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Assessing Sustainable Development by Genuine Saving Indicator from Multidimensional Perspectives^{*}

Masayuki Sato[†] and Sovannroeun Samreth[‡]

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Abstract

This paper investigates the path of genuine saving (GS) based on the perspectives of average, trend and stability. The theoretical basis of GS can be seen in several studies, such as Arrow *et al.* (2003) and Dasgupta (2004); its database has been developed by the World Bank. With these contributions, GS is now considered as one of the most important indicators for evaluating the sustainable development. However, among previous studies on GS, only few studies focused on dynamic perspective. This paper points out this shortage in the literature, and then re-examines the sustainability performance in various countries based not only on the average, but also on the trend and stability of GS path. The results of evaluating GS based on these multidimensional perspectives are different from those of unidimensional perspective. These results provide us richer information on the sustainability of each country.

Keywords: Sustainable Development, Genuine Saving, Average, Trend, Stability

JEL Classification: O10, Q01, Q56

1. Introduction

The concept of GS is first introduced by Pearce and Atkinson (1993); it is now

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considered as one of the most important indicators for the study of sustainable development.¹ Its database has been developed by the World Bank. Recently, theoretical basis of GS has been sophisticated by eminent studies, such as Arrow *et al.* (2003) and Dasgupta (2004).

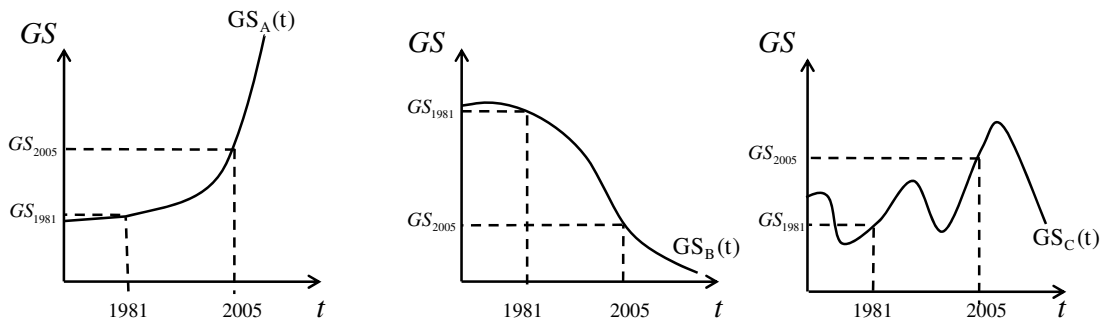
Based on these theoretical developments and database, a considerable number of studies on sustainability have been conducted using GS indicator. However, in most of the previous researches, they focused mainly on the average of GS over a given time period (see, for example, Arrow *et al.*, 2004; Atkinson and Hamilton, 2003); there are few studies which paid attention to the trend and stability of the GS path.

The path of GS is very important when considering sustainable development of a country by the historical view. In order to illustrate this, let us consider an example. Assume that there are three countries, A, B and C. Figure 1 shows the GS paths of these countries over the period of 25 years. Suppose that countries A, B and C have the same averages of GS over this period which can be calculated as below.

$$\frac{1}{25} \int_{1981}^{2005} GS_A(t) dt = \frac{1}{25} \int_{1981}^{2005} GS_B(t) dt = \frac{1}{25} \int_{1981}^{2005} GS_C(t) dt$$

Then, can we argue that the sustainability performance of each country is the same? Taking into account only the average of GS to evaluate the sustainability may cause misleading interpretation because the trend of countries A and B are different from each other; moreover, the stability of country A's GS path is also different from country C's. From Figure 1, it is clear that the country A's GS path is the most desirable because it is an increasing path compared to country B's, and a stable path compared to country C's.

Figure 1: Different paths of genuine savings



¹ This concept is also called “Genuine Investment” (Arrow *et al.*, 2003), “Adjusted Net Saving” (World Bank), and “Inclusive Investment” (Dasgupta, 2007). All of them imply the change of wealth as a source of welfare.

From this example, it is worth noting that when we analyze the sustainability of a country by using GS indicator, it is better to take into account not only the average, but also the trend and stability of its GS path. In this paper, we analyze the path of GS indicator based on multidimensional perspectives; average, trend and stability.

The rest of this paper is organized as followings. In Section 2, we provide some basic knowledge on the concepts of sustainable development and genuine saving. In Section 3, we describe the methods used for our analysis. Data source description and some remarks are in Section 4. Section 5 is results and discussions. Section 6 is conclusion.

2. Sustainable Development and Genuine Saving

There are a lot of definitions of “Sustainable Development.” Among others, the most famous definition may be the one proposed in Brundtland report “*Our Common Future*,” in which sustainable development is defined as “development that meets the needs of the present without compromising the ability of future generations to meet their own needs” (World Commission, 1987). This definition has gained popularity because it takes into account the intergenerational equity. However, the definition in this report is not clear enough to make the concept applicable in economic analysis. Arrow *et al.* (2003) described this concept of sustainability as non-declining welfare in the future. In this meaning, inclusive wealth (W), which is the source of welfare, must be maintained at all points of time.

Following the standard definition, we define W as:

$$W_t \equiv KM_t + KH_t + KN_t, \quad (1)$$

where W_t is wealth at t , and KM_t , KH_t and KN_t are the accumulated monetary values of inclusive man-made capital, human capital, and natural capital at the point of time t respectively.

Genuine saving (GS) are defined as the time-differentiation of equation (1).

$$GS_t \equiv \frac{dW_t}{dt} = \frac{dKM_t}{dt} + \frac{dKH_t}{dt} + \frac{dKN_t}{dt} \quad (2)$$

Therefore, to be sustainable, equation (2) must be non-negative at all points of time t . We call this “sustainability condition.” This is formally written as equation (3):

$$GS_t \geq 0, \text{ for all } t \quad (3)$$

In practice, we need to measure the values of the right-hand side of equation (2). But it is difficult to measure the values of all capitals, especially the values of KH and KN . Therefore, we have to choose the main or important specific types of KH and KN . In the database of the World Bank, World Development Indicators (WDI), KH includes education expenditure. KN includes the depletion of energy, mineral and forest, and the emission of CO_2 .

In the analysis of GS, many researchers focused on whether the countries have positive GS or not. Specifically, they focused mainly on the average of GS over a given time period. However, as noted in section 1, it is important that the track of GS path should be also taken into account. In the following sections, we observe not only the average, but also the trend and the stability of GS path.

3. Methods

We evaluate the performance of GS based on three perspectives: average, trend, and stability.

Firstly, we calculate the average of GS for the period from $t=1$ to $t=T$.

$$Ave = \frac{1}{T} \sum_{t=1}^T GS_t \quad (4)$$

This value provides us the rough sketch of countries' sustainability. If its *Ave* is positive, a country can be evaluated as being sustainable at least during the study period of $[1, T]$.

Secondly, we calculate the difference of GS in each year and take its average. This value is defined as "*Trend*."

$$Trend = \frac{1}{T-1} \sum_{t=1}^T (GS_t - GS_{t-1}) \quad (5)$$

This trend value indicates whether a country's GS path is upward or downward. If the trend value is positive, the path is upward; when it is negative, the path is downward. If the averages of GS are the same, the country which has upward path should be evaluated as having better GS performance. If a country has very small or negative trend, even if the country has positive average of GS, the country may be considered as

being on the trend toward unsustainable state in the future.

Thirdly, we calculate the stability of GS path. In this calculation, we employed the HP-filter (Hodrick and Prescott, 1997), which represents the potential smoothing path; then we calculate the differences between actual GS and the HP-based GS (HPGS). We define the deviation (*Dev*) of GS path as the sum of square of these differences.

$$Dev = \sum_{t=1}^T (ActualGS_t - HPGS_t)^2 \quad (6)$$

Dev indicates the stability of GS path. If *Dev* is high, the country's GS path is not stable and vice versa. If the averages (or trends) of GS are the same, the country which has stable growth path should be evaluated as having better GS performance.

In this paper, we evaluate the GS performance of each country based on three perspectives mentioned above; average, trend and stability. Based on these perspectives, we are able to obtain richer information about countries' sustainability. Possibly, some countries, which are evaluated by previous studies as sustainable because of having positive averages of GS, may not be sustainable, because of having sharply downward trends or high deviations of GS path.

4. Data and Some Remarks

The GS data, used for our analysis, are measured as percentage of GNI (Gross National Income). The data are available from the World Bank's WDI. There are 208 countries and regions in the database; however, due to the data availability, only 84 countries are selected. The list of the selected countries is presented in Table 1 in the next section.

Before conducting the analysis and discussion, let us observe interesting GS paths of some countries. As the first remark, Figure 2 shows the GS path of Ethiopia, USA and UK. The three countries have similar average values of GS, but USA and UK have more stable paths of GS compared to Ethiopia; moreover USA has negative trend of GS path.² Generally, we can suggest that UK has the best GS performance from integrated perspectives (average, trend and stability). As the second remark, let us take a look at the cases of Japan, China and Sweden. Their GS paths are presented in Figure 3. These three countries also have the similar values of GS average. China has the highest trend;

² The numeric values of *Ave.*, *Dev.*, and *Trend* can be found in Table 1 in the next section.

however, China's GS path is the most unstable. This instability can be thought as the result of the failure of managing the balance between the economic development and the environmental conservation. Therefore, the policy that stabilizes GS path is important for China's sustainable development in the future. For Japan and Sweden cases, even the GS average of Sweden is a bit lower than that of Japan, Sweden's GS path has positive trend, while Japan's GS path has negative trend. This indicates that GS average of Sweden may be on the trend to become higher than that of Japan. From integrated perspectives, Sweden may be evaluated as being better than Japan in term of GS performance.

Besides the two remarks above, there are also some other interesting cases. Here, we restraint ourselves from presenting all of the cases.³ In the next section, the shape of the GS paths, presented here, are summarized by three values; *Ave.*, *Dev.*, and *Trend*.

Our main message in this section is that when we take into account the GS trend and stability, the evaluation of sustainability performance may be different from the evaluation which based only on GS average.

Figure 2: GS paths of Ethiopia, USA and UK
(Real line: Actual GS, Dot line: HP-based GS)

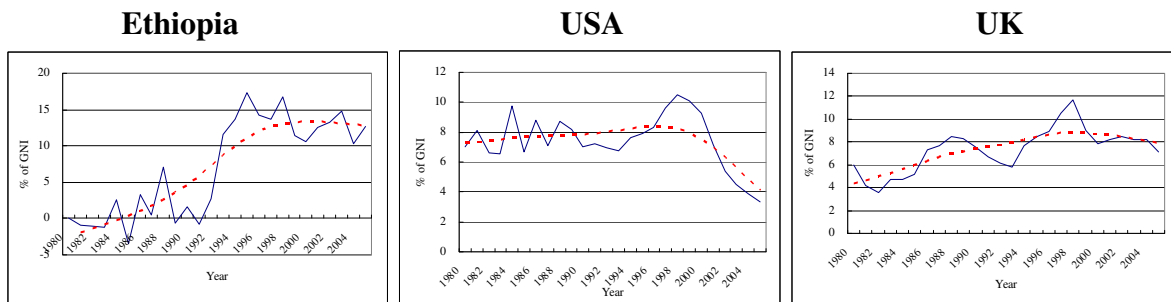
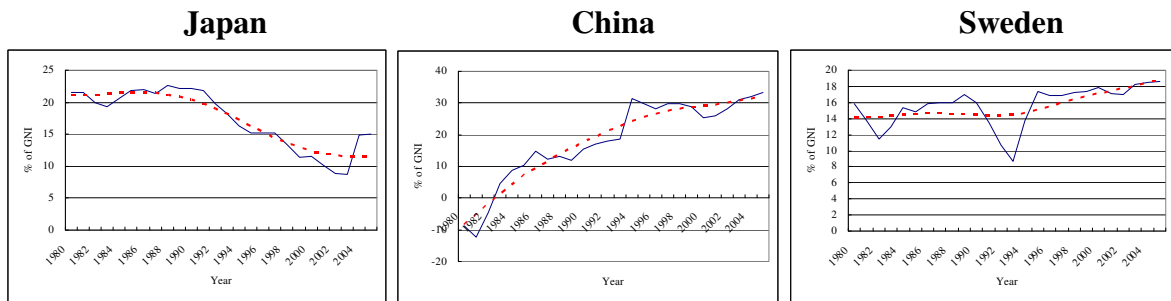


Figure 3: GS paths of Japan China and Sweden



³ The figures of GS paths of other countries can be provided upon request.

5. Results and Discussions

In this section, we evaluate 84 countries' sustainability from 3- dimensional perspectives. The results are presented in Figure 4. X-axis is average (*Ave*) of GS for 1980-2005⁴; the greater the GS average of a country is, the better the GS performance (in other word, the better the sustainability) of that country. Y-axis represents deviation (*Dev*) of GS path; the smaller the value is, the more desirable the GS path. Z-axis is the Trend; the higher, the better. Noting that the best performance of GS path is at upper right corner of the cube; the worst performance is at the opposite side, lower left corner of the cube. The coordinates and abbreviations of country names are shown in Table 1.

To interpret the results and derive the implications, we generate some basic statistics. The results of these basic statistics are provided in Tables 2 and 3. From Figure 4, Tables 1, 2 and 3, the interpretations and implications of the results are summarized below—as general view, group-based view and country view.

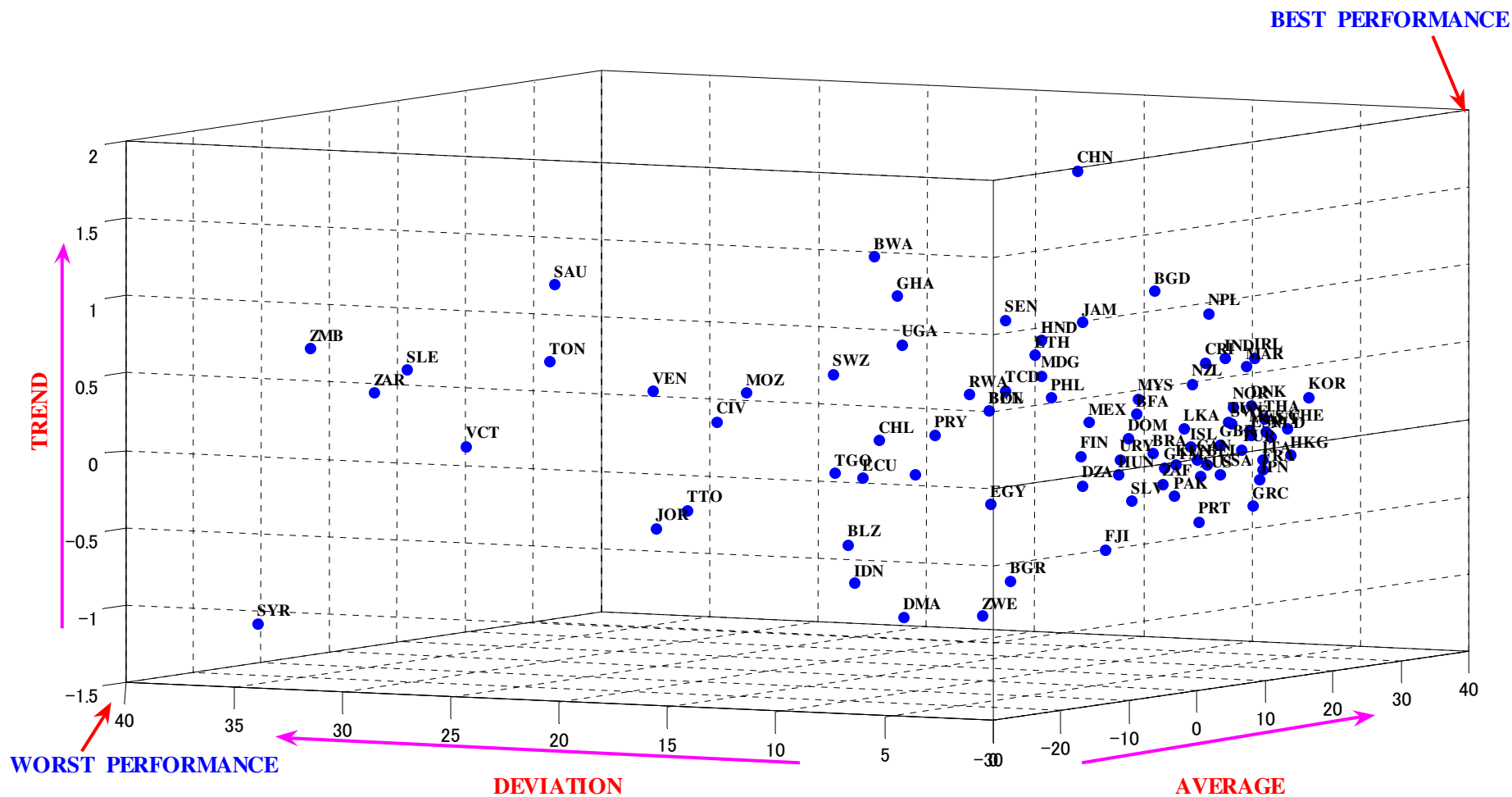
- (1) From the first glance at Figure 4, we can see that, in general, developed countries have good sustainability performance because their GS plots are located in upper right space. It is also worth noting that the countries, whose plots are located in the lower left space of the cube, are the plots of oil-rich countries and developing countries.
- (2) From Tables 1 and 2, we can observe that the number of countries, which have negative *Ave.*, is 13. Most of them are developing countries and many of them are located in sub-Saharan Africa and petroliferous area. The number of countries, which have negative *Trend*, is 35. This fact implies that even the countries whose GS averages are positive for the period of 1980-2005 and are judged as being sustainable, not negligible number of counties, including many developed countries, may be heading toward the state of being unsustainable. From these findings, even developed counties need to implement new and alternative development policies.
- (3) As for high income countries, let us take a look at the OECD column in Table 2. It is characterized as high *Ave.* and low *Dev.* It implies the well-managed developing process and this is highly evaluated. It is noteworthy that *Trend* shows near zero value. It means that these countries are reaching the limits of compensating the

⁴ Due to the availability of data, the sample periods of some countries fall smaller than 1980-2005.

Table 1: Country list

No.	Country Name	Code	Ave.	Dev.	Trend	No.	Country Name	Code	Ave.	Dev.	Trend	No.	Country Name	Code	Ave.	Dev.	Trend
1	Algeria	(DZA)	7.05	7.53	-0.26	29	France	(FRA)	12.27	0.85	-0.15	57	Paraguay	(PRY)	9.70	15.14	0.00
2	Australia	(AUS)	6.14	1.83	-0.16	30	Ghana	(GHA)	2.42	14.61	0.95	58	Philippines	(PHL)	14.55	11.30	0.24
3	Austria	(AUT)	13.19	0.96	0.09	31	Greece	(GRC)	11.17	0.96	-0.38	59	Portugal	(PRT)	8.58	2.63	-0.47
4	Bangladesh	(BGD)	9.89	5.13	0.99	32	Guatemala	(GTM)	1.10	1.85	-0.07	60	Rwanda	(RWA)	4.76	12.06	0.32
5	Belgium	(BEL)	12.01	3.30	-0.13	33	Honduras	(HND)	15.44	12.09	0.60	61	Saudi Arabia	(SAU)	-23.09	22.47	1.14
6	Belize	(BLZ)	14.08	20.56	-0.77	34	Hong Kong, Chin	(HKG)	21.29	2.36	-0.12	62	Senegal	(SEN)	0.01	8.86	0.85
7	Benin	(BEN)	0.27	9.74	0.25	35	Hungary	(HUN)	12.45	7.59	-0.23	63	Sierra Leone	(SLE)	-6.97	34.28	0.41
8	Bolivia	(BOL)	-4.58	11.59	-0.14	36	Iceland	(ISL)	8.70	3.07	0.00	64	South Africa	(ZAF)	4.27	2.92	-0.20
9	Botswana	(BWA)	31.52	24.82	0.95	37	India	(IND)	11.33	2.33	0.57	65	Spain	(ESP)	11.53	1.17	0.08
10	Brazil	(BRA)	9.89	5.15	-0.06	38	Indonesia	(IDN)	13.07	19.94	-1.01	66	Sri Lanka	(LKA)	16.05	5.64	0.06
11	Bulgaria	(BGR)	11.75	12.34	-0.94	39	Ireland	(IRL)	14.89	2.06	0.55	67	St. Vincent and the Grenadin	(VCT)	13.04	37.83	-0.24
12	Burkina Faso	(BFA)	5.46	4.57	0.23	40	Italy	(ITA)	12.01	0.77	-0.09	68	Swaziland	(SWZ)	12.71	20.82	0.34
13	Canada	(CAN)	8.68	2.75	-0.07	41	Jamaica	(JAM)	11.85	9.01	0.76	69	Sweden	(SWE)	15.55	3.31	0.11
14	Chad	(TCD)	-4.25	7.51	0.43	42	Japan	(JPN)	17.34	2.58	-0.26	70	Switzerland	(CHE)	19.13	1.83	0.07
15	Chile	(CHL)	-2.23	14.00	0.05	43	Jordan	(JOR)	15.31	29.77	-0.73	71	Syrian Arab Republic	(SYR)	-15.24	38.51	-1.21
16	China	(CHN)	18.13	11.21	1.68	44	Kenya	(KEN)	12.43	4.93	-0.14	72	Thailand	(THA)	20.83	3.43	0.10
17	Congo, Dem. Rep.	(ZAR)	-6.29	35.98	0.24	45	Korea, Rep.	(KOR)	24.00	2.39	0.23	73	Togo	(TGO)	2.09	17.38	-0.21
18	Costa Rica	(CRI)	9.66	2.71	0.55	46	Madagascar	(MDG)	0.70	7.43	0.49	74	Tonga	(TON)	16.15	34.97	0.31
19	Cote d'Ivoire	(CIV)	4.69	23.67	0.06	47	Malaysia	(MYS)	13.61	7.03	0.26	75	Trinidad and Tobago	(TTO)	-10.82	20.15	-0.38
20	Denmark	(DNK)	10.78	0.91	0.27	48	Mauritius	(MUS)	16.82	2.89	0.07	76	Tunisia	(TUN)	11.90	2.29	0.16
21	Dominica	(DMA)	6.89	15.73	-1.16	49	Mexico	(MEX)	3.73	6.20	0.18	77	Turkey	(TUR)	15.91	2.94	-0.06
22	Dominican Republi	(DOM)	12.91	7.22	0.01	50	Morocco	(MAR)	16.95	3.05	0.47	78	Uganda	(UGA)	-4.85	12.12	0.70
23	Ecuador	(ECU)	-8.98	12.65	-0.14	51	Mozambique	(MOZ)	-2.30	20.08	0.32	79	United Kingdom	(GBR)	7.33	1.27	0.04
24	Egypt, Arab Rep.	(EGY)	10.54	12.83	-0.44	52	Nepal	(NPL)	14.35	4.01	0.83	80	United States	(USA)	7.42	1.28	-0.15
25	El Salvador	(SLV)	4.74	4.57	-0.33	53	Netherlands	(NLD)	14.89	1.30	0.05	81	Uruguay	(URY)	5.13	5.15	-0.06
26	Ethiopia	(ETH)	7.29	9.81	0.57	54	New Zealand	(NZL)	9.48	3.25	0.41	82	Venezuela, RB	(VEN)	-6.90	22.99	0.35
27	Fiji	(FJI)	10.33	7.49	-0.70	55	Norway	(NOR)	13.53	2.58	0.24	83	Zambia	(ZMB)	-12.09	37.13	0.56
28	Finland	(FIN)	11.88	9.10	-0.11	56	Pakistan	(PAK)	10.33	4.29	-0.33	84	Zimbabwe	(ZWE)	8.50	12.59	-1.15

Figure 4: Scatter plots of GS in the 3-dimensional space



depletion of resources and environment by the accumulation of man-made capital originated from the economic growth. The patterns of development in this group need to shift from resource-dependency.

- (4) Many countries with high deviation are developing and low-income countries (see Table 3); in general, these countries have the inferior sustainability performance. Some countries in this group show high performance, but they could be better off if they can manage to control the instability risk of GS paths. Therefore, a stabilizing policy is important and worth introducing.
- (5) For the case of OPEC group as resource rich countries (Table 2), the negative average and trend are instantly found. In addition, deviation is also quite high. These facts imply the serious depletion of natural resource and they have not been successful to compensate this resource depletion by accumulating man-made capital. We can argue that the developments of these countries are not sustainable. Looking squarely at the possibility of exhaustion of resources, we should somehow improve the sustainability by all means, such as technological innovation and international cooperation.
- (6) As the final remarks of group view, let us discuss low-income group. As a whole, the high trend of this group is worth noting. It reflects the variety of international efforts for rising from the worst state. However, we should pay attention to the bipolarization of this group. While there are several countries, such as India and Kenya, have relatively good development, there are still many countries suffered from malfunction of society and economy, resulting in negative averages of GS, which mean unsustainability. Many of them are located in sub-Saharan Africa. As conventionally pointed, this area is strongly needed to improve both socially and economically.
- (7) The country with the highest GS average is Botswana. Botswana succeeded in realizing the remarkable economic growth based on its abundant mineral resources. But Botswana has quite high instability of GS path. Botswana's situation is similar to oil-rich countries' we discussed in (5).
- (8) The country with the lowest GS is Saudi Arabia. The economy of this country is heavily depending on oil resource, which is not renewable. Clearly, it is impossible

to continue lengthily present economic structure. To realize sustainable development, the plentiful money obtained from oil resource should be more effectively used.

- (9) The lowest deviation country is Italy.⁵ Hence we can say that Italy has succeeded in smoothing GS path. But we should also bear in mind that accumulation of productive base in Italy is recently slowing down (i.e. negative trend of GS path). In contrast, Syria has quite volatile GS path. Because Syria has considerably negative average, highest deviation, and negative trend, we have to apprehend its sustainability in the future.

Table 2: Descriptive statistics of GS

	All Countries			OECD			OPEC			Low-income		
	Average	Deviation	Trend	Average	Deviation	Trend	Average	Deviation	Trend	Average	Deviation	Trend
Mean	8.16	10.2	0.07	12.30	2.28	0.01	-4.37	17.74	-0.14	2.75	13.74	0.33
SD	9.10	9.99	0.52	4.22	1.76	0.24	11.93	10.61	0.75	7.16	10.74	0.50
Max	31.52	38.51	1.68	24.00	9.10	0.55	13.07	38.51	1.14	14.35	37.13	0.99
Min	-23.09	0.77	-1.21	6.14	0.77	-0.47	-23.09	6.20	-1.21	-12.09	2.33	-1.15

- Note:** 1. All Countries refer to the 84 selected countries.
 2. OECD refers to the group of OECD member countries. In this study, it contains 21 countries.
 3. OPEC refers to the group of OPEC member and its candidate countries. In this study, it contains 8 countries.
 4. Based on the definition proposed by the World Bank, Low-income country group here consists of 20 countries. The World Bank defines Low-income economies as “those in which 2005 GNI per capita was \$875 or less.”

Table 3: Correlation Matrix

	<i>Ave.</i>	<i>Dev.</i>	<i>Trend</i>
<i>Ave.</i>	1		
<i>Dev.</i>	-0.41727	1	
<i>Trend</i>	-0.01476	-0.05959	1

Note: Based on the data of All Countries

6. Conclusion and Remarks

In this study, we found that even if some countries are judged as sustainable from conventional criterion, i.e. average of GS, there are some countries which do not perform well from the perspectives of trend and stability.

⁵ Italy and France have quite similar values.

From the viewpoint of average, our results provide a similar assessment to previous studies on the sustainability of each country; as a whole, high-income countries show relatively good sustainability, and low-income countries and resource-dependent countries are problematic in sustainability (Atkinson and Hamilton, 2003, and Dietz *et al.*, 2007). However, by adding the viewpoints of trend and stability, our results show a different judgment on sustainability. Our criteria require both positive trend and small deviation. Some countries with positive trend could not meet these criteria, and therefore the judgments are downwardly revised from our criteria.

In this way, our study enriches the assessment on the development of each country. Our suggestion can be summarized as follows. For realizing sustainable development, we should pay attention to the change of wealth, i.e. GS. Needless to say, we should aim for the positive GS in order not to compromise the ability of future generations to meet their own needs. Simultaneously, we must aim for the smoothing path of development. When designing sustainability policy, the track of development path should be always carefully beheld.

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