CAN THE MEASURE OF DEVELOPMENT BE IMPROVED?[1]

Luca Muzzioli, Viola Taormina

Abstract. Over the past few decades, the concept of development has undergone a significant transformation, from a primarily economic perspective to a more holistic, multidisciplinary approach. This shifted the focus from conventional economic indicators such as Gross National Product to a more comprehensive evaluation, epitomized by the Human Development Index (HDI). Nevertheless, the structural changes brought by globalization have exacerbated socioeconomic disparities within countries, underscoring the urgent need for further reforms. The primary objective of this study is to enhance the HDI by introducing an economic inequality coefficient that improves its sensitivity to disparities. To achieve this, the HDI is deconstructed into its three core components, and three distinct coefficients of economic distribution—namely, the Gini Coefficient, Theil Index, and Atkinson Index—are each integrated into the HDI through four distinct computational approaches. A rigorous analysis, commencing with a correlation study, followed by a comprehensive robustness examination, was conducted to identify the most effective and dependable index, christened the Just Human Development Index (JHDI). Notably, the incorporation of the Gini Coefficient into the normalization formula of the Income Index (referred to as JHDI-G1) exhibited the highest correlation value when compared to all other alternatives and the traditional HDI. This assessment was made in reference to five chosen validation indices: the Inequality-Adjusted HDI, Gender Development Index, Gender Inequality Index, Multidimensional Poverty Index, and Ecological Footprint per capita. These findings highlight the tangible potential for better consideration of inequalities in development measurement. This achievement is primarily attributed to the integration of the Gini Coefficient, a method that maintains the ease of HDI calculation while significantly enhancing its sensitivity to economic inequalities.

[1] Both the authors equally contributed to data collection, data analysis, and the drafting of the article.

1. Introduction

The evolution of the concept of development and the associated metrics is a highly relevant subject within the realm of scientific research. Throughout history, the understanding of development has undergone profound transformations, transitioning from a predominantly economic viewpoint, cantered around Gross Domestic Product (GDP), to a more comprehensive approach that encompasses the holistic well-being of individuals. The term "development" initially emerged during the latter half of the 19th century as a synonym for economic growth, which referred to achieving sustained increases in income per capita to enable a nation to expand its output at a rate surpassing the population growth rate, as defined by Todaro and Smith (2015). In this perspective, welfare was equated with consumption, implying that higher purchasing power among citizens led to greater levels of satisfaction. State policies, aiming to foster growth focused on bolstering industrial production and encouraging the shift of investments from agriculture to the manufacturing sector. GDP, as a measure of economic growth, account for the monetary value of all final goods and services produced within a nation's borders during a specified period, typically a year, while excluding various factors crucial for development. These calculations do not incorporate non-monetary aspects like health, education, environmental quality, and overall quality of life, included the externalities affecting the environment and the sustainable management of natural resources. Moreover, GDP only acknowledges formal employment, neglecting the value of unpaid labour, as discussed by Fleurbaey and Blanchet (2013). A few decades after the Second World War, numerous non-European countries embarked on decolonization processes and experienced economic growth, which, however, did not translate into improved living conditions for the population. Despite the increased GDP rates, poverty and social vulnerability persisted, failing to diminish. This evidence led many scholars to reconceptualize the term 'development,' viewing it more as a process of 'redistributing growth' with a focus on eradicating poverty and inequality. One of the seminal contributions in this direction came from economist Dudley Seers, paving the way for the formulation of the so called "*basic needs approach*". This development model emerged as an alternative to GDP and emphasized the satisfaction of people's fundamental needs as the foundation for evaluating a country's level of development. Todaro and Smith (2015) underline how this new conception revolutionized the measurement framework, introducing new indicators such as access to adequate food, safe and healthy housing, education, and healthcare services. While the Basic Needs approach offers a broader perspective in contrast to GDP, it also faces limitations, especially regarding the intricacy of measuring, given the complexity of quantifying fundamental requirements. Conventional statistics and indicators might come up short in encompassing the complete spectrum of

individuals' necessities and defining a universal set of needs applicable to all societies. One of the most significant contributions to alternative theories of economic growth was formulated in the late 1990s by economist and Nobel laureate Amartya Sen. According to Sen, poverty is not a phenomenon that can be adequately measured solely by income levels or utility; rather, what holds utmost importance is "*what a person is, or can be, and does, or can do*." Sen's approach underscores that well-being isn't solely contingent on the characteristics of consumed commodities, as in the utility approach, but rather on the agency individuals have in using and realizing the potential of these commodities, as articulated in Sen's work (1999).

1.1. Human Development Index and Measures of Inequalities

The human development index of Amartya Sen has represented a turning point in development measurement methodologies, managing to combine in its computation indicators of both economic and social. HDI is a composite index that measures development according to three fundamental dimensions:

- Life expectancy: influenced by factors such as access to health care, food, environmental conditions and drinking water.
- Literacy rate: considering adult literacy and the rate of schooling.
- GDP per capita: average income of a country divided by its population.

Each indicator is normalized using a specific scale and assigned a value between 0 and 1, where 1 represents the highest level of human development. Then the indicators are aggregated using the geometric mean resulting in a measure of a country's human well-being. Since the late 1990s, the conception of human development and the formulation of HDI have given rise to several formulations of approaches to measure development, such as the Capabilities Approach or all composite indices aimed at measuring dimensions such as Poverty and Gender. In recent years, due to the growing gap between different social classes and between different regions of the world, it has been necessary to highlight the extent of inequalities within development indices. A first contribution in this sense came from Hicks, who conceived a first version of the human development index considering an inequality coefficient. In accordance with the standard of well-being conceived by Amartya Sen, Hicks used the GINI coefficient to measure the economic distribution within the population. The index constructed by Hicks foresees the application of the coefficient GINI to the three dimensions of HDI, then the results are the normalize with the following formula: Having as a final formula:

$$IAXi = \frac{(\text{actual Xi value} - \min \text{Xi value}) * \bar{\lambda}(1 - \text{Gi})}{\max \text{Xi value} - \min \text{Xi value}} \quad (1)$$

where G_i is the Gini coefficient for each *i* dimension (i=1,2,3) (Hicks, 1997).

Hicks' proposed index has faced numerous critiques over the years, especially concerning its consistency within subgroups. It's conceivable that welfare increases in one region while remaining stagnant in another, ultimately resulting in an overall decrease in general welfare. The practical challenges in applying this interpretation of the Inequality-Adjusted Human Development Index (IHDI) prompted a re-evaluation, spearheaded by scholars Foster, Lopez-Calva, and Szekely during their 2005 study in Mexico (Foster et al., 2007). The revamped approach to addressing inequality introduces a novel inequality coefficient, the Atkinson coefficient, into the calculation. This coefficient is applied to the three indicators of the HDI, then the results are aggregated with a mathematical average that provides the values of the Inequalities Adjusted Human Development Index (IHDI). The main strength of IHDI lies in its comprehensive calculation, which considers inequality in all three dimensions: life expectancy, education, and income. This approach allows the derivation of new values, allowing a comparison between HDI and IHDI to reveal the extent of "loss of human development due to inequality." It highlights disparities and inequalities within a given country. However, the methodology used does not offer any understanding of the specific dimensions in which individuals experience inequality, thus limiting the ability to identify which indicator is most affected by this phenomenon. The theoretical issues that the following paper aims to raise concern in particular the growing income inequalities that have occurred in the last twenty years. According to the 2022 World Inequality Report, the poorest 50% of the population collectively collect 8.5% of global income, equal to an average income of €2,800 per year or €230 per month per person. The average 40% of the population earns 39.5% of total income, with their income closely reflecting the global average at €16,500 per year (€1,375 per month). By contrast, the richest 10% of the population captures 52% of total income, exceeding the global average by more than five times, with an average income of 87,200 euros per year per adult (7,300 euros per month). The research question to which the following analysis seeks an answer is whether, in the light of the above data, it is still feasible to discuss improvements in human development without considering economic inequality? Starting from this evidence, the present work aims to reshape the formulation of the HDI into a new index of development called "Just Human Development Index" (JHDI). The necessity to address the increase in income inequalities within countries suggest that inequalities should not be accounted on all three dimensions of the HDI but considered as a "penalty function" solely within the income indicator. The aim, therefore, is not to change the HDI in its entirety, but rather to replace the income indicator with a “fairer” measure to capture the current trends in income concentration.

2. Methods

2.1. Selection of income inequality coefficients

Economic inequality coefficients to embed were selected on the basis of the work of De Maio (2007). Among the coefficients addressed in the paper, Coefficient of Variation (CoV) was excluded because of its limited use in literature while for Kakwani progressivity index, Robin Hood index (also known as Pietra Ratio), and the Sen Poverty Measure, the exclusion was due to the lack of available data. Therefore, the research focused on the following coefficients: Gini Coefficient (GC), Generalised Entropy index (GE), and Atkinson Index (AI). In both GE and AI, the sensitivity parameters (α and ε, respectively) were set at 2 because the higher the value, the more sensitive these indices become to inequalities at the bottom of the income distribution.

2.2. Selection of databases

Secondly, for the data collection two open-access databases were identified on the web: the World Bank Database (WB-DB)[2] and the United Nation University-World Income Inequality Database (UNU-WIID)[3]. The former includes only the Gini Coefficient, while the latter includes Gini Coefficient, Theil Index, and Atkinson Index. The latest available HDI values (2021)[4] have been downloaded from the United Nation Development Program website and then disaggregated into its components: Life expectancy at birth Index (LEI), Education Index (EI), and Income Index (II). The values of the original variable which the components were calculated from have also been considered.

2.3. Alternative methods to embed an inequality coefficient.

Four methods of embedding were developed and tested to identify the most performative coefficient. The first method (JII1) embeds the coefficient as a penalty function of the Income Index (II) during its normalization step with the following formula:

$$JII1i = \frac{\ln(\hat{I}i * ICr) - \ln(100)}{\ln(75000 * ICi) - \ln(100)} \quad (2)$$

where IC_r is the reference value chosen for each Inequality Coefficient (GINI=0.25; Theil=0.15; Atkinson=0.15) and $\hat{I}_i$ is the i-th country yearly Gross National Income (GNI) per capita value capped at 75000$. The JII1 was then reaggregated with LEI and EI by geometric mean.

[2] Link to the World Bank Database (last access: July 14th, 2023)
[3] Link to the UNU-WII Database (last access: July 14th, 2023)
[4] Link to the HDI Database (last access: July 14th, 2023)

The second method (JII2) embeds the coefficient with a calculation similar to that used to compute the Education Index from the Mean Years of Schooling and the Expected Years of Schooling:

$$JII2i = \frac{1}{2} * \left(\frac{\hat{I}i}{75000} + \frac{ICr}{\mathrm{ICi}}\right) \quad (3)$$

where IC_r is the reference value chosen for each Inequality Coefficient (GINI=0.25; Theil=0.15; Atkinson=0.15) and $\hat{I}_i$ is the i-th country yearly GDP per capita value capped at 75000$. The JII2 was then reaggregated with LEI and EI by geometric mean.

The third and fourth methods are based on the normalization of the Inequality Coefficient with a min-max method:

$$JII3i = 1 - \frac{ICi - ICmin}{ICmax - ICmin} \quad (4)$$

where IC_{max} and IC_{min} are fixed for GINI at 0.8 and 0.2 (Theil: 1 and 0.1; Atkinson: 0.8 and 0.1), respectively, while IC_i is capped at 0.2 (Theil and Atkinson: 0.1). The difference between the two methods relies on the fact that JII3 was considered as a fourth dimension and thus aggregated to LEI, EI, and II by geometric mean, while in JII4 the min-max normalization underwent two consecutive steps of geometric mean aggregation: it was firstly aggregated solely to II and only then to LEI and EI.

2.4. Selection of validation indices

To evaluate the capacity of the different alternatives, several indices have been selected. Four indices related to inequalities and poverty with reliable, open-access, and recent data have been identified: the Inequality-Adjusted Human Development Index (IHDI) is related to the inequalities in human development, the Gender Inequality Index (GII) and the Gender Development Index (GDI) consider gender inequalities, and Multidimensional Poverty Index (MPI) is related to poverty. In addition, a validation index linked to the environmental impact of countries was selected to verify which HDI alternative has the higher ability to take this paramount factor into consideration. The selected index was the Ecological Footprint per capita that documents "the extent to which human society stays within or exceeds the regenerative capacity of the planet" (Kitzes *et al.* 2008).

2.5. Statistical analysis

Statistical analysis was carried out on SPSS Ver. 27.0.1.0. A Shapiro-Wilk test assessed the non-normal distribution of variables. A multivariate analysis was performed with the Spearman's rank correlation test. Correlation of the alternatives was computed against the validation indices reported in sector 2.4. Obtained correlations were converted into absolute values and then cumulated to identify the 4 alternatives that correlate the most. Finally, a robustness analysis, composed by an

uncertainty and sensitivity analysis, was carried out on the more correlated variants to evaluate how uncertainty in the input factors propagates through the structure of the composite indicator and affects the composite indicator values (uncertainty analysis), and assess the contribution of the individual source of uncertainty to the output variance (sensitivity analysis) (Nardo *et al.*, 2005). Uncertainty analysis was realized by studying the index's behavior from the inclusion and exclusion of individual indicators. In the sensitivity analysis, the modification of the results on the variation of an added random noise was studied. Lastly, the HDI and the most performative alternative were compared in the ranking capacity and the division of countries into the 4 categories of the HDI.

Table 1 – *Correlation analysis by Spearman's rank-order correlation coefficient.*

	IHDI	GII	GDI	MPI	EF pc	Cumulative Correlation
HDI	-0.925**	0.984**	0.637**	-0.928**	0.849**	4.324
JHDIG1-WB	-0.925**	0.985**	0.646**	-0.930**	0.851**	4.337
JHDIG2-WB	-0.912**	0.977**	0.600**	-0.901**	0.812**	4.202
JHDIG3-WB	-0.925**	0.985**	0.613**	-0.922**	0.817**	4.263
JHDIG4-WB	-0.910**	0.974**	0.590**	-0.899**	0.809**	4.183
JHDIG1-UNU	-0.927**	0.987**	0.634**	-0.927**	0.854**	4.328
JHDIG2-UNU	-0.928**	0.987**	0.613**	-0.921**	0.829**	4.278
JHDIG3-UNU	-0.932**	0.989**	0.605**	-0.922**	0.823**	4.271
JHDIG4-UNU	-0.922**	0.982**	0.587**	-0.906**	0.821**	4.217
JHDIT1-UNU	-0.927**	0.988**	0.631**	-0.926**	0.853**	4.325
JHDIT2-UNU	-0.913**	0.973**	0.590**	-0.887**	0.812**	4.176
JHDIT3-UNU	-0.927**	0.985**	0.597**	-0.911**	0.820**	4.240
JHDIT4-UNU	-0.916**	0.975**	0.577**	-0.884**	0.815**	4.167
JHDIA1-UNU	-0.926**	0.987**	0.630**	-0.925**	0.853**	4.321
JHDIA2-UNU	-0.912**	0.973**	0.586**	-0.882**	0.807**	4.161
JHDIA3-UNU	-0.932**	0.989**	0.603**	-0.920**	0.823**	4.266
JHDIA4-UNU	-0.922**	0.982**	0.587**	-0.901**	0.821**	4.213

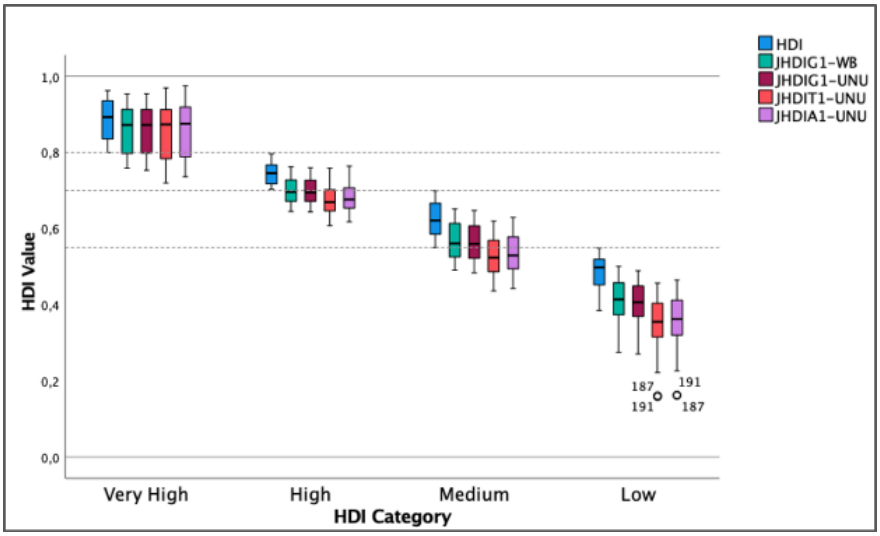
Abbreviations: IHDI:Inequality-Adjusted Human Development Index; GII=Gender Inequality Index; GDI=Gender Development Index; MPI=Multidimensional Poverty Index; EF pc= Ecological Footprint per capita. $^{**}= p<0.01$

3. Results

The identification of the income inequality coefficient and the embedding method that can give to the Human Development Index a better correlation in respect to the individual indicators it is composed of, and 5 external validation indices is the main goal of this study. Table 1 shows the results of the correlation analysis. From the 16 alternatives tested, the 4 variants higher in correlation were selected: JHDIG1-WB, JHDIG1-UNU, JHDIT1-UNU, and JHDIA1-UNU. It is worth noting that only JHDIG1-WB showed a higher correlation than the HDI and all of the more correlated variants use the formula (2) of calculation.

Figure 1 depicts the differences in rank classification between the HDI and the 4 high-correlation variants. According to UNDP Report 2014, the plot is divided into the 4 categories of human development (Very High>0.8; 0.7<High<0.8; 0.55<Medium<0.7; Low<0.55) and the 4 variants' boxplots are depicted in relation to the country's classification of the original HDI. In comparison to the original HDI, all the variants showed lower median values for each HDI category, and the differences are progressively larger for lower values of HDI. Table 2 shows the uncertainty analysis of the HDI variants obtained by summing the absolute ranking differences after alternatively excluding one of the indicators of the original set. The assessment of the degree of influence of each indicator inside the calculation of the HDI and its alternatives reflects the statistical reliability of the indices.

Figure 1 – *Boxplots of the rank classification of the HDI and the 4 high-correlation variants (dotted lines represent the cut-off values for the 4 HDI classification groups).*



HDI: Human Development Index.

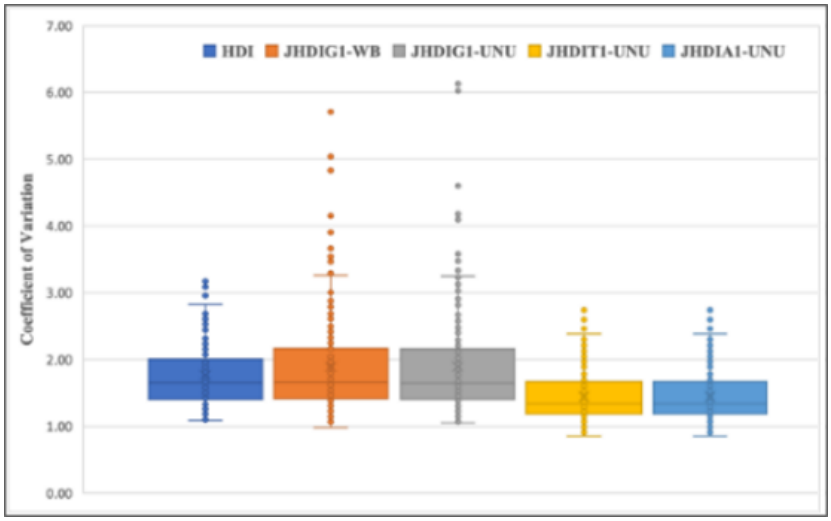
Table 2 – *Mean, root mean squared, and range of variation in country's ranking shifts obtained by excluding alternatively one indicator of the original set.*

Excluded indicator	HDI	JHDIG1-WB	JHDIG1-UNU	JHDIT1-UNU	JHDIA1-UNU
Mean of the absolute ranking differences					
LEI	5.19	10.95	5.81	7.01	6.82
EI	8.42	11.54	7.97	8.69	8.53
II	7.38	11.13	7.38	7.38	7.38
Mean	**7.00**	**11.21**	**7.05**	**7.69**	**7.58**
R.m.s.	**1.34**	**0.24**	**0.91**	**0.72**	**0.71**
CoV	**19.21**	**2.18**	**12.91**	**9.39**	**9.43**
Root mean squared of the absolute ranking differences					
LEI	4.90	7.44	4.82	6.07	5.96
EI	6.74	9.43	6.34	7.11	6.81
II	6.75	8.67	6.75	6.75	6.75
Mean	**6.13**	**8.51**	**5.97**	**6.64**	**6.51**
R.m.s.	**0.87**	**0.82**	**0.83**	**0.43**	**0.38**
CoV	**14.16**	**9.62**	**13.94**	**6.49**	**5.91**
Range of the absolute ranking differences					
LEI	30.00	35.00	25.00	39.00	41.00
EI	36.00	44.00	29.00	40.00	41.00
II	34.00	39.00	34.00	34.00	34.00
Mean	**33.33**	**39.33**	**29.33**	**37.67**	**38.67**
R.m.s.	**2.49**	**3.68**	**3.68**	**2.62**	**3.30**
CoV	**7.48**	**9.36**	**12.55**	**6.97**	**8.53**

LEI: Life Expectancy Index; EI: Education Index; II: Income Index; R.m.s.: Root Mean Squared; CoV: Coefficient of Variation.

On the other side, the sensitivity analysis, showed in Figure 2, verifies the intrinsic robustness of the indices through the study of the modifications that occur when a random disturb is added to each individual indicator. The minimum median value for the CoV was observed in JHDIT1-UNU and JHDIA1-UNU (1.337), followed by JHDIG1-UNU (1.648), HDI (1.650), and JHDIG1-WB (1.658).

Figure 2 – *Boxplots of the coefficients of variation of the HDI and its alternatives obtained by adding a random disturb for each individual indicator*.



4. Discussion

The results of the correlation analysis clearly demonstrate that embedding formula (2) exhibited the highest correlation with the validation indices for all the tested coefficients. As anticipated, this was likely due to the application of these coefficients as a penalty function to Gross National Income per capita (GNI pc) when calculating the Income Index. Furthermore, as a testament to its robustness, the GINI coefficient consistently showed the highest correlation, irrespective of the database used, even though differences in country rankings were observed between the World Bank (WB) and United Nations University (UNU) databases. The uncertainty analysis identified the Gini coefficient from UNU and the WB database as having the lowest means and the lowest coefficients of variation, respectively. On the other hand, the sensitivity analysis revealed an overall very low variability, ranging from 1.34% (JHDIT1 and JHDIA1) to 1.66% (JHDIG1-WB). These results indicate that HDI variants exhibit similar or, in some cases, even greater robustness than the traditional HDI, confirming the solidity of the first embedding method. From these findings, several observations can be made. Firstly, among the top ten positions in the new JHDI, Hong Kong completely disappears, despite being ranked 4th in the traditional HDI. This suggests a significant conclusion: including an income distribution coefficient within the economic welfare indicator as a "penalty function" disproportionately disadvantages high-income countries without effective redistribution policies. This effect is further evident in the new JHDI's top ten

positions, which are predominantly occupied by European countries, particularly those in Scandinavia and Northern Europe. These countries are characterized by high levels of "social protection," where contributory systems based on substantial wages provide efficient public services and welfare states. Conversely, the rankings for the lowest positions remain virtually unchanged, indicating that countries with the lowest Human Development Index also exhibit the poorest income distribution. This deduction appears to corroborate the development patterns in African countries in recent years, where economic growth, if it occurred, did not translate into well-being for the entire population but rather concentrated within the highest income brackets. This is also consistent with the challenges faced by African countries, including the fragility and poor structure of their state apparatus, which struggles to function as an efficient administrative entity and faces difficulties in planning public policy interventions, particularly in remote areas. The strength of this study lies in its focus on reshaping a widely accepted index rather than developing a new composite indicator, which is a common approach in contemporary literature. Therefore, the Just Human Development Index (JHDI) stands out as a readily applicable tool, given the abundance of available data and its ease of calculation. However, one limitation of this study is the omission of decile ratios and derived inequality coefficients, such as the Palma ratio, from the testing framework. Additionally, other means of aggregation, such as the Mazziotta-Pareto Index (Mazziotta & Pareto, 2018), were not explored. Thus, incorporating an inequality coefficient as a penalty function not only maintains the ease of calculation and the robustness of the HDI but also enhances its correlation with inequality. This approach may have significant political implications by highlighting that human development remains incomplete if economic growth is not balanced by income distribution policies (Cingano, 2014).

References

ANAND S., SEN A. 1994. Human Development Index: Methodology and Measurement. pp. 138-151.

CHATTERJEE S.K. 2005. Measurement of human development: an alternative approach. *Journal of Human Development*, Vol. 6, pp. 31-53.

CHERCHYE L., OOGHE E., PUYENBROECK T.V. 2008. Robust human development rankings. *Journal of Economic Inequality*, Vol. 6, pp. 287-321.

CINGANO F. 2014. Trends in Income Inequality and its Impact on Economic Growth.*OECD Social, Employment and Migration Working Papers*, No. 163, OECD Publishing, Paris.

DE MAIO F.G. 2007 Income inequality measures *J Epidemiol Community Health*, Vol.61, pp. 849–852.

DORFMAN R. 1979. A Formula for the Gini Coefficient. *The Review of Economics and Statistics***,** pp. 146-149.

FLEURBAEY M. BLANCHET D. 2013. Beyond GDP: Measuring Welfare and Assessing Sustainability, *Oxford University Press*.

FOSTER J.E., LOPEZ-CALVA L.F. SZEKELY M. 2007. Measuring the Distribution of Human Development: methodology and an application to Mexico. *Journal of Human Development*, pp. 5-25.

HICKS D.A. 1997. The Inequality-Adjusted Human Development Index: A Constructive Proposal. *World Development*, Vol. 25, No. 8, pp. 1283-1298.

KITZES J., WACKERNAGEL M., LOH J., PELLER A., GOLDFINGER S., CHENG D., TEA K. 2008. Shrink and share: humanity's present and future Ecological Footprint. *Philos Trans R Soc Lond B Biol Sci*, Vol. 363(1491), pp. 467-75.

MAZZIOTTA M. & PARETO A. 2018. Measuring Well-Being Over Time: The Adjusted Mazziotta–Pareto Index Versus Other Non-compensatory Indices. *Social Indicators Research: An International and Interdisciplinary Journal for Quality-of-Life Measurement*, Springer, Vol. 136(3), pp. 967-976

NARDO M., SAISANA M., SALTELLI A., TARANTOLA S., HOFFMAN A., GIOVANNINI E. 2005. Handbook on Constructing Composite Indicators: Methodology and User Guide, *OECD Statistics Working Papers*, No. 2005/03, OECD Publishing, Paris.

SEN A. 1999. Development as freedom. *Oxford University Press*.

TODARO M.P., SMITH S.C. 2015. Economic Development – *Pearson*.

UNDP (United Nations Development Programme). 2014. Human Development Report 2014: Sustaining Human Progress: Reducing Vulnerabilities and Building Resilience. New York.

Luca MUZZIOLI, Sapienza University, luca.muzzioli@uniroma1.it
Viola TAORMINA, Rome3 University, vio.taormina@stud.uniroma3.it