An index for sustainable development

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Abstract

A measure of development only in terms of consumption of goods is too narrow. Indeed, development is a wider and more complex concept and both theoretical and empirical analysis should be broadened to include a large set of those aspects which contribute to determine the standard of life of people. An answer to this topic is represented by the Human Development Index which ranks nations according to the aggregation of three socioeconomic indicators, whose choice might seem restrictive, especially when a large set of countries with different paths of development is considered. As a possible improvement of this well-known index some economic, social and environmental indicators have been added in order to derive a comprehensive aggregated index of development. In addition, non-replaceability among the various dimensions of development is assumed, that is only a condition where the different components show the same relative proportions is considered sustainable over time. To this aim a concave Sustainable Socioeconomic Development Index which penalizes progressively the dissimilarity among the components is presented and applied to a large sample of countries. With respect to the hypothesis of perfect substitutability among the different variables, the final ranking of countries is quite different in the case of the Sustainable Socioeconomic Development Index, where penalisations to unbalanced degrees of development have been applied.
Keywords: index, development, sustainable development, ranking, HDI.

1   Introduction

The measure of development in terms of only consumption of goods is too narrow, as remarkably outlined *inter alia* by Sen [1]. Indeed development is a wider and more complex concept and empirical analysis should be broadened to include a large set of those aspects which contribute to determine the standard of

life of people. The concept of development is strictly connected to a multidimensional analysis on the empirical field: even if fundamental, the consumption of goods represents only one of the components which have to be taken into account together with a number of other peculiarities of human life.

An answer to this topic is represented by the Human Development Index (HDI henceforth), proposed by the United Nations Development Programme (UNDP) [2], which ranks nations according to their citizen's quality of life, approximated by life expectancy, educational attainment and adjusted real income. Although HDI introduces the multidimensionality in the concept of development, the choice of those indicators might seem restrictive, especially when a large set of countries with different paths of development is considered.

As a possible improvement of HDI some economic, social and environmental indicators will be added to the set of variables usually considered in this kind of works, in order to derive a comprehensive aggregated index of development.

The common definition of sustainable development identifies as sustainable the capability of satisfying the needs of the present generation without compromising for the future ones the ability of fulfilling their needs (World Commission on Environment and Development [3]). This work embraces a different approach to the concept of sustainability.

2 An index for sustainable development

In this work, several characteristics of development have been simultaneously considered: their overall vision provides useful information about its ability to be not susceptible to sharp changes in the future. This revised concept of sustainability automatically implies a definition of balancing. Indeed, development refers to several different characteristics, each of them equally important, so complete substitutability among them cannot be assumed, that is an implicit concept of balance must be introduced (Casadio and Palazzi [4]).

It means that non replaceability among the various dimensions of development is assumed, that is only a path where the different components show the same proportions is considered sustainable over time. Broadly speaking, only development that takes place with harmony for all its elements is considered sustainable over time. Indeed, there are a number of examples of non-balanced growth paths all over the world and a balanced path could be considered as a better proxy of well being and development (Chakravarty [5]).

With the above considerations about balanced and sustainable development in mind, the ideal balance between the components of a development index derived from N rescaled variables occurs when they are all equal; that is, the ideal balance locus is the diagonal straight line passing through the points $(0, \ldots, 0)$ and $(1, \ldots, 1)$ in the N-dimensional real variable space R^N.

Hence, a concave index which penalizes progressively the dissimilarity among the components of development is proposed:

$$SSDI_i = (w_{X1}X_{1i} + \ldots + w_{XN}X_{Ni}) - a \bullet VAR(w_{X1}X_{1i} ; \ldots ; w_{XN}X_{Ni}), \quad (1)$$

where $SSDI_i$ is the Sustainable Socioeconomic Development Index for the generic unit i and w_{Xi} is the weight of the generic variable X_i. Of course, in order to make variables comparable, their values has been rescaled between 0 and 1, so also the range of value for SSDI is between 0 and 1; the value of parameter a determines the entity of penalization. The concavity of the proposed index reflects the non-replaceability of the considered variables, penalizing the imbalances progressively.

The former addend of (1) represents a weighted average of the variables, the latter the "penalty". Variance has been adopted as heterogeneity index: in the case of equal values for all the variables, that is the optimal situation of sustainable development, the penalty will be null; on the contrary, the more heterogeneous the values of the considered variables, higher the "penalty" the given unit will pay for.

Figure 1 shows the two variables case: without loss of generality, adopting the arithmetic mean, that is without introducing a penalty, according to (1) both the most sustainable situation B and the polar cases A and C should assume the same value for the index. Point B is sustainable because the considered variables present all the same value; vice versa, points A and C present the maximum value for one variable and null for the other: they are two socially unsustainable situations, so a penalty will be applied. Indeed points A and C shift to A' and C', respectively; conversely, point B does not pay for any penalty.
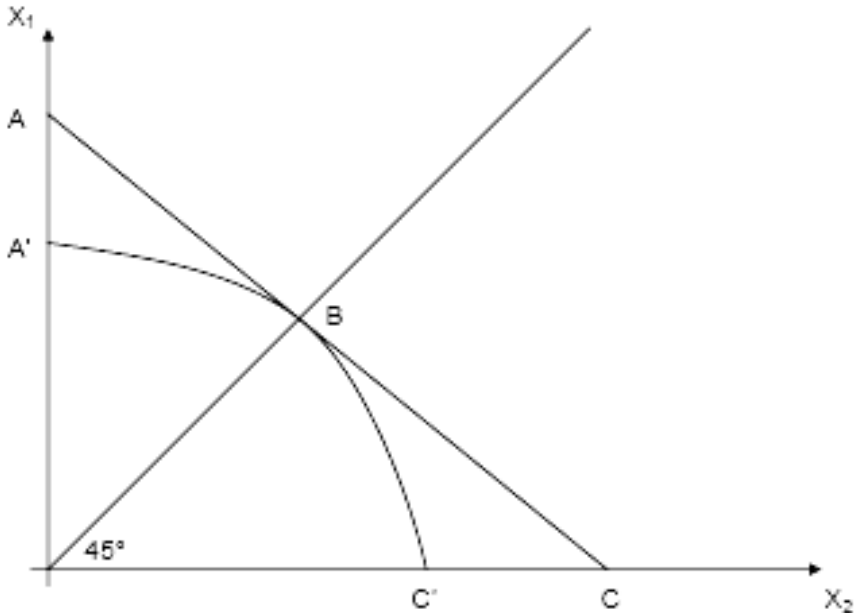

Figure 1:   Concavity of SDI: the two variables case.

Table 1:   Comparison between HDI and SSDI applied to the same variables.

Country	Life expec- tancy index	Educa- tion index	GDP index	HDI	HDI rank	SSDI	SS- DI rank	Ranking diffe- rence
Norway	0.91	0.99	0.99	0.965	1	0.964	1	=
Iceland	0.93	0.98	0.97	0.960	2	0.960	2	=
Australia	0.92	0.99	0.95	0.957	3	0.957	3	=
Ireland	0.88	0.99	1	0.956	4	0.955	4	=
Sweden	0.92	0.98	0.95	0.951	5	0.951	5	=
Canada	0.92	0.97	0.96	0.950	6	0.950	6	=
Japan	0.95	0.94	0.95	0.949	7	0.949	7	=
Switzerland	0.93	0.95	0.97	0.947	9	0.947	8	1
United States	0.88	0.97	1	0.948	8	0.947	9	-1
Finland	0.89	0.99	0.95	0.947	11	0.946	10	1
Netherlands	0.89	0.99	0.96	0.947	10	0.946	11	-1
Belgium	0.9	0.98	0.96	0.945	13	0.944	12	1
Luxembourg	0.89	0.94	1	0.945	12	0.944	13	-1
Austria	0.9	0.96	0.96	0.944	14	0.944	14	=
Denmark	0.87	0.99	0.96	0.943	15	0.942	15	=
France	0.91	0.97	0.95	0.942	16	0.942	16	=
Italy	0.92	0.96	0.94	0.940	17	0.940	17	=
United Kingdom	0.89	0.97	0.96	0.940	18	0.939	18	=
Spain	0.91	0.98	0.92	0.938	19	0.938	19	=
New Zealand	0.9	0.99	0.91	0.936	20	0.935	20	=
Germany	0.9	0.96	0.94	0.932	21	0.932	21	=
Israel	0.92	0.95	0.92	0.927	23	0.927	22	1
Hong Kong, China	0.95	0.88	0.96	0.927	22	0.926	23	-1
Greece	0.89	0.97	0.9	0.921	24	0.920	24	=
Singapore	0.9	0.91	0.94	0.916	25	0.916	25	=
Korea, Rep. of	0.87	0.98	0.89	0.912	26	0.911	26	=
Slovenia	0.86	0.98	0.89	0.910	27	0.909	27	=
Portugal	0.87	0.96	0.88	0.904	28	0.903	28	=
Cyprus	0.9	0.91	0.91	0.903	29	0.903	29	=
Czech Republic	0.85	0.93	0.88	0.885	30	0.884	30	=
Barbados	0.84	0.96	0.84	0.879	31	0.877	31	=
Malta	0.89	0.86	0.87	0.875	32	0.875	32	=
Kuwait	0.87	0.87	0.88	0.871	33	0.871	33	=
Brunei Darussalam	0.86	0.88	0.88	0.871	34	0.871	34	=
Hungary	0.8	0.95	0.86	0.869	35	0.867	35	=
Argentina	0.83	0.95	0.82	0.863	36	0.861	36	=
Poland	0.83	0.95	0.81	0.862	37	0.860	37	=
Bahrain	0.82	0.86	0.89	0.859	39	0.859	38	1
Chile	0.89	0.91	0.78	0.859	38	0.857	39	-1
Slovakia	0.82	0.92	0.83	0.856	42	0.855	40	2
Estonia	0.78	0.97	0.83	0.858	40	0.855	41	-1
Lithuania	0.79	0.97	0.81	0.857	41	0.854	42	-1
Uruguay	0.84	0.95	0.76	0.851	43	0.848	43	=
Croatia	0.84	0.9	0.8	0.846	44	0.845	44	=
Qatar	0.8	0.85	0.88	0.844	46	0.843	45	1
Latvia	0.78	0.96	0.79	0.845	45	0.842	46	-1
Seychelles	0.8	0.88	0.85	0.842	47	0.841	47	=
Costa Rica	0.89	0.87	0.76	0.841	48	0.839	48	=
United Arab Emirates	0.89	0.71	0.92	0.839	49	0.835	49	=
Bahamas	0.75	0.86	0.87	0.825	52	0.824	50	2
Saint Kitts and Nevis	0.75	0.92	0.81	0.825	51	0.823	51	=
Mexico	0.84	0.86	0.77	0.821	53	0.820	52	1
Cuba	0.88	0.93	0.67	0.826	50	0.820	53	-3
Bulgaria	0.79	0.92	0.73	0.816	54	0.813	54	=
Tonga	0.79	0.93	0.73	0.815	55	0.811	55	=
Oman	0.82	0.77	0.84	0.810	56	0.810	56	=
Antigua and Barbuda	0.82	0.8	0.81	0.808	59	0.808	57	2
Trinidad and Tobago	0.75	0.88	0.8	0.809	57	0.808	58	-1
Panama	0.83	0.88	0.72	0.809	58	0.807	59	-1
Malaysia	0.81	0.84	0.77	0.805	61	0.805	60	1
Romania	0.78	0.9	0.74	0.805	60	0.803	61	-1
Mauritius	0.79	0.81	0.8	0.800	63	0.800	62	1
Bosnia and Herzegovina	0.82	0.87	0.71	0.800	62	0.798	63	-1
Libyan Arab Jamahiriya	0.81	0.86	0.72	0.798	64	0.796	64	=
Macedonia, TFYR	0.82	0.87	0.7	0.796	66	0.793	65	1
Russian Federation	0.67	0.95	0.77	0.797	65	0.790	66	-1
Brazil	0.76	0.88	0.74	0.792	69	0.790	67	2
Dominica	0.84	0.86	0.67	0.793	68	0.789	68	=
Colombia	0.79	0.86	0.72	0.790	70	0.788	69	1
Belarus	0.72	0.95	0.71	0.794	67	0.788	70	-3

Table 1: Continued.

Country	Life expec-tancy index	Educa-tion index	GDP index	HDI	HDI rank	SSDI	SS-DI rank	Ranking diffe-rence
Saint Lucia	0.79	0.89	0.69	0.790	71	0.787	71	=
Thailand	0.75	0.86	0.73	0.784	74	0.782	72	2
Venezuela, RB	0.8	0.87	0.68	0.784	72	0.781	73	-1
Albania	0.82	0.88	0.65	0.784	73	0.779	74	-1
Saudi Arabia	0.78	0.72	0.82	0.777	76	0.776	75	1
Samoa (Western)	0.76	0.9	0.67	0.778	75	0.774	76	-1
Lebanon	0.79	0.86	0.68	0.774	78	0.771	77	1
Ukraine	0.69	0.94	0.69	0.774	77	0.767	78	-1
China	0.78	0.84	0.68	0.768	81	0.766	79	2
Kazakhstan	0.64	0.96	0.72	0.774	79	0.765	80	-1
Peru	0.75	0.87	0.67	0.767	82	0.764	81	1
Armenia	0.78	0.91	0.62	0.768	80	0.761	82	-2
Tunisia	0.81	0.75	0.73	0.760	87	0.759	83	4
Ecuador	0.82	0.86	0.61	0.765	83	0.759	84	-1
Grenada	0.67	0.88	0.73	0.762	85	0.758	85	=
Philippines	0.76	0.89	0.64	0.763	84	0.758	86	-2
Saint Vincent and Grenadines	0.77	0.81	0.69	0.759	88	0.758	87	1
Suriname	0.74	0.84	0.7	0.759	89	0.757	88	1
Turkey	0.73	0.81	0.73	0.757	92	0.756	89	3
Jordan	0.78	0.86	0.64	0.760	86	0.756	90	-4
Fiji	0.72	0.87	0.69	0.758	90	0.755	91	-1
Paraguay	0.77	0.86	0.65	0.757	91	0.753	92	-1
Sri Lanka	0.82	0.81	0.63	0.755	93	0.751	93	=
Belize	0.78	0.77	0.7	0.751	95	0.750	94	1
Dominican Republic	0.71	0.83	0.72	0.751	94	0.750	95	-1
Iran, Islamic Rep.	0.76	0.75	0.72	0.746	96	0.746	96	=
Maldives	0.7	0.87	0.65	0.739	98	0.735	97	1
Georgia	0.76	0.91	0.56	0.743	97	0.733	98	-1
Azerbaijan	0.7	0.89	0.62	0.736	99	0.730	99	=
El Salvador	0.77	0.76	0.65	0.729	101	0.728	100	1
Algeria	0.77	0.71	0.7	0.728	102	0.728	101	1
Occupied Palestinian Territories	0.8	0.89	0.53	0.736	100	0.724	102	-2
Cape Verde	0.76	0.73	0.68	0.722	106	0.721	103	3
Jamaica	0.76	0.79	0.62	0.724	104	0.721	104	=
Guyana	0.64	0.9	0.63	0.725	103	0.717	105	-2
Turkmenistan	0.63	0.91	0.64	0.724	105	0.716	106	-1
Syrian Arab Republic	0.81	0.74	0.6	0.716	107	0.712	107	=
Indonesia	0.7	0.83	0.6	0.711	108	0.707	108	=
Viet Nam	0.76	0.81	0.55	0.709	109	0.703	109	=
Egypt	0.75	0.73	0.62	0.702	111	0.700	110	1
Nicaragua	0.75	0.75	0.6	0.698	112	0.696	111	1
Kyrgyzstan	0.7	0.92	0.49	0.705	110	0.690	112	-2
Bolivia	0.66	0.87	0.55	0.692	115	0.683	113	2
Uzbekistan	0.69	0.91	0.49	0.696	113	0.681	114	-1
Moldova, Rep. of	0.72	0.89	0.48	0.694	114	0.680	115	-1
Honduras	0.72	0.77	0.56	0.683	117	0.679	116	1
Mongolia	0.66	0.91	0.5	0.691	116	0.677	117	-1
Guatemala	0.71	0.68	0.63	0.673	118	0.672	118	=
Vanuatu	0.73	0.71	0.57	0.670	119	0.667	119	=
Morocco	0.75	0.54	0.63	0.640	123	0.636	120	3
South Africa	0.37	0.8	0.79	0.653	121	0.633	121	=
Tajikistan	0.65	0.9	0.41	0.652	122	0.632	122	=
Gabon	0.48	0.71	0.7	0.633	124	0.627	123	1
Equatorial Guinea	0.3	0.77	0.89	0.653	120	0.621	124	-4
India	0.64	0.61	0.58	0.611	126	0.611	125	1
Namibia	0.37	0.79	0.72	0.626	125	0.609	126	-1
São Tomé and Principe	0.64	0.76	0.42	0.607	127	0.597	127	=
Solomon Islands	0.63	0.67	0.48	0.592	128	0.589	128	=
Cambodia	0.52	0.69	0.53	0.583	129	0.580	129	=
Myanmar	0.59	0.76	0.39	0.581	130	0.570	130	=
Comoros	0.64	0.53	0.5	0.556	132	0.554	131	1
Lao People's Dem. Rep.	0.5	0.66	0.5	0.553	133	0.550	132	1
Pakistan	0.64	0.46	0.52	0.539	134	0.536	133	1
Bhutan	0.64	0.48	0.5	0.538	135	0.535	134	1
Ghana	0.53	0.54	0.52	0.532	136	0.532	135	1
Botswana	0.16	0.78	0.77	0.570	131	0.528	136	-5
Bangladesh	0.64	0.46	0.49	0.530	137	0.527	137	=
Nepal	0.62	0.51	0.45	0.527	138	0.525	138	=
Papua New Guinea	0.51	0.52	0.54	0.523	139	0.523	139	=
Sudan ac	0.53	0.53	0.5	0.516	141	0.516	140	1

Table 1:　Continued.

Country	Life expectancy index	Education index	GDP index	HDI	HDI rank	SSDI	SSDI rank	Ranking difference
Congo	0.46	0.72	0.38	0.520	140	0.509	141	-1
Timor-Leste	0.52	0.63	0.39	0.512	142	0.507	142	=
Madagascar	0.51	0.66	0.36	0.509	143	0.502	143	=
Cameroon	0.34	0.66	0.51	0.506	144	0.497	144	=
Uganda	0.39	0.67	0.45	0.502	145	0.495	145	=
Togo	0.49	0.54	0.46	0.495	147	0.494	146	1
Djibouti	0.47	0.52	0.5	0.494	148	0.494	147	1
Yemen	0.6	0.51	0.36	0.492	150	0.487	148	2
Mauritania	0.47	0.49	0.49	0.486	153	0.486	149	4
Haiti	0.45	0.5	0.49	0.482	154	0.482	150	4
Kenya	0.37	0.69	0.41	0.491	152	0.481	151	1
Gambia	0.52	0.42	0.5	0.479	155	0.478	152	3
Lesotho	0.17	0.77	0.54	0.494	149	0.463	153	-4
Zimbabwe	0.19	0.77	0.51	0.491	151	0.463	154	-3
Swaziland	0.1	0.72	0.67	0.500	146	0.460	155	-9
Senegal	0.52	0.39	0.47	0.460	156	0.459	156	=
Eritrea	0.49	0.5	0.38	0.454	157	0.453	157	=
Rwanda	0.32	0.61	0.42	0.450	158	0.443	158	=
Guinea	0.48	0.34	0.51	0.445	160	0.442	159	1
Nigeria	0.31	0.63	0.41	0.448	159	0.439	160	-1
Angola	0.27	0.53	0.51	0.439	161	0.432	161	=
Benin	0.49	0.4	0.4	0.428	163	0.427	162	1
Tanzania, U. Rep. of	0.35	0.62	0.32	0.430	162	0.421	163	-1
Côte d'Ivoire	0.35	0.46	0.46	0.421	164	0.420	164	=
Zambia	0.21	0.63	0.37	0.407	165	0.392	165	=
Mozambique	0.28	0.47	0.42	0.390	168	0.387	166	2
Congo, Dem. Rep. of the	0.31	0.54	0.33	0.391	167	0.386	167	=
Malawi	0.25	0.64	0.31	0.400	166	0.385	168	-2
Burundi	0.32	0.52	0.32	0.384	169	0.380	169	=
Ethiopia	0.38	0.4	0.34	0.371	170	0.371	170	=
Chad	0.31	0.29	0.51	0.368	171	0.363	171	=
Central African Republic	0.24	0.42	0.4	0.353	172	0.350	172	=
Guinea-Bissau	0.33	0.39	0.33	0.349	173	0.349	173	=
Burkina Faso	0.38	0.23	0.41	0.342	174	0.339	174	=
Mali	0.39	0.24	0.38	0.338	175	0.336	175	=
Sierra Leone	0.27	0.45	0.29	0.335	176	0.332	176	=
Niger	0.33	0.26	0.34	0.311	177	0.310	177	=

Source: UNDP and author's elaborations.

SSDI must fulfil the concavity and monotony conditions: in order to save space the proofs are not reported and are available upon request. As regards the monotony, parameter a must fulfil the following condition: $a \in (0, 0.5]$.

3　The case of HDI

This section of the work applies the proposed SSDI to the three variables of HDI (life expectancy, school enrolment, per capita GDP), in order to investigate about the sensitivity of the ranking derived through that well known UNDP index.

Table 1 shows the ranking of countries with respect to SSDI values, derived applying the highest degree of penalisation, that is in the case of parameter a equal to 0.5. It is worth of noting that even if the number of variables is restricted, so as expected the ranking remains quite stable, for some countries the difference of positions in the SSDI ranking with respect to HDI one is evident. Introducing a penalisation in the measurement of development, for example Swaziland and Botswana lose nine and five positions, respectively, while Tunisia, Mauritania and Haiti gain all four positions in the SSDI ranking.

4   The case of a wide set of variables

As already highlighted, the choice of only three variables, as the case of HDI seems to be too restrictive and criticisable. Once investigated the potentiality of the proposed SSDI in the previous didactical section, here a wider set of variables has been considered, embracing an extended range of fields, all relative to development, investigating about its sustainability over time.

In particular, Table 2 shows the selected variables, each for a given aspect of development. In order to avoid redundancy among the chosen indicators, parsimony concerning the number of variables has been however observed: of course the proposed application may be enriched considering several other fields of development and selecting a huge number of variables, but it is beyond the aim of this work.

Table 2:   Selected variables for SSDI.

Field	Selected indicator
Economic welfare	GDP per capita (PPP)
Economic structure	Industry, value added (% of GDP)
Economic perspectives	Gross fixed capital formation (% of GDP)
Public policy	General government final consumption expenditure (% of GDP)
Health	Life expectancy at birth (year)
Education	School enrolment index
Environment	CO_2 emissions (kg per 2000 PPP $ of GDP)
ICT diffusion	Mobile phones (per 1,000 people)
Structure of population	Age dependency ratio (dependents to working-age population)

Table 3 shows the ranking of countries with respect to SSDI values, comparing its ranking with respect to the case of an index constituted by a simple average of variables. As expected, considering several variables, also a high number of loss and gained positions in the SSDI ranking with respect to the case of simple average has been observed. This phenomenon is particularly worth of noting because it underlines the importance of the concept of sustainability of development. With respect to the hypothesis of perfect substitutability among the different variables, that is deriving the development index through a simple average of variables, the final ranking of countries is quite different in the case of SSDI, where penalizations to unbalanced degrees of development have been applied.

For example, Iceland is the first country of the world in terms of simple average of variables, third in terms of SSDI, because of its heterogeneity of the values of the considered variables. Vice versa, Czech Republic, second most developed country in the world in terms of simple average, thanks to its low variability of the single components gains the first place of SSDI ranking. For example, both Hong Kong and Macao lose 22 positions, while Morocco gains 24 places.

Table 3:   Comparison between simple average and SSDI.

Country	Simple average	Simple average rank	SSDI	SSDI rank	Ranking difference
Czech Republic	0.69	2	0.64	1	1
Slovenia	0.69	4	0.62	2	2
Iceland	0.70	1	0.62	3	-2
Ireland	0.69	6	0.60	4	2
Norway	0.69	5	0.60	5	=
Spain	0.68	8	0.60	6	2
Portugal	0.67	13	0.60	7	6
Austria	0.68	9	0.60	8	1
Denmark	0.68	10	0.60	9	1
Sweden	0.69	3	0.60	10	-7
Finland	0.68	12	0.59	11	1
Netherlands	0.67	14	0.59	12	2
Italy	0.68	11	0.58	13	-2
Korea, Rep.	0.66	17	0.58	14	3
Malta	0.65	25	0.58	15	10
Singapore	0.67	16	0.58	16	=
Slovak Republic	0.64	26	0.58	17	9
Belgium	0.66	18	0.57	18	=
Japan	0.66	19	0.57	19	=
Luxembourg	0.68	7	0.57	20	-13
Croatia	0.63	31	0.57	21	10
Greece	0.66	22	0.57	22	=
Germany	0.66	20	0.56	23	-3
Estonia	0.63	33	0.56	24	9
France	0.66	21	0.56	25	-4
Australia	0.65	24	0.56	26	-2
Antigua and Barbuda	0.62	35	0.56	27	8
Lithuania	0.63	30	0.56	28	2
United Kingdom	0.65	23	0.56	29	-6
China	0.61	37	0.55	30	7
Kuwait	0.63	29	0.55	31	-2
Canada	0.64	27	0.54	32	-5
New Zealand	0.63	28	0.54	33	-5
Hungary	0.63	32	0.54	34	-2
Cyprus	0.62	34	0.53	35	-1
Latvia	0.61	38	0.53	36	2
Hong Kong, China	0.67	15	0.53	37	-22
Chile	0.60	41	0.52	38	3
Thailand	0.59	43	0.51	39	4
Oman	0.56	50	0.51	40	10
Bulgaria	0.58	44	0.51	41	3
Azerbaijan	0.57	48	0.51	42	6
Poland	0.59	42	0.50	43	-1
Malaysia	0.55	53	0.50	44	9
United States	0.61	39	0.50	45	-6
Bahrain	0.58	45	0.50	46	-1
Barbados	0.60	40	0.50	47	-7
Bosnia and Herzegovina	0.57	47	0.50	48	-1
Jamaica	0.53	63	0.49	49	14
Equatorial Guinea	0.62	36	0.49	50	-14
Grenada	0.55	52	0.49	51	1
Saudi Arabia	0.53	71	0.48	52	19
Mauritius	0.57	49	0.48	53	-4
Romania	0.56	51	0.47	54	-3
Tunisia	0.55	57	0.46	55	2
Iran, Islamic Rep.	0.53	67	0.46	56	11
Belarus	0.54	59	0.46	57	2
Algeria	0.53	69	0.46	58	11
Morocco	0.51	83	0.45	59	24
Russian Federation	0.54	61	0.45	60	1
Jordan	0.51	81	0.45	61	20
Guyana	0.53	68	0.45	62	6
Botswana	0.51	76	0.45	63	13
Brazil	0.55	55	0.45	64	-9
Mexico	0.53	64	0.45	65	-1
Colombia	0.54	60	0.44	66	-6
Costa Rica	0.55	54	0.44	67	-13
Macao, China	0.58	46	0.44	68	-22
Turkey	0.52	72	0.44	69	3
Argentina	0.55	56	0.44	70	-14
Armenia	0.54	58	0.43	71	-13
Ukraine	0.51	78	0.43	72	6
Albania	0.53	65	0.43	73	-8
Dominican Republic	0.51	80	0.43	74	6

Table 3:   Continued.

Country	Simple average	Simple average rank	SSDI	SSDI rank	Ranking difference
South Africa	0.49	89	0.43	75	14
Trinidad and Tobago	0.52	73	0.43	76	-3
Philippines	0.51	79	0.43	77	2
Panama	0.53	66	0.43	78	-12
Vietnam	0.51	77	0.43	79	-2
Dominica	0.54	62	0.43	80	-18
Indonesia	0.51	82	0.42	81	1
Ecuador	0.50	86	0.42	82	4
Fiji	0.52	75	0.42	83	-8
Gabon	0.48	97	0.41	84	13
Nicaragua	0.48	94	0.41	85	9
Kazakhstan	0.49	88	0.41	86	2
Lebanon	0.49	90	0.40	87	3
El Salvador	0.49	91	0.40	88	3
Georgia	0.50	87	0.40	89	-2
Peru	0.50	85	0.40	90	-5
Venezuela, RB	0.49	93	0.40	91	2
Sri Lanka	0.52	74	0.40	92	-18
Uruguay	0.53	70	0.40	93	-23
Belize	0.48	96	0.40	94	2
Moldova	0.48	95	0.40	95	=
Egypt, Arab Rep.	0.47	98	0.40	96	2
Tonga	0.50	84	0.39	97	-13
Paraguay	0.49	92	0.39	98	-6
Mauritania	0.43	113	0.39	99	14
Mongolia	0.46	104	0.39	100	4
Namibia	0.47	99	0.39	101	-2
Turkmenistan	0.46	105	0.39	102	3
Honduras	0.46	103	0.38	103	=
Syrian Arab Republic	0.45	109	0.38	104	5
Bolivia	0.45	106	0.38	105	1
India	0.45	110	0.38	106	4
Angola	0.46	101	0.37	107	-6
Kyrgyz Republic	0.46	100	0.37	108	-8
Swaziland	0.45	108	0.37	109	-1
Vanuatu	0.46	102	0.36	110	-8
Macedonia, FYR	0.43	114	0.36	111	3
Nigeria	0.41	116	0.36	112	4
Cape Verde	0.45	107	0.35	113	-6
Congo, Rep.	0.41	115	0.35	114	1
Eritrea	0.44	112	0.34	115	-3
Cambodia	0.41	117	0.33	116	1
Papua New Guinea	0.40	120	0.32	117	3
Bangladesh	0.41	118	0.32	118	=
Ghana	0.38	124	0.31	119	5
Haiti	0.38	123	0.31	120	3
Guatemala	0.40	119	0.31	121	-2
Yemen, Rep.	0.36	134	0.30	122	12
Pakistan	0.37	127	0.30	123	4
Malawi	0.44	111	0.30	124	-13
Lao PDR	0.39	122	0.30	125	-3
Nepal	0.38	125	0.30	126	-1
Mozambique	0.36	135	0.30	127	8
Djibouti	0.37	129	0.29	128	1
Senegal	0.35	137	0.29	129	8
Tajikistan	0.39	121	0.29	130	-9
Togo	0.36	136	0.29	131	5
Uzbekistan	0.38	126	0.29	132	-6
Kenya	0.36	132	0.29	133	-1
Gambia, The	0.36	131	0.29	134	-3
Cameroon	0.36	133	0.28	135	-2
Zambia	0.35	139	0.28	136	3
Sudan	0.36	130	0.28	137	-7
Comoros	0.37	128	0.28	138	-10
Rwanda	0.34	142	0.26	139	3
Zimbabwe	0.34	141	0.26	140	1
Sierra Leone	0.32	148	0.26	141	7
Uganda	0.35	138	0.26	142	-4
Central African Republic	0.33	144	0.26	143	1
Guinea	0.34	143	0.26	144	-1
Benin	0.32	147	0.25	145	2
Ethiopia	0.32	145	0.25	146	-1
Tanzania	0.32	146	0.25	147	-1
Cote d'Ivoire	0.31	149	0.24	148	1

Table 3:   Continued.

Country	Simple average	Simple average rank	SSDI	SSDI rank	Ranking difference
Chad	0.34	140	0.23	149	-9
Mali	0.30	151	0.23	150	1
Madagascar	0.30	150	0.22	151	-1
Burkina Faso	0.29	153	0.21	152	1
Burundi	0.29	152	0.21	153	-1
Guinea-Bissau	0.28	154	0.21	154	=
Congo, Dem. Rep.	0.27	155	0.18	155	=
Niger	0.25	156	0.17	156	=

Source: author's elaborations.

5   Conclusions

This paper offers a substantive contribution to the debate about the measurement of a wide and multidimensional concept like development. More specifically, it tries to fill a missing link in the theory between sustainability of development and its measurement, introducing a different definition of sustainability: only development that takes place with harmony is considered sustainable over time.

Following this basic consideration, a concave Sustainable Socioeconomic Development Index which penalizes progressively the dissimilarity among the components of development has been derived. Firstly, it has been applied to the three components of the Human Development Index, providing the comparison of the two rankings. Then the proposed index has been applied to a wider set of nine variables, each of them linked to a given aspect of development, comparing the derived ranking to the case without penalisations.

As expected, considering several variables, also a high number of loss and gained positions in the Sustainable Socioeconomic Development Index ranking with respect to the case of simple average has been observed. This phenomenon is particularly worth of noting because it underlines the importance of the proposed concept of sustainability of development. With respect to the hypothesis of perfect substitutability among the different variables, that is deriving the development index through a simple average of variables, the final ranking of countries is quite different in the case of Sustainable Socioeconomic Development Index, where penalizations to unbalanced degrees of development have been applied.

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