generates 13–14% of values per year as GDP (14.6% in 1990 and 13.2% in 2014). This means that, when compared to the world's total GDP above, which accounts for 4% of IW, Japan's (IW) productivity is high. As for the breakdown, PC increased from $13 trillion (2nd) to $21 trillion (2nd) (+56.7%; 120th), HC increased from $12 trillion (7th) to $15 trillion (9th) (+19.3%; 118th), and NC decreased from $567 billion (32nd) to $458 billion (29th) (–19.2%; 89th). This trend of seeing large increases in PC, small increases in HC, and decreases in NC is consistent with global trends. As for the features of Japan, the PC is relatively large and the NC is remarkably small. Also, due to the relatively large size of the country, the growth rate is ranked relatively low.

Next, we can confirm the values per-capita in Japan (the lower part of the table). Note that the population was approximately 120 million in both 1990 and 2014, meaning it increased by 3.0%. GDP-per-capita increased to $31.2 thousand (10th) in 1990 and $37.6 thousand (19th) in 2014

(+20.5%; 109th). Meanwhile, IW-per-capita increased from $212 thousand (45th) in 1990 to $284 thousand (39th) in 2014 (+34.0%; 25th). As for the characteristics of Japan, both GDP- and IW-per-capita increased, and it can be said that sustainable development is being carried out. Moreover, although the GDP-per-capita drops from 10th place to 19th, the IW-per-capita advanced from 45th place to 39th, meaning that the sustainability becomes relatively high. As for the specifics of the breakdown, PC-per-capita increased from $108.2 thousand (7th) to $164.7 thousand (10th) (+52.2%, 85th); HC-per-capita increased from $99.7 thousand (43rd) to $115.6 thousand (42nd) (+15.9%, 66th); and NC-per-capita decreased from $4.6 thousand (104th) to $3.6 thousand (92nd) (–21.7%, 39th). These trends, which see an increase in PC and HC and a decrease in NC, are consistent with global trends.

Based upon these facts, Japan (as of 2014) is characterized by its large scale (in terms of total value, being 3rd place in GDP and 5th place in IW) and its low per-capita values (for per-capita, it is 19th in GDP and 39th in IW). As an aspect of the IW, relatively speaking, the PC is large and the NC is small.

4. Inclusive Wealth in Japan and the G7

This section will discuss IW and its measures of productivity in Japan by comparison to the G7 (Table 5–4). As mentioned above, productivity here refers to efficiency or a contribution ratio of production factors to what is create as value added. The simplest way to measure productivity is by taking the value-added divided by the production factor. Labor productivity can be expressed in terms of the value-added per hour or person.

For example, it is often said that Japan has a low amount of labor productivity. According to the Japan Productivity Center (JPC) (2018), Japan’s labor productivity was the lowest among the G7 countries in 2017 (the top of Table 5–4). In purchasing power parity dollars (PPP$), Japanese labor productivity is $47.5 per-hour, $43 thousand per-capita (5th in the G7), and $84 thousand per-working-person (the lowest). The 5th rank for per-capita drops to 7th for per-working-person because Japan has a relatively large working population, with a working population ratio of 51.5% (i.e., the working population divided by the population).

Japan’s (working) population is projected to decrease due to the country’s low birthrate and its aging population, and the population decrease and the country’s low labor productivity are serious problems for economic growth. For example, because labor productivity is expressed as the “value-added when divided by population,” the value-added can be expressed conversely as the “labor productivity multiplied by the population.” Therefore, in order to maintain the present level of value added, despite the decreasing (working) population, the country must raise its labor productivity.

Productivity can be considered not only in terms of labor but also in terms of the IW. Because IW consists of three forms of capital, we can calculate how these forms of capital generate what is value added (GDP). For example, this chapter can calculate the IW-productivity as the "GDP divided by the IW." Similarly, we can calculate the PC (HC or NC) productivity as the "GDP divided by the PC (HC or NC)." Based on this concept, we would like to examine the level of Japan's IW-productivity within the G7.

Table 5–4 shows the G7 data (2014) from IWR2018. Regarding the total amount (the center part of the chart), Japan ranked 2nd for GDP, IW, PC, and HC; 4th in NC; and 2nd in terms of population. Note that the U.S. ranked first in all categories. Within each category, there is a disparity in the NC, with the U.S. predominating ($9.5 trillion), followed by Canada ($4.1 trillion) in 2nd place, Germany ($1.4 trillion) at 3rd, and the bottom four countries (Japan, Italy, France, and the U.K.) with less than $0.5 trillion.

Next, regarding the per-capita indicator (the center part of the table), Japan's GDP-per-capita was $37.6 thousand, ranking 5th, which is consistent with the estimates of the JPC (2018). Japan's IW-per-capita was $284 thousand ranked at 3rd place, next to Canada ($328 thousand) and Germany ($285 thousand). This means that the sustainability of Japan is as high as that of Germany. The breakdown shows that PC-per-capita is 1st at $164.7 thousand, HC-per-capita is 2nd at $115.6 thousand (1st is Germany), and NC-per-capita is 6th at $3.6 thousand (at the bottom is the U.K.). Thus, in Japan, PC- and HC-per-capita are relatively large, and NC-per-capita is relatively small.

Finally, the productivity (at the bottom of the table) is confirmed. Japan's IW-productivity ranks 6th at 13.2%. The highest country is the U.K. (20.6%) and the lowest is Canada (11.7%). Therefore, not only labor productivity but also IW-productivity are low in Japan, meaning that value added has not been produced well. The breakdown shows that PC-productivity is the lowest at 22.8%. Although this result may seem surprising, it indicates that Japan has a poor level of investment efficiency in terms of PC (e.g., facilities and buildings).

Next, HC-productivity is ranked 6th at 32.6%. It is at the lowest level of the G7, as Germany (the lowest) has almost the same ratio (32.5%). Therefore, regarding only the results from Japan, they are consistent with those of the JPC (2018). According to these numbers, the U.K. ranked 6th in value-added per-hour ($53.5) and 6th in value-added per-employee ($90 thousand). However, according to the results of this section, the HC-productivity of the U.K. is in 1st place at 52.2%. As mentioned above, the HC represents almost health capital (the value of life), and so it is assumed that the relatively low level of health capital in the U.K. increases its HC-productivity (see Section 5.2 for the value of HC).

Finally, Japan ranks 2nd in NC-productivity at 1,044%. At 1st place, with 1,612%, is the U.K., a similar island country. This means that they produce greater value-added with a relatively scarce level of NC.

In summary, Japan has the worst-level productivity in the G7 regarding not only its labor but also its IW (sixth). In particular, its PC- and HC-productivities are low. This means that one issue is to find out how to increase not only the country's labor productivity but also the amount of its value-added per facility and building.

5. Inclusive Wealth by Prefecture

5.1 Total Amount

In the previous analysis, we have discussed the IW by country. This section will introduce a discussion about how the IW data can be utilized for domestic regional development. As for data at the municipal level, the IW of 1,742 municipalities in Japan has been compiled in terms of what is "EvaCva-sustainable," as developed by Fujitsu Research Institute (K.K.).

This section examines IW by prefecture. The data are based on Managi (2019) and the 2015 edition of the IW. The (nominal) gross regional product (GRP) was obtained from the Cabinet Office (2019).

First, regarding the total amount (Table 5–5), the top three in terms of GRP are 1st, Tokyo (¥104 trillion), 2nd, Aichi (¥40 trillion), and 3rd, Osaka (¥39 trillion), and the bottom three are 45th, Shimane (¥2.6 trillion), 46th, Kochi (¥2.4 trillion), and 47th, Tottori (¥1.8 trillion). The top three in terms of IW are 1st, Tokyo (¥491 trillion), 2nd, Osaka (¥225 trillion), and 3rd, Kanagawa (¥216 trillion), and the bottom three are 45th, Yamanashi (¥25 trillion), 46th, Okinawa (¥21 trillion), and 47th, Tottori (¥20 trillion). Therefore, regarding the total amount, the rankings of the GRP and IW are correlated.

Regarding the breakdown, for PC, the highest ranked are 1st, Tokyo (¥273 trillion), 2nd, Aichi (¥142 trillion), and 3rd, Osaka (¥137 trillion), and the lowest ranked are 45th, Kochi (¥13 trillion), 46th, Okinawa (¥12 trillion), and 47th, Tottori (¥11 trillion). The rankings related to the PC are also similar to that of the GRP. As for the HC, the highest ranked are 1st, Tokyo (¥217 trillion), 2nd, Kanagawa (¥97 trillion), and 3rd, Osaka (¥87 trillion), and the lowest are 45th, Tottori (¥8 trillion), 46th, Okinawa (¥7.8 trillion), and 47th, Miyazaki (¥6.4 trillion). The rankings of the HC are also similar to that of the GRP. Note that the HC (Total ¥1,290 trillion) can be divided into educational capital (¥52 trillion) and health capital (¥1,238 trillion). Because health capital accounts for as much as 96% of the total, the HC is almost all health capital. As for the NC, the highest are 1st, Hokkaido (¥52.4 trillion), 2nd, Nagasaki (¥5.1 trillion), and 3rd, Shizuoka (¥4.3 trillion), and the lowest are 45th, Nara (¥0.5 trillion), 46th, Shiga (¥0.4 trillion), and 47th, Osaka (¥0.4 trillion). As features, the NC is remarkably high in Hokkaido, and unlike the tendencies measured above, the size of the NC is not correlated with the size of the GRP.

It may seem counterintuitive that the NC rankings are 45th, Nara and 46th, Shiga, but this is due to the following reasons. For example, Nara may appear to have a high NC because it is famous for the deer in its Nara Park (in Nara city), but the value of deer is not included in the NC. Moreover, Nara has high historical values; according to the Agency for Cultural Affairs (2019), as of February 2019, the number of national treasures (arts, crafts, and buildings) it held was 203, which ranks 3rd place in Japan, and the number of important cultural properties was 1,327, which ranks it at 3rd place.

Again, however, the value of these cultural products in Nara is not reflected in the NC. In addition, Shiga also appears to have a high value of NC because Shiga has Lake Biwa, which is the largest lake in Japan and is registered as a Ramsar Convention Wetland. However, the value of the lake is not reflected in the NC (note that the PC and NC consider the values of ports, ships, and living fishery resources).

5.2 Per-Capita Indicators

Next, regarding the per-capita indicator (Table 5–6), the highest GRP-per-capita are 1st, Tokyo (¥7.72 million per-capita), 2nd, Aichi (¥5.29 million), and 3rd, Shizuoka (¥4.67 million), and the lowest GRP-per-capita are 45th, Saitama (¥3.07 million), 46th, Tottori (¥3.06 million), and 47th, Nara (¥2.62 million). The results of the measures of GRP-per-capita are generally intuitive; the highest are in Tokyo (1st), Aichi (2nd), and Osaka (7th). Other areas ranked high include the North Kanto region (4th, Tochigi, 6th, Ibaraki, and 8th, Gunma), and areas in the Pacific belt zone such as Shizuoka (3rd) and Mie (5th).

Meanwhile, regarding the IW-per-capita, the highest ranked are 1st, Shimane (¥44.07 million), 2nd, Yamaguchi (¥43.11 million), and 3rd, Fukui (¥42.28 million), and the lowest ranked are 45th, Saitama (¥21.09 million), 46th, Kyoto (¥14.13 million), and 47th, Chiba (¥12.78 million). Although these may not be intuitive, the results of IW-per-capita do not correlate well with the GRP-per-capita. The highest ranked in terms of the IW-per-capita is the Chugoku area (1st, Shimane and 2nd, Yamaguchi), the Japan Sea side (3rd, Fukui, 4th, Toyama, and 5th, Akita), the Shikoku area (6th, Kochi, and 8th, Tokushima), and Mie (7th), etc. In terms of the above-mentioned GRP-per-capita rankings, the IW-per-capita is also high in Tokyo (1st for both GRP and IW) and Mie (5th for GRP and 7th for IW). Other prefectures that have a high level of GRP-per-capita but a low level of IW-per-capita are Aichi, Shizuoka, Tochigi, Gunma, and Osaka, etc. (e.g., Aichi is 2nd in terms of GRP and 35th in terms of IW while Shizuoka is 3rd in terms of GRP and 31th in terms of IW).

According to the breakdown, the PC-per-capita is the highest in 1st, Fukui (¥23.79 million), 2nd, Yamaguchi (¥22.8 million), and 3rd, Toyama (¥22.8 million), and the lowest is in 45th, Okinawa (¥12.07 million), 46th, Nara (¥11.91 million), and 47th, Saitama (¥10.39 million). The features of those that are the highest ranked is unclear, but as possibilities (in these prefectures), there is the existence of harbors, many power plants, expensive public works (per-capita), and many factories, etc.

Next, the HC-per-capita is the highest in 1st, Shimane (¥19.16 million), 2nd, Yamaguchi (¥19 million), and 3rd, Fukui (¥17.16 million), and the lowest is in 45th, Miyazaki (¥5.81 million), 46th, Kumamoto (¥5.7 million), and 47th, Chiba (¥2.32 million). As mentioned above, the HC refers almost exclusively to health capital, and this means that the higher an area is ranked, the higher the value of longevity. Here, note that Chiba has remarkably the lowest HC-per-capita and is an outlier. This is probably because the nonparametric method, which is an estimation method (see Section 2.3), often derives outliers. A low HC means there is a low marginal cost per education (years) and health (longevity) on the production function of the frontier approach. In other words, one year's worth of education and longevity for Chiba residents can be procured relatively cheaply as a production factor (again, this estimate is an outlier, and there is a high possibility that it will fluctuate significantly upon re-estimation).

The NC-per-capita is the highest in 1st, Hokkaido (¥9.74 million), 2nd, Kochi (¥4.09 million), and 3rd, Nagasaki (¥3.71 million), and is the lowest in 45th, Saitama (¥13 thousand), 46th, Tokyo (¥60 thousand), and 47th, Osaka (¥40 thousand). Hokkaido (1st) stands out even on a per-capita basis.

5.3. Inclusive Wealth Productivity

Finally, we can confirm the levels of IW-productivity (Table 5–7). To begin with, the IW-productivity (which is the GRP divided by IW) is the highest in 1st, Tokyo (21%), 2nd, Chiba (21%), and 3rd, Aichi (20%), and is the lowest in 45th, Akita (9%), 46th, Tottori (9%), and 47th, Shimane (8%). This ranking is similar to that of the GRP-per-capita (where it is highest in 1st, Tokyo, 7th, Chiba, 2nd, Aichi and is the lowest in 40th, Akita, 47th, Tottori, and 45th, Shimane). However, it is not perfectly correlated, and in some prefectures, GRP-per-capita is low even when IW-per-capita is high. For example, Okinawa ranks 4th in IW-per-capita but 11th in GRP-per-capita while Kyoto ranks 5th in IW-per-capita but 21st in GRP-per-capita.

Looking at the range that the IW-productivity can take, the highest is 20–21% whereas the lowest is 8–9%, and it differs at 2.3 times the maximum between the top and the bottom. Therefore, regarding their level of IW-productivity, Akita, Tottori, and Shimane have the potential to raise their GRP to more than twice the current level. Meanwhile, it may prove difficult to further increase their productivity as in higher ranked prefectures such as Tokyo, Chiba, and Aichi. In these top prefectures, (economic) policies to increase the total amount itself (i.e., not productivity) will be effective (for example, measures to increase investments in PC, promote health, and better the nature environment).

Regarding the breakdown, PC-productivity is the highest in 1st, Tokyo (38%), 2nd, Okinawa (35%), and 3rd, Saitama (30%), and is the lowest in 45th, Akita (17%), 46th, Shimane (17%), and 47th, Tottori (16%). Tokyo (1st) also ranks 1st for IW-per-capita, and Okinawa (2nd) ranks 4th in terms of IW-per-capita, suggesting that prefectures with a high IW-per-capita tend to rank high for PC-per-capita. Meanwhile, prefectures with a high PC-per-capita and a low IW-per-capita are Saitama (3rd for PC and 14th for IW) and Kanagawa (4th for PC and 11th for IW). Regarding the range of PC productivity, the highest is 35–38% and the lowest is 16–17%, which therefore means that the gap is approximately two times at most.

HC-productivity is the highest in 1st, Chiba (140%), 2nd, Aichi (73%), and 3rd, Kyoto (64%), and is the lowest in 45th, Kochi (22%), 46th, Akita (20%), and 47th, Shimane (19%). In terms of trends, in prefectures with a high HC-productivity (which almost always refers to labor productivity), the IW-per-capita is most likely to be low. For example, Chiba (1st) is in 47th place in terms of IW-per-capita (¥15.47 million), Aichi (2nd) is in 35th place in terms of IW-per-capita (¥26.51 million), and Kyoto (3rd) is in 46th place in terms of IW-per-capita (¥20.7 million). Therefore, there is a tendency to see a trade-off between the HC-productivity and the IW-per-capita. Except for the outlier of 140% in Chiba, the range of HC-productivity is 73% at the highest and 19–20% at the lowest, meaning that the maximum gap is more than three times.

Finally, NC-productivity is the highest in 1st (12 thousand %), 2nd, Osaka (11 thousand %), and 3rd, Kanagawa (2.7 hundred %), and is the lowest in 45th, Nagasaki (86%), 46th, Kochi (80%), and 47th, Hokkaido (36%). In general, prefectures with a high IW- and a high level of PC-productivity tend to have a high level of NC-productivity. It is not appropriate to estimate the range of NC-productivity because there is too large of a variation, but the upper limit is 10,000% or more and the lower limit is 100% or less, meaning that the maximum gap is 100 times or more.

6. Damage Analysis of the Nankai Trough Earthquake

6.1 Damage from the Nankai Trough Earthquake: Produced Capital

In order to evaluate social resilience, this section would like to consider what kind of impact a disaster will have on the IW. The NTE (Asahi Shimbun Digital, 2015; Cabinet Office, 2014, 2015) was expected to have had larger damage than the Great East Japan Earthquake (March 2011). According to damage estimates (published in August 2012) by the Cabinet Office (2014, 2015), in the worst case, the death toll was 323 thousand, the number of injured people was 623 thousand, and the direct damage amount (the accumulated loss of buildings, electricity, communications, water and sewerage, other assets, and disaster waste disposal costs) was ¥169 trillion nationwide in total. Note that regarding the estimated figures of dead people, they are not necessarily matched between the national figures and the sum of prefectures in each of the worst cases (i.e., the sum of each prefecture will be 436 thousand total).

Table 5–8 predicts the decrease in GRP based on the direct damage amount from the NTE. First, the direct damage is ¥169 trillion nationwide, involving 36 prefectures. Five prefectures with the largest amount of direct damage are Aichi (¥30.7 trillion), Osaka (¥24 trillion), Shizuoka (¥19.9 trillion), Mie (¥16.9 trillion), and Ehime (¥10.9 trillion). Because the direct damage will be almost all PC, we can estimate how much IW (i.e., almost all PC) will be lost by calculating the PC-loss-ratio (as of 2015) (i.e., damage divided by PC). Five prefectures that had the largest PC losses are Kochi (81%), Wakayama (56%), Tokushima (47%), Ehime (43%), and Mie (41%). Thus, Kochi and Wakayama will lose most of their PC, whereas the whole of Japan will lose about 8% of its PC.

Based on these rates of PC-loss, we can estimate how much the GRP decreases. Here, we simply assume that the PC-productivity is constant before and after the earthquake, and the estimated value will be the PC-loss-rate multiplied by GRP (as of 2015) (i.e., the direct damage amount divided by PC times the GRP). Five prefectures with the worst expected GRP losses are 1st, Aichi (¥8.6 trillion), 2nd, Osaka (¥6.9 trillion), 3rd, Shizuoka (¥5 trillion), 4th, Mie (¥3.4 trillion), and 5th, Ehime (¥2.1 trillion). Japan as a whole was expected to lose up to ¥42.7 trillion of GDP in a year if the PC is not recovered at all after the NTE. Note that this value is the maximum annual loss. For example, if PC recovered soon, the GDP loss was expected to be smaller, so we can calculate a more realistic annual GDP loss by multiplying this ¥42.7 trillion by the annual equipment damage rate (0–100%).

6.2 Damage from the Nankai Trough Earthquake: Human Capital

Next, the damage to HC is estimated (the right side of Table 5–8). First, the worst number of fatalities from each prefecture is 436 thousand in total (which is not the same as the nationwide expectation of 323 thousand). Deaths were expected to occur in 30 prefectures, and five prefectures with the largest numbers are 1st, Shizuoka (109 thousand), 2nd, Wakayama (80 thousand), 3rd, Kochi (49 thousand), 4th, Mie (43 thousand), and 5th, Miyazaki (42 thousand). The number of evacuees was expected to be 7.43 million during the first day and 9.66 million during the first week. Evacuees on the first day were expected to appear in 37 prefectures, where the top five prefectures were 1st, Aichi (1.3 million), 2nd, Osaka (1.2 million), 3rd, Shizuoka (0.9 million), 4th, Mie (0.56 million), and 5th, Kochi (0.51 million). The one-week evacuees are expected to appear in 40 prefectures, where the top five prefectures are 1st, Aichi (1.9 million), 2nd, Osaka (1.5 million), 3rd, Shizuoka (1.1 million), 4th, Mie (0.69 million), and 5th, Ehime (0.54 million).

Here, we would like to estimate how much the HC will decrease. First, in cases of death, the HC will be lost, depending on the number of deaths. Although physically-vulnerable people such as infants and the elderly will be more likely to be dead, here for simplification, we assume that people with an average HC will die. Based on this assumption, to estimate the HC-loss, we first calculate the death ratio as "the number of deaths divided by the population" and then multiply this ratio by the HC (i.e., the number of deaths divided by the population multiplied by the HC). For HC, the value for 2015 is taken from Managi (2019).

The estimated amount of the HC loss due to fatalities (436 thousand) is ¥4.8 trillion in total (0.4% of the total HC). The top five prefectures are 1st, Wakayama (¥1.1 trillion), 2nd, Shizuoka (¥850 billion), 3rd, Kochi (¥750 billion), 4th, Mie (¥560 billion), and 5th, Tokushima (¥480 billion).

Then, in cases of evacuation, the HC itself is not lost unlike in cases of death. Because people find it difficult to engage in educational activities and work during an evacuation, however, such an HC will not be able to produce value added. Importantly, the evacuation usually involves movement, and so the HC will move. In the worst case, all evacuees would move to other prefectures. At this time, we would like to calculate how much of the HC will be transferred in this worst case scenario. It will represent how much each prefecture holds in terms of the disaster risk. Even in the case of an evacuation, there can be some bias in the HC for people who can evacuate immediately. For example, people with higher incomes may be able to evacuate more quickly while socially vulnerable people may not be able to evacuate even if after a disaster occurs. However, for simplicity, we assume that the evacuees have an average HC. Based on this assumption, we can calculate the maximum amount of HC movement: we first calculate the percentage of the population by "evacuees divided by the population" and then multiply it by the value of the HC (i.e., the number of evacuees divided by the population multiplied by the HC).

Due to evacuations on the first day after the NTE, the total amount of HC transfer isa total of ¥75.8 trillion (5.9% of Japan's HC). The top five prefectures (first day) are 1st, Osaka (¥11.9 trillion), 2nd, Aichi (¥9.4 trillion), 3rd, Kochi (¥7.8 trillion), 4th, Mie (¥7.3 trillion), and 5th, Shizuoka (¥7.1 trillion). Similarly, for the first week, the total amount of HC transfer (due to the evacuation) is ¥96.2 trillion (7.5% of Japan's HC). The top five prefectures (1st week) are 1st, Osaka (¥14.8 trillion), 2nd, Aichi (¥13.8 trillion), 3rd, Mie (¥9 trillion), 4th, Shizuoka (¥8.7 trillion), and 5th, Kochi (¥7.6 trillion).

7. Strengthening Social Resilience: Challenges and Prospects

This chapter defines strengthening social resilience as seeing an increase in IW (per-capita). This is based on the idea that even if the GDP does not increase, an area's sustainability will increase as long as the IW increases. When an external shock such as a disaster occurs, capital is liable to be damaged, which suggests that a region with a larger IW will have an easier time recovering. Note that resilience and productivity are likely to conflict. As mentioned above, because productivity is expressed by the value-added when divided by production factors, productivity is more likely to improve with fewer production factors. To reduce the production factor is to eliminate the reserve and the surplus. Meanwhile, the reserve and the surplus are important for the concept of resilience, and they can be utilized for looking at an emergency external shock.

In the case of Japan, as mentioned above, the total amount of IW is the 5th largest in the world (as of 2014). Meanwhile, the IW-per-capita (39th) and productivity are not ranked as high in the world. Therefore, it has become a challenge for Japan to raise itself in terms of the per-capita index and productivity, while keeping a top of the world ranking regarding its total amount of IW.

From the viewpoint of the IW, domestic investment is important for strengthening social resilience in Japan. It is necessary to invest in and utilize PC and NC appropriately. First, making investments in PC (buildings and equipment) enhances resilience directly. In recent years, domestic manufacturers have returned their overseas factories to Japan due to geopolitical risks and wage hikes in developing countries; such a domestic return phenomenon should increase the PC. Next, regarding the investments in NC, the main policy should be toward using non-exhaustible resources because exhaustible resources are most likely to be scarce in the future unless there is successful development in marine resources, etc. Regarding the measures of non-exhaustible resources, it is likely to be effective if there is a raise in the prices of agricultural products, fish, and wood, and indirectly there are increases in the value of farmland, fishery resources, and forests. For example, it will become important to increase the value-added via measures such as organic cultivation and branding. It is also important to utilize these resources effectively. Note that the value of the domestic NC may increase by imposing high tariffs and non-tariff barriers on imported goods under protectionist trade policies; however, such policies could increase domestic dependence, potentially consuming the domestic NC more quickly.

In terms of using human resource development in order to strengthen social resilience in Japan, making investments in HC (health and education) is important. Regarding health policy, the amount of the social security expenditure for the general account budget in the 2019 fiscal year is ¥34 trillion, which is one-third of the annual expenditure, and any increase in the medical expenditures becomes a financial problem. However, according to what is discussed in this chapter, an increase in medical expenses is likely to contribute to an increase in the HC. Therefore, if there is a reduction in the medical expenses, it should be required to allocate them sustainably and efficiently (however, how to use the medial expenditures is a difficult question regarding what is sustainable and efficient). Meanwhile, regarding educational policy, the introduction of free high-school education and the upturn in the university entrance ratio should contribute to an increase in the HC. Therefore, as measured, it would be effective to raise the advancement rate to universities and graduate schools, increase the employment of highly skilled professionals and human resources (including the elderly [silver]), and enhance the (educational) market value.

In the case of developing or other countries, it will be important to stimulate domestic investment in the same way as Japan. Regarding PC, it is important to increase investment from home and foreign countries. For HC, the policies that enhance medical treatment and education and raises the market value (personnel expenses) of the human being is important. As for the NC, it will be necessary to shift industries away from the use of exhaustible resources and to increase the value of non-exhaustible resources and encourage investment in them.

8. Conclusions

This chapter put forward an outline of IW and carried out its analysis mainly in terms of Japan based on the estimated values of the three facets of IW capital: PC, HC, and NC. As an analysis of its contents, there are three indexes of IW, which are the total amount, the per-capita index, and productivity (i.e., value added divided by IW). As for the specific contents, it verified a comparison between 1990 and 2014 for the whole world (Section 3), for the IW of Japan (Section 3), a comparison between Japan and G7 (Section 4), a look at the IW by prefecture (Section 5), and the relevance of IW to measuring the damage due to NTE (Section 6).

The results are summarized as follows. The total IW of 140 countries in 2014 is $1,216 trillion, which is approximately 21 times the annual GDP. The GDP-per-capita, which is a conventional development index, has increased in 128 out of 140 countries from 1990 to 2014, and superficially, it appears that the economy is growing smoothly. However, the IW-per-capita, which is a new sustainability indicator, has increased only in 89 countries, and it is difficult to say that sustainable development has been achieved in many countries. In Japan, GDP-per-capita dropped and its ranking fell from 10th ($31.2 thousand) to 19th ($37.6 thousand) during the same period, while its ranking in terms of IW-per-capita rose from 45th ($212 thousand) to 39th ($284 thousand). Therefore, this shows that sustainability has relatively improved from the viewpoint of SDGs.

When compared with the G7 countries, Japan's HC-productivity (which equals labor productivity) is ranked 6th among the G7, while PC-productivity is ranked the lowest. This suggests that the reason for Japan's low level of competitiveness lies not only due to labor but also to ordinary capital (i.e., capital and investment efficiencies), such as equipment and buildings. Meanwhile, its NC productivity is second in the G7, next to the U.K.

In the analysis of the prefectures, the prefectures with the largest IW-per-capita are 1st, Shimane, 2nd, Yamaguchi, and 3rd, Fukui. Though the rankings of these prefectures may be contrary to intuition, the potential factors that help them to rank so high are as follows: the existence of ports, power plants, the existence of large-scale public works, and the fact that they have many factories.

Also, in analyzing the NTE, it was found that 8% of PC (the current total: ¥2,159.6 trillion) would disappear in the worst case. The HC (the current total: ¥1,289.9 trillion) would lose 0.4% due to fatalities (total 436 thousand people) and be transferred due to evacuation by 5.9% on the first day and 7.5% during the first week.

As for future research subjects regarding IW, the following should be considered. First, IW is still an incomplete indicator, and large-scale revisions should continue in the future (Section 2). Concretely, regarding HC, the remaining issues will be about how to develop an estimate of the shadow price in education and health and to find out what kinds of other HC factors to consider except for education and health. Regarding the NC, it is necessary to examine what should be included in addition to the five factors currently considered.

On the application side, as shown in the main sections, the measurement of the IW can be subdivided, such as into the prefectural level. Therefore, the IW can be used for assessing the sustainability of municipalities. In the future, by making links to a geographic information system, we expect that taking the measurement of the IW will be possible in each of the local meshes (i.e., separating areas on a map with a square, such as one-kilometer). Here, we would like to consider the spatial, geographical, and temporal changes (e.g., discount rate) of the IW. IW is capital, but a portion of capital that can be transferred. Besides, because the IW is a stock index, it is also affected by time. For example, when considering IW in terms of policy, it is important to consider how to allocate IW and how to set the discount rate.

As a cautionary note for economic policy, how to consider IW and productivity will become important. The size of the IW (i.e., how to increase the IW) is more consistent with the goals of the SDGs than GDP. For example, regarding disasters, the size of the IW tends to lead to the size of resilience. Meanwhile, from the viewpoint of productivity, the IW is also a production factor that produces value added. Therefore, in order to raise productivity, it is necessary to take measures such as either (or both) relatively decreasing IW itself (as size) and/or increasing the value added per IW (as productivity). Because reducing the IW itself is against SDGs and welfare, it is important to increase the value added without reducing the IW.

Specifically, while raising PC-productivity, it is important to think about how to raise investment efficiency for facilities and buildings. To raise HC productivity, it is necessary to increase value-added per-education and per-longevity. Therefore, while quality per-education-year and per-longevity are extended, it is also necessary for the elderly to engage in work that produces value added. Finally, to raise NC productivity, key plans should look to raise the resource value (brand value) of the forests, fishery, and minerals and to produce value added from farmlands (i.e., there should be a reduction in abandoned farmland), etc. Also, because Japan is an energy importing country, NC-productivity will improve relatively by increasing the diffusion rate of renewable energy and decreasing the degree of dependence on crude oil. Thus, finding out how to strike a balance between IW-size and productivity is a remaining issue for economic policy that is discussed in this chapter.

References

Arrow, K.J., P. Dasgupta, L.H. Goulder, K.J. Mumford, and K. Oleson. (2012) Sustainability and the measurement of wealth, *Environment and Development Economics*, Vol.17, No.3, pp.317–353. doi:10.1017/S1355770X12000137

Dasgupta, P., A. Duraiappah, S. Managi, E. Barbier, R. Collins, B. Fraumeni, H. Gundimeda, G. Liu, and K.J. Mumford. (2015) How to measure sustainable progress, *Science*, Vol.350, No.6262, p.748. doi:10.1126/science.350.6262.748

Färe, R., S. Grosskopf, D.W. Noh, and W. Weber. (2005) Characteristics of a polluting technology: Theory and practice, *Journal of Econometrics*, Vol.126, No.2, pp.469–492. doi: 10.1016/j.jeconom.2004.05.010

Jorgenson, D., and B.M. Fraumeni. (1992) The Output of the education Sector, in Griliches, Z., eds., *Output Measurement in the Services Sector,* pp.303 –338, Chicago: University of Chicago Press. https://www.nber.org/chapters/c7238

King, R.G., and R. Levine. (1994) Capital fundamentalism, economic development, and economic growth, *Carnegie-Rochester Conference Series on Public Policy*, Vol.40, pp.259–292. doi:10.1016/0167-2231(94)90011-6

Managi, S. and P. Kumar, eds. (2018) *Inclusive Wealth Report 2018*, London: Routledge. https://doi.org/10.4324/9781351002080

Managi, S., eds. (2019) *Wealth, Inclusive Growth and Sustainability*, Routledge, New York, USA. https://www.crcpress.com/9780367002367

Tamaki, T., K.J. Shin, H. Nakamura, H. Fujii, and S. Managi. (2018) Shadow prices and production inefficiency of mineral resources, *Economic Analysis and Policy*, Vol.57, pp.111–121. doi:10.1016/j.eap.2017.03.005

United Nations. (2015) Transforming our world: the 2030 Agenda for Sustainable Development. (外務省訳「我々の世界を変革する：持続可能な開発のための 2030 アジェンダ」。) <http://www.un.org/ga/search/view_doc.asp?symbol=A/70/L.1> <https://www.mofa.go.jp/mofaj/files/000101402.pdf>

UNEP, 2018, Executive Summary: Inclusive Wealth Report 2018. <https://www.unenvironment.org/resources/report/inclusive-wealth-report-2018>

UNU-IHDP, and UNEP. (2012) *Inclusive Wealth Report 2012: Measuring progress toward sustainability*. Cambridge: Cambridge University Press. http://www.ihdp.unu.edu/publications/?id=451

UNU-IHDP, and UNEP. (2014) *Inclusive Wealth Report 2014: Measuring progress toward sustainability*. Cambridge: Cambridge University Press. https://www.unenvironment.org/resources/report/inclusive-wealth-report

Asahi Shimbun Digital (2015), Damage estimation of Nankai Trough earthquake, The Asahi Shimbun Company. [朝日新聞デジタル (2015)「南海トラフ地震の被害想定」，朝日新聞社。] <http://www.asahi.com/special/nankai_trough/>

Cabinet Office (2005) Summary of Estimates: Financial stock of private enterprises confirmed: 2003 report (1995 standard: 93SNA) (FY1980–2003) (February 25, 2005). [内閣府 (2005)「推計の概要」『民間企業資本ストック確報：平成 15 年度確報値(平成 7 年基準:93SNA) (昭和 55～平成 15 年度)(平成 17 年 2 月 25 日)』。] <https://www.esri.cao.go.jp/jp/sna/data/data_list/minkan/files/files_minkan.html>

Cabinet Office (2005) Publication of “SNA Estimation Method Manual (revised 2007)” [内閣府 (2007) 「「SNA 推計手法解説書(2007 年改訂版)」の公表について」。] <https://www.esri.cao.go.jp/jp/sna/data/reference1/h12/sna_kaisetsu.html>

Cabinet Office (2014) Nankai Trough Great Earthquake Countermeasures Working Group (first report) (announced on August 29, 2012). [内閣府 (2014) 「南海トラフ巨大地震対策検討ワーキンググループ（第一次報告）（平成２４年８月２９日発表）」。]

<http://www.bousai.go.jp/jishin/nankai/nankaitrough_info.html>
Cabinet Office (2015) Nankai Trough Great Earthquake Countermeasures Working Group (second report) (announced on March 18, 2013). [内閣府 (2015) 「南海トラフ巨大地震の被害想定（第二次報告）について（平成２５年３月１８日発表）」。] <http://www.bousai.go.jp/jishin/nankai/nankaitrough_info.html>
Cabinet Office (2015) Prefectural economic calculation (FY2006–2015) (2008SNA, 2011 reference figures). [内閣府 (2019) 「県民経済計算（平成 18 年度 - 平成 27 年度）（2008SNA, 平成 23 年基準計数）」。] <https://www.esri.cao.go.jp/jp/sna/data/data_list/kenmin/files/contents/main_h27.html>
Japan Productivity Center [JPC] (2018) International comparison of labor productivity: 2018 edition. [日本生産性本部 (2018) 『労働生産性の国際比較 2018 年度版』。] <https://www.jpc-net.jp/intl_comparison/>
Agency for Cultural Affairs (2019) List of designated national treasures and important cultural properties by prefecture (as of February 1, 2019). [文化庁 (2019) 「国宝・重要文化財都道府県別指定件数一覧(平成 31 年 2 月 1 日現在)」。] <http://www.bunka.go.jp/seisaku/bunkazai/shokai/pdf/r1392247_01.pdf>

Abbreviations

GDP: gross domestic product

GRP: gross regional product

HC: Human capital

IW: Inclusive Wealth

IWI: Inclusive Wealth index

IWR: Inclusive Wealth report

JPC: Japan Productivity Center

NC: Natural capital

NTE: Nankai Trough earthquake

PC: Produced capital

PIM: perpetual-inventory-method

SDGs: Sustainable Development Goals

SNA: System of National Accounts

TFP: total factor productivity

UNSDS: United Nations Sustainable Development Summit

VSL: value of statistical life

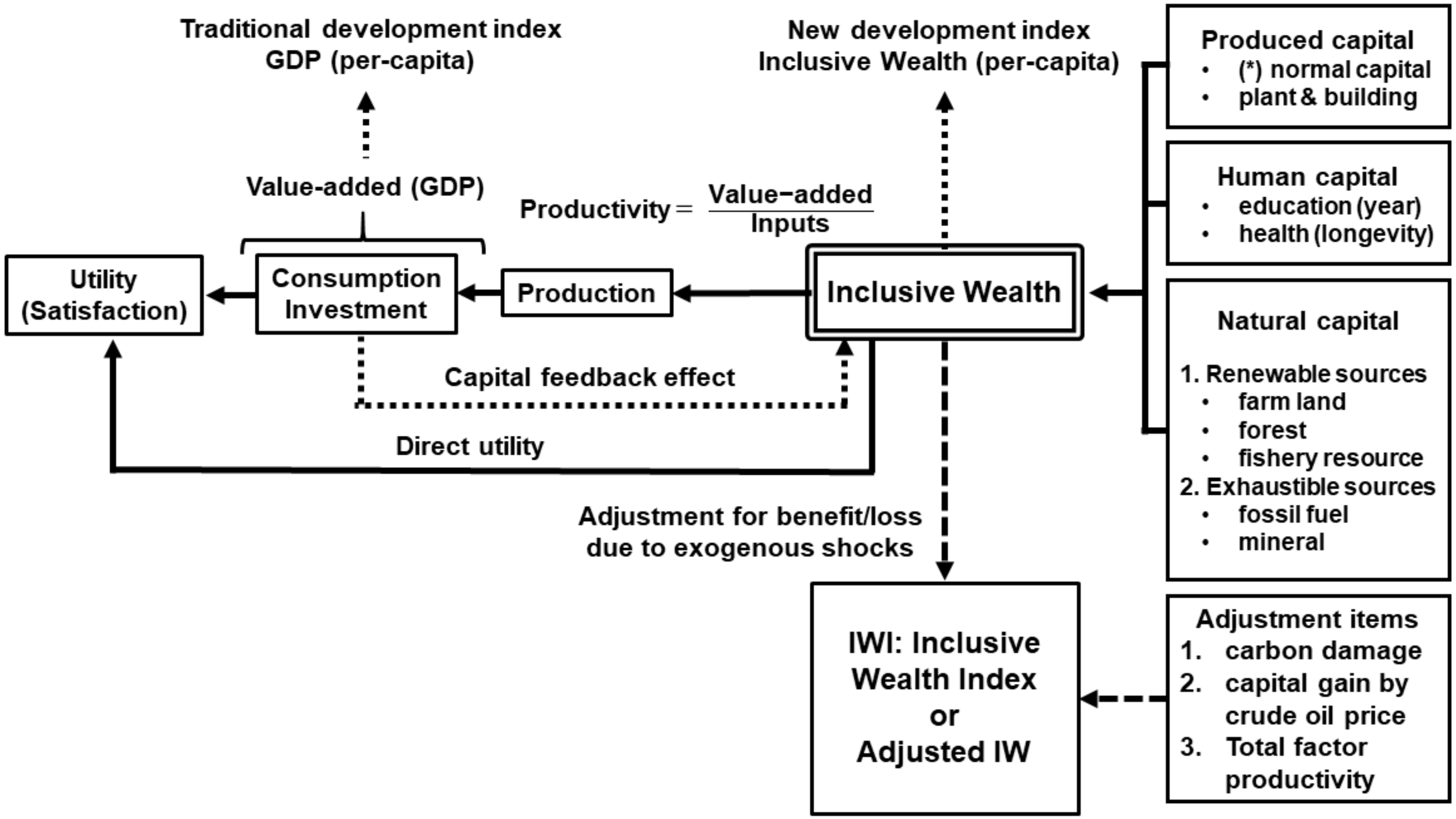

Figure 5–1. Utility model based on three capitals

Note: Modified from Managi and Kumar (2018).

Table 5–1. Revision of the Inclusive Wealth Report

Item	IWR2012	IWR2014	IWR2018
Target	· 20 countries between 1990 and 2008	· 140 countries between 1990 and 2010	· 140 countries between 1990 and 2014
Produced capital (PC)	· King and Levine (1994) · Normal "capital" in economics · Perpetual-inventory-method (discount rate: 7%)	· Discount rate: 4%	· The same as 2014
Human capital (HC)	· Arrow et al. (2012) · The value of HC is first calculated from education years and compensation from work training, and then it is multiplied by the shadow price of this value (i.e., calculated from the population, mortality rate by gender and age, labor force by gender and age, etc.) (note that the shadow price is the average wage of labor per HC). (* The shadow price is the average wage of labor per HC) · Compensation by job training (interest rate 8.5%)	· Actual estimation is the same as 2012 · Jorgenson and Fraumeni (1992) is proposed as a method of measuring educational capital	· Health capital is included in HC · The shadow price of education and health is estimated by the frontier approach (Färe et al., 2005; Tamaki et al., 2018)
Health capital	· Measured separately, not included in HC · Arrow et al. (2012) · Estimated by multiplying the expected discounted life of the population by VSL	· Health capital is not estimated · There are three effects of health capital: direct welfare, productivity, and longevity	· Included in HC
Natural capital (NC)	· Agricultural land (cultivated land, grazing land) · Forest (wood, non-wood value) · Fossil fuel · Mineral · Fishery resources (only four countries as example)	· Fishery resources are not calculated	· Introducing the value of fishery resources for the first time
Adjustment items	1. Carbon damage 2. Capital gains due to changes in crude oil prices 3. Total factor productivity (TFP)	· The same as 2012	· The same as 2012

Notes: Sources: UNU-IHDP and UNEP (2012, 2014), UNEP (2018), and Managi and Kumar (2018).

Table 5–2. Inclusive Wealth in the world (140 countries, IWR2018)

Items	1990	2014	Growth rate	Increase and decrease (140 countries over the 15 years)	
				Increase / unchanged	Decrease
Total amount ($10 billion)					
Annual GDP	30,536	56,834	86.1%	136 ctry	4 ctry
Inclusive wealth (IW)	808,548	1,216,323	50.4%	135 ctry	5 ctry
Produced capital (PC)	88,891	195,471	119.9%	136 ctry	4 ctry
Human capital (HC)	614,864	929,269	51.1%	133 ctry	7 ctry
Natural capital (NC)	104,799	91,584	−12.6%	31 ctry	109 ctry
* Population (100 million)	49.5	69.0	39.4%	127 ctry	13 ctry
Simple average (thousand dollars)					
GDP-per-capita	8.2	11.9	45.5%	128 ctry	12 ctry
IW-per-capita	220.7	210.7	−4.5%	89 ctry	51 ctry
PC-per-capita	24.8	40.8	64.2%	120 ctry	20 ctry
HC-per-capita	136.6	139.1	1.9%	122 ctry	18 ctry
NC-per-capita	59.3	30.8	−48.0%	12 ctry	128 ctry

Notes: Source: IWR2018. Objects are 140 countries in 1990 and 2014. The population is back-calculated from GDP and GDP-per-capita. The dollar is the real U.S. dollar in 2005. The rate is the simple increase in rate from 1990 to 2014.

Table 5–3. Japan's GDP and Inclusive Wealth (1990 and 2014, IWR2018)

Items	1990	(Rank)	2014	(Rank)	Growth	(Rank)
Total amount ($10 billion)						
Annual GDP	3,851	2nd	4,781	3rd	24.1%	128th
Inclusive wealth (IW)	26,237	6th	36,085	5th	37.5%	88th
Produced capital (PC)	13,360	2nd	20,939	2nd	56.7%	120th
Human capital (HC)	12,310	7th	14,688	9th	19.3%	118th
Natural capital (NC)	567	32nd	458	29th	−19.2%	89th
* Population (100 million)	1.2	7th	1.2	10th	3.0%	122nd
Simple average (thousand dollars)						
GDP-per-capita	31.2	10th	37.6	19th	20.5%	109th
IW-per-capita	212	45th	284	39th	34.0%	25th
PC-per-capita	108.2	7th	164.7	10th	52.2%	85th
HC-per-capita	99.7	43rd	115.6	42nd	15.9%	66th
NC-per-capita	4.6	104th	3.6	92nd	−21.7%	39th

Notes: Source: IWR2018. The population is back-calculated from GDP and GDP-per-capita. The dollar is the real U.S. dollar in 2005. The rate is the simple increase in rate from 1990 to 2014. The ranking is calculated for all 140 countries (however, we excluded countries for which the increase rate cannot be calculated from the rankings).

Table 5–4. Comparison of Inclusive Wealth in G7 (2014)

Items	Japan	G7 rank	U.S.	Germany	U.K.	France	Italy	Canada
Labor productivity (as of 2017) (JCP, 2018）								
Working population (million)	65.5	2nd	150.1	40.9	31.3	26.6	23.1	17.8
Working population ratio (working population divided by total population)	51.5%	1st	47.0%	50.4%	48.4%	40.1%	38.0%	50.2%
Value-added per hour (PPP$)	47.5	7th	72.0	69.8	53.5	67.8	55.5	53.7
Value-added per-capita (PPP$)	43,301	5th	59,774	50,878	43,402	42,858	39,621	46,705
Value-added per working person (PPP$)	84,027	7th	127,075	100,940	89,674	106,998	104,179	93,093
Total amount ($10 billion)								
Annual GDP	4,781	2nd	14,683	3,227	2,677	2,361	1,745	1,360
Inclusive wealth (IW)	36,085	2nd	88,166	23,091	12,962	14,733	11,917	11,659
Produced capital (PC)	20,939	2nd	47,411	11,749	7,667	9,019	7,072	4,468
Human capital (HC)	14,688	2nd	31,265	9,928	5,129	5,439	4,510	3,088
Natural capital (NC)	458	4th	9,490	1,413	166	275	335	4,103
* Population (100 million)	1.2	2nd	3.2	0.8	0.6	0.6	0.6	0.4
Per-capita index (thousand dollars)								
GDP-per-capita	37.6	5th	46	39.8	41.4	35.5	28.7	38.3
IW-per-capita	284	3rd	276	285	201	222	196	328
PC-per-capita	164.7	1st	148.7	145.1	118.7	135.6	116.3	125.7
HC-per-capita	115.6	2nd	98	122.6	79.4	81.8	74.2	86.9
NC-per-capita	3.6	6th	29.8	17.4	2.6	4.1	5.5	115.4
Productivity index (ratio)								
GDP divided by IW	13.2%	6th	16.7%	14.0%	20.6%	16.0%	14.6%	11.7%
GDP divided by PC	22.8%	7th	31.0%	27.5%	34.9%	26.2%	24.7%	30.4%
GDP divided by HC	32.6%	6th	47.0%	32.5%	52.2%	43.4%	38.7%	44.0%
GDP divided by NC	1,043.9%	2nd	154.7%	228.4%	1,612.3%	858.7%	520.9%	33.1%

Notes: The data are obtained from the JPC (2018) and IWR2018. The population is back-calculated from GDP and GDP-per-capita. The dollar is the real U.S. dollar in 2005. The rate is the simple increase in rate from 1990 to 2014. The ranking is calculated among the G7 countries.

Table 5–5. Inclusive Wealth by prefecture (2015, unit: trillion yen)

Prefectures	Production (GRP)	Rank	IW	Rank	PC	HC	NC
Hokkaido	19.0	8th	193.8	5th	97.5	43.9	52.4
Aomori	4.5	31st	37.7	33rd	21.7	12.2	3.8
Iwate	4.7	28th	42.7	26th	24.5	14.6	3.6
Miyagi	9.5	14th	72.2	14th	38.9	29.6	3.6
Akita	3.4	40th	38.3	31st	19.8	16.6	2.0
Yamagata	4.0	35th	34.3	34th	20.3	12.2	1.9
Fukushima	7.8	20th	65.1	17th	41.3	21.1	2.7
Ibaraki	13.0	11th	91.8	11th	58.8	30.2	2.8
Tochigi	9.0	15th	53.9	21st	36.0	16.6	1.3
Gunma	8.7	17th	52.5	22nd	34.2	17.2	1.2
Saitama	22.3	5th	153.3	6th	75.5	76.8	1.0
Chiba	20.2	7th	96.2	10th	79.5	14.4	2.3
Tokyo	104.3	1st	491.0	1st	273.0	217.2	0.9
Kanagawa	33.9	4th	215.6	3rd	117.1	97.3	1.2
Niigata	8.8	16th	80.6	12th	47.4	30.3	2.9
Toyama	4.6	29th	40.5	28th	24.3	14.8	1.4
Ishikawa	4.6	30th	32.4	37th	20.8	9.8	1.8
Fukui	3.2	42nd	33.3	35th	18.7	13.5	1.0
Yamanashi	3.3	41st	25.1	45th	15.6	8.7	0.8
Nagano	8.6	18th	69.9	15th	40.4	27.5	2.0
Gifu	7.6	22nd	49.8	23rd	35.1	13.2	1.5
Shizuoka	17.3	10th	102.6	9th	69.2	29.1	4.3
Aichi	39.6	2nd	198.4	4th	142.0	54.4	2.0
Triple	8.3	19th	67.0	16th	41.1	23.6	2.2
Shiga	6.2	23rd	42.5	27th	30.0	12.1	0.4
Kyoto	10.3	13th	54.0	20th	36.9	16.2	1.0
Osaka	39.1	3rd	224.7	2nd	136.9	87.4	0.4
Hyogo	20.5	6th	142.6	7th	91.2	48.6	2.7
Nara	3.6	38th	29.5	40th	16.2	12.8	0.5

Wakayama	3.5	39th	32.4	36th	17.8	13.3	1.4
Tottori	1.8	47th	20.3	47th	10.7	8.0	1.6
Shimane	2.6	45th	30.6	39th	15.2	13.3	2.1
Okayama	7.8	21st	56.7	19th	34.8	20.8	1.0
Hiroshima	11.9	12th	78.1	13th	53.5	23.1	1.5
Yamaguchi	5.9	24th	60.6	18th	32.0	26.7	1.8
Tokushima	3.1	43rd	27.8	42nd	15.0	11.8	0.9
Kagawa	3.8	36th	32.3	38th	17.0	14.7	0.6
Ehime	4.9	27th	45.8	25th	25.6	16.8	3.4
Kochi	2.4	46th	27.2	43rd	13.0	11.1	3.0
Fukuoka	18.9	9th	109.6	8th	74.2	34.0	1.4
Saga	2.8	44th	26.0	44th	15.9	9.4	0.6
Nagasaki	4.4	32nd	38.3	32nd	22.2	10.9	5.1
Kumamoto	5.6	25th	39.9	29th	28.0	10.2	1.8
Oita	4.4	33rd	38.3	30th	24.0	12.7	1.6
Miyazaki	3.6	37th	28.0	41st	18.4	6.4	3.2
Kagoshima	5.4	26th	46.9	24th	26.8	17.1	2.9
Okinawa	4.1	34th	21.1	46th	11.7	7.8	1.6

Notes: We obtain IW data from Managi (2019) and GRP data from Cabinet Office (2019). GRP is represented as a nominal value (trillion yen).

Table 5–6. IW-per-capita by prefecture (2015, unit: 10,000 yen)

Prefectures	GRP-per-capita	Rank	IW-per-capita	Rank	PC-per-capita	HC-per-capita	NC-per-capita
Hokkaido	352	34th	3,601	10th	1,812	815	974
Aomori	347	36th	2,879	27th	1,657	929	293
Iwate	369	31st	3,338	15th	1,914	1,140	285
Miyagi	406	18th	3,091	22nd	1,665	1,270	156
Akita	329	40th	3,744	5th	1,931	1,620	193
Yamagata	352	35th	3,053	23rd	1,802	1,083	168
Fukushima	409	15th	3,401	13th	2,156	1,105	141
Ibaraki	445	6th	3,146	20th	2,014	1,035	97
Tochigi	457	4th	2,729	33rd	1,823	842	64
Gunma	439	8th	2,663	34th	1,731	870	61
Saitama	307	45th	2,109	45th	1,039	1,057	13
Chiba	325	42nd	1,547	47th	1,278	232	37
Tokyo	772	1st	3,633	9th	2,020	1,607	6
Kanagawa	372	26th	2,362	40th	1,283	1,066	14
Niigata	384	24th	3,497	12th	2,056	1,315	126
Toyama	436	10th	3,796	4th	2,280	1,384	132
Ishikawa	396	20th	2,811	29th	1,800	850	160
Fukui	411	14th	4,228	3rd	2,379	1,716	132
Yamanashi	389	22nd	3,006	25th	1,866	1,039	101
Nagano	408	17th	3,333	16th	1,925	1,311	97
Gifu	372	27th	2,450	39th	1,728	648	74
Shizuoka	467	3rd	2,772	31st	1,869	787	116
Aichi	529	2nd	2,651	35th	1,897	727	27
Triple	456	5th	3,689	7th	2,266	1,301	122
Shiga	436	9th	3,009	24th	2,125	857	27
Kyoto	396	21st	2,070	46th	1,413	620	37
Osaka	442	7th	2,542	37th	1,549	989	4
Hyogo	370	28th	2,576	36th	1,649	878	49
Nara	262	47th	2,164	43rd	1,191	935	39
Wakayama	366	32nd	3,368	14th	1,845	1,381	142

Tottori	306	46th	3,538	11th	1,861	1,396	280
Shimane	370	30th	4,407	1st	2,186	1,916	306
Okayama	405	19th	2,949	26th	1,813	1,083	53
Hiroshima	420	12th	2,746	32nd	1,881	813	52
Yamaguchi	418	13th	4,311	2nd	2,280	1,900	131
Tokushima	408	16th	3,672	8th	1,990	1,560	123
Kagawa	387	23rd	3,313	17th	1,746	1,501	66
Ehime	355	33rd	3,307	18th	1,851	1,210	246
Kochi	330	38th	3,729	6th	1,790	1,529	409
Fukuoka	370	29th	2,148	44th	1,454	667	28
Saga	331	37th	3,116	21st	1,906	1,132	78
Nagasaki	318	43rd	2,778	30th	1,615	793	371
Kumamoto	312	44th	2,236	41st	1,565	570	101
Oita	375	25th	3,286	19th	2,061	1,091	134
Miyazaki	329	39th	2,538	38th	1,671	581	286
Kagoshima	327	41st	2,845	28th	1,628	1,040	178
Okinawa	427	11th	2,176	42nd	1,207	803	166

Notes: We obtain IW data from Managi (2019) and GRP data from Cabinet Office (2019). GRP is represented as a nominal value (trillion yen).

Table 5–7. IW-productivity by prefecture (2015)

Prefectures	IW-productivity	Rank	PC-productivity	HC-productivity	NC-productivity
Hokkaido	10%	41st	19%	43%	36%
Aomori	12%	27th	21%	37%	118%
Iwate	11%	36th	19%	32%	130%
Miyagi	13%	21st	24%	32%	260%
Akita	9%	45th	17%	20%	171%
Yamagata	12%	30th	20%	32%	209%
Fukushima	12%	28th	19%	37%	290%
Ibaraki	14%	17th	22%	43%	460%
Tochigi	17%	9th	25%	54%	716%
Gunma	16%	10th	25%	50%	715%
Saitama	15%	14th	30%	29%	2,307%
Chiba	21%	2nd	25%	140%	868%
Tokyo	21%	1st	38%	48%	11,939%
Kanagawa	16%	11th	29%	35%	2,735%
Niigata	11%	37th	19%	29%	305%
Toyama	11%	32nd	19%	31%	331%
Ishikawa	14%	18th	22%	47%	247%
Fukui	10%	42nd	17%	24%	311%
Yamanashi	13%	23rd	21%	37%	384%
Nagano	12%	25th	21%	31%	422%
Gifu	15%	13th	22%	57%	503%
Shizuoka	17%	8th	25%	59%	402%
Aichi	20%	3rd	28%	73%	1,972%
Triple	12%	24th	20%	35%	374%
Shiga	14%	15th	21%	51%	1,612%
Kyoto	19%	5th	28%	64%	1,081%
Osaka	17%	6th	29%	45%	10,767%
Hyogo	14%	16th	22%	42%	754%
Nara	12%	26th	22%	28%	679%
Wakayama	11%	38th	20%	27%	258%
Tottori	9%	46th	16%	22%	109%
Shimane	8%	47th	17%	19%	121%
Okayama	14%	20th	22%	37%	760%
Hiroshima	15%	12th	22%	52%	806%
Yamaguchi	10%	43rd	18%	22%	319%
Tokushima	11%	35th	21%	26%	331%
Kagawa	12%	29th	22%	26%	585%
Ehime	11%	39th	19%	29%	144%
Kochi	9%	44th	18%	22%	80%
Fukuoka	17%	7th	25%	55%	1,342%
Saga	11%	40th	17%	29%	425%
Nagasaki	11%	33rd	20%	40%	86%
Kumamoto	14%	19th	20%	55%	309%
Oita	11%	34th	18%	34%	280%
Miyazaki	13%	22nd	20%	57%	115%
Kagoshima	11%	31st	20%	31%	184%
Okinawa	20%	4th	35%	53%	257%

Notes: We obtain IW data from Managi (2019) and GRP data from Cabinet Office (2019). GRP is represented as a nominal value (trillion yen). We calculate IW-productivity by GRP divided by IW, PC-productivity by GRP divided by PC, HC-productivity by GRP divided by HC, and NC-productivity by GRP divided by NC.

Table 5–8. Damage prediction of Nankai Trough earthquake: The prediction of GRP decrease is based on the direct damage amount and the HC loss and transfer.

Prefectures	Direct damage amount (100 thousand yen) (original data)	GRP decrease amount (prediction, 100 thousand yen)	# of fatalities (person) (original data)	# of evacuees on 1st day (original data)	# of evacuees on 1st week (original data)	Conversion to HC (100 million yen)		
						Fatalities (loss amount)	Evacuation on 1st day (transfer amount)	Evacuation on 1st week (transfer amount)
Ibaraki	500	111	20	1,300	400	2	135	41
Tochigi	—	—	—	—	30	—	—	3
Gunma	—	—	—	10	400	—	1	35
Saitama	2,000	592	—	4,300	7,100	—	454	750
Chiba	6,000	1,526	1,600	58,000	7,900	37	1,343	183
Tokyo	6,000	2,293	1,500	15,000	20,000	241	2,410	3,214
Kanagawa	7,000	2,028	2,900	77,000	40,000	309	8,208	4,264
Niigata	—	—	—	—	10	—	—	1
Toyama	—	—	—	—	90	—	—	12
Ishikawa	200	44	—	400	600	—	34	51
Fukui	3,000	518	—	7,100	8,800	—	1,219	1,510
Yamanashi	9,000	1,878	400	22,000	86,000	42	2,286	8,935
Nagano	5,000	1,059	50	8,900	27,000	7	1,167	3,541
Gifu	13,000	2,795	200	32,000	89,000	13	2,074	5,768
Shizuoka	199,000	49,754	109,000	900,000	1,100,000	8,581	70,849	86,593
Aichi	307,000	85,549	23,000	1,300,000	1,900,000	1,672	94,491	138,102
Triple	169,000	34,035	43,000	560,000	690,000	5,596	72,882	89,801
Shiga	16,000	3,284	500	42,000	160,000	43	3,600	13,714
Kyoto	45,000	12,625	900	190,000	340,000	56	11,786	21,091
Osaka	240,000	68,554	7,700	1,200,000	1,500,000	762	118,683	148,353

Hyogo	50,000	11,231	5,800	240,000	320,000	509	21,073	28,097
Nara	34,000	7,489	1,700	140,000	290,000	159	13,088	27,112
Wakayama	99,000	19,640	80,000	450,000	460,000	11,045	62,130	63,511
Tottori	1,000	164	—	1,200	1,500	—	168	209
Shimane	1,000	169	—	1,100	1,800	—	211	345
Okayama	32,000	7,154	1,200	100,000	250,000	130	10,830	27,075
Hiroshima	30,000	6,695	800	100,000	180,000	65	8,128	14,630
Yamaguchi	7,000	1,283	200	23,000	26,000	38	4,369	4,939
Tokushima	70,000	14,356	31,000	360,000	370,000	4,835	56,144	57,703
Kagawa	39,000	8,646	3,500	160,000	220,000	525	24,021	33,029
Ehime	109,000	20,900	12,000	400,000	540,000	1,452	48,415	65,360
Kochi	106,000	19,508	49,000	510,000	500,000	7,491	77,963	76,434
Fukuoka	2,000	509	10	3,200	2,600	1	213	173
Saga	100	17	—	90	300	—	—	34
Nagasaki	1,000	197	80	18,000	1,900	6	1,427	151
Kumamoto	4,000	796	20	12,000	22,000	1	683	1,253
Oita	20,000	3,642	17,000	140,000	120,000	1,855	15,277	13,095
Miyazaki	48,000	9,455	42,000	310,000	350,000	2,439	18,000	20,323
Kagoshima	7,000	1,406	1,200	32,000	29,000	125	3,327	3,015
Okinawa	1,000	354	10	7,300	400	1	586	32
Total	16,888,800	427,397	436,290	7,425,900	9,662,830	48,036	757,686	962,484

Notes: We use data on the direct damage amount from Asahi Shimbun Digital (2015), PC data from Managi (2019), and GRP data (nominal value) from Cabinet Office (2019). The estimated GRP loss is calculated as the direct damage amount divided by PC times GRP. Therefore, this estimation of the GRP loss amount is the maximum loss amount in a year, and the loss amount also decreases, depending on the recovery of the annual facility restoration rate. We use data on population and PC from Managi (2019) and fatalities and evacuees (first day and first week) due to NTE (in the worst case) from Asahi Shimbun Digital (2015) and the Cabinet Office (2014, 2015). The simple total number of fatalities (summing up the values of each prefecture) is 436 thousand, but it is assumed that the maximum number of fatalities is 323 thousand total. When converting to HC, we calculate it as the number of fatalities divided by the population times HC.