Center for Strategic Management & Innovation

Study Report Vol.3

GDP+i

- A Proposed New Economic Indicator for the Digital Age -

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Contents

Summary

It has been nearly 90 years since the concept of GDP (Gross Domestic Product) emerged as an indicator of a country's economic strength, level of development, and the welfare of its people. Simon Kuznets, the godfather of GDP statistics, published a report in 1934 that was the first to visualize that U.S. national income had halved between 1929 and 1932, which was widely read with shock by many in the U.S. at the time. Subsequently, governments began to compute GDP statistics for their countries, keeping a close eye on how large their economies were, how many percentage points their GDPs changed year on year, whether their GDPs were higher than other countries, and, if they were low, what the causes were. Among the various economic and social indicators, GDP became the single most important indicator on a country's report card.

However, GDP has been subject to criticisms since its inception, for example, for failing to take into account the environmental destruction ("negative externalities") caused by production activities; for failing to value activities that are not traded in the market but are valuable, such as domestic labor; for the rule that government spending to support people's livelihoods and improve their wellbeing is added to GDP as an output, even though it should be subtracted from GDP as a cost (in other words, as long as government spending is increased, GDP can be increased as much as desired), and for the fact that material wealth alone, as indicated in GDP, does not express people's true wellbeing.

This report illustrates how the rapid digitalization of society in the 21st century has further

reduced the usefulness of GDP statistics. The key to this is the "consumer surplus" created by digital technology. Further, with the aim of eliminating the "out-of-focus" nature of GDP statistics, Nomura Research Institute (NRI) proposes a new indicator called "GDP+i".

GDP+i evaluates economies and societies not in terms of lines, but in terms of a plane. This can be seen as a major shift in values, abandoning the overly simplistic view of economic evaluation that "the higher the number, the better", and moving toward a plethora of potentialities that could be considered the best for a country, a region, or its people. As the name of the new indicator suggests, we also believe that GDP+i is analogous to the emergence of the complex number (a + bi) in mathematics. This paper argues that if material economic outcomes are "real numbers = a", then the invisible satisfaction and utility generated by digital technology are "imaginary numbers = i", and the economy should be evaluated from the perspective of the complex plane, which combines real and imaginary numbers.

1 What GDP (Gross Domestic Product) Does and Does Not Measure

(1) The Origin of GDP Statistics

The archetype of GDP statistics used in countries around the world today was established in the 1940s. These calculation rules were called the National Income Accounts or the System of National Accounts, and even before 1940, economists such as Simon Kuznets in the U.S. and Colin Clark in the U.K. had taken the lead in collecting data and formulating rules. The report[1] published by Kuznets in 1934 was the first to show numerically that U.S. national income had halved during the Great Depression from 1929 to 1932. It was a shocking report that became a bestseller in the U.S. at the time.

GDP statistics were subsequently introduced in many countries around the world, and as of 2022, most countries in the world publish their GDP. This made GDP the most important indicator for policy makers, and how large their country's GDP was and whether it had increased/decreased compared to last year became key questions.

GDP statistics are characterized by their ability to look at economic conditions not only from the perspective of production, but also from the perspectives of expenditure and distribution, based on the "three-sided equivalence principle". The logic is that the amount of money produced in a given period is equal to the amount of money spent by someone else on purchases,

[1] Kuznetz S. "National Income in 1929-32. A report to the Senate, 73rd Congress, 2nd Session. Washington DC" 1934, pp. 5-6

which in turn is also the amount of money earned by someone else. In other words, GDP statistics enable economic assessments from the three perspectives of production, expenditure, and distribution, and looking at the breakdown of each allows governments to consider a variety of policies. For example, policy packages such as industrial promotion measures for specific industries (production side), fiscal expenditure policies such as large-scale public investment (expenditure side), and taxation policies (distribution side) have developed alongside GDP statistics.

(2) Problems with GDP

However, GDP (or the national income accounting as it was initially called) has long been noted for its problems. Kuznetz sought to measure the economic wealth of a country's people through national income calculations, but contrary to his original intention, the U.K., and the U.S., which were entering World War II, prioritized the visualization of a country's productive and military power. If GDP is a measure of the economic wealth of a country's people, then infrastructure investment and military spending for national defense should be subtracted from GDP as expenses to achieve the wealth of the people, but instead it was decided to add them to GDP. As Kuznets himself pointed out, this policy only tautologically acknowledges that government spending increases economic growth figures, not whether it increases people's wealth. Masahiko Shimizu, my mentor and professor emeritus at Keio University, rephrased

Kuznets' words to make them easier to understand, expressing them as "GDP increases even if the government buys bullets and sinks them to the bottom of the ocean without using them".

It has long been pointed out that the amount of income alone cannot explain life satisfaction or happiness. Bertrand Russell, in his "The Conquest of Happiness", states that money helps increase happiness up to a point, but beyond that point it does not seem to increase happiness[2]. Economist Easterlin analyzed data on (1) whether people in countries with high income levels are happier than people in countries with low-income levels, and (2) whether an increase in the average income of a country increases the level of happiness of its people and concluded that there is little relationship in both cases[3]. This is known as the Easterlin paradox. Easterlin argued that national income is an indicator of the "economic welfare" level, but not of the broader concept of "social welfare", and that an increase in the economic welfare level does not necessarily mean an increase in the social welfare level.

GDP is, to begin with, an indicator that evaluates quantity and is not good at evaluating quality. It is also not intended to measure subjective aspects such as life satisfaction and happiness. Robert Kennedy, brother of J.F. Kennedy and Attorney General of that administration, said, "It measures neither our wit nor our courage, neither our wisdom nor our learning, neither our compassion nor our devotion to our country, it measures everything in short, except that which

[2] Bertrand Russell, The Conquest of Happiness, translated by Sadao Ando, Iwanami Bunko, p. 54

[3] "Does Economic Growth Improve the Human Lot? Some Empirical Evidence" Richard A. Easterlin, 1974

makes life worthwhile."

Many other problems have been pointed out by many experts, such as the fact that the environmental destruction caused by production activities is not evaluated as a negative aspect, and that activities which are not traded in the market but are valuable, such as domestic labor, are not accounted for.

(3) History of "Beyond GDP" Indicator Development

For this reason, many experts have been proposing a new indicator to replace GDP (commonly known as the Beyond GDP indicator). The overall picture[4], as summarized by economists Fleurbaey and Blanchet, is shown in Figure 1.

There are four major approaches to Beyond GDP indicators. Of these, the accounting/monetization approach has the longest history and is represented by the Measurement of Economic Welfare (MEW), proposed by Tobin and Nordhaus in 1972. Tobin et al were aware of the problem that GDP does not represent the level of human welfare, nor does it provide information about how much humanity can continue to consume into the future. Therefore, using GDP as a starting point, they attempted to create a more accurate indicator of welfare levels by adding factors that improve human welfare (leisure time, domestic labor,

[4] "Beyond GDP: Measuring Welfare and Assessing Sustainability" Marc Fleurbaey, Didier Blanchet, Oxford University Press, 2013

etc.) and subtracting factors that negatively affect welfare (commuting, air pollution, etc.).

The synthetic index approach is not concerned with monetary conversion. For example, the Human Development Index (HDI), published by the United Nations Development Program (UNDP) since the 1990s, is a composite index of statistics relating to health, education, and income by country and region. The HDI is based on the capability approach advocated by Nobel Prize winner in economics Amartya Sen.[5]

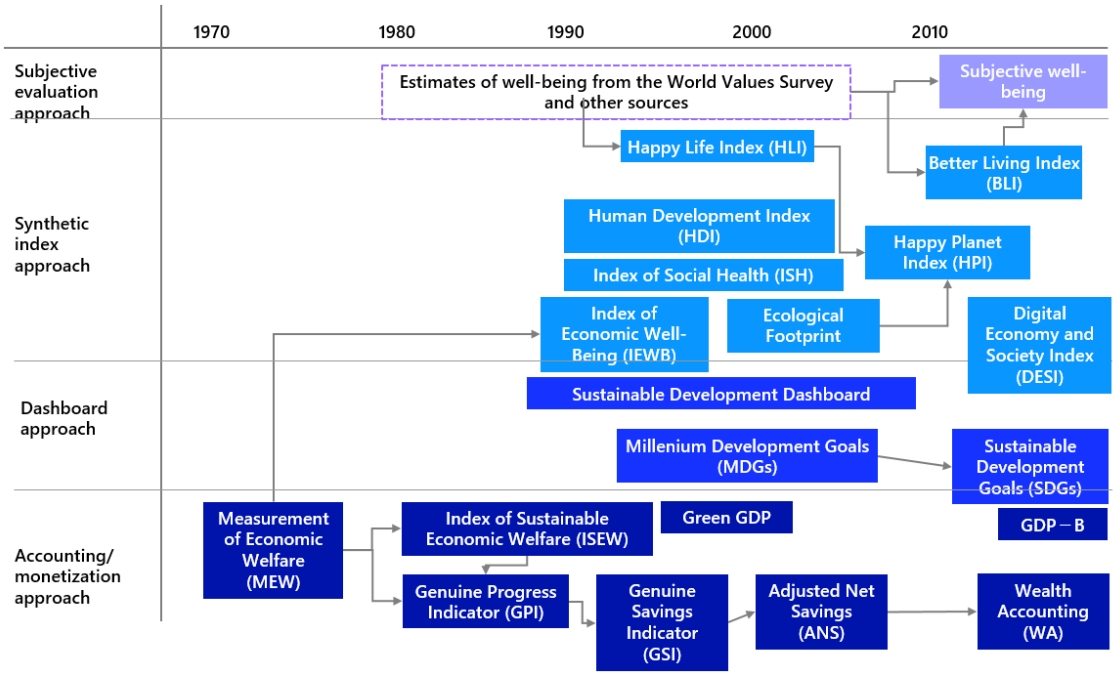
Another non-monetary approach is the subjective evaluation approach. There have been previous attempts to index subjective perceptions, such as the level of happiness of a country's people, but they were all built around objective indicators. However, since the 2010s, the Organization for Economic Cooperation and Development (OECD) has also put effort into measuring "subjective well-being (SWB)" through surveys of individual people. According to OECD guidelines, there are five core question areas for measuring subjective well-being: life satisfaction, purpose in life (sense of accomplishment), happiness, anxiety, and mental depression.

While the approaches introduced so far, whether monetary or non-monetary, have tried to create a single indicator, there is another approach that does not stick to a single indicator—the dashboard approach. This approach seeks to gain a bird's-eye view of the economy and society

[5] For more on the capability approach, see Amartya Sen, "Inequality Reexamined: Potential and Freedom", translated by Yukio Ikemoto et al, Iwanami Gendai Bunko, 2018, etc.

through multiple indicators. Typical examples of the dashboard approach are the Millennium Development Goals (MDGs), formulated by the United Nations in 2001, and their successors, the Sustainable Development Goals (SDGs), adopted in 2015.

Figure 1: History of Beyond GDP Indicator Development and Typical Examples



Source: NRI, based on "Beyond GDP", Marc Fleurbaey and Didier Blanchet (*DESI and GDP-B in the figure have been added by NRI).

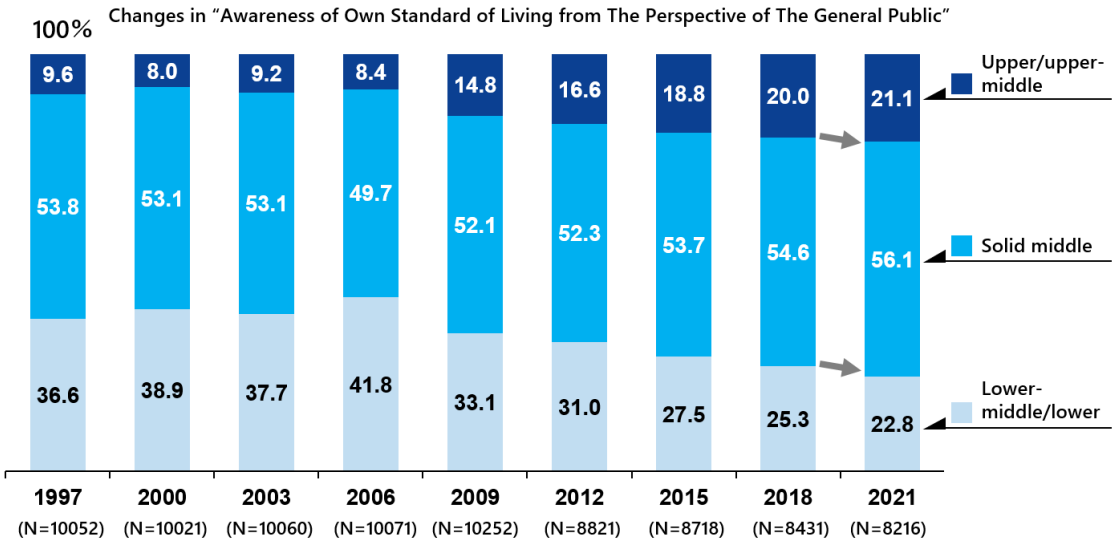
(4) Consumer Surplus Generated by Digital Technology

The era in which most of the world's population is connected online has arrived. In 2021, the number of smartphone users was estimated to exceed 6.2 billion out of a global population of 8 billion. With the launch of the iPhone in 2007, smartphones quickly spread throughout the world. Smartphones and the apps available on them have significantly changed our daily lives.

Aside from the cost of connecting to the Internet, voice and video calls, maps, social networking, calculators, weather, clocks, pedometers, and other functions are now available as free apps, and we can also enjoy music and videos via the Internet anytime, anywhere.

Figure 2 shows the results of the Survey of 10,000 Consumers conducted by NRI once every three years in Japan. The respondents were asked to rate their "awareness of their own standard of living from the perspective of the general public" on a 5-point scale. As can be seen, the number of respondents who consider themselves to be in the "upper" or "upper-middle" class has been slowly increasing since around 2009. In other words, Japanese people's overall level of life satisfaction is improving. In 2009, it just so happened that the global financial crisis triggered by the subprime lending problems in the U.S. kicked off a period of low growth (long-term stagnation) worldwide. Looking at Japan's GDP statistics, there is no indication that the economic growth rate increased starting around 2009. Average wages did not increase either. In other words, the main economic indicators do not explain this phenomenon at all.

Figure 2: Changes in "Awareness of Own Standard of Living from The Perspective of The General Public"



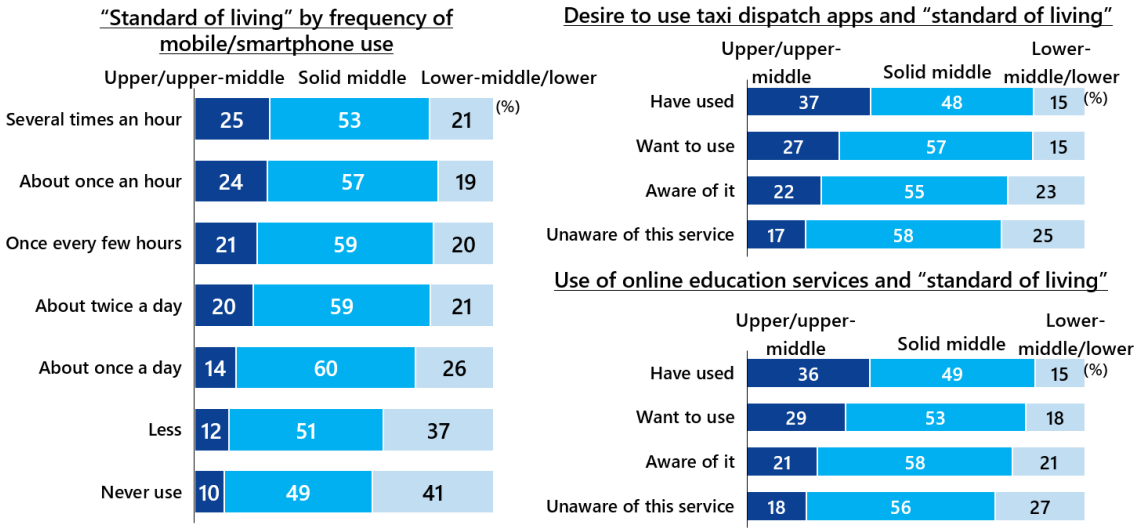
Source: NRI "Survey of 10,000 Consumers" (1997-2021)

Note: Excluding non-responses.

So, what is behind these results? The key to the answer lies in the timing of the change around 2009. As mentioned earlier, the iPhone debuted in the U.S. in 2007 and in Japan in 2008, and the number of users exploded; our hypothesis is that the penetration and diffusion of digital services embodied by smartphones led to an increase in Japanese people's awareness of their standard of living.

In fact, a closer look at the characteristics of the respondents who identified themselves as "upper/upper-middle class" revealed that those with higher incomes were more likely to do so. In addition, the data also revealed that those who use smartphones more frequently and those who use various digital services such as taxi-dispatch services and online learning services have a higher awareness of their own standard of living (Figure 3).

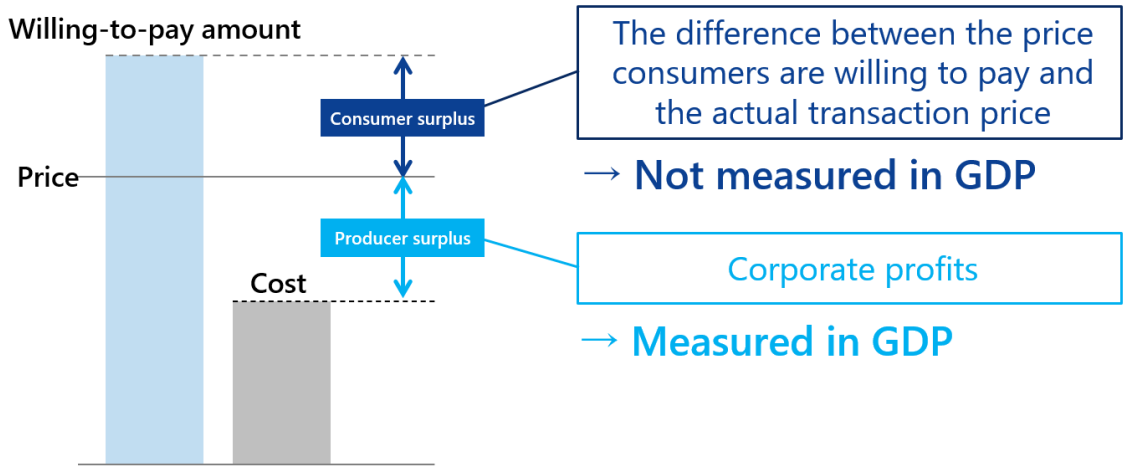
Figure 3: Frequency of Mobile/Smart Phone Use, Use of Various Digital Services and "Standard of Living"



Source: NRI "Survey of 10,000 Consumers" (2021)

We turned to the concept of "consumer surplus" in economics to consider the positive aspects of life satisfaction created by digital technology. Consider a particular commodity (e.g., shoes). The difference between the cost of producing the good and its price is called "producer surplus" and corresponds to the company's profit. In contrast, "consumer surplus" is the difference between the maximum amount consumers are willing to pay for a product (willingness to pay) and the actual price. In other words, if a pair of shoes that consumers were willing to pay 10,000 yen for were sold for 6,000 yen, they would have received a "bargain" worth 4,000 yen.

Figure 4: Producer Surplus and Consumer Surplus



As noted in Figure 4, producer surplus is the profits of companies and is measured in GDP. In contrast, consumer surplus is the subjective satisfaction gained by consumers and is not measured in GDP. We believe that digital technology is greatly expanding consumer surplus.

There are three reasons for this: first, the Internet has facilitated price comparisons, creating downward pressure on prices. The Internet has brought "search costs" down to zero. Now people can easily find out how much the same product costs at different stores by looking at price comparison sites, and buy online from the cheapest store. As Figure 4 shows, falling prices increase consumer surplus.

Second, distribution and reproduction costs have been significantly reduced as some products, such as music and movies, have become intangible digital content. Even for tangible goods, distribution costs have been reduced through direct purchases from producers online, rather than through convoluted distribution channels. Thus, digital technology contributes significantly to cost reductions for producers, which are partly reflected in lower prices. Lower

costs and the resulting lower prices increase consumer surplus.

Third, and this is the most important reason, is the emergence of free digital services. For example, social networking services (SNS) can be used free of charge, apart from the cost of an Internet connection. The fact that they are free does not mean that they have no value. NRI once conducted a survey of Facebook and other major SNS users asking them the maximum they would pay per month if they were to be charged starting next month (see below for details). Many responded zero yen, but others gave higher amounts, with the average being between 1,000 yen and 2,000 yen per month. Multiplying this by the number of users at the time of the survey and further annualizing, the results show that major SNSs generate an annual consumer surplus of about 20 trillion yen in Japan. SNSs earn profits from advertisers, and these profits are included in GDP as producer surplus, but the 20 trillion yen consumer surplus (the total amount users would be willing to pay for SNSs) is not included in GDP. In addition to SNSs, services that can be used for free, such as Google's search service and map app, have many users, and it is easy to imagine that, like SNSs, they are generating a huge consumer surplus.

For the above reasons, digital technology has greatly expanded "consumer surplus", which is not measured by GDP. While factors not measured by GDP, such as environmental destruction and domestic labor, have been pointed out in the past, "consumer surplus" is gaining prominence as a major new factor that reduces the usefulness of GDP.

2 Methodology for Estimating Consumer Surplus Generated by Digital Technology

How do we estimate the consumer surplus generated by digital technology? Currently, various researchers are examining and improving the methods, which can be roughly classified into three categories: (1) the survey method, (2) the experimental method, and (3) the utility function method. Methods (1) and (2) create consumer surplus data from scratch, while method (3) transforms existing data into consumer surplus using econometric methods.

Figure 5: Methodology for Estimating Consumer Surplus Generated by Digital Services

① Survey method	● Ask consumers the monetary value they would assign to a particular digital service (e.g., a search engine such as Google). ● There are two categories: (WTP: Willingness to Pay), which is the maximum amount a consumer is willing to pay for a particular service, and willingness to accept (WTA: Willingness to Accept), which is the amount required to give up using that service. ● Features methods such as (a) asking respondents to respond directly with an amount, (b) asking respondents to respond with a range of amounts, or (c) estimating amounts by showing pairs of services and asking respondents to answer multiple questions about which they value more. ● Suitable for estimating consumer surplus for specific digital services, but not for estimating digital services as a whole. ● A representative example is NRI's 2019 consumer surplus estimate study for SNSs.
② Experimental method	● Used to estimate the value of specific digital services (e.g., Facebook). ● Gathers participants for an experiment that involves an actual exchange of money (reward). The most common method is to ask the willingness to accept (WTA). ● Like the survey method, it is not suitable for estimating consumer surplus of digital services as a whole. ● A representative example is the Facebook consumer surplus estimate study conducted in the U.S. by Brynjolfsson et al.
③ Utility function method	● Allows not only value estimation of specific digital services, but also monetary value estimation of digital services as a whole (e.g., the overall amount of consumer surplus generated by digital technology in Japan). ● Estimates utility for the country using statistical data on time spent on the Internet, (non-online) entertainment/work/sleep, Internet speed, income, consumer spending, etc., and the difference with the utility in a hypothetical state where the Internet is not available is converted to monetary terms. ● While it has the advantage of being able to estimate the consumer surplus generated by digital services as a whole, it has the drawbacks of model validity, difficulty in comprehension, and difficulty in verifying estimates.

(1) Survey method

An example of the survey method is the SNS consumer surplus estimate conducted by NRI in 2019 in collaboration with Dr. Tsuji of Kobe International University and Dr. Kakizawa of Osaka University.[6] In this study, users of LINE, Facebook, Instagram, and Twitter in Japan were asked about their willingness to pay (WTP) and willingness to accept (WTA) using an Internet questionnaire. The WTP is the maximum amount of money they would be willing to pay to use the service, and the WTA is the minimum amount of money they need to receive as compensation for giving up the use of the service. For example, the question asking WTP to LINE users was as follows.

> Q. Currently, you do not have to pay any particular fee to use the basic LINE service, but we will assume that the fee structure is a blank slate. How much would you be willing to pay per month to use the current LINE service? Please keep in mind that this amount would be paid from your household budget each month, and therefore would have an impact on your household budget.

Then, as initial values, 500 yen, 1,500 yen, and 3,000 yen are randomly presented to respondents, who then select "yes" or "no" as to whether or not they would pay those amounts. If the respondent answers "No" to the 500-yen question, the next question will be "Would you pay 250 yen?" The process is then repeated, with respondents choosing "yes" or "no" again,

[6] The "Personal" Value of SNSs - The consumer surplus generated by major SNSs in Japan is 20 trillion yen per year -, Takeshi Mori and Hiroyuki Nitto, NRI Report, January 2020.
(https://www.nri.com/jp/knowledge/report/lst/2020/scs/digital/0129)

until each respondent's response reaches one of several monetary categories.

The survey estimated the consumer surplus generated by the four SNSs in Japan as a whole to be about 20 trillion yen by taking the average of WTP and WTA for each SNS, taking it as the average consumer surplus per user, multiplying it by the number of users in Japan, and then multiplying it by 12 (annualized). The survey method is suitable for estimating the consumer surplus of specific digital services, but is not suitable for estimating the consumer surplus of digital services as a whole, as it would require a huge survey.

(2) Experimental Method

An example of the experimental method is that of Brynjolfsson et al. with Facebook users in the U.S.[7]. As the Facebook users participating in the experiment came to the venue, they were asked to choose a piece of paper from a box. The piece of paper indicates some amount from $1 to $1,000, and the experiment participants are told that if they do not use Facebook for one month, this amount will be given to them after one month. This surveyed the willingness to accept (WTA) amount to give up using Facebook.

The following method was devised to check whether a participant subsequently used Facebook. The supervisor of the experiment changed the password of the participant's

[7] Brynjolfsson. E. et. al. (2019). "Using massive online choice experiments to measure changes in well-being" PNAS Vol. 116 | No. 15, 7250-7255, https://doi.org/10.1073/pnas.1815663116

Facebook account then and there, wrote the new password on a piece of paper, sealed it in an envelope, and gave it to the participant. If the participant returned one month later and the seal was not opened, he or she did not use Facebook; if the seal was opened, the participant was deemed to have been unable to resist logging in with the new password. The results of this experiment showed that about 80% of those who drew a $1 piece of paper continued to use Facebook (i.e., forfeited the reward). In contrast, about 80% of those who drew a $1,000 piece of paper gave up using Facebook (i.e., decided that the reward was better). In this study of how many people could refrain from Facebook use at different reward amounts, the median was $37.76/month, which Brynjolfsson et al. state is the consumer surplus that Americans get from Facebook.

The strength of the experimental method is that it can reveal the monetary value that each person perceives with respect to digital services by preparing actual rewards, whereas the survey method poses only hypothetical questions. However, as with the survey method, there is a drawback that it is difficult to collect a large number of samples (several hundred at the most). Further, as with the survey method, it is suitable for estimating consumer surplus for individual digital services, but it is difficult to apply it to digital services as a whole given the large amount of work involved.

(3) Utility Function Method

An example of consumer surplus estimation using the utility function method is the study by Brynjolfsson and Oh[8]. In this study, the consumer surplus generated by digital services as a whole (overall Internet usage) is estimated from a utility function for the entire U.S. The estimates of consumer surplus for Japan presented later in this paper are calculated by applying this model (hereafter referred to as the "BO model") to Japan.

The BO model uses a utility function called the CES function, in which the "elasticity of substitution" between goods and services is held constant. To put it simply, it assumes that the degree of substitution of one particular good or service for another in conjunction with a change in price is "constant", such as the degree of substitution of commodity B due to a rise in the price of commodity A, or the degree of substitution of commodity C due to a rise in the price of commodity B. Although it is questionable whether this assumption is valid, it is one that is often made when estimating utility functions. Strictly speaking, however, the BO model assumes that only the degree of substitution between the Internet and TV is greater than the other combinations (i.e., the Internet and TV are highly competitive and easily substituted).

The BO model estimates a utility function on the basis of time statistics such as the average time Americans spend on the Internet, watching TV, and working, as well as statistics on

[8] Brynjolfsson. E. and Oh. JooHee (2012). "The Attention Economy: Measuring the Value of Free Digital Services on the Internet" Thirty Third International Conference on Information Systems, Orlando 2012

average wages, Internet connection costs, average Internet speed, and consumer spending other than Internet access costs. From this, the utility that Americans are getting from using the Internet is estimated. In contrast, the model also estimates utility in a hypothetical situation where Internet access is not available. By setting the cost of an Internet connection extremely high, it creates a situation in which no one uses the Internet. Let us call the former "with Internet utility" and the latter "without Internet utility." Since "with Internet utility" > "without Internet utility", the difference between the two is the utility of digital services obtained by using the Internet, which is converted into money using the concept of equivalent valuation (EV), and is deemed the consumer surplus generated by digital services.

The paper estimates the consumer surplus generated by digital services in the U.S. from 2007-2011, and the results show that an average consumer surplus of $838 billion per year was generated, which is equivalent to 5.8% of the U.S. GDP. In other words, that much value is not accounted for in the GDP statistics.

The utility function method has the advantage of being able to estimate the consumer surplus generated by digital services as a whole using statistical data, but it also has the disadvantages of being a complicated model structure that is difficult to understand, questions about the validity/reliability of the utility function, and difficulties in verifying estimates.

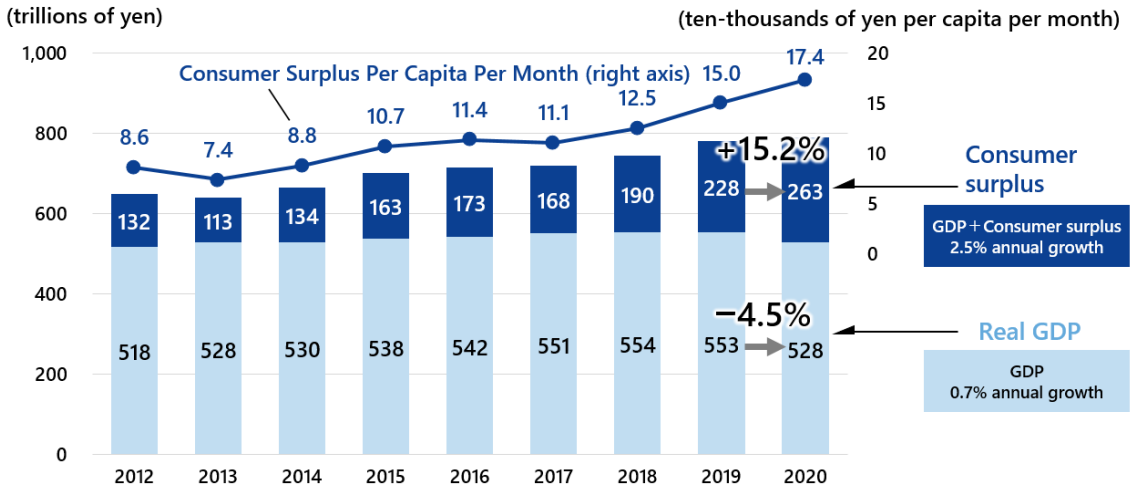
3 Proposed New Economic Indicator for the Digital Age: "GDP+i"

(1) Consumer Surplus Generated by Digital Services in Japan

Adopting the BO model introduced in the section on the utility function method, NRI estimated the consumer surplus generated by digital services in Japan in collaboration with Dr. Oh, who constructed the model. Figure 6 shows the estimated consumer surplus in Japan together with GDP.

The consumer surplus is estimated for the period from 2012 to 2020. Japan's GDP during this period increased only 0.7% per year, from 518 trillion yen in 2012 to 528 trillion yen in 2020. The drop in GDP in 2020 due to the COVID-19 pandemic was particularly large at -4.5%. In contrast, the consumer surplus generated by digital services in Japan as a whole was 132 trillion yen in 2012 and nearly doubled to 263 trillion yen in 2020, amounting to about 50% of GDP in 2020. The consumer surplus per capita per month increased from 86,000 yen in 2012 to 174,000 yen in 2020.

Figure 6: Consumer Surplus Generated by Digital Services and GDP (Japan)



Source: GDP from Cabinet Office; consumer surplus from joint research by NRI and Handong Global University (2022)

Looking at GDP alone, Japan appears to be in a "prolonged stagnation", but the sum of GDP and consumer surplus shows a steady increase. In fact, the rate of change in the sum of GDP and consumer surplus grew at an annual rate of 2.5% over the same period. In other words, the improvement in the Japanese people's standard-of-living awareness shown in Figure 2 cannot be explained by looking at GDP alone but can ultimately be explained by looking at both GDP and consumer surplus.

Why is consumer surplus growing? Following the mechanism of the BO model, most of it can be explained by the increase in the amount of time spent on the Internet. Economics has the concept of opportunity cost, which means that if a person uses Internet services for one hour, he or she is giving up on income that could have been earned if the person had spent that hour at work. In other words, the "opportunity to earn income" exists as a cost, and the fact that people are using online services even at that cost means that they recognize the value of the

service as being at least equal to the cost. The amount of time Japanese people spend on the Internet increased significantly between 2012 and 2020. According to the Ministry of Internal Affairs and Communications' White Paper on Information and Communications, the average time spent using the Internet in a day (weekdays) more than doubled, from 71.6 minutes in 2012 to 168.4 minutes in 2020.

The cost of an Internet connection is also declining every year in real terms considering improvements in transmission speed (if you continue to pay the same amount, but the transmission speed doubles, the price is considered to have dropped by 50% in real terms). As explained in Figure 4, lower prices increase consumer surplus. Other factors such as Japanese consumer spending and wages are also accounted for in the model, but their changes during this period were small and their impact on consumer surplus was likewise small.

In fact, Brynjolfsson, one of the architects of the BO model, proposed a measure of GDP plus consumer surplus as "GDP-B" as shown in Figure 6.[9]The B here stands for Benefit or Beyond. However, Brynjolfsson does not use the utility function method, but rather uses a survey method to estimate consumer surplus for individual goods and services, and then seeks out a way to aggregate these estimates. The reason for this is that we want to estimate consumer surplus not only for digital services, but also for real goods. Certainly, real goods such as food,

[9] Brynjolfsson E. and Collis A. (2019). "How Should We Measure the Digital Economy" Harvard Business Review, November-December 2019

sundries, and furniture also generate consumer surplus (sense of bargain) to a greater or lesser extent, but in the case of the BO model, we cannot estimate the consumer surplus generated by real goods, even though we can use it to estimate the consumer surplus of digital services.

(2) Proposed New Economic Indicator: GDP+i

While NRI has been much inspired by the "GDP-B" idea by Brynjolfsson et al., we propose a slight change to the concept. Instead of simply adding up producer surplus (GDP) and consumer surplus, NRI proposes to plot GDP on the horizontal axis and consumer surplus on the vertical axis and evaluate the economy on a flat plane.

And rather than simply plotting them on a plane, we also examined the idea of how producer surplus (GDP) and consumer surplus should be viewed. Producer surplus is the profits of companies and is an objective concept calculated on the basis of rules. Consumer surplus, on the other hand, is a subjective concept that exists only in the mind of each individual. Tadao Umesao, a scholar of civilization, once described the industrial sector as a real-numbers entity and the information industry as an imaginary entity[10], and we believe this metaphor applies to producer surplus and consumer surplus as well. In other words, GDP (producer surplus) is a real number and consumer surplus is an imaginary number. In mathematics, complex numbers (a+bi, where a and b are real numbers and i is an imaginary

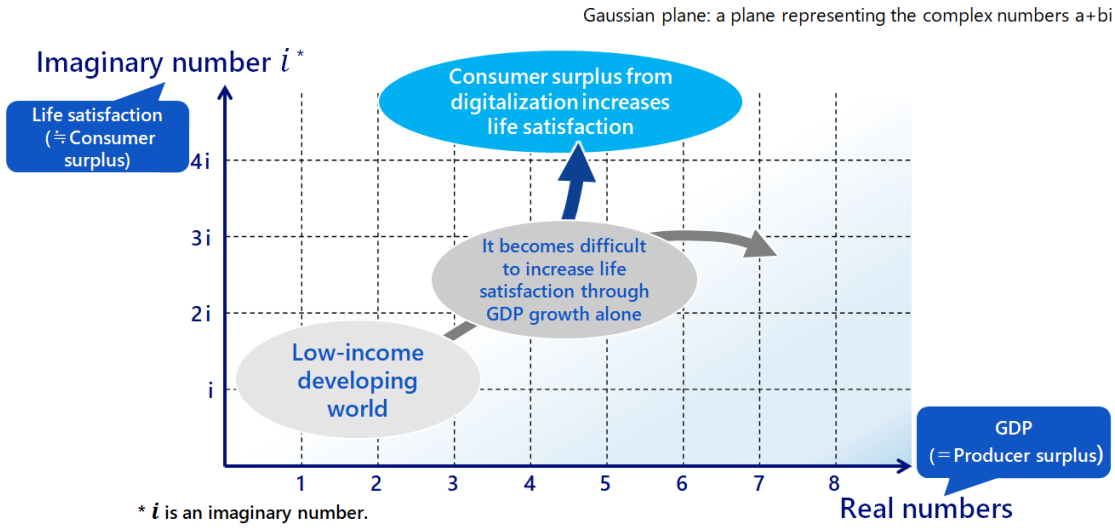
[10] Tadao Umesao, The Civilization of Information, Chuko Bunko

number) that combine real and imaginary numbers are represented in the complex number plane (Gaussian plane), and following this approach, we propose the concept of "GDP+i".

Figure 7 illustrates the concept of GDP+i. GDP is on the horizontal axis and subjective indicators such as consumer surplus or life satisfaction are on the vertical axis. Developing countries not only have low GDP, but also low life satisfaction, and are located at the lower left in the figure. As (per capita) GDP increases, people's life satisfaction will also increase up to a certain level (per capita GDP of about $10,000 to $15,000), but as Easterlin states, it becomes difficult to increase life satisfaction through GDP growth alone. This is where digital technology can contribute to improvement on the vertical axis. The evidence of this is seen in the recent expansion of consumer surplus, and the use of digital technology can contribute to the improvement of people's life satisfaction through a variety of channels[11].

[11] For example, the majority of teleworkers in Japan have recorded an increase in life satisfaction. For details, see "The Status and Future Prospects of Telework in Japan, the U.S., and Europe in 2022," Takeshi Mori, NRI Report, February 28, 2023, etc.

Figure 7: Economic Evaluation Based on GDP+i

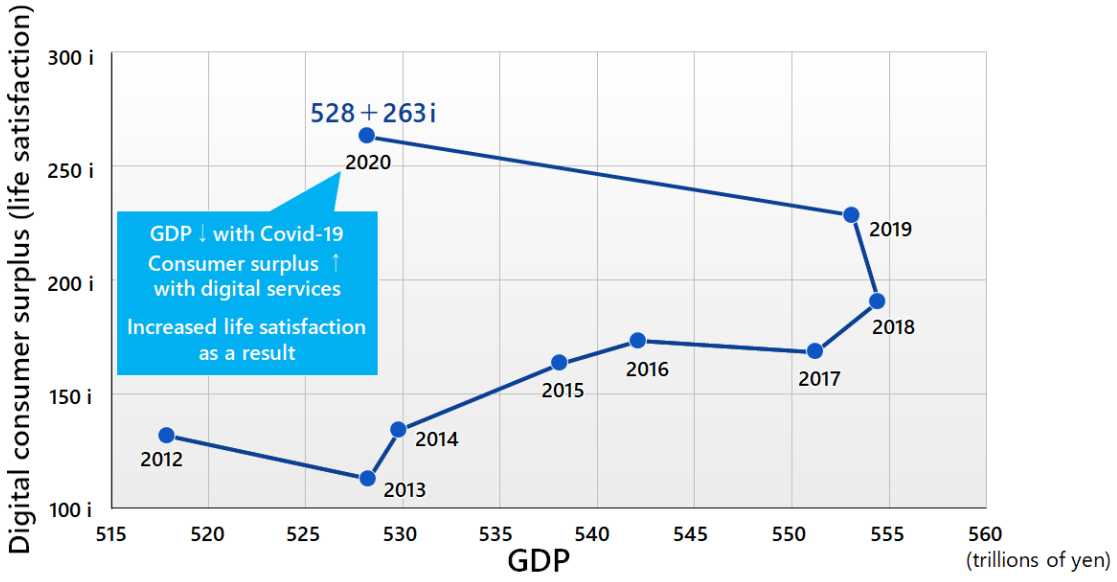


Evaluating society in terms of a plane rather than lines also means a shift away from the simplistic conventional view of economic evaluation that "bigger is better". It is true that the upper right is better than the lower left, but it is difficult to say whether the lower right or the upper left region is better. In the lower right region, the income level is extremely high, and the country is rich, but for some reason people's life satisfaction is low. In contrast, in the upper left region, the income level is not high, but people's life satisfaction is quite high. If we draw a line connecting the lower right and upper left, we should be able to draw a line (what economists call a "no discrimination line") that says that every point on that line is equally desirable. Of course, which area is preferred will vary from person to person. In the words of Inglehart, a proponent of the theory of cultural evolution, those who prefer the lower right are materialists, while those who prefer the upper left are post-materialists.

(3) Japan's GDP+i

Let us express Japan's GDP and consumer surplus shown in Figure 6 in the form of "GDP+i" (Figure 8). As can be seen, from 2012 to 2018, Japan's economic and social progress was on a slight uptrend. GDP declined just a bit in 2019, but consumer surplus continued to increase. In 2020, GDP declined significantly due to COVID-19 (-4.5%), but consumer surplus increased significantly (+15.2%) due to the rapid digitalization of society caused by lockdowns. Looking at GDP alone, Japan's results may seem dismal, but we can see that the consumer surplus compensated for the decline, albeit mildly.

Figure 8: Japan's GDP+i (2012-2020)



Source: GDP from Cabinet Office; consumer surplus from joint research by NRI and Handong Global University (2022)

Figure 8 takes "consumer surplus from digital services" as the vertical axis, but as Brynjolfsson points out, consumer surplus is also generated from real goods, so some may

argue that this is not sufficient. Figure 8 is only an example, and it is quite possible to bring a subjective indicator other than consumer surplus (e.g., subjective well-being as proposed by the OECD) to the vertical axis. We can continue to discuss what to use for the vertical axis.

NRI collects a diverse range of emotional expressions from tweets on Twitter to gauge an index called the "feeling index" daily[12]. Emotions such as joy, anger, and anxiety are some of the important factors that make up happiness levels. In the future, it is possible that a system will emerge that can quantify the level of happiness and life satisfaction of citizens based on their comments etc. on SNSs.

[12] https://www.nri.com/jp/news/newsrelease/lst/2022/cc/0330_1

4 Conclusion

It is said that Cardano, a 16th century Italian mathematician, was the first to note the existence of imaginary numbers (numbers that become negative when squared) in the world of mathematics. However, Descartes, a French mathematician, coined the term "nombre imaginaire" (imaginary number) with a negative meaning, because a number that becomes negative when squared cannot be drawn. Later, the German mathematician Gauss discovered the existence of complex numbers by adding imaginary and real numbers together, and further developed a method to draw complex numbers on a plane (hence the name Gaussian plane).

The discovery of imaginary and complex numbers has enriched our society not only through mathematics, but also through developments in electrical engineering, aerodynamics, and quantum physics, etc. I believe that such breakthrough developments should be applied to economics as well. This is the "GDP+i" proposed in this paper. The "evolution from real numbers to complex numbers" in mathematics is, in the context of the economy, the "evolution from GDP to well-being". This is because well-being includes not only material sufficiency such as income (real number) but also mental sufficiency (imaginary number).

The equation "a+bi", which represents a complex number, seems to imply the progress of digital society in the 21st century. Technologies such as metaverse, digital twin, and augmented reality (AR) are beginning to enter the limelight, and these digital technologies are creating a mixture of physical space (real numbers) and cyber space (imaginary numbers), which is

represented by “bi”. It can be said that “a+bi” (“a”, the existing economy of physical space, plus “bi”, the economy of physical-cyber space) portrays the digital society of the 21st century itself.

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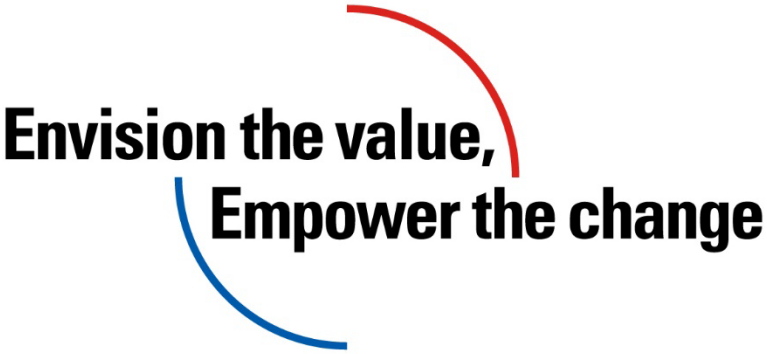

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