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

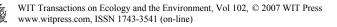
In this work, several characteristics of development have been simultaneously considered: their overall vision provides useful information about its ability to be not susceptible to sharp changes in the future. This revised concept of sustainability automatically implies a definition of balancing. Indeed, 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 \mathbb{R}^N .

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

$$SSDI_{i} = (w_{Xl}X_{li} + ... + w_{XN}X_{Ni}) - a \cdot VAR(w_{Xl}X_{li};...;w_{XN}X_{Ni}), \quad (1)$$



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.

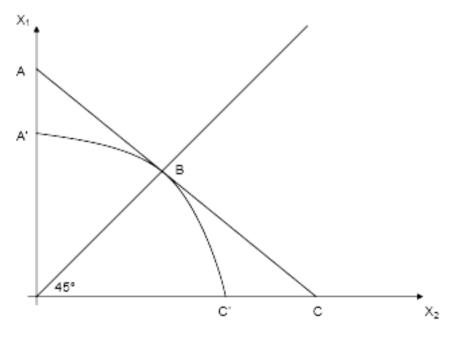


Figure 1: Concavity of SDI: the two variables case.

| Country | Life expec- tancy | Educa- | GDP | HDI | HDI ran | SSDI | SS- DI | Ranking diffe- |
|---|----------------------|--------------|----------------------|----------------|------------|----------------|-----------|-------------------|
| - | index | tion index | index | | k | | rank | rence |
| Norway | 0.91 | 0.99 | 0.99 | 0.965 | 1 | 0.964 | 1 | = |
| Iceland Australia | 0.93 0.92 | 0.98 0.99 | 0.97 0.95 | 0.960 0.957 | 2 3 | 0.960 0.957 | 2 3 | = |
| Ireland | 0.92 | 0.99 | 0.95 | 0.957 | 3 4 | 0.957 | 3 | = |
| Sweden | 0.88 | 0.99 | 0.95 | 0.950 | 4 5 | 0.955 | 4 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 0.89 | 0.96 0.97 | 0.94 0.96 | 0.940 0.940 | 17 18 | 0.940 0.939 | 17 18 | = |
| United Kingdom | 0.89 | 0.97 | 0.96 | 0.940 | 10 | 0.939 | 10 | = |
| Spain New Zealand | 0.91 | 0.98 | 0.92 | 0.936 | 20 | 0.935 | 20 | = |
| Germany | 0.9 | 0.96 | 0.91 | 0.930 | 20 | 0.933 | 20 | = |
| Israel | 0.92 | 0.90 | 0.94 | 0.932 | 23 | 0.932 | 22 | - |
| 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 0.8 | 0.88 0.95 | 0.88 0.86 | 0.871 0.869 | 34 35 | 0.871 0.867 | 34 35 | = |
| Hungary Argentina | 0.83 | 0.95 | 0.80 | 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 0.89 | 0.88 0.87 | 0.85 0.76 | 0.842 0.841 | 47 48 | 0.841 0.839 | 47 48 | = |
| Costa Rica United Arab Emirates | 0.89 | 0.87 | 0.76 | 0.839 | 40 49 | 0.839 | 40 49 | = |
| Bahamas | 0.05 | 0.86 | 0.92 | 0.825 | 49 52 | 0.833 | 49 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 Rospia and Herzegovina | 0.79 0.82 | 0.81 0.87 | 0.8 0.71 | 0.800 0.800 | 63 62 | 0.800 0.798 | 62 63 | 1 -1 |
| Bosnia and Herzegovina | | | 0.71 | 0.800 | 62 64 | 0.798 | 63 64 | -1 |
| Libyan Arab Jamahiriya Macedonia, TFYR | 0.81 0.82 | 0.86 0.87 | 0.72 | 0.798 | 66 | 0.796 | 64 65 | - 1 |
| Russian Federation | 0.62 | 0.87 | 0.77 | 0.790 | 65 | 0.793 | 66 | -1 |
| | | | 0.74 | 0.792 | 69 | 0.790 | 67 | 2 |
| | 0.76 | | | | | | | |
| Brazil Dominica | 0.76 0.84 | 0.88 0.86 | | | 68 | | 68 | = |
| Brazil | 0.76 0.84 0.79 | | 0.67 0.67 0.72 | 0.793 0.790 | | 0.789 | | |

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



| Country | Life expec- tancy index | Educa- tion index | GDP index | HDI | HDI ran k | 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 0.64 | 0.79 0.9 | 0.62 0.63 | 0.724 0.725 | 104 103 | 0.721 0.717 | 104 105 | = -2 |
| Guyana | | | | | | | | |
| 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 0.709 | 108 109 | 0.707 | 108 | = |
| Viet Nam | 0.76 | 0.81 | 0.55 | | | 0.703 | 109 | |
| Egypt | 0.75 0.75 | 0.73 0.75 | 0.62 0.6 | 0.702 0.698 | 111 112 | 0.700 0.696 | 110 111 | 1 1 |
| Nicaragua | 0.75 | 0.75 | 0.6 | 0.098 | 112 | 0.690 | 112 | -2 |
| Kyrgyzstan Bolivia | 0.66 | 0.92 | 0.49 | 0.692 | 115 | 0.683 | 112 | 2 |
| Uzbekistan | 0.69 | 0.07 | 0.33 | 0.696 | 113 | 0.681 | 113 | -1 |
| Moldova, Rep. of | 0.72 | 0.89 | 0.49 | 0.694 | 114 | 0.680 | 114 | -1 |
| Honduras | 0.72 | 0.09 | 0.48 | 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 |



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| Country | Life expec- tancy index | Educa- tion index | GDP index | HDI | HDI ran k | SSDI | SS- DI rank | Ranking diffe- rence |
|--------------------------|-------------------------------|----------------------|--------------|-------|-----------------|-------|-------------------|----------------------------|
| 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.

| 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 | CO2 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 2: Selected variables for SSDI.

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.

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| Cummy average rank SJU SJU have difference Slovenia 0.69 2 0.64 1 1 Slovenia 0.69 4 0.62 2 2 Leeland 0.70 1 0.62 3 -2 Ireland 0.69 6 0.60 4 2 Norway 0.69 6 0.60 5 -2 Ireland 0.69 6 0.60 7 6 Austria 0.68 10 0.60 9 1 Denmark 0.68 12 0.69 11 1 Sweden 0.66 17 0.58 13 -2 Italy 0.66 17 0.58 14 3 Stovak Rep. 0.66 18 0.57 18 = Japan 0.66 18 0.57 19 = Luxemburg 0.66 23 0.66 26 -2 | Table 3: | Table 3: Comparison between simple average and SSDI. | | | | | | | | |
|---|--------------------|--|------------------------|------|-----------|-----------------------|--|--|--|--|
| Slovenia 0.69 4 0.62 2 2 Ireland 0.69 6 0.60 4 2 Norway 0.69 6 0.60 4 2 Norway 0.69 6 0.60 6 2 Spain 0.66 13 0.60 6 2 Denmark 0.68 10 0.60 9 1 Denmark 0.68 12 0.59 11 1 Netherlands 0.67 14 0.59 11 1 Netherlands 0.66 17 0.88 13 -2 Korea, Rep. 0.66 17 0.88 16 9 9 Slovak Republic 0.66 18 0.57 18 = - Japan 0.66 20 0.56 27 2.3 - 3 Greace 0.66 23 0.56 24 9 - Lubhania </th <th>Country</th> <th>Simple average</th> <th>Simple average rank</th> <th>SSDI</th> <th>SSDI rank</th> <th>Ranking difference</th> | Country | Simple average | Simple average rank | SSDI | SSDI rank | Ranking difference | | | | |
| Iceland 0.70 1 0.62 3 2 Norway 0.69 6 0.60 4 2 Norway 0.69 5 0.60 5 = Spain 0.68 8 0.60 6 2 Austria 0.68 9 0.60 7 6 Austria 0.68 12 0.59 11 1 Nemerina 0.68 12 0.59 11 1 Netherlands 0.67 14 0.58 13 -2 Korea, Rep. 0.66 17 0.58 14 3 Malta 0.65 25 0.58 15 10 Slovak Republic 0.64 26 0.56 17 9 Bejgum 0.66 20 0.57 22 = Greace 0.66 21 0.56 26 -2 Austraia 0.63 33 0.56 22 <t< td=""><td>Czech Republic</td><td>0.69</td><td></td><td>0.64</td><td></td><td></td></t<> | Czech Republic | 0.69 | | 0.64 | | | | | | |
| Ireland 0.69 6 0.60 4 2 Spain 0.68 8 0.60 6 2 Portugal 0.67 13 0.60 7 6 Austria 0.68 9 0.60 8 1 Demmark 0.68 10 0.60 9 1 Sweden 0.68 12 0.69 11 1 Nation 0.66 17 0.58 14 3 Singapore 0.66 17 0.58 14 3 Singapore 0.66 18 0.57 18 = Japan 0.66 19 0.57 19 = Luxembourg 0.68 7 0.57 20 -13 Croata 0.63 23 0.56 24 9 France 0.66 21 0.56 24 9 France 0.66 23 0.56 29 -6 | | | | | | | | | | |
| 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 Netherlands 0.677 14 0.59 12 2 Italy 0.668 17 0.58 14 3 Matia 0.667 16 0.58 16 = Sinya Republic 0.66 18 0.57 18 = Japan 0.666 18 0.57 18 = Luxembourg 0.66 20 0.55 23 -3 Gereace 0.666 20 0.55 24 9 France 0.652 23 0.55 30 -7 Contia 0.63 32 0.55 30 <td< td=""><td></td><td></td><td></td><td></td><td></td><td>-2</td></td<> | | | | | | -2 | | | | |
| Spain 0.68 8 0.60 6 2 Austria 0.67 13 0.60 8 1 Demmark 0.68 9 0.60 8 1 Sweden 0.68 10 0.60 9 1 Sweden 0.68 12 0.59 11 1 Netherlands 0.67 14 0.59 13 -2 Korea, Rep. 0.66 17 0.58 14 3 Malta 0.67 12 0.58 16 10 Shapa 0.66 18 0.57 19 = Japan 0.66 22 0.57 22 = Greece 0.66 22 0.57 22 = Greece 0.66 22 0.57 22 = Greece 0.66 21 0.56 26 -2 Austraia 0.62 33 0.56 28 2 | | | | | | | | | | |
| Portugal 0.67 13 0.60 7 6 Austria 0.68 10 0.60 9 1 Denmark 0.68 10 0.60 9 1 Sweden 0.69 3 0.60 10 -7 Finland 0.68 12 0.59 12 2 Italy 0.66 17 0.58 13 -3 Kores, Rep. 0.66 17 0.58 16 - Sitvak Republic 0.66 18 0.57 18 = Japan 0.66 19 0.57 20 -13 Croatia 0.63 31 0.57 21 10 Gerece 0.66 20 0.56 23 -3 Estonia 0.63 33 0.56 25 -4 Austria 0.63 23 0.56 28 -2 Luxembourg 0.66 21 0.55 30 | | | | | | | | | | |
| Austria 0.88 9 0.60 8 1 Sweden 0.68 10 0.60 9 1 Sweden 0.69 3 0.60 10 -7 Finland 0.88 12 0.59 11 1 Netherlands 0.67 14 0.59 12 2 Korea, Rep. 0.66 17 0.58 14 3 Matla 0.65 25 0.56 15 10 Sirovak Republic 0.66 19 0.57 19 = apan 0.66 20 0.56 23 -3 Croatia 0.68 19 0.57 21 10 Greece 0.66 21 0.56 26 -2 Austraia 0.63 33 0.56 28 2 Antigua and Barbuda 0.62 33 0.56 28 2 United Kingdom 0.63 32 0.55 | | | | | | | | | | |
| Denmark 0.68 10 0.60 9 1 Finland 0.68 12 0.59 11 1 Netherlands 0.67 14 0.59 12 2 Italy 0.68 11 0.58 13 -2 Singapore 0.66 17 0.58 14 3 Malta 0.65 25 0.58 16 = Singapore 0.67 16 0.58 17 9 Belgium 0.66 18 0.57 18 = Japan 0.66 22 0.57 20 -13 Croata 0.63 33 0.56 22 = Cance 0.66 21 0.56 25 -4 Australia 0.63 29 -6 7 8 Luthwania 0.63 29 -55 31 -2 Canada 0.64 27 0.55 30 - | | | | | | | | | | |
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| Finland 0.68 12 0.59 11 1 Netherlands 0.67 14 0.59 12 2 Italy 0.68 11 0.58 13 -2 Singapore 0.66 17 0.58 14 3 Matta 0.65 25 0.58 16 = Siovak Republic 0.64 18 0.57 18 = Japan 0.66 18 0.57 18 = Japan 0.68 7 0.57 20 -13 Croata 0.63 31 0.56 24 9 Greece 0.66 23 0.56 24 9 France 0.63 30 0.56 28 -2 Autstalia 0.62 35 0.56 27 8 Lithuania 0.63 29 0.55 31 -2 Canada 0.61 37 0.55 30 | | | | | | | | | | |
| Netherlands 0.67 14 0.59 12 2 Korea, Rep. 0.66 17 0.58 14 3 Malta 0.65 25 0.58 15 10 Singapore 0.67 16 0.58 17 9 Belgium 0.66 19 0.57 19 = Luxenbourg 0.68 7 0.57 20 -13 Crotatia 0.63 31 0.57 21 10 Geremany 0.66 20 0.56 23 -3 Estonia 0.63 33 0.56 24 9 France 0.66 21 0.56 28 -4 Austraila 0.63 23 0.56 28 -2 Austraila 0.63 23 0.56 28 -2 Austraila 0.63 29 0.55 31 -2 Chaustraila 0.63 29 0.55 | | | | | | | | | | |
| Italy 0.68 11 0.58 13 -2 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 20 -13 Croatia 0.63 31 0.57 22 = Germany 0.66 22 0.57 22 = Germany 0.66 24 0.56 26 -2 Antigua and Barbuda 0.65 24 0.56 28 2 United Kingdom 0.65 23 0.56 28 2 United Kingdom 0.63 30 0.56 28 2 United Kingdom 0.63 32 0.54 33 -5 Hungary 0.63 32 0. | | | | | | | | | | |
| Kořez, Rep. 0.66 17 0.58 14 3 Malta 0.65 25 0.58 16 = Slovak Republic 0.66 18 0.57 18 = Japan 0.66 18 0.57 19 = Luxembourg 0.68 7 0.57 20 -13 Croatia 0.63 31 0.57 21 10 Gereco 0.66 22 0.56 23 -3 Estonia 0.63 31 0.56 24 9 France 0.66 21 0.56 25 -4 Australia 0.65 23 0.56 27 8 Lithuania 0.63 29 0.55 31 -2 Canada 0.64 27 0.54 33 -5 Huingdry 0.63 28 0.54 33 -5 Huingdry 0.63 28 0.54 33 | | | | | | | | | | |
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| Belgium 0.66 18 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 21 10 Germany 0.66 22 0.57 22 = Australia 0.63 33 0.66 23 -3 Estonia 0.63 33 0.66 25 -4 Australia 0.65 24 0.66 25 -4 Australia 0.65 24 0.66 27 8 Liftwaria 0.63 30 0.56 28 2 United Kingdom 0.63 29 0.55 31 -2 Canada 0.64 27 0.54 32 -5 Hungary 0.63 32 0.54 33 -5 Hungary 0.63 32 0.51 <t< td=""><td>Singapore</td><td></td><td>16</td><td>0.58</td><td></td><td></td></t<> | Singapore | | 16 | 0.58 | | | | | | |
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| 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 28 2 Lithuania 0.63 30 0.56 28 2 United Kingdom 0.66 23 0.55 31 -2 Canada 0.64 27 0.54 32 -5 Hungary 0.63 32 0.54 33 -5 Hungary 0.63 32 0.54 34 -2 Cyprus 0.62 34 0.53 36 -2 Hong Kong, China 0.67 15 0.53 37 -22 Chie 0.60 41 0.52 38 3 Thailand 0.59 43 0.51 <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> | | | | | | | | | | |
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| 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 33 -5 Cyprus 0.62 34 0.53 35 -1 Latvia 0.61 38 0.53 37 -22 Chile 0.60 41 0.52 38 3 Thailand 0.59 43 0.51 40 10 Bulgaria 0.58 53 0.51 40 10 Bulgaria 0.58 44 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 Barbados 0.62 36 0.49 49 </td <td>United Kingdom</td> <td>0.65</td> <td>23</td> <td>0.56</td> <td>29</td> <td>-6</td> | United Kingdom | 0.65 | 23 | 0.56 | 29 | -6 | | | | |
| Canada 0.64 27 0.54 32 -5 New Zealand 0.63 28 0.54 33 -5 Hungary 0.62 34 0.53 35 -1 Latvia 0.67 15 0.53 36 2 Hong Kong, China 0.67 15 0.53 37 -22 Chile 0.60 41 0.52 38 3 Thailand 0.58 43 0.51 39 4 Oman 0.56 50 0.51 40 10 Bulgaria 0.55 53 0.50 43 -1 Malaysia 0.55 53 0.50 44 9 United States 0.61 39 0.50 45 -6 Bahrain 0.53 63 0.49 49 14 Jamaica 0.53 63 0.49 50 -14 Babrain 0.53 63 0.49 < | | | | | | | | | | |
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| Hungary Cyprus0.63 0.6232 340.53 0.5335 35-1 1 1 1 1 0.61Latvia0.61 0.6738 150.53 | | | | | | | | | | |
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| Hong Kong, China0.67150.533722Chile0.60410.52383Thailand0.59430.51394Oman0.56500.514010Bulgaria0.58440.51413Azerbaijan0.57480.51426Poland0.59420.5043-1Malaysia0.55530.50449United States0.61390.5045-6Barbarain0.58450.5046-1Barbados0.60400.5047-7Bosnia and Herzegovina0.57470.5048-1Jamaica0.62360.4950-14Equatorial Guinea0.62360.4950-14Grenada0.55570.46552Saudi Arabia0.55570.46561Irunisia0.55570.46561Irunisia0.51830.455924Maritius0.51830.456120Irunisia0.55550.465811Jordan0.51830.456120Grenada0.55550.465811Jordan0.51840.456120Grenada0.55550.46 <td< td=""><td></td><td></td><td></td><td></td><td></td><td></td></td<> | | | | | | | | | | |
| Chile 0.60 41 0.52 38 3 Thalland 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 47 -7 Bosnia and Herzegovina 0.57 47 0.50 48 -1 Jamaica 0.53 63 0.49 50 -14 Grenada 0.55 52 0.49 51 1 Saudi Arabia 0.55 57 0.46 55 2 Mauritius 0.55 57 0.46 | | | | | | | | | | |
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| 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 0.55 57 0.46 55 2 Mauritius 0.56 51 0.47 54 -3 Tunisia 0.55 57 0.46 56 11 Belarus 0.54 59 0.46 58 11 Morocco 0.51 83 0.45 61 20 Guyana 0.53 68 | | 0.57 | 48 | 0.51 | 42 | 6 | | | | |
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| 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 | | | | | | | | | | |
| 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 | Turkey | | 72 | | 69 | | | | | |
| Ukraine 0.51 78 0.43 72 6 Albania 0.53 65 0.43 73 -8 | Argentina | 0.55 | 56 | 0.44 | 70 | -14 | | | | |
| Albania 0.53 65 0.43 73 -8 | | | | | | | | | | |
| | | | | | | | | | | |
| LUOMINICAN REPUBLIC 0.51 80 0.43 74 6 | | | | | | | | | | |
| | Dominican Republic | 0.51 | 80 | 0.43 | 74 | 6 | | | | |

Table 3. Comparison between simple average and SSDI



| | Table | 3: Cor | itinued. | | |
|------------------------------------|-------------------|------------------------|--------------|------------|-----------------------|
| 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 -2 |
| Georgia | 0.50 | 87 | 0.40 | 89 | -2 -5 |
| Peru | 0.50 | 85 | 0.40 | 90 | |
| Venezuela, RB | 0.49 | 93 74 | 0.40 | 91 | 2 -18 |
| Sri Lanka | 0.52 | | 0.40 | 92 | |
| Uruguay | 0.53 | 70 | 0.40 | 93 | -23 |
| Belize | 0.48 0.48 | 96 95 | 0.40 0.40 | 94 95 | 2 |
| Moldova | 0.48 | 95 98 | 0.40 | 95 96 | = 2 |
| Egypt, Arab Rep. | 0.47 | 98 84 | 0.40 | 96 97 | -13 |
| Tonga | 0.50 | 84 92 | 0.39 | 97 98 | -13 -6 |
| Paraguay Mauritania | 0.49 | 92 113 | 0.39 | 98 99 | -6 14 |
| | 0.43 | 104 | 0.39 | 100 | 4 |
| Mongolia Namibia | 0.46 | 99 | 0.39 | 100 | -2 |
| Turkmenistan | 0.47 | 105 | 0.39 | 101 | -2 3 |
| Honduras | 0.46 | 103 | 0.38 | 102 | 5 |
| Syrian Arab Republic | 0.46 | 103 | 0.38 | 103 | 5 |
| Bolivia | 0.45 | 105 | 0.38 | 104 | 1 |
| India | 0.45 | 110 | 0.38 | 105 | 4 |
| Angola | 0.45 | 101 | 0.37 | 100 | -6 |
| Kyrgyz Republic | 0.46 | 100 | 0.37 | 108 | -8 |
| Swaziland | 0.45 | 108 | 0.37 | 100 | -0 -1 |
| Vanuatu | 0.46 | 102 | 0.36 | 110 | -8 |
| Macedonia, FYR | 0.43 | 114 | 0.36 | 111 | 3 |
| Nigeria | 0.40 | 116 | 0.36 | 112 | 4 |
| Cape Verde | 0.45 | 107 | 0.35 | 113 | -6 |
| Congo, Rep. | 0.41 | 115 | 0.35 | 114 | ı 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 |
| Тодо | 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 7 |
| Sierra Leone | 0.32 | 148 | 0.26 | 141 | -4 |
| Uganda Control African Bopublia | 0.35 | 138 | 0.26 | 142 | |
| Central African Republic | 0.33 | 144 | 0.26 | 143 | 1 |
| Guinea | 0.34 | 143 | 0.26 | 144 | -1 2 |
| Benin Ethiopia | 0.32 0.32 | 147 | 0.25 | 145 | -1 |
| Ethiopia | | 145 | 0.25 | 146 | -1 -1 |
| Tanzania Cote d'Ivoire | 0.32 | 146 149 | 0.25 | 147 148 | -1 |
| | 0.31 | 149 | 0.24 | 140 | I |

Table 3: Continued.



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|------------------|-------------------|------------------------|---------|-----------|-----------------------|
| 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 | = |

Table 3: Continued.

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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