A Novel Two-Phase Approach to Computing a Regional Social Progress Index

Vincent Charles[*], **Tatiana Gherman**, and **Ioannis E. Tsolas**

Abstract

In recent decades, concerns have emerged regarding the fact that standard macro-economic statistics (such as gross domestic product) do not provide a sufficiently detailed and accurate picture of societal progress and wellbeing and of people's true quality of life. This has further translated into concerns regarding the design of related public policies and whether these actually have the intended impact in practice. One of the first steps in bridging the gap between wellbeing metrics and policy intervention is the developement of improved wellbeing measures. The calculation of a regional Social Progress Index (SPI) has been on the policymakers' agenda for quite some time, as it is used to assist in the proposal of strategies that would create the conditions for all individuals in a society to reach their full potential, enhancing and sustaining the quality of their lives, while reducing regional inequalities. In this manuscript, we show a novel way to calculate a regional SPI under a two-phase approach. In the first phase, we aggregate the item-level information into sub-factor-level indices and the sub-factor-level indices into a factor-level index using an Objective General Index (OGI); in the second phase, we use the factor-level indices to obtain the regional SPI through a pure data envelopment analysis (DEA) approach. We further apply the method developed to analyse a single period of social progress in Peru. The manuscript is a contribution to the practical measurement of social progress.

Keywords Data Envelopment Analysis, Objective General Index, Social Progress Index.

1. Introduction

Economic growth is an interesting and puzzling concept. For more than five decades, nations around the world have assessed their general wellbeing based on this indicator, most com-monly captured via the computation of the gross domestic product (GDP); the common view has been that the higher the economic growth, the better the nation's overall performance (Kuznets, 1934; Kubiszewski et al., 2013). Governments, businesses, and the civil society alike, they have all equated economic growth to progress; it is no wonder then that economic policies around the world have largely been shaped by the end goal of maximizing GDP growth. This

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perception has, nonetheless, been challenged since a long time ago. For example, as early as 1974, Easterlin's paradox (Easterlin, 1974) highlighted that at a point in time human happiness varies directly with economic growth both among and within nations, but over time happiness does not trend upward as income continues to grow.

In time, a plethora of economic and statistical research, accompanied by psychological research, have challenged the position of authority of the GDP as an indicator of national progress on a number of fronts, showing the discrepancy between monetary valuation and perceived well-being (Davies, 2015). According to Porter, Stern, & Green (2016, p. 32), "social progress is the capacity of a society to meet the basic human needs of its citizens, establish the building blocks that allow citizens and communities to enhance and sustain the quality of their lives, and create the conditions for all individuals to reach their full potential". In line with this definition, there has been a constant increase in the number of calls to address basic human needs, promote equality and opportunity for all people, improve the quality of life of people, and protect the environment, among others. What these calls are indicative of is a shortcoming of GDP to capture the essence of inclusive growth, wherein inclusive growth is a combination of both economic and societal progress. There is an increased awareness that GDP has mistakenly been used as a proxy indicator of the citizens' wellbeing, human progress, and overall social and economic health and welfare (Cobb, Halstead, & Rowe, 1995; Stiglitz, Sen, & Fitoussi, 2009; Stiglitz, Sen, & Fitoussi, 2010). Can a nation register a high rate of economic growth but a slow societal progress at the same time? Evidence points to yes.

Without a doubt, GDP is an important economic instrument for measuring and comparing market activity, but it is only that: a barometer of a nation's raw economic activity. The search for better instruments to measure people's wellbeing has translated into the creation of various initiatives, most of which materialised in the 2000s. For example, the year 2007 marked a particular point in time when four main bodies, represented by the European Commission, the European Parliament, the Organisation for Economic Co-operation and Development (OECD), and the World Economic Forum (WEF), organised a conference aimed at clarifying "which indices are most appropriate to measure progress, and how these can best be integrated into the decision-making process and taken up by public debate" (European Commission, 2007). Further, in 2008, the Commission on the Measurement of Economics Performance and Social Progress (also known as the Stiglitz Commission) was set up, whose main objective was to propose better indicators of social wellbeing (Stiglitz, Sen, & Fitoussi, 2009); interestingly enough, the Commission highlighted the wellbeing measurement as a necessary accompaniment to GDP. More precisely, the Commission's aim was "to identify the limits of GDP as an indicator of economic performance and social progress, including the problems with its measurement; to consider what additional information might be required for the production of more relevant indicators of social progress; to assess the feasibility of alternative measurement tools, and to discuss how to present the statistical information in an appropriate way" (Stiglitz, Sen, & Fitoussi, 2009). More recently, at a special UN summit in 2015, a document titled "Transforming Our World: The 2030 Agenda for Sustainable Development" was adopted, which represented a commitment of Heads of State and Government to eradicate poverty and achieve sustainable

development by 2030 world-wide. This document also differentiated between GDP and social progress when it formulated its objective as: "By 2030, build on existing initiatives to develop measurements of progress on sustainable development that complement gross domestic prod-uct, and support statistical capacity-building in developing countries."

All in all, "The Beyond GDP" initiative has brought together a large number of countries who found themselves cooperating on developing indicators that are as clear as GDP, but more inclusive of environmental and social aspects of progress. Such efforts further led to the creation of Wikiprogress, the official online platform for the OECD-hosted Global Project on "Measur-ing the Progress of Societies" and whose purpose is to share information on the measurement of social, economic and environmental progress. Some of the indices included in The Global Project are: Genuine Progress Indicator, Global Peace Index, Happy Planet Index, Human Development Index, Sustainable Society Index, The Climate Competitiveness Index, The Bet-ter Life Index, The Legatum Prosperity Index, and World Happiness Index, among others. Despite all these efforts, however, there is no single methodology and no general agreement on the existence of a set of standardised or holistic indicators to measure social progress. Here, we join the calls for the development of improved methodologies to measure social progress.

In this manuscript, we show a novel way to calculate a regional social progress index (SPI) under a two-phase approach. In the first phase, we aggregate the item-level information into sub-factor-level indices and the sub-factor level indices into a factor-level index using an Ob-jective General Index (OGI); in the second phase, we use the factor-level indices to obtain the regional SPI through a pure DEA approach. The benefits of our proposed method are twofold: on the one hand, we account for the variation in the two stages of the first phase and on the other hand, we build an index based on relative measures in the second phase. We further apply the method developed to analyse a single period of social progress in Peru. The manuscript is a contribution to the practical measurement of social progress.

2. Social Progress Index

The Social Progress Imperative (Social Progress Imperative, 2018), a global non-profit based in Washington, DC, defines social progress as "the capacity of a society to meet the basic human needs of its citizens, establish the building blocks that allow citizens and communities to enhance and sustain the quality of their lives, and create the conditions for all individuals to reach their full potential". In line with this definition, the Social Progress Imperative has been calculating a Social Progress Index ever since 2013; this index measures 51 social and environmental indicators, across three broad dimensions of social progress: Basic Human Needs, Foundations of Wellbeing, and Opportunity (see Figure 1). In the words of the organisation itself, "the index doesn't measure people's happiness or life satisfaction, focusing instead on actual life outcomes in areas from shelter and nutrition to rights and education. This exclusive focus on measurable outcomes makes the index a useful policy tool that tracks changes in society over time." Below, we proceed to describe the three factors briefly:

1. The *The Basic Human Needs* factor "assesses how well a country provides for its people's essential needs by measuring access to nutrition and basic medical care, if they have access to safe drinking water, if they have access to adequate housing with basic utilities, and if society is safe and secure" (Social Progress Imperative, 2018). In other words, it answers the question: Does everyone have the basic needs for survival met?

2. The *Foundations of Wellbeing* factor "measures whether citizens have access to basic education, can access information and knowledge from both inside and outside their country, and if there are the conditions for living healthy lives. Foundations of Wellbeing also measures a country's protection of its natural environment: air, water, and land, which are critical for current and future wellbeing" (Social Progress Imperative, 2018). It answers the question: Does everyone have access to what is needed to improve their lives?

3. The *Opportunity* factor "measures the degree to which a country's citizens have personal rights and freedoms and are able to make their own personal decisions as well as whether prejudices or hostilities within a society prohibit individuals from reaching their potential. Opportunity also includes the degree to which advanced forms of education are accessible to those in a country who wish to further their knowledge and skills, creating the potential for wide-ranging personal opportunity" (Social Progress Imperative, 2018). It answers the question: Does everyone have a chance to pursue their goals, dreams, and ambitions?

The design of the Social Progress Index is based on four principles: it comprises exclusively social and environmental indicators, it is holistic and relevant to all countries, it focuses on outcomes not inputs, and it is an actionable instrument:

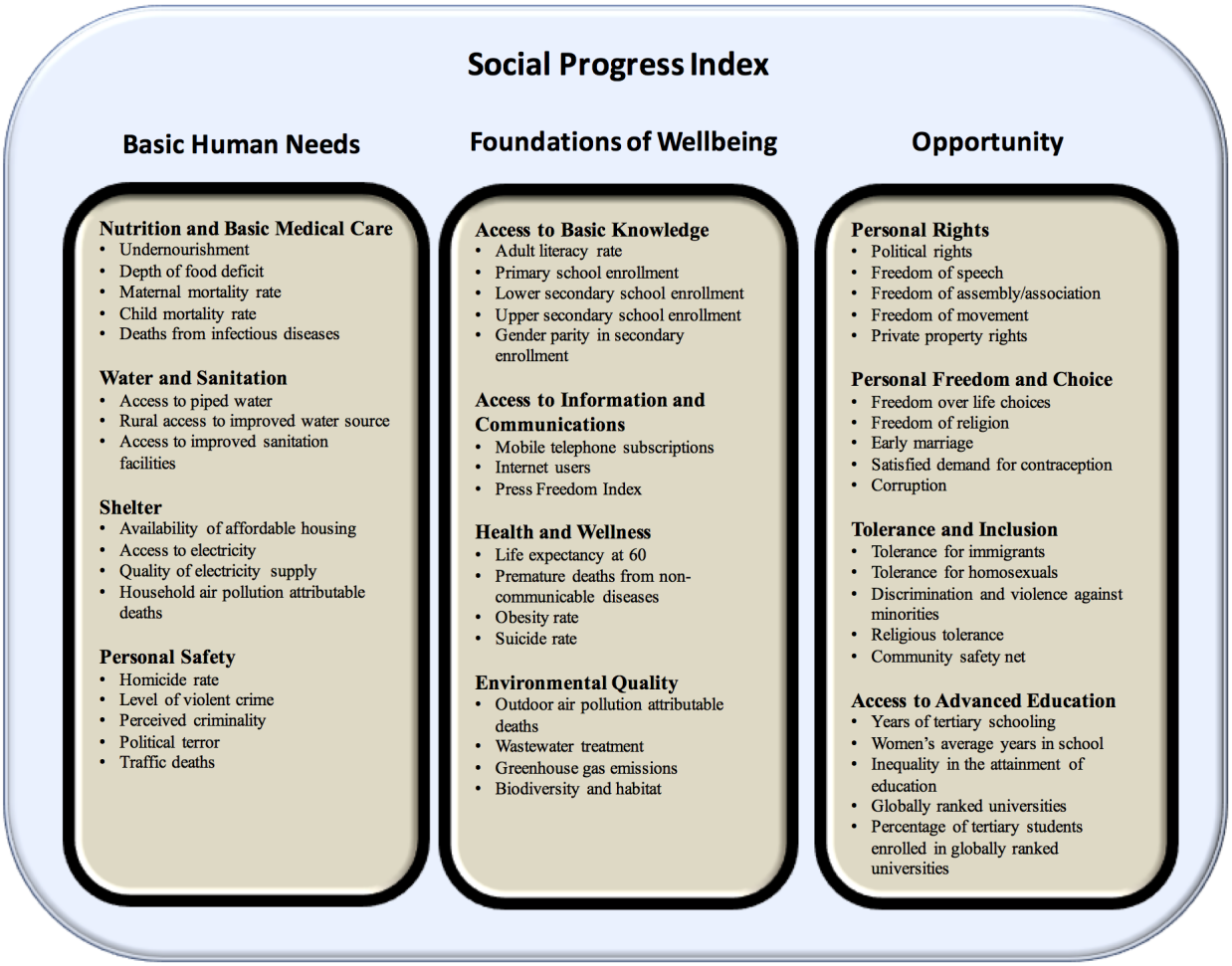
(a) *It comprises exclusively social and environmental indicators*: The aim of the Social Progress Index is to measure social progress directly, without the need to appeal to economic proxies. This very clear differentiation which is made between economic development and social development would make it possible to both identify the factors that contribute to social progress and assess the relationship between economic development and social development.

(b) *It is holistic and relevant to all countries*: The Social Progress Index encompasses dimensions, components, and indicators which are relevant to all countries around the Globe; as such, it is computed for all the countries, independent of their stage of development.

(c) *It focuses on outcomes not inputs*: The Social Progress Index focuses exclusively on outcomes; in other words, emphasis is placed on what value people receive from the government's public services, and not how much money is actually spent on providing the public services.

(d) *It is an actionable instrument*: The Social Progress Index produces both an aggregate country score and a ranking, and is granular enough to allow interested parties, such as practitioners and policymakers, to devise strategies and actions meant to foster social progress.

The overall Social Progress Index score is calculated as a simple average of the three dimensions or factors of social progress: Basic Human Needs, Foundations of Wellbeing, and Opportunity.



Source: Social Progress Imperative, 2018.

Fig. 1. Social Progress Index Framework, as defined by the Social Progress Imperative, 2018.

Similarly, each dimension is the simple average of its four components.

For the purposes of the present analysis, we take the scores computed and used to assess social progress at the regional level by CENTRUM Católica Graduate Business School (2016). It is to be mentioned that CENTRUM used the same framework proposed by the Social Progress Imperative.

3. Methodology: two-phase approach to Construct a Social Progress Index

3.1. Phase I: OGI

The Regional Social Progress Index is a univariate index that can be generated based on fac-tors, sub-factors, and items. Every factor is composed of four unique sub-factors and each sub-factor is composed of a set of items (Figure 1). In the first stage of phase I, we compute the sub-factor-level OGIs considering the items; then, in the second stage of phase I, we com-pute the factor-level OGIs considering the sub-factor-level OGIs. Upon obtaining the three phase I factor-level OGIs, we further proceed to compute the phase II DEA-based SPI using the phase I factor-level OGIs as inputs. The resulting SPI is referred to as the *Social P rogress Index* for the given application. In the subsequent paragraphs, we shall start by highlighting the importance of the OGI and detail the computational procedure and the relevant foundations.

Let us consider a data matrix of n entities (regions) with p variates (could be factors or sub-factors or items under sub-factors). In order to rank the entities, a general index that combines the p variates into a univariate index should be constructed. If the data are uncorrelated, the general index can be constructed as the sum of standardized scores (Z-scores) and if the data are correlated, the first principal component may be employed as a general index, as it maxi-mizes the variance of the index under weight constraints. Nevertheless, one of the undesirable features of such approaches is that these indices can be negatively correlated with some of the variates. To tackle such shortcomings, Sei (2016) proposed an OGI that is always positively correlated with each of the variates. We apply the notion of OGI under a two-stage framework to study the social progress of the regions.

The objective general index (OGI) can be defined in line with Sei (2016) and Charles & Sei (2019) as:

$$G = \sum_{l=1}^{p} w_l X_l, \tag{1}$$

where X_l is the l^{th} random variable and the positive weight vector $\{w_l\}_{l=1}^{p}$ is the solution to equation (2), which is known to have a unique solution as long as the covariance matrix of $X_l's$ denoted by $S_{lm} = E[X_l X_m]$ is not singular (Marshall & Olkin, 1968):

$$\sum_{m=1}^{p} w_i S_{lm} w_m = 1, \quad l = 1, \ldots, p. \tag{2}$$

Equation (2) implies that each variable X_l has a positive correlation with the OGI since equation (2) can be rewritten as:

$$E[(w_l X_l)G] = 1. \tag{3}$$

A naive algorithm to obtain the weights is to solve the quadratic equation (2) with respect to $w_l > 0$, given $\{w_m\}_{m \neq l}$ for each l, and repeat this process until convergence. The algorithm is detailed as follows, in line with Sei (2016) and Marshall & Olkin (1968):

Algorithm:
Input: A positive definite matrix $\mathbf{S} \in \mathbf{R^{pxp}}$, initial value $\mathbf{w}_0 (= \mathbf{1}_p)$, tolerance $\epsilon > 0$.
Output: A vector $0 < \mathbf{w} = (w_1, ..., w_p)^T$, such that $\mathbf{DSD}$ is a bi-unit matrix (*i.e.*, $\mathbf{DSD}_p = \mathbf{1}_p$), where $\mathbf{D} = diag(\mathbf{w})$:

(i) $\mathbf{w} \longleftarrow \mathbf{w}_0$.
(ii) For l = 1,..., p, in order, solve the quadratic equation (2) with respect to w_l.
(Note: $\mathbf{DSD}_p \equiv w_l \sum_{m=1}^{p} S_{lm} w_m$, where elements of $\mathbf{S}$ are denoted by S_{lm}.)
(iii) If $\|\mathbf{w} - \mathbf{w}_0\| < \epsilon$, output $\mathbf{w}$. Otherwise, $\mathbf{w}_0 \longleftarrow \mathbf{w}$ and go to step (ii).

One can note from Sei (2016) that a weight map $\mathbf{w} = \mathbf{w}(\mathbf{S})$ is said to be consistent if the weight vector $\mathbf{w}$ is positive for any $\mathbf{S}$; and it is said to be covariance consistent if $\mathbf{Sw}$ is positive for any $\mathbf{S}$. The weight map of OGI is both consistent and covariance consistent. By contrast, other index generation methods fail to satisfy the consistency property (such as the $\mathbf{w} = \mathbf{S}^{-1}\mathbf{1_p}$ method), the covariance consistency property (such as the sum of Z-scores), or both (such as the first principal component).
The following lemma characterises the OGI by an orthogonality condition:
[Orthogonality (Charles & Sei, 2019)] Let $w_1, \ldots, w_p$ be positive numbers, $G = \sum_{l=1}^{p} w_l X_l$, and $\Delta_l = w_l X_l - G/p$. Then, the following two conditions are equivalent:

(a) G is the OGI.

(b) $E[G\Delta_l] = 0$ and $E[G^2] = p$.

In the above lemma, we will call Δ_l as *the residual of OGI*.

Let $\{X^i_{jk} \mid i \in I, j \in J_i, k \in K_j\}$ be a set of random variables. In our setting, the index set for social progress factors is $I = \{BHN, FoW, Opp\}$ ={Basic Human Needs, Foundations of Wellbeing, Opportunity}.

Likewise, the index set for the social progress sub-factors for every factor could be considered as follows: J_{BHN} = {Nutrition and Basic Medical Care, Water and Sanitation, Shelter, Personal Safety}, J_{FoW} = {Access to Basic Knowledge, Access to Information and Communications, Health and Wellness, Environmental Quality}, and J_{Opp} = {Personal Rights, Personal Freedom and Choice, Tolerance and Inclusion, Access to Advanced Education}. In the same way, K_j is the set which consists of the j^{th} sub-factor's items that are listed in Figure 1.

Let us define the two-stage OGI as follows:

Definition 3.1 (Two-stage OGI) *For the given i^{th} factor for each $j \in J_i$, compute the OGI of $\{X^i_{jk}\}_{k\in K_j}$ by:*

$$G^i_j = \sum_{k\in K_j} w^i_{jk} X^i_{jk}, \quad E[(w^i_{jk} X^i_{jk}) G^i_j] = 1, \quad k \in K_j. \tag{4}$$

Then, compute the joint OGI of $\{G^i_j\}_{j\in J_i}$ by:

$$G^i = \sum_{j\in J_i} w^i_j G^i_j, \quad E[(w^i_j G^i_j) G^i] = 1, \quad j \in J_i. \tag{5}$$

The resultant index G^i is the i^{th} two-stage OGI.

The two conditions (4) and (5) suggest that each G^i_j is the representative of sub-factors X^i_{jk}'s and G^i summarises G^i_j's for every given $i \in I$.

Properties of OGI

Property 3.1 *Equation (4) in the definition of the two-stage OGI implies that $E[X^i_{jk} G^i_j]$ is positive.*

Property 3.2 *Equation (5) in the definition of the two-stage OGI implies that $E[G^i_j G^i]$ is positive.*

Lemma 3.1 (Lack of Lag) *In general, $E[X^i_{jk} G^i_j] > 0$ and $E[G^i_j G^i] > 0 \nRightarrow E[X^i_{jk} G^i] > 0$.*

Proof: See Charles & Sei (2019) for a counter-example.

The two-stage OGI is considered as a kind of ANOVA (analysis of variance) decomposition.

3.2. Phase II: DEA

Data envelopment analysis (DEA), introduced by Charnes, Cooper, & Rhodes (1978), is a linear programming technique that facilitates the estimation of the efficiency of units within production contexts characterized by multiple outputs and inputs. In time, DEA has gained reputation as an excellent management science tool, supporting decision-making processes in a variety of fields. In the present manuscript, the objective is to rank the regions according to their social progress performance in the various factors, but without imposing an ad-hoc valuation (weight) for any of them.

Below, we proceed to introduce two different DEA models, namely radial and non-radial pure DEA. On the one hand, because the DMUs are evaluated in the best possible light, radial pure DEA focuses on the performance of the factor(s) in which the DMU performs the best; in practice, this means that the built index will end up emphasizing few factors or even one single factor and disregard the performance of the others. On the other hand, non-radial pure

DEA addresses this issue by focusing on the performance of all the factors (Charles & Diaz, 2016). Both models are useful and serve different purposes and hence, our aim is to provide the readers with a comparison between the two.

3.2.1 Radial Pure DEA

Having obtained the factor-level index for every factor through the two-stage OGI, in line with Lovell & Pastor (1999), the following system would produce the DEA-based index of social progress for region o, that has a vector of $|I|$ outputs (the factors) $G_o = (G_o^1, ..., G_o^{|I|})$ and belongs to a set of R regions:

$$\begin{aligned} \max_{\phi,\lambda_1,...,\lambda_R} \quad & \phi \\ \text{s.t.} \quad & \phi G_0^i \leq \sum_{r \in R} G_r^i \lambda_r, \quad \forall i \in I \\ & \sum_{r \in R} \lambda_r = 1, \quad \lambda_r \geq 0, \quad \forall r \in R. \end{aligned} \tag{6}$$

The result of this system would produce a vector $(\phi_o, \lambda_{o1}, ..., \lambda_{oR})$ for region o. Upon solving System (6) for every region, $r \in R$, we use the results to construct a social progress index $\theta_r^{radial} = 1/\phi_r$ for each of the regions.

3.2.2 Non-radial Pure DEA

Let us consider System (6) in light of the non-radial DEA (Charles & Zegarra, 2014), wherein importance has been given to all the factors under study. Similarly to the radial approach, we use the factor-level index obtained from the two-stage OGI and plug it into the following System (7). This in turn produces the non-radial pure DEA-based index of social progress for region o, which has a vector of $|I|$ outputs (the factors) $G_o = (G_o^1, ..., G_o^{|I|})$ and belongs to a set of R regions:

$$\begin{aligned} \max_{\Phi^1,...,\Phi^{|I|},\lambda_1,...,\lambda_R} \quad & \sum_{i \in I} \Phi^i \\ \text{s.t.} \quad & \Phi^i G_o^i \leq \sum_{r \in R} G_r^i \lambda_r, \quad \forall i \in I \\ & \sum_{r \in R} \lambda_r = 1, \quad \lambda_r \geq 0, \quad \forall r \in R. \end{aligned} \tag{7}$$

The result of this system would produce a vector $(\Phi_o^1, ..., \Phi_o^{|I|}, \lambda_{o1}, ..., \lambda_{oR})$ for region o. Upon solving System (7) for every region, $r \in R$, we use the results to construct a social progress index $\theta_r^{non-radial} = |I| / \sum_{i \in I} \Phi_r^i$ for each of the regions.

4. Inferences from the Analytics

Table 1 shows the OGI indices for all the three factors of social progress, the social progress indices for the year 2015, as well as the associated ranking, for both the radial and non-radial

DEA applied in the second phase of our modelling. It is to be noted that radial DEA refers to the indices obtained by running the pure DEA method with radial expansion (System 6), while the non-radial DEA refers to the indices attained by running the non-radial pure DEA method (System 7).

The interpretation of the results is quite straightforward. First, the table shows the situation of the regions in view of each of the three factors considered, that is Basic Human Needs, Foundations of Wellbeing, and Opportunity. We can quickly observe that the best performers in the BHN factor are Ica, Callao, and Lambayeque, while the worst performers are Madre de Dios, followed by Puno. Similarly, Tacna, Cusco, Huancavelica, and Ancash are the best performers in the FoW factor, with Ucayali, Lima Provincias, and Loreto as the worst performers. Lastly, in the Opp factor, Moquequa, Ica, Lambayeque, Ancash, and La Libertad are the best performers and Puno, Loreto, Madre de Dios, Pasco, Amazonas, Ucayali, and Huanuco are the worst performers.

Second, the table provides the ranking of the regions based on both the radial and non-radial DEA-based SPI. An immediate observation is that, independent of method used and despite some variations, the coastal regions are in general the highest performers in terms of social progress, while the jungle regions tend to be the worst performers. This finding is consistent with previous research (Charles & D'Alessio, 2019). A visual representation of the results will yield additional insights and this is what we proceed to do in the next sub-section.

Table 1
SPI: Ranking of Regions based on Radial and Non-Radial Pure DEA

DMU	Regions	BHN	FoW	Opp	SPI-R	Rank-R	SPI-NR	Rank-NR
1	Amazonas[3]	18.51	20.77	9.63	0.9168	16	0.8033	19
2	Ancash[1]	18.31	22.02	14.18	0.9956	2	0.9377	7
3	Apurimac[2]	17.59	20.88	12.23	0.9219	15	0.8655	13
4	Arequipa[1]	20.23	21.65	13.57	0.9793	4	0.9526	4
5	Ayacucho[2]	19.93	21.94	12.24	0.9761	7	0.9174	10
6	Cajamarca[2]	17.08	21.64	12.12	0.9453	12	0.8625	15
7	Callao[1]	21.51	19.59	11.34	0.9858	3	0.8818	12
8	Cusco[2]	17.07	22.52	10.08	0.9674	10	0.8139	18
9	Huancavelica[2]	16.71	22.17	12.12	0.9630	11	0.8613	16
10	Huanuco[2]	17.40	21.13	9.76	0.9076	18	0.7953	20
11	Ica[1]	21.82	21.38	14.70	1.0000	1	1.0000	1
12	Junin[2]	17.21	21.32	12.22	0.9364	13	0.8637	14
13	La Libertad[1]	18.05	21.56	14.01	0.9771	6	0.9231	8
14	Lambayeque[1]	21.36	19.88	14.19	0.9789	5	0.9576	3
15	Lima Metropolitana[1]	20.01	21.57	13.25	0.9709	8	0.9401	6
16	Lima Provincias[1]	17.46	16.84	10.54	0.8002	21	0.7665	21
17	Loreto[3]	17.37	16.45	8.51	0.7961	22	0.7004	24
18	Madre de Dios[3]	13.49	17.71	9.51	0.7662	23	0.6864	26
19	Moquegua[1]	20.23	21.76	14.90	1.0000	1	0.9843	2
20	Pasco[2]	16.92	19.33	9.51	0.8470	20	0.7612	22
21	Piura[1]	20.32	21.30	13.40	0.9677	9	0.9450	5
22	Puno[2]	15.49	21.18	7.61	0.9098	17	0.6897	25
23	San Martin[3]	18.80	19.80	11.70	0.8975	19	0.8579	17
24	Tacna[1]	19.39	23.28	12.11	1.0000	1	0.9209	9
25	Tumbes[1]	20.36	18.98	12.28	0.9331	14	0.8836	11
26	Ucayali[3]	16.56	15.16	9.68	0.7589	24	0.7065	23
Statistics	Min	13.49	15.16	7.61	0.7589	1	0.6864	1
	Q1	17.11	19.64	9.84	0.9082	5.25	0.7973	7.25
	Median	18.05	21.18	12.12	0.9453	11	0.8637	13
	Q3	20.18	21.65	13.36	0.9785	17.75	0.9341	19.75
	Max	21.82	23.28	14.9	1.0000	24	1.0000	26
	Mean	18.43	20.45	11.75	0.9269	11.62	0.8569	13.5
	SD	2.00	2.00	2.00	0.0700	7.47	0.0900	7.65

Note: BHN - Basic Human Needs, FoW - Foundations of Wellbeing, Opp - Opportunity, SPI - Social Progress Index. $^{1} = Coast$,$^{2} = Highlands$,$^{3} = Jungle$.

4.1. Visual analytics

Figure 2 presents the boxplots of factors vs. classifications. With three factors and three classifications, the figure shows a total of nine boxplots, wherein each boxplot represents a specific factor and a specific classification. Furthermore, there are three median lines drawn horizontally in red colour; these represent the respective factor medians and are provided along with their 95% median confidence intervals. Among the three factor medians, the lowest median is recorded in the case of the Opp factor, followed by the BHN factor and then the FoW factor.

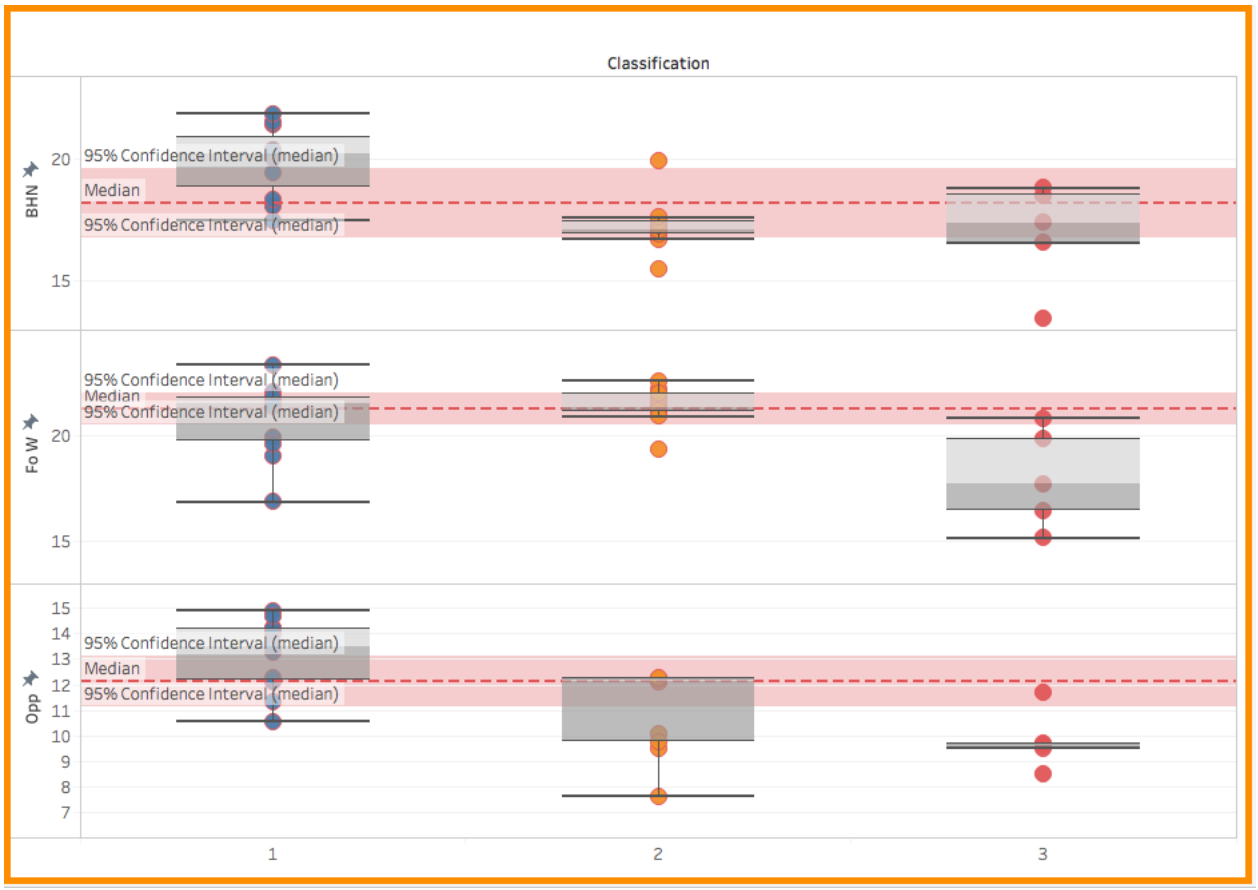


Fig. 2. Boxplots of Factors vs. Classifications.

[a]Note. 1 = Coastal regions; 2 = Highlands regions; 3 = Jungle regions.

Although based on Table 1, one can observe that the standard deviations of the three factors are the same, still, in Figure 2, we can see that there is a difference in the width of the confidence interval. The variation is high in the case of BHN when compared to the other two factors, FoW and Opp; by contrast, FoW registers a narrower confidence interval. We can observe that in the case of the BHN factor, the median of the coastal region falls outside the interval, while the other two medians of the highlands and jungle regions fall inside the interval. In the case of the FoW factor, the first two medians of the coastal and highlands regions fall inside the interval, while the third median of the jungle region falls outside the interval. Lastly, in the case of the Opp factor, the medians of all the regions fall outside the interval. Overall, the interesting observation to make here is that in two out of three cases

(for FoW and Opp), the medians of the third classification (that is, the jungle) are below the respective factor medians. This means that the jungle regions perform particularly poorly in the FoW and Opp factors. By contrast, in two out of three cases (for BHN and Opp), the medians of the first classification (that is, the coast) are above the respective factor medians. In other words, the coastal regions are performing particularly well in the BHN and Opp factors.

Figure 3 shows the correlations among the three factors, BHN, FoW, and Opp. The highest correlation is between BHN and Opp; the correlation coefficient value is 0.683, which is significant at the 0.01 level. The correlation between FoW and Opp is 0.485, which is significant at the 0.05 level. Lastly, the correlation between BHN and FoW is not significant, with p-value = 0.148.

Fig. 3. Factor Correlations.

Figure 4 further shows that all the three factors correlate with both the radial and the non-radial DEA-based SPIs. An interesting observation to make, however, is that the FoW factor contributes to a greater extent to the construction of the radial DEA-based SPI (correlation coefficient = 0.872, significant at the 0.01 level), whereas in the case of the non-radial DEA-based SPI, the BHN and Opp factors are the ones contributing more towards its construction (correlation coefficients are 0.814 and 0.947, respectively, at the 0.01 level).

Figure 5 represents the correlations between the radial DEA-based SPI and the non-radial DEA-based SPI. It is to be noted that the legend of the region classifications in the graph is the same as before: 1 is the coast (represented with a circle symbol), 2 is the highlands (represented with a square symbol), and 3 is the jungle (represented with a star symbol). This

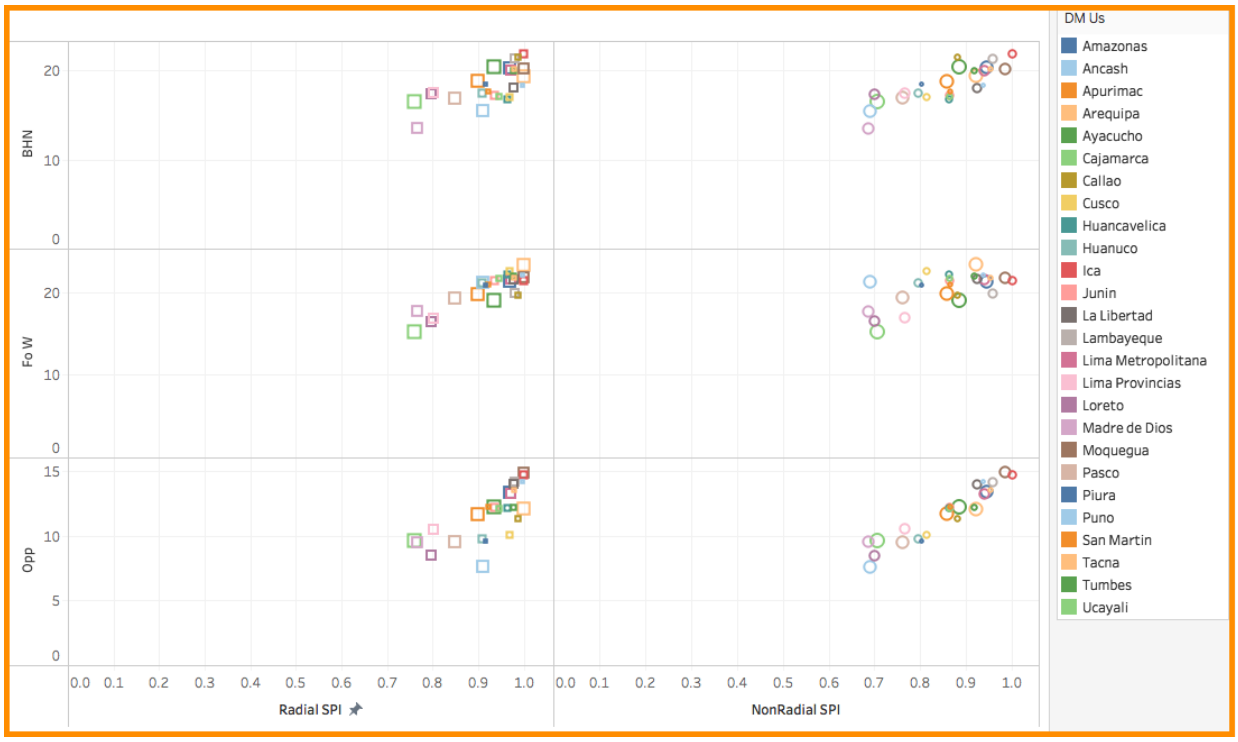


Fig. 4. Correlations between factors and radial vs. non-radial DEA-based SPI.

graph shows a positive correlation between the radial DEA-based SPI and the non-radial DEA-based SPI, with a correlation coefficient of 0.867, which is significant at the 0.01 level. The horizontal and vertical lines represent the averages of the non-radial DEA-based SPI and the radial DEA-based SPI, respectively; with the following confidence intervals: 0.8189 – 0.8948 for the non-radial DEA-based SPI and 0.8970 – 0.9568 for the radial DEA-based SPI. We also provide the trend line, represented by the dotted line, along with its 95% confidence band. We can observe that the average of the radial DEA-based SPI is higher than the average of the non-radial DEA-based SPI (0.9269 versus 0.8569). Also, the radial DEA-based SPI counts with a higher variation, which can be appreciated from the width of the confidence interval.

Based on Figure 5, we can draw some noteworthy observations. First, in the case of the non-radial DEA-based SPI, we can notice that except for one region (Lima Provincias), all the coastal regions are above the average. Similarly, in the case of the radial DEA-based SPI, we can notice that except for two regions (Lima Provincias and Tumbes), all the coastal regions are above the average yet again. This indicates that overall, coastal regions tend to be better performers in terms of social progress than the highlands and jungle regions. Further, we can notice that while in the case of the radial DEA-based SPI, there is only one highlands region (Ayacucho) situated above the average, in the case of the radial DEA-based SPI, we have four highlands regions that are above the average; this is because these four regions are performing well in a particular dimension, which "pushes" them into the high performers category. This happens because, as Charles & Diaz (2016) indicated, the non-radial DEA-based SPI values the performance in every factor, whereas the radial DEA-based index tends to focus almost exclusively on the factors in which the DMU performs better.

Fig. 5. Correlation between the radial and non-radial DEA-based SPIs.

Another observation to make is that the reqions of Ica, Moquegua, Lambayeque, Ancash, Arequipa, La Libertad, Ayacucho, and Tacna are above the averages of both the radial and non-radial DEA-based SPIs; in other words, independent of the type of DEA model used, these regions are the ones that can be said to be high performers in terms of social progress. This observation is noteworthy considering that according to Table 1, some of these regions are ranked in the middle, which would make them to be perceived as average performers instead. For example, see Ayacucho, a region that ranks 7th according to the radial DEA and 10th according to the non-radial DEA; or see La Libertad, which ranks 6th according to the radial DEA and 8th according to the non-radial DEA. Despite this, a visual representation clearly indicates that both Ayacucho and La Libertad are high performers, which points towards the cautiousness that should be attached to the interpretation of ranks, in general. Furthermore, Ayacucho is an interesting and isolated case; this is the only highlands region that is situated above the averages of both the radial and non-radial DEA-based SPIs, joining the high performers group of coastal regions.

By contrast, the worst performers are Pasco, Lima Provincias, Loreto, Ucayali, and Madre de Dios. These regions are well below the averages of both the radial and non-radial DEA-based SPIs; the reason behind their low performance lies in the fact that they each obtain rather poor scores in at least one factor of social progress. As such, Lima Provincias performs poorly in the FoW factor, Pasco in the Opp factor, Loreto and Ucayali in both FoW and Opp, and Madre de Dios in BHN and Opp. In light of this observation, concerned policymakers and regional authorities should give particular attention to these five cases, recommending local strategies,

so as to improve the social investment in the mentioned factors and thus increase the regions' social progress level (Charles & D'Alessio, 2019). San Martin, Huanuco, Puno, Amazonas, Apurimac, and Junin are also located below the mentioned averages. Nevertheless, they are within the confidence interval of the average for either the radial or the non-radial DEA-based SPI; therefore, it can be said that they are average performers in terms of social progress.

Finally, Figure 6 represents the rank correlations between the radial DEA-based SPI and the non-radial DEA-based SPI. The legend of the region classifications in the graph is the same as in Figure 5. This graph shows a positive correlation between the SPI radial rank and the SPI non-radial rank, with a correlation coefficient of 0.885, which is significant at the 0.01 level. The horizontal and vertical lines represent the medians of the SPI radial rank (median = 11.5) and the SPI non-radial rank (median = 13.5), respectively, with their median confidence intervals.

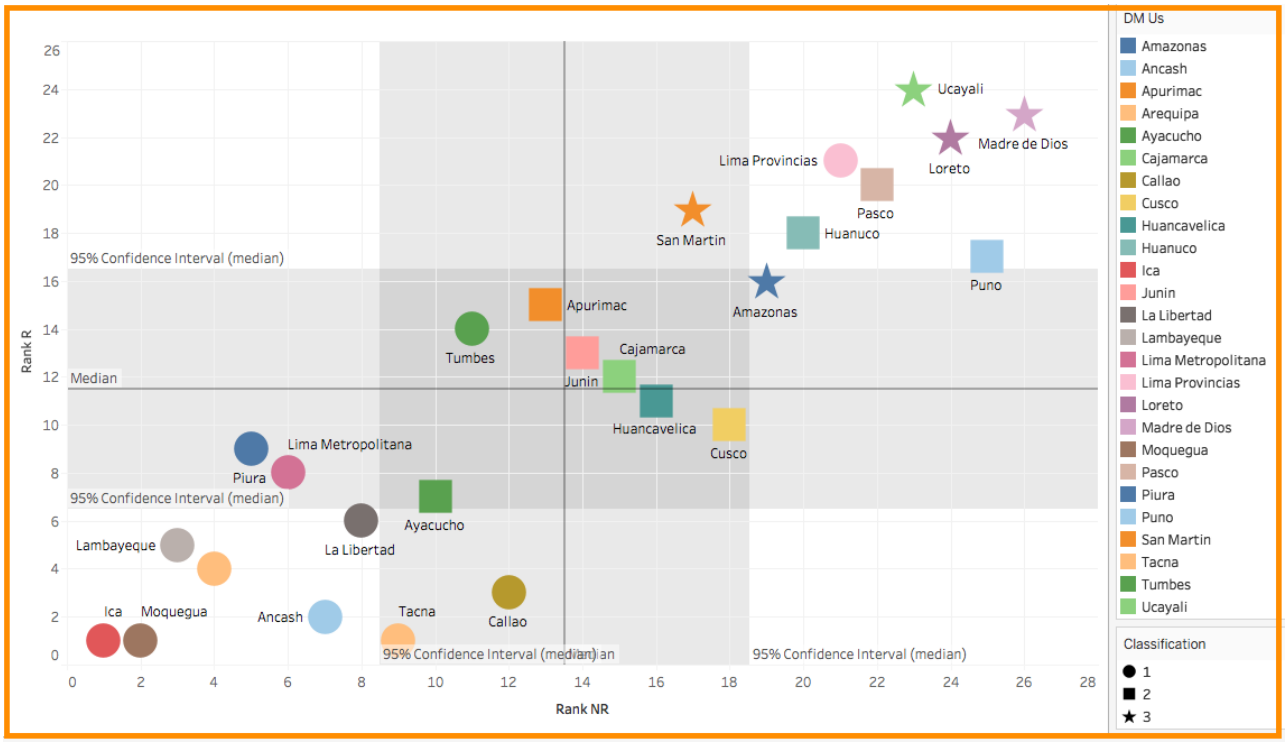


Fig. 6. Rank correlation between the radial and non-radial DEA-based SPIs.

At a closer inspection, we can observe that, similar to Figure 5, the same group of coastal regions dominate the rank (Ica, Moquegua, Lambayeque, Ancash, La Libertad, and Arequipa), with the exception of two regions, Ayacucho and Tacna, who find themselves positioned rather as average performers in view of the ranks occupied; also, we can notice that the worst perform-ers are the jungle regions. Overall, Figures 5 and 6 yield consistent insights. Perhaps the most interesting observations to make here are in relation to Lima Metropolitana and Huancavel-ica. On the one hand, Lima Metropolitana is generally ranked 1st in terms of competitiveness (CENTRUM Cat ólica Graduate Business School, 2012; Charles & Zegarra, 2014), counting with the highest GDP share (53,6%, INEI, 2009) and the second highest GDP per capita in the country (S/.12,860, according to INEI, 2009), and one of the lowest poverty rates in the coun-

try (15.4%, according to INEI, 2014). Despite this, however, Lima Metropolitana does not top the rank, being more of an average performer in terms of social progress. On the other hand, Huancavelica is generally considered to be the least competitive region in the country (Charles, 2015a; Charles, 2015b), counting with the highest poverty rate in the country (77.2%, according to INEI, 2009) and one of the lowest GDP per capita (S/.3,453, according to INEI, 2014); but then again, despite this, Huancavelica ranks as an average performer in social progress.

Another interesting case is posed by the region of Madre de Dios. This region has a relatively high GDP per capita (S/.7,555, according to INEI, 2014) and the lowest poverty rate in the country (12.7%, according to INEI, 2009); in terms of social progress, however, it is ranked 23rd in the radial DEA and 26th in the non-radial DEA, making it the worst performer among all the regions. These are fascinating cases, whose results are counter-intuitive, drawing attention to the fact that ranks and scores should always be taken with a pinch of salt. Furthermore, this further supports the necessity to develop better and more refined methodologies for the creation of regional indices for social progress, the kind of indices that can reflect to the reality with higher accuracy.

5. Conclusions

It has been the endeavour of the present manuscript to introduce an improved methodology to measure social progress at the regional level, with an application to the Peruvian regions. Our approach joins together the methodology of the Objective General Index in the first phase (Sei, 2016) with Data Envelopment Analysis in the second phase. This approach to measuring social progress is novel and represents the main contribution of the manuscript. The benefits are twofold: on the one hand, we account for the variation in the two stages of the first phase and on the other hand, we build an index based on relative measures in the second phase. The approach, however, is not without limitations. From a methodological point of view, while we do account for variation at the sub-factor level, we do not account for the same at the factor level; this is an avenue for future research. Furthermore, from a conceptual stand, the framework and variables adopted here are by no means perfect, our analysis being confined to the framework developed by Social Progress Imperative (2018). Despite this, the proposed approach is a step forward towards an improved measurement of wellbeing and social progress.

The data generated using this approach allowed us both to rank the Peruvian regions more accurately and to determine the sources of competitive strength or weakness of each region. As previously mentioned, some of the results obtained are according to expectations, especially when seen at a more 'macro' level. As such, findings suggest that the most efficient regions in terms of social progress are located on the coast, with the regions of Ancash, Arequipa, Ica, La Libertad, Lambayeque, and Moquegua forming the group of high performers in view of both radial and non-radial DEA. In a similar fashion, the worst performers are located in the jungle regions and the group is composed of Loreto, Madre de Dios, and Ucayali. The high-lands regions are generally average performers. But some other results are counter-intuitive,

see the cases of Lima Metropolitana and Huancavelica, for example. Despite being perceived as generally the best and worst regions, respectively, in terms of a variety of aspects such as competitiveness and poverty rate, these regions are both classified as rather average performers in terms of social progress.

Today, there is a plethora of metrics that have been developed to measure social progress. Seen in isolation, each indicator tells a different, yet incomplete story. Overall, there is no single methodology and no general agreement on the existence of a set of standardised or holistic indicators to measure social progress. This highlights that in order to get a more realistic picture of the wellbeing of a region, it is important to develop more accurate measures of social progress, which do not only consider the expansion of the set of variables considered in the assessment of social progress, but also integrate various methods and approaches together, refining thus, the methodology used to measure social progress. As mentioned, the latter has been the endeavour of the present manuscript.

Economic growth is, for obvious reasons, important. But if economic growth does little to improve social wellbeing, should it be a primary goal of government policy, as it keeps on being today? This continues to be a fascinating question, given its far-reaching policy implications. The only sure conclusion, as Easterlin (1974) also acknowledged, is that we need much more research on the nature and causes of human welfare. Bradburn (1969, p. 233) made a similar point when he stated that: "Insofar as we have greater understanding of how people arrive at their judgments of their own happiness and how social forces are related to those judgments, we shall be in a better position to formulate and execute effective social policies." Without much doubt, designing measurements that combine objective wellbeing data with subjective wellbeing data (Diener, 2002; Diener & Oishi, 2000) can lead to a much richer notion of a nation's wellbeing status. We position this as an avenue for future research on the topic. It is the belief of the authors that the proposed social progress index, together with the GDP and other measures of societal progress, can account for the virtuous dynamics of inclusive growth, which is essential to strengthen not only in Peru, but worldwide.

Overall, the present study has important implications for practice. Social progress and wellbeing throughout the world has arrived at a critical turning point (Estes, 2019), so providing a better snapshot of the ranking of the regions in a country in terms of social progress may help policymakers concerned with creating the conditions for nations to satisfy at least the basic social and material needs of their increasing populations (Estes & Morgan, 1976) to identify the weaknesses and strengths of each region, the main gaps, and the potential for improvement; this, in turn, could further assist them in guiding policies of social investment. Moreover, meaningful comparisons can be made among regions.

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