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Simulation Analysis of the Effects of the Global Redistribution of Wealth on Subjective Well-being in the World[1)]

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I. Development, Globalization, and Subjective Well-being

After World War II, the *North–South problem*—the problem of the wide disparity in wealth between the developed nations, mainly located in the Northern Hemisphere, and the underdeveloped nations, located in the Southern Hemisphere—has been recognized as a critical problem in international politics. To address this problem, dependency theories have been developed by several social scientists, including A. G. Frank (1969) and S. Amin (1976). These theories focus on the dominance and dependence relationship between centers (metropolises) and peripheries (satellites) of

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the global capitalist system, insisting that these structural relationships maintain the low socioeconomic levels seen in the underdeveloped nations.

Thereafter, a considerable amount of international efforts to cope with this problem were made by the United Nations, the OECD Development Assistance Committee (DAC), and the World Bank. Each developed nation contributes to the official development assistance (ODA) in accordance with the international frameworks of these organizations. The first UN framework for development was the first *United Nations Development Decade (1961–1970)*, proposed by John F. Kennedy, the former president of the United States, who planned to transfer 1% of the developed nations' GNP to the underdeveloped nations. The United Nations Development Program (UNDP) was founded in 1965, and one of its latest activities is the *Millennium Development Goals*, a framework derived from the *United Nations Millennium Declaration* in 2000. However, the *Human Development Report 2005* states that it will be difficult to achieve the MDGs by 2015 unless international cooperation, including the provision of development assistance, is successfully implemented (UNDP 2005).

In recent years, many scholars and activists have warned that globalization, especially the economic globalization led by the American neoclassical economic framework, or the so-called "Washington consensus," will worsen inequality and poverty in the world (Giddens 2000; Stiglitz 2002, 2006). In fact, there is empirical evidence to support this. For example, Milanovic (2002) analyzed the inequality in income distribution across the world using household survey data from 91 nations, pointing out that the Gini coefficient of the world increased from 62.8 in 1988 to 66.0 in 1993, and was higher than that of the most unequal nations in the world. According to such statistics, it is claimed that 25% of the world's population possess 77.7% of the world's wealth, while the other 75% manage with the remaining 22.3%.[2)] It was subsequently reported that the average Gini coefficient of countries has steadily increased between 1990 and 2000 (IMF 2007).

This kind of change, which may be caused by globalization, consequently affects people's well-being. In the present study, we investigate the change in subjective well-being and ill-being. Subjective well-being, or happiness, can be defined as "the degree to which an individual judges the overall quality of his/her life as a whole in a favorable way" (Veenhoven 1984). With respect to subjective well-being and the distribution of wealth in the world, many studies have found a positive relationship between the level of wealth and the level of subjective well-being in nations, and that poor nations tend to have lower levels of subjective well-being while developed nations tend to have higher levels, although there is a diminishing marginal effect

2) Milanovic (2005) subsequently added 1998 data to the figures and recalculated the Gini coefficients of the three time periods. As a result, the world Gini coefficient for 1988 becomes 61.9, 65.2 for 1993, and 64.2 for 1998. On the other hand, some insist that disparity in the world's income has not spread, but converged (Dollar and Kraay 2002; Sala-i-Martin 2002).

(Veenhoven 1993; Inglehart 1997; Diener et al. 1999; Inglehart and Klingemann 2000; Diener and Biswas-Diener 2002; Frey and Stutzer 2002).

With regard to globalization and the distribution of wealth in the world, we wish to answer the following question: how does a certain redistribution of the world's wealth affect people's subjective well-being and ill-being? In other words, how many people in the world will be better or worse off as a result of the redistribution of wealth? A certain way of redistributing wealth in our model can represent the economic assistance provided to underdeveloped nations by developed nations, along with a sort of global exploitation of the peripheries by the center. In this study, we employ the nominal GDP as the operational variable of the wealth of each nation. Of course, in reality, there are several alternative ways of providing development assistance, such as technology transfer and educational assistance, and nowadays these seems to be prime ways to assist underdeveloped nations rather than the direct transfer of wealth. In this study, however, we would like to restrict our focus to the transfer of wealth itself, so as to show the restricted effects of the redistribution of wealth according to a simple simulation study.

In the fields of welfare and public economics, there have been many theoretical and normative studies on the relationship between the distribution of wealth and people's utilities and social welfare. For example, a well-known theory states that by assuming a strictly increasing and concave utility function, the equalizing redistribution improves social welfare (i.e., aggregated utilities) (Atkinson 1970; Lambert 2001). These theoretical studies, however, have mainly focused on the transfer and redistribution of wealth within a single society, and have focused less on the transfer of wealth among societies and the subsequent effect. On the other hand, quite a few studies have been devoted to the empirical analysis of the relationship between wealth level and subjective well-being at the national level, as well as at the micro level. However, no study has focused on the prediction of the change in people's subjective well-being and ill-being by the global redistribution of wealth using empirical data.

Therefore, we have constructed a simulation model to assess the effects of the possible redistribution and exploitation of wealth, as represented by the nominal GDP, on people's subjective well-being and ill-being in the world. We call this framework a "virtual redistribution analysis," or VRA. We will estimate the changes in subjective well-being and ill-being in each nation and the world that are due to the virtual redistribution of the GDP according to a VRA, assuming an empirical relationship between the level of wealth and the level of subjective well-being.[3)] This framework is quite simple in the sense that it assumes that the redistribution of the nominal GDP is the only factor behind changes in well-being; as such, other important factors such as a

3) Ishida (2009) has analyzed the effect of domestic virtual redistribution on SWB using Japanese survey data.

nation's economic development, a nation's allocation of resources between the economic and social sectors, and so forth are not considered. This might be one of the flaws of this study. However, it can also be said that because this framework is fairly simple, it allows us to derive a simpler and stronger conclusion, as well as policy implications, in terms of wealth redistribution and well-being. We believe that this study is a good start for developing our model.

II. GDP Per Capita and Subjective Well-Being

In this section, we wish to define subjective well-being and subjective ill-being used in our model. We treat these measurements as binary rather than as ordinal or continuous because our primary concern is whether or not a person regards her/himself as being well or ill and how this judgment is affected by wealth redistribution, and as such the degree of well-being or happiness is a secondary concern. Furthermore, by assuming these measurements to be binary, we can avoid the problems that are inherent in the cardinal utility approach, that is, the measurement of utility and the interpersonal comparison of utility (Robbins 1932).

Using Inglehart's definition of subjective well-being (1997), we simultaneously employ two types of scales to assess the subjective well-being (SWB) and subjective ill-being (SIB) in each nation. These scales are happiness and life satisfaction; in many studies, both are often regarded as a singular index of SWB. We employ *The World Values Survey 1999–2004* dataset[4] to estimate the SWB and SIB in each nation and from that obtain the data for 69 nations and regions.[5] In *The World Values Surveys*, the question on happiness is written as follows: "Taking all things together, would you say you are very happy, quite happy, not very happy, or not at all happy?" On the other hand, life satisfaction is measured by a 10-point scale going from 1 for "dissatisfied" to 10 for "satisfied," using the opening phrase, "All things considered, how satisfied are you with your life as a whole these days?" As for happiness, we combined "very happy" and "quite happy" into the "happy" category, and "not very happy" and "not at all happy" into the "unhappy" category. As for life satisfaction, we consider a reading of 7 to 10 points as "satisfied" and of 1 to 4 points as "unsatisfied," for the sake of convenience and simplicity. We define SWB as the percentage of people in a nation who feel happy *and* satisfied with their life to highlight the notion. Similarly, we define SIB as the percentage of people in a nation who feel unhappy *and* unsatisfied.

4) This is taken from *The European and World Values Surveys Four-Wave Integrated Data File, 1981–2004*, v.20060423, 2006, distributed by the European Values Study Foundation and World Values Survey Association. Aggregate file producers: ASEP/JDS, Madrid, Spain/Tilburg University, Tilburg, the Netherlands. Aggregate file distributors: ASEP/JDS and ZA, Cologne, Germany.

5) Because data pertaining to happiness is not available for Great Britain, we exclude it from our analysis.

Combining these two scales alleviates the cross-cultural and cross-linguistic equivalence problem of the meaning of happiness (Diener and Diener and Diener 1995; Wierzbicka 2004), since doing so allows us to exclude apparently contradictory cases such as "happy but unsatisfied" or the converse "unhappy but satisfied." Hence, we can obtain the SWB and SIB values in a strict and robust way. Table 1 provides the definitions of these variables. It is worth noting here that SWB and SIB are not mutually exclusive concepts, since not having SWB does not necessarily indicate having SIB, and hence analyzing the respective changes in SWB and SIB is warranted.

Table 1: The Definition of SWB and SIB

	Life satisfaction		
Happiness	Satisfied (10–7)	Neither (6–5)	Unsatisfied (4–1)
Happy	SWB		
Unhappy			SIB

In the next part of our study, we calculated each nation's nominal GDP per-capita in American dollars according to its purchasing power parity (PPP), and each nation's total population for the year 2002 per the *Human Development Report 2004*: *Cultural Liberty in Today's Diverse World* (HDR 2004) (UNDP 2004). Note that the GDP data for Iraq, Serbia, and Montenegro is not available and that the report contains no information pertaining to Puerto Rico and Northern Ireland, as these are not UN members; hence, we exclude these nations and regions from our analysis. In addition, since there is no 2002 data for Bosnia and Herzegovina in HDR 2004, we substituted the 2004 data in HDR 2006 for it. In sum, we analyze the data of 65 nations. A list of nations and other details pertaining to the data is provided in Table 2. Figure 1 and Figure 2 illustrate the relationship between the GDP per capita and the SWB and SIB, respectively. It is important to note that due to data restrictions, we are only able to consider the redistribution statistics among 65 nations. Thus, our analysis is a kind of approximation of worldwide redistribution.

Table 2: GDP per capita (PPP US$), Total Population (million), SWB and SIB in Each Nation (1999-2004)

	GDP per capita	Popula -tion	SWB	SIB		GDP per capita	Popula -tion	SWB	SIB		GDP per capita	Popula -tion	SWB	SIB
Tanzania	523	35.1	20.44	4.07	Venezuela	5,794	24.2	64.36	4.17	Portugal	17,290	10	60.51	5.86
Nigeria	896	113.9	60.78	3.07	Iran	5,884	70.3	38.7	13.46	Slovenia	17,367	2	62.27	7.06
Uganda	1,208	23.3	33.87	10.19	Romania	6,423	22.4	30.43	35.88	Republic of Korea	17,380	46.7	45.52	6.82
Bangladesh	1,602	137.4	29.79	11.1	Turkey	6,974	66.7	35.79	18.1	Spain	19,472	39.9	61.87	3.7
Pakistan	1,928	141.3	9.75	20.57	Bosnia and Herzegovina	7,032	3.91	36.2	9.43	Israel	20,131	6	60.03	7.65
Viet Nam	1,996	78.1	42.84	2.03	Latvia	7,045	2.4	28.12	23.65	Singapore	23,356	4	69.61	1.92
Republic of Moldova	2,109	4.3	13.56	29.97	Lithuania	7,106	3.7	37.45	18.35	Italy	23,626	57.5	63.97	6.62
India	2,358	1,008.9	25.71	14.69	Belarus	7,544	10.2	23.56	23.56	France	24,223	59.2	66.9	5.26
Zimbabwe	2,635	12.6	15.53	33.17	Croatia	8,091	4.7	54.77	8.82	Sweden	24,277	8.8	77.82	3.47
Kyrgyzstan	2,711	4.9	48.89	7.83	Russian Federation	8,377	145.5	21.95	35.97	Finland	24,996	5.2	82	3.11
Indonesia	3,043	212.1	59.39	0.71	Mexico	9,023	98.9	75.7	1.34	Germany	25,103	82	69.87	8.45
Albania	3,506	3.1	26.24	27.25	Poland	9,051	38.6	44.89	14.25	Netherlands	25,657	15.9	87.62	1.1
Morocco	3,546	29.9	36.32	9.76	South Africa	9,401	43.3	48.73	10.54	Japan	26,755	127.1	52.74	5.32
Egypt	3,635	67.9	40.13	5.68	Chile	9,417	15.2	56.16	6.66	Austria	26,765	8.1	80.09	3.73
Ukraine	3,816	49.6	21.47	37.83	Estonia	10,066	1.4	40.15	17.3	Belgium	27,178	10.2	75.27	4.79
Jordan	3,966	4.9	34.02	9.66	Slovakia	11,243	5.4	43.45	16.58	Denmark	27,627	5.3	84.75	2.18
Philippines	3,971	75.7	49.83	3.59	Saudi Arabia	11,367	20.3	62.24	2.75	Canada	27,840	30.8	79.88	1.82
China	3,976	1,275.1	48.43	11.02	Argentina	12,377	37	62.64	6.04	Iceland	29,581	0.3	86.71	1.56
Peru	4,799	25.7	39	10.49	Hungary	12,416	10	36.78	15.7	Ireland	29,866	3.8	84.55	1.69
Macedonia	5,086	2	28.67	17.05	Czech Republic	13,991	10.3	64.38	5.96	United States	34,142	283.2	77.43	2.77
Algeria	5,308	30.3	41.14	11.35	Greece	16,501	10.6	56.91	12.35	Luxembourg	50,061	0.4	80.37	2.52
Bulgaria	5,710	7.9	30.15	30.98	Malta	17,273	0.4	76.82	1.2	Total	7,935.05	4,795.8	44.57	11.08

GDP per capita (PPP US$) and total population in each nation in 2002 are taken from HDR 2004 (UNDP 2004). The values for Bosnia and Herzegovina are those for the year 2004 in HDR 2006, as the values for 2002 are not available in HDR 2004. SWB and SIB are calculated using the *World Values Survey wave 1999-2004* dataset.

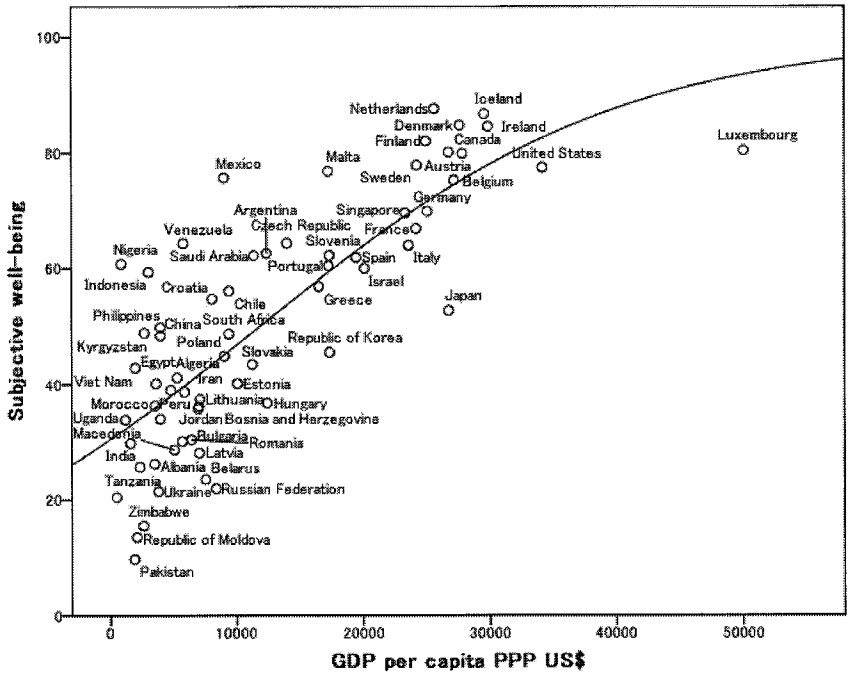

Figure 1: Relationship between GDP per capita (PPP US$) and SWB

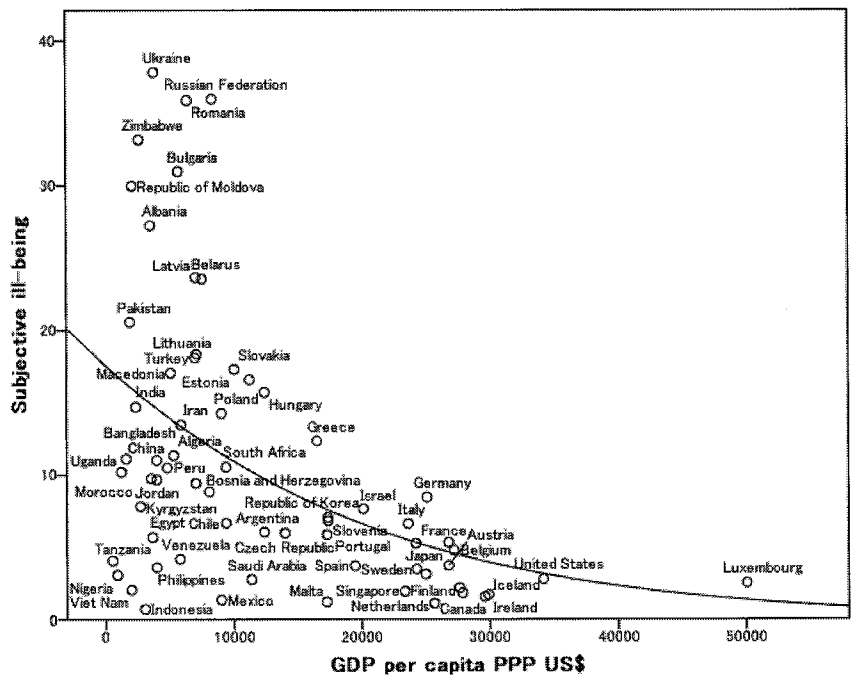

Figure 2: Relationship between GDP per capita (PPP US$) and SIB

The total population of the 65 nations in our study is 4,795,000, and the total GDP (calculated according to the PPP in US dollars) is approximately 38 trillion, 55 billion dollars. It follows that the GDP per capita when all 65 nations are considered together is US$7935.05. Here, we would like to introduce some notations. Let SWB_k represent the subjective well-being rate and SIB_k represent the subjective ill-being rate of nation k. Furthermore, let P_k represent the population of nation k. Thus, the world SWB rate and SIB rate can be defined as $\text{world SWB} = \sum_k (SWB_k \times P_k) / \sum_k P_k$ and $\text{world SIB} = \sum_k (SIB_k \times P_k) / \sum_k P_k$, respectively. The world SWB rate and SIB rate (both given in percentage terms), as calculated from the dataset, are 44.57% and 11.08%, respectively.

III. Logit Model

Both the SWB and SIB rates can be regarded as the probability of success of a single Bernoulli trial, whose possible outcomes are confined to "success" and "failure"; in our analysis, having SWB and not having SWB, and having SIB and not having SIB are the possible outcomes. The logit of the SWB and SIB rates are

$$\text{logit}(SWB) = \ln\left(\frac{SWB}{1-SWB}\right), \quad \text{logit}(SIB) = \ln\left(\frac{SIB}{1-SIB}\right).$$

We adopt the following two regression models for estimating the logit of SWB and SIB:

$$\text{logit}(SWB) = \alpha_{SWB} + \beta_{SWB}\gamma, \quad \text{logit}(SIB) = \alpha_{SIB} + \beta_{SIB}\gamma,$$

where γ indicates GDP per capita (PPP US$).[6] Thus, we can obtain the following result:

$$SWB = \frac{1}{1+\exp\{-\alpha_{SWB} - \beta_{SWB}\gamma\}}, \quad SIB = \frac{1}{1+\exp\{-\alpha_{SIB} - \beta_{SIB}\gamma\}}.$$

The marginal effect of γ on SWB is

$$\frac{d}{d\gamma} SWB = \beta_{SWB} \frac{\exp\{-\alpha_{SWB} - \beta_{SWB}\gamma\}}{(1+\exp\{-\alpha_{SWB} - \beta_{SWB}\gamma\})^2} = \beta_{SWB}\, SWB(1-SWB).$$

Estimating the coefficients pertaining to SWB using the maximum likelihood estimation (MLE) method, we get $\alpha_{SWB} = -0.825$ (the standard error (SE) is 0.011)

6) Although a probit model is also available for our present purposes, we chose to use a logit model since it works much better for interpreting the meanings of coefficients.

and $\beta_{SWB} = 6.97 \times 10^{-5}$ (SE = 7.68×10^{-7}). Both are significant at the 1% level.[7] The marginal effect of GDP per capita on SWB at the mean value of US$12,668 is 0.00174%, which indicates that an increase of one dollar in GDP per capita increases the SWB rate by 0.00174%. Corresponding with this, coefficients pertaining to SIB are estimated to be $\alpha_{SIB} = -1.546$ (SE = 0.016) and $\beta_{SIB} = -5.506 \times 10^{-5}$ (SE = 1.38×10^{-6}) with significance at the 1% level.[8] The marginal effect of GDP per capita on SIB at the mean value is −0.00048%. The lines in Figure 1 and Figure 2 show the regression models for SWB and SIB, respectively.[9]

IV. Virtual Redistribution of Wealth

We introduce a form of virtual redistribution of wealth in terms of the world's GDP, whose most important consideration is postulating the redistribution rule to determine how the total amount of global wealth is to be redistributed, that is, how much wealth is to be taken from which nations, and how much is to be transferred to which nations. Although many forms of redistribution will be considered, we will first focus on the transfer of wealth between developed nations, especially those that are high-income and are part of the Organization for Economic Cooperation and Development (OECD), and lesser-developed nations. The *high-income OECD nations* (OECD group) available in our dataset include: Spain, Italy, France, Sweden, Finland, Germany, Netherlands, Japan, Austria, Belgium, Denmark, Canada, Iceland, Ireland, the United States, and Luxembourg. We also add Singapore and Israel to the OECD group because their GDP per capita is higher than the lowest GDP per capita in the high-income OECD group. On the other hand, in our simulation model, *lower developed nations* (Lower group), are decided by a cutoff value of GDP per capita. As a first step in our series of analyses, we adopt US$5,000.00 as an exemplar, thereby including Tanzania, Nigeria, Uganda, Bangladesh, Pakistan, Vietnam, the Republic of Moldova, India, Zimbabwe, Kyrgyzstan, Indonesia, Albania, Morocco, Egypt, Ukraine, Jordan, the Philippines, China, and Peru. OECD has a GDP of US$21,303.5 billion (55.98% of the total amount) that is shared by 747.7 million people (15.59% of total amount), while Lower (less than US$5,000.00 as GDP per capita) has a GDP of $9943.1 billion (26.13% of the total amount) that is shared by 3303.8 million people (68.89% of the total amount).

We simulate two modes of transfer between OECD and Lower. Let us denote a rate of transferring arbitrary wealth by the symbol τ. One way in which the redistribution

7) The likelihood ratio χ^2 of this model is 9626.06 with 1 degree of freedom; this indicates that we can safely reject the null hypothesis that all coefficients are zero. Pseudo R^2 is .0758.

8) The likelihood ratio χ^2 is 1943.01 with 1 degree of freedom, thereby rejecting the null hypothesis; pseudo R^2 is .0312.

9) These prediction equations for SWB and SIB are almost the same as the prediction equations excluding Luxembourg as an outlier.

can be executed is the transfer of $100\tau\%$ of the sum of GDP from the OECD to Lower; we call this "fair redistribution." The idea behind redistribution is the enhancement of the overall subjective well-being, and the decrease of overall subjective ill-being. A natural course of reasoning suggests that we should take some wealth from rich nations and give the same amount to poor nations; this, we assume, would solve the problem. However, the reality of the effects of today's world globalization seems to be the opposite. Hence, we adopt a contradictory approach and transfer $100\tau\%$ of the sum of GDP from Lower to OECD; we call this "exploitation" for the sake of simplicity.

To do this, let G (namely, *Givers*) represent a set of nations that give a part of their wealth to other nations, and let T (*Takers*) represent a set of nations that take wealth from other nations. In other words, nations in G contribute a part of their wealth to nations in T. Each nation's GDP per capita and population are denoted by γ_k and P_k, respectively. Then, the total GDP for each group can be defined as $W_G = \sum_{g \in G} \gamma_g P_g$ and $W_T = \sum_{t \in T} \gamma_t P_t$, respectively. Therefore, the total transferred wealth is given in the term τW_G. We employ a proportional rule to postulate the tax burden on each person in G and a source of allocation for each person in T. The philosophy of the proportional rule is considerably simple: the richer you are, the more taxes you should pay, and the poorer you are, the more allocation you should receive.

We assume that the tax burden on each person in G is determined in proportion to his or her share of the total wealth of G. Suppose that person i belonging to nation $g \in G$ has income x_{gi}. Additionally, suppose that the GDP per capita of $g \in G$ is equal to the average income of g, that is,

$$\gamma_g = \sum_{i=1}^{P_g} x_{gi} \Big/ P_g .$$

Since i's income share of the total wealth of G is x_{gi}/W_G, i's tax burden b_{gi} should be

$$b_{gi} = \tau W_G \frac{x_{gi}}{W_G} = \tau x_{gi},$$

and i's income after transfer x'_{gi} should be

$$x'_{gi} = x_{gi} - b_{gi} = (1-\tau)x_{gi}.$$

This means that each person in each nation contributes $100\tau\%$ of her/his own wealth. In other words, the summation of $\tau\, x_{gi}$ in G is equal to $\tau\, W_G$, that is,

$$\sum_{g\in G}\sum_{i=1}^{P_g}\tau x_{gi} = \sum_{g\in G}\tau\gamma_g P_g = \tau W_G .$$

Since GDP per capita is regarded as the average income of the nation, the GDP per capita of nation g in G after transfer should be

$$\gamma'_g = \sum_{i=1}^{P_g} x'_{gi} \Big/ P_g = (1-\tau)\gamma_g .$$

As long as $0 < \tau < 1$ holds, it is apparently true that for any persons i and j of G nation, $x_i > x_j \Rightarrow b_i > b_j$; suggesting that relatively wealthier people carry a relatively heavier burden for redistribution. At the same time, we get $\gamma_g > \gamma_h \Rightarrow \gamma'_g > \gamma'_h$ for any nations g and h in G, indicating the order preservation of the rank of GDP per capita within *Givers*.

We also assume that transferring wealth is allocated among people in *Takers* based on one's income share. Suppose that person j belonging to nation $t \in T$ has income x_{tj}. Then, j's allocation a_{tj} is defined as:

$$a_{tj} = \tau W_G \frac{W_T - x_{tj}}{\sum_{t\in T}\sum_{i=1}^{P_t}(W_T - x_{ti})} = \tau W_G \frac{W_T - x_{tj}}{\sum_{t\in T} P_t(W_T - \gamma_t)} .$$

In other words, j's allocation is determined by $(W_T - x_{tj})\big/\sum_i (W_T - x_i)$, where i indicates an arbitrary person who is a member of an arbitrary *Takers* nation, thus indicating the degree of relative smallness of j's income share in all of the members of *Takers* nations. If $\tau \neq 0$ holds, we obtain the figure $x_i > x_j \Rightarrow a_i < a_j$ for any persons i and j belonging to T nations. This implies that redistribution allocates much more to the poorer people. Consequently, j's income after the transfer will be

$$x'_{tj} = x_{tj} + a_{tj} = (1-\Omega)x_{tj} + \Omega W_T ,$$

where $\Omega = \tau W_G \Big/ \left(\sum_{k\in T} P_k - 1\right) W_T$, and the GDP per capita of nation t in T after redistribution γ'_t will be

$$\gamma'_t = (1-\Omega)\gamma_t + \Omega W_T .$$

This equation indicates that the order preservation of the rank of GDP per capita

within T is satisfied if the condition

$$1-\Omega>0 \Leftrightarrow \left(\sum_{k\in T} P_k - 1\right) W_T > \tau W_G$$

is satisfied. In empirical terms, almost all cases, including the cases we are trying to analyze here, satisfy this condition.

It is worth noting changes of inequalities, measured by the Gini coefficient, within *Givers* and *Takers* and also within each of the nations G and T caused by transfer of wealth. As for *Givers* and also a certain nation of *Givers*, the Gini coefficient remains unchanged by redistribution as long as $\tau \neq 0$ holds.[10] On the other hand, as for *Takers* and a certain nation of *Takers*, the Gini coefficient is sure to decrease by transferring wealth as long as $\tau \neq 0$ and $\left(\sum_{k\in T} P_k - 1\right) W_T > \tau W_G$ hold.[11] These findings

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10) The Gini coefficient of a n-dimensional income vector $\boldsymbol{x} = (x_1, x_2, \ldots, x_n)$, denoted by *Gini*($\boldsymbol{x}$), is defined as

$$Gini(\boldsymbol{x}) = \frac{1}{2n^2\mu}\sum_{i=1}^{n}\sum_{j=1}^{n}\left|x_i - x_j\right|,$$

where μ indicates the mean value of $\boldsymbol{x}$. Suppose $\tau \neq 0$, then the Gini coefficient of the after transfer income $\boldsymbol{x}' = (x_1', x_2', \ldots, x_n') = ((1-\tau)x_1, (1-\tau)x_2, \ldots, (1-\tau)x_n)$ will be

$$Gini(\boldsymbol{x}') = \frac{1}{2n^2(1-\tau)\mu}\sum_{i=1}^{n}\sum_{j=1}^{n}\left|(1-\tau)(x_i - x_j)\right| = \frac{1}{2n^2\mu}\sum_{i=1}^{n}\sum_{j=1}^{n}\left|(x_i - x_j)\right|.$$

Thus, *Gini*($\boldsymbol{x}$) = *Gini*($\boldsymbol{x}$').

11) According to the above discussion, Takers member j"s income after the transfer is $x_i' = (1-\Omega)x_i + \Omega W_T$. The Gini coefficient of the after-transfer income vector $\boldsymbol{x}$' will be

$$Gini(\boldsymbol{x}') = \frac{1}{2n^2((1-\Omega)\mu + \Omega W_T)}\sum_{i=1}^{n}\sum_{j=1}^{n}\left|(1-\Omega)(x_i - x_j)\right|$$

$$= \frac{1-\Omega}{2n^2(\mu + \Omega(W_T - \mu))}\sum_{i=1}^{n}\sum_{j=1}^{n}\left|x_i - x_j\right|$$

Note here that $\Omega > 0$ since $\tau \neq 0$. $\Omega > 0$ leads to $1 > 1-\Omega$. Besides, since μ indicates the average income of a nation $t \in T$, i.e., GDP per capita γ_t, or the average income of all of the people who live in any Takers nations, it is apparently true that $W_T > \mu$. Consequently,

$$\frac{1}{2n^2\mu} > \frac{1-\Omega}{2n^2(\mu + \Omega(W_T - \mu))},$$

indicating *Gini*($\boldsymbol{x}$) > *Gini*($\boldsymbol{x}$').

about changes in the Gini coefficient suggest that, with respect to "fair redistribution," the transference of wealth we employ in this study can be regarded as a kind of egalitarian means of redistribution, because it reduces the inequalities of aid-receiving nations, while it never makes the inequalities of aid-giving nations worse.

Additionally, we assume that in the case of fair redistribution, transfer is valid unless the lowest national GDP per capita in G is equal to or greater than the highest national GDP per capita in T. This assumption can be represented by the following condition:

$$\max\{\gamma_t \mid t \in T\} \leq \min\{\gamma_g \mid g \in G\} \Rightarrow \max\{\gamma'_t \mid t \in T\} \leq \min\{\gamma'_g \mid g \in G\}.$$

To summarize, the manipulation of fair distribution and exploitation satisfy the order preservation within G and T. Figure 3 provides an example of fair redistribution. The gray and white bars show the GDP per capita before and after redistribution, respectively.

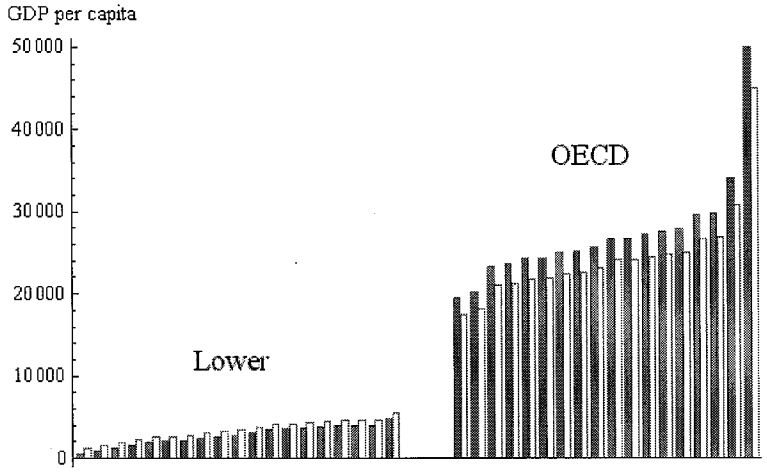

Figure 3: Transfer of 10% of the total GDP of the OECD to Lower (PPP GDP per capita less than 5,000 US$)

Finally, we estimate the SWB and SIB of each nation i after fair redistribution or exploitation using the following equations:

$$SWB'_i = SWB_i + \frac{1}{1+\exp\{-\alpha_{SWB} - \beta_{SWB}\gamma'_i\}} - \frac{1}{1+\exp\{-\alpha_{SWB} - \beta_{SWB}\gamma_i\}},$$

$$\mathrm{SIB}'_i = \mathrm{SIB}_i + \frac{1}{1+\exp\{-\alpha_{SIB} - \beta_{SIB}\gamma'_i\}} - \frac{1}{1+\exp\{-\alpha_{SIB} - \beta_{SIB}\gamma_i\}}.$$

The changes in the world SWB rate and SIB rate by fair redistribution and

exploitation with changes in parameter t are our prime concerns.

V. Results

1. One-Percent Transfer

We will now show the results of a series of VRAs. First, we analyze the effect of the transfer of 1% of OECD's GDP to Lower. This situation roughly corresponds to the plan that Kennedy formulated in his proposal to the UN. One percent of OECD's GDP is $US213,035 million. Simply put, the per-capita contribution of OECD's denizens is about $285.00. This redistribution will increase the SWB in the world from 44.569% to 44.585%, which is a net increase of 0.016%, which means that this redistribution will make 76,240 people in the world subjectively well-off. On the other hand, the SIB will drop by 0.022%, from 11.083% to 11.061%, which suggests that 104,531 people will no longer be in a state of ill-being. In conclusion, this redistribution increases the world SWB and decreases the world SIB. Moreover, it is interesting that the rate of decrease of SIB is much greater than that the rate of increase of SWB.

Corresponding with this, we analyze the effect of the transfer of 1% of OECD's GDP (US$213,035 million) from Lower to OECD as an example of exploitation. Each person in Lower, on average, is deprived of $64.00 due to this exploitation. The world SWB decreases from 44.569% to 44.554%—a net decrease of 0.015%—indicating that 73,363 people will no longer be in a state of well-being. Additionally, the world SIB increases from 11.083% to 11.104%, a net increase of 0.021%. The exploitation increases the number of people in the world in the state of ill-being by 101,654. Table 3 provides a short summary of these analyses.

Table 3: Effects of transfer of 1% of OECD's GDP to Lower (fair redistribution) and from Lower to OECD (exploitation)

	Fair redistribution		Exploitation	
	before	after	before	after
SWB (%)	44.569	44.585	44.569	44.554
	+0.016 (76,240 people)		−0.015 (73,363 people)	
SIB (%)	11.083	11.061	11.083	11.104
	−0.022 (104,531 people)		+0.021 (101,654 people)	

2. Exploitation of Wealth

In this subsection, we show the results of the general simulation analysis of exploitation for different transfer amounts of wealth. In the following figures, the

horizontal line indicates the amount of wealth being transferred (in $US billion) corresponding to τ, the proportion of the amount of wealth. We do this to compare the effects of the amount of the transfer between exploitation and fair redistribution on SWB and SIB. Figure 4 and Figure 5 show the change in SWB and SIB due to exploitation, respectively. Figure 6 shows the changes in the net decrease of SWB and the net increase of SIB due to exploitation. The value of those graphs furthest to the right is $9,943 billion, indicating the ultimate exploitation when all of the wealth of Lower is transferred to OECD, that is, $\tau = 1$. These figures reveal that exploitation makes the situation worse both in terms of SWB and SIB, and is proportional to the amount being transferred.

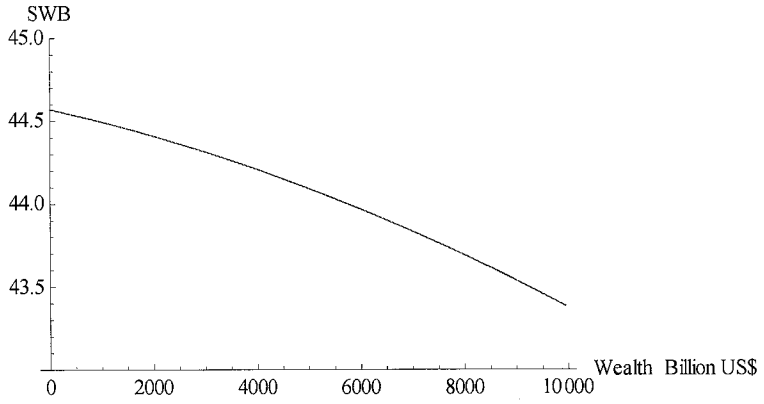

Figure 4: Change in SWB due to exploitation vis-à-vis the amount of wealth being transferred

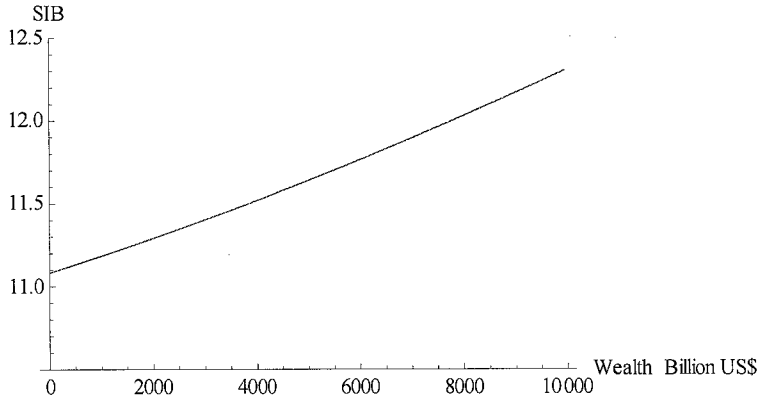

Figure 5: Change in SIB due to exploitation vis-à-vis the amount of wealth being

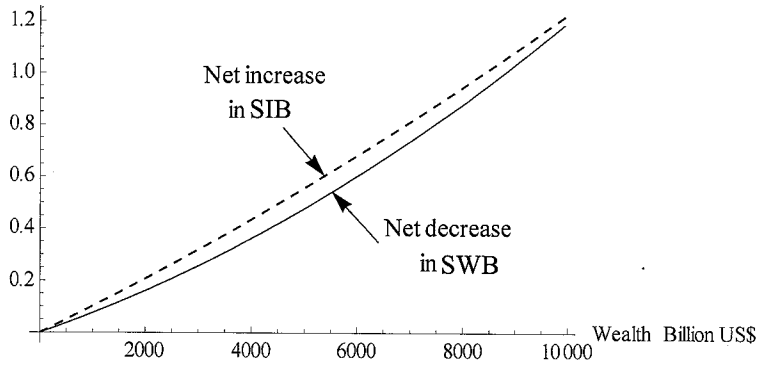

Figure 6: Net decrease/increase in SWB/SIB due to exploitation

3. Fair Redistribution of Wealth

The following figures show the results of the general simulation analysis of fair redistribution for different transfer amounts of wealth. Figure 7 and Figure 8 indicate the changes in SWB and SIB by fair redistribution, respectively. Figure 9 indicates the changes in the net increase of SWB and in the net decrease of SIB. The furthest point to the right on these graphs is \$12,600 billion, which is the largest amount that can be transferred from OECD to Lower while satisfying the order-preserving assumption. At this point, $\tau = 0.566$, indicating that every contributor in OECD pays 57% of their wealth for redistribution.

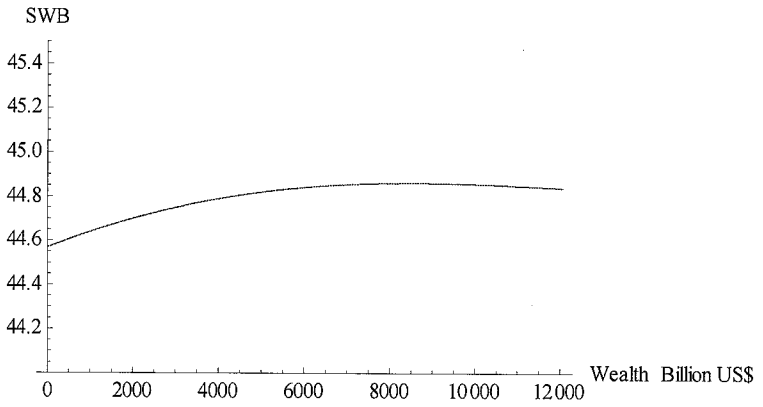

Figure 7: Change in SWB due to the redistribution of wealth vis-à-vis the amount of wealth being transferred

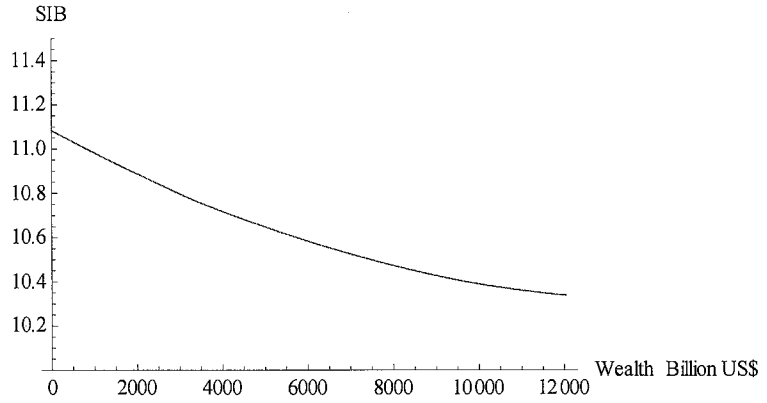

Figure 8: Change in SIB due to the redistribution of wealth vis-à-vis the amount of wealth being transferred

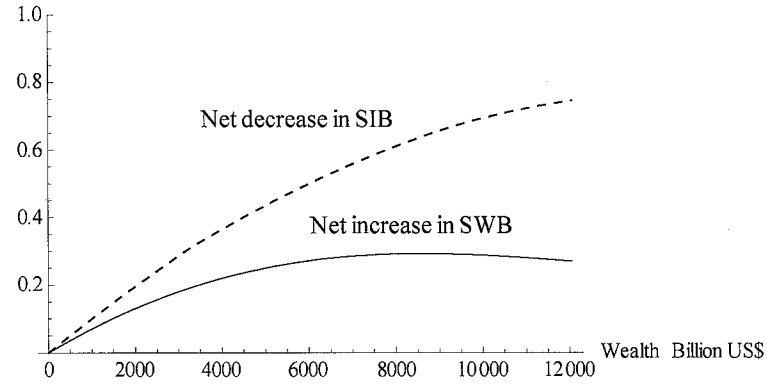

Figure 9: Net increase/decrease in SWB/SIB due to fair redistribution

We can observe from these figures that, in general, the fair redistribution of wealth contributes to an increase in the world SWB and decrease in the world SIB. These results are coherent with the derivation obtained from distribution theories in economics. However, it is interesting that with respect to SWB, the graph has a saturation point at around US$8,563 billion ($\tau = 0.402$) with SWB = 44.861%. This indicates that with regard to the increase of SWB, a moderate transfer amount is most efficient. On the other hand, the SIB curve increases consistently. Besides, the net decrease in SIB is always higher than the net increase in SWB. From these findings, we can derive a policy implication that suggests that the evaluation of redistribution varies depending on whether the enhancement of SWB or the diminution of SIB is the prime concern for policymakers. Also, for those who give priority to the diminution of SIB in the world, adopting an appropriate manner of redistributing wealth is much more important than for those who give priority to the enhancement of SWB.

VI. Future Tasks

Thus far, we have conducted a series of VRAs and noted some findings and implications from these analyses by focusing on the changes in SWB and SIB. From here, we want to continue further in our analysis to see the effects of different amounts of redistribution and/or the exploitation of wealth in order to gain a better understanding of globalization. What follows are a couple of considerations for future tasks, which are out of the scope of the present paper.

First, we are interested in taking into account intranational inequalities and its effects on the distribution of SWB and SIB within a nation, in addition to international inequality. SWB and SIB are obviously related to the each nation's average level of GDP. However, the distributional changes of wealth within nations, either by redistribution or exploitation across nations, will lead to changes in the inequality within nations. Domestic policy perspectives cannot ignore this issue since domestic policies and global policies are substantively intertwined. We are tempted to explore the possibilities for redistribution and/or exploitation among nations being conducive to diminishing inequalities and disparities within both types of nations (OECDs and Lower). We suggest that the problem of domestic inequality is strongly connected to the problem of governance in domestic distribution. There is a large difference between democracies and autocracies in how each distributes domestic wealth among people. In future studies, we will attempt to address this untouched issue.

Second, we are interested in focusing on the problems of relative deprivation within nations, which might be caused by the redistribution and/or exploitation of wealth across nations. If the transfer of wealth from wealthier countries to those that are less-wealthy incurs a severe burden for some segments within nations, it would produce severe relative deprivation even if the transfer were to increase global SWB.

In the present study, we made an empirical observation about the positive relationship between the GDP and the level of SWB and SIB to conduct a simulation analysis from a strongly normative perspective; in other words, we have sought to discover the changes in the global SWB and SIB levels that are based in the redistribution and exploitation of wealth, both of which were virtual. Eventually, we wish to assess the domestic changes that are caused by global changes since both are interlinked.

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