

# A Computational Model Based on Shannon Entropy to Analyze Social Development in South America

Alexi Delgado, Betsabe Ayala

**Abstract:** *In the world, the level of social development of a country is an important factor since it guarantees the improvement of the quality of life in its population. In this study, we evaluated social development using quantitative and qualitative variables to measure the level of development of South American countries. The entropic-weight method, from Shannon's entropy theory, was applied for the purpose of obtaining a classification showing the social development level in the countries on the list. To calculate the weight of the criteria, the entropy-weight method was applied, followed by the classification of the countries studied in concordance with a weighted sum. In this work, thirteen criteria and ten countries were studied, using data from the year 2016. The results showed that the two best ranked countries were Chile and Uruguay, and the two worst ranked countries were Venezuela and Colombia. In addition, an informative map of social development in the mentioned countries, which varies in a scale of colors, was presented. As a result, the method used in the present article revealed interesting results and it could be used on other social studies considering additional evaluation criteria. The results of this work could serve to governments of South America countries to make the best decision on social problems.*

**Index Terms:** *Shannon entropy; Entropy-weight method; Social development; South America.*

## I. INTRODUCTION

The measurement of social development raises central questions in three different areas: first, there is a debate on the theoretical nature; second, on the methodological nature; and third, on the ethical conflict. In addition, from the point of view of the theory, two complementary strategies stand out. On the one hand, the broadening of the focus of interest, which is reflected both in the incorporation of new dimensions to the notion of development; and on the other hand, in the recognition of new social subjects [1].

In terms of social development, the United Nations' primary task is to promote global collaboration in accordance with the Copenhagen Declaration on Social Development and the Program of Action of the World Summit for Social Development. In addition, social development covers a wide range of areas including: poverty eradication, job creation, cooperation, population ageing, youth, family, social integration, disabled peoples, indigenous peoples and civil society [2]. Moreover, social development, in a certain way,

would be the result of the improvement of collective welfare indexes such as life expectancy, infant mortality, disposable income, caloric intake or access to social services; in other words, all that means that human groups live longer, have greater enjoyment of consumer goods and suffer less the penalties imposed by the onslaught of nature, disease and the risks to which we are exposed [3]. In addition, social development is defined as the development of both the human capital and the social capital in a society. It entails an evolution or positive change in the personal, group and institutional relationships of a society. It mainly involves Economic and Human Development, its future project is Social Welfare [4]. Both empirical evidence and operational experience demonstrate that Social Development supports economic growth as well as better interventions and a better quality of life [5].

Parallely, to the notion of development is that of growth. This concept, in the strict sense, is expressed with a simple statistical measurement. The growth would be the change suffered by the Gross Domestic Product (GDP) of an economy between one year and another or a group of years. The size of an economy is captured by the measurement of its GDP, since this includes the total production of a country's goods and services. Measuring GDP from the National Accounts serves not only to determine growth, but also as a basis for some form of poverty measurement [3]. In addition, the family income per capita is one of the indicators most used in the analysis of the living conditions of the population as it measures the economic capacity of households to consume and save. Family income refers only to the material dimension of well-being. However, it is also used to observe the economic mobility of people or families, to measure monetary poverty 4 or the size of the middle class [6]. The United Nations Development Program (UNDP) presented the UN index of human development 2016 in late March 2017. The study measures income per capita, but also education and health [7]. Moreover, the World Happiness Report, prepared by the UN since 2012, increasingly recognized, which qualifies 155 countries as one to ten in terms of their happiness, according to a survey of 1,000 people in each country. The criterion considers GDP per capita, as well as social support, life expectancy and perceived freedom and corruption of people in their country. It presents interesting contrasts: Venezuela, for example, which for that year (2016) was close to the average referring to the GDP per capita of South America, ranks 82nd, the lowest of all the countries in this part of the continent. In addition,

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the study developed in this paper is very important from the point of the view social topics and could help to the governments to make the best decision on policies management [8].

Then, in this article a case study was conducted, ten countries from South America were classified according to thirteen criteria established for this study : Population density (C1), Life expectancy at birth (C2), Access to electricity (C3), Central government debt (C4), Perception of Corruption Index (C5), GDP per capita (C6), Doing Business (C7), World Happiness Index (C8), Global Innovation Index (C9), Global Competitiveness Index (C10), Unemployment rate (C11), Human Development Index (C12), and Gender Inequality Index (C13); and the countries studied were: Venezuela, Colombia, Ecuador, Peru, Bolivia, Chile, Brazil, Paraguay, Uruguay, and Argentina; as this countries are the most big and the most representatives in South America.

In turn, the entropy weight method, grounded on Shannon's entropy theory, was applied for the calculation of the objective weights of the criteria [9]. In fact, the entropy-weight method has a broad range of application on different problems, as demonstrated by the work to analyze a plant selection problem, in Ecuador [10], to evaluate a novel procedure clinical significance [11], or to apply a data analysis [12]. In this way, the entropy weight method has potential to be applied to different studies, particularly in the problem that proposed in this work.

In consequence, the particular purpose of this research is to obtain a ranking on social development levels of South American countries by means of a weighted sum, which considered the criteria weight achieved by applying the entropy weight method. The information used in this study was collected from international organizations to 2016 year.

Then, this article is presented as follows. In Section 2, a description of the input weight method is provided. In Section 3, we detail both the case study and the evaluation criteria; we also show the case study calculations applying the entropy-weight method. In Section 4, we analyze social development assessment results and compare these results with similar indicators. Finally, the conclusions will be presented in Section 5.

## II. METHODOLOGY

In this section, the entropy-weight method is described:

### A. The Shannon entropy theory

Shannon's entropy, first developed by Claude Shannon, is an uncertainty measure in the data expressed in terms of the theory of probability [13]. In addition, further investigations have applied this measure to a wide range of applications, including:

- Economics [14].
- Medicine [15].
- Social conflict [16].

Shannon shown that: for all  $p_i$  within of the estimated probability distribution  $P$ , the measure  $H$  satisfies the following properties [17], [18]:

1.  $H$  is a continuous positive function;

2. If all  $p_i$  is equal,  $p_i=1/n$ , then  $H$  should be a monotonic increasing function of  $n$ ; and,
3. For all,  $n \geq 2$ ,  $H(p_1, p_2, \dots, p_n) = h(p_1 + p_2, p_3, \dots, p_n + p_1 + p_2)H(p_1 p_1 + p_2, p_2 p_1 + p_2)$

Shannon also determined that the only function that satisfied these conditions is:

$$H_{Shannon} = - \sum_i p_i \log(p_i) \quad (1)$$

Where:  $0 \leq p_i \leq 1$ ;  $\sum_{i=1}^n p_i = 1$

### B. The entropy-entropy method

An approach of Shannon entropy is the entropy-weight method, which can be applied as a weighting calculation method [19], [20]. Consequently, the entropy-weight method can be presented in concordance with the following steps [21]:

Step 1: Normalize the evaluation criteria using Eq. 2:

$$P_{ij} = \frac{x_{ij}}{\sum_i x_{ij}} \quad (2)$$

Step 2: Calculate the entropy measure ( $H_j$ ) of every criteria using Eq. 3:

$$H_j = -k * \sum_{i=1}^m P_{ij} \ln(P_{ij}) \quad (3)$$

Where  $k = (\ln(m))^{-1}$

Step 3: Calculate the divergence ( $div_j$ ) by Eq. 4:

$$div_j = 1 - e_j \quad (4)$$

Step 4: Finally, the normalized weights ( $w_j$ ) of each criterion are obtained by Eq. 5:

$$w_j = \frac{div_j}{\sum_j (div_j)} \quad (5)$$

## III. CASE STUDY

For this study, we considered ten countries of South American to obtain a social development ranking for this part of the continent, these countries are the biggest ones of South America [22]. In addition, the criteria taken into account were considered important for the development of the country and the impact on the population. To this end, the report of the World Summit on Social Development, has been taken into account, this includes globalization, the transformations of the world economy, poverty, unemployment and social disintegration, which were the facts that drove the debate and put on the table the dimensioning of the social aspects of development, placing emphasis on the least developed, and most isolated countries. In this way, it is very important increasing the number of resources assigned to social development to improve and strengthen the framework for intergovernmental assistance in a spirit of partnership [23].

In this way, we proposed some of these commitments for the measurement of social development in the countries of South America. The social criteria values were obtained from 2016 year. The evaluation criteria determined finally are presented below:

#### A. Evaluation criteria

##### 1. Population Density (C1)

The World Bank defines it as the mid-year population, divided by the territorial area in square kilometers. The population includes every inhabitant, irrespective of their legal status or nationality, except for refugees with no permanent settlement in the country of asylum, who are usually treated as part of the population of the country of origin. The land area is the total area of a country, not including the area covered by internal water bodies in most cases of rivers and lakes [24]. In addition, the population density indicates the number of people in each km<sup>2</sup> of the surface of a country. If this dimension is increased, it would imply that the population increased and as a result, there would be less social development, this criterion was considered as indirect.

##### 2. Life expectancy at birth (C2)

The World Bank defines it as the age range that a newborn would live if the mortality rates at the time of birth did not change throughout the life of the infant [25]. In addition, the life expectancy at birth for this study would be the number of years lived until 2016, divided by the number of births of the same year. If this indicator would increase it would mean that more people lived more years, which implies a higher quality of life and better social development, this criterion was considered as direct.

##### 3. Access to electricity (C3)

The World Bank defines it as the proportion of the population that accesses electricity. The electrification data is gathered from both industry and household surveys [26]. In addition, access to electricity is the relationship between the numbers of people who have electricity divided by the total population, this indicator implies social inclusion and therefore a better social development, this criterion was considered as direct.

##### 4. Central government debt (C4)

Central government debt is regarding to percentage of GDP. The government debt refers to the total balance of direct contractual fixed-term obligations of the Government with other obligations outstanding at a given period. National and foreign liabilities, such as money, demand deposits, securities, except shares and borrowings, are included [27]. In addition, a low ratio between debt and GDP suggests that an economy which produces and sells sufficient goods and services to cover its debts without further debt is related to a country's economy and social development, this criterion was considered indirect.

##### 5. Perception of Corruption Index (C5)

The perception index of corruption that measures, on a scale of zero (perception of very corrupt) to one hundred (perception of absence of corruption), the levels of depiction of corruption in the state sector in a given country and consists of a composite index, which is based on various surveys of experts and companies, whose established the corruption as the abuse of the entrusted power to obtain private benefits [28]. In addition, an index close to 0 would

show a very high perception of corruption, which would imply less social development for the country, this criterion was considered as direct.

##### 6. GDP per capita (C6)

It is the total of all the final goods and services made by a country in one year, split by the population estimated for the mid-year and evaluated in dollars [29]. In addition, GDP per capita is the ratio of GDP to total population, the higher this index the greater the social development of the country, this criterion was considered as direct.

##### 7. Doing Business (C7)

Provides an objective measurement of the rules that regulate business activity and its application in the economies and cities at the subnational and regional levels of each country [30]. In addition, this dimension indicates improvements in the regulation of business activity, which also takes into account inclusion and, therefore, better social development, this criterion was considered as direct.

##### 8. World Happiness Index (C8)

Evaluates the population's life span on a scale, with 0 meaning the worst possible life and 10 meaning the best possible life. The total population is divided into ten geographical regions, the distributions that result differ greatly both in form and in mean average values. Average levels of happiness also differ between regions and countries. [8]. In addition, this indicator measures the happiness of the population of a country, including its well-being, the closer this indicator is to 10, the better the social development for the country will be, this criterion was considered as direct.

##### 9. Global Innovation Index (C9)

The Global Innovation Index presents in-depth measures of countries' innovation performance. The indicators examine a wide view of all innovation, covering the political environment, education, infrastructure and business sophistication. [31]. In addition, this indicator measures the economic prosperity of the country, which implies well-being in the population, the higher the index, the better the country's social development will be, this criterion was considered as direct.

##### 10. Global Competitiveness Index (C10)

This criterion is used to measure the capacity of countries to deliver high levels of welfare to their nationals. This in turn is related to the country's productivity in using available resources. Therefore, the Global Competitiveness Index assesses the group of institutions, policies and elements that shape sustainable current and medium-term rates of economic prosperousness [32]. In addition, this indicator measures authority's capacity to supply prosperity to the population, the higher the index, and the better social development the country will have, this criterion was considered as direct.

##### 11. Unemployment rate (C11)

The unemployment rate is the share of the labor force that is unemployed, given as a percentage. If the economy is in bad shape and jobs are few, the unemployment rate can be projected to grow. As that if the economy grows at a healthy pace and jobs are relatively abundant, it can be expected to decline [33]. In addition, this dimension indicates the PEA that does not get work because of the population of working age. Moreover, a large percentage of the

unemployment rate means less formality at work, lower quality of life for this sector, and less social development for the country, this criterion was considered as indirect.

12. *Human Development Index (C12)*

For the UNDP, this is a condensed measure of the average accomplishments in the most relevant aspects of human development: a long and healthy life, knowledge and a respectable quality of life. HDI represents the geometric mean of the standard indices for each of the three dimensions [7]. In addition, this indicator measures the achievements obtained by the country for the welfare of the population, the higher the index, the better the social development for the country, this criterion was considered as direct.

13. *Gender Inequality Index (C13)*

For the UNDP, the GII stands for inequality indicator. It assesses gender inequalities in three significant dimensions of human development: reproduction health, as measured by the maternal mortality ratio, and adolescent birth rates. Therefore, the greater the value of the GII, the greater the disparities between women and men and the greater the losses to human development [7]. In addition, this indicator measures gender inequality, whether in the workplace or in health, as the higher the index, the lower the country's social development, this criterion is considered indirect.

B. *Calculations*

The data obtained for each criterion are presented in Table I. Then, in order to apply the entropy-weight method, the data obtained from countries studied of South America is ordered and presented as in Table I.

**TABLE I  
COUNTRIES STUDIED IN THIS WORK**

Cod	Country	C1 <sup>1</sup>	C2 <sup>2</sup>	C3 <sup>3</sup>	C4 <sup>4</sup>	C5 <sup>5</sup>	C6 <sup>6</sup>	C7 <sup>7</sup>	C8 <sup>8</sup>	C9 <sup>9</sup>	C10 <sup>10</sup>	C11 <sup>11</sup>	C12 <sup>12</sup>	C13 <sup>13</sup>
Co1	Argentina	16.022	76.577	100.00	53.32	36	12478.8	57.45	6.599	30.24	3.81	8.40	0.827	0.362
Co2	Bolivia	10.051	69.125	93.04	46.20	33	3100.4	49.85	5.823	25.24	3.54	3.12	0.674	0.446
Co3	Brazil	24.844	75.509	100.00	73.54	40	8561.0	56.53	6.635	33.19	4.06	11.61	0.754	0.414
Co4	Chile	24.087	79.522	100.00	21.04	66	13516.3	69.56	6.652	38.41	4.64	6.74	0.847	0.322
Co5	Colombia	43.852	74.381	99.00	57.97	37	5806.0	70.92	6.357	34.16	4.30	8.35	0.727	0.393
Co6	Ecuador	65.973	76.327	99.94	42.87	31	5969.2	57.97	6.008	27.11	3.96	4.60	0.739	0.391
Co7	Paraguay	16.928	73.120	98.40	24.88	30	4079.4	59.03	5.493	28.20	3.65	5.25	0.693	0.464
Co8	Peru	24.823	74.983	94.85	23.21	35	6031.0	70.25	5.715	32.51	4.23	3.53	0.740	0.385
Co9	Uruguay	19.678	77.493	100.00	50.69	71	15226.1	61.85	6.454	34.28	4.17	7.84	0.795	0.284
Co10	Venezuela	35.790	74.545	99.60	32.80	17	7480.0	33.37	5.250	22.32	3.27	7.86	0.767	0.461

<sup>1, 2, 3, 4, 11</sup> Data is obtained of The World Bank for 2016 [23]–[26], [32]. <sup>4</sup> Additional data is obtained of International Monetary Fund [34] and webpage Datosmacro [35]. <sup>5</sup> Data is obtained of Transparency International Corruption Perceptions Index 2016 [28]. <sup>6</sup> Data is obtained of Statistical Yearbook for Latin America and the Caribbean 2017 [29]. <sup>7</sup> Data is obtained of Doing Business 2017 [30]. <sup>8</sup> Data is obtained of World Happiness Report 2017 [8]. <sup>9</sup> Data is obtained of The Global Innovation Index 2016 [31]. <sup>10</sup> Data is obtained of The Global Competitiveness Report 2016-2017 [32]. <sup>12, 13</sup> Data is obtained of Human Development Report 2016 [7].

The case study calculations using the detailed steps of the input weight method are performed as follows:

**Step 1:** First, we inverted the values of each of the criteria C1, C4, C11 and C13, as they are indirect criteria. Subsequently, the criterion values were normalized using Equation 2. The results are presented in Table II.

**TABLE II**  
**NORMALIZED VALUES IN EACH COUNTRY**

Cod	1/C1	C2	C3	1/C4	C5	C6	C7	C8	C9	C10	1/C11	C12	1/C13
Co1	0.136	0.102	0.102	0.068	0.091	0.152	0.098	0.108	0.099	0.096	0.068	0.109	0.106
Co2	0.216	0.092	0.094	0.079	0.083	0.038	0.085	0.095	0.083	0.089	0.184	0.089	0.086
Co3	0.088	0.100	0.102	0.049	0.101	0.104	0.096	0.109	0.109	0.102	0.050	0.100	0.093
Co4	0.090	0.106	0.102	0.172	0.167	0.164	0.119	0.109	0.126	0.117	0.085	0.112	0.119
Co5	0.050	0.099	0.101	0.063	0.093	0.071	0.121	0.104	0.112	0.109	0.069	0.096	0.098
Co6	0.033	0.102	0.101	0.085	0.078	0.073	0.099	0.099	0.089	0.100	0.125	0.098	0.098
Co7	0.128	0.097	0.100	0.146	0.076	0.050	0.101	0.090	0.092	0.092	0.109	0.092	0.083
Co8	0.088	0.100	0.096	0.156	0.088	0.073	0.120	0.094	0.106	0.107	0.163	0.098	0.100
Co9	0.111	0.103	0.102	0.072	0.179	0.185	0.105	0.106	0.112	0.105	0.073	0.105	0.135
Co10	0.061	0.099	0.101	0.111	0.043	0.091	0.057	0.086	0.073	0.083	0.073	0.101	0.083

**Step 2:** Next, the entropy ( $H_j$ ) of each criterion  $C_j$  is determined by Eq. 3. The results are shown in Table III.

**TABLE III**  
**ENTROPY VALUES IN THE CASE STUDY**

Cod	1/C1	C2	C3	1/C4	C5	C6	C7	C8	C9	C10	1/C11	C12	1/C13
Co1	0.118	0.101	0.101	0.079	0.095	0.124	0.099	0.104	0.099	0.098	0.080	0.105	0.103
Co2	0.144	0.095	0.097	0.087	0.090	0.054	0.091	0.097	0.089	0.094	0.135	0.094	0.092
Co3	0.093	0.100	0.101	0.064	0.101	0.102	0.098	0.105	0.105	0.101	0.065	0.100	0.096
Co4	0.094	0.103	0.101	0.132	0.130	0.129	0.110	0.105	0.113	0.109	0.091	0.106	0.110
Co5	0.065	0.099	0.100	0.075	0.096	0.081	0.111	0.102	0.106	0.105	0.080	0.098	0.099
Co6	0.049	0.101	0.101	0.091	0.087	0.083	0.099	0.099	0.093	0.100	0.113	0.099	0.099
Co7	0.115	0.098	0.100	0.122	0.085	0.065	0.100	0.094	0.095	0.095	0.105	0.095	0.090
Co8	0.093	0.100	0.098	0.126	0.093	0.083	0.110	0.096	0.104	0.104	0.128	0.099	0.100
Co9	0.106	0.102	0.101	0.082	0.134	0.136	0.103	0.103	0.107	0.103	0.083	0.103	0.117
Co10	0.074	0.100	0.101	0.106	0.059	0.095	0.071	0.092	0.083	0.089	0.083	0.101	0.090
Entropy( $H_j$ )	<b>0.949</b>	<b>1.000</b>	<b>1.000</b>	<b>0.964</b>	<b>0.968</b>	<b>0.951</b>	<b>0.992</b>	<b>0.999</b>	<b>0.995</b>	<b>0.998</b>	<b>0.963</b>	<b>0.999</b>	<b>0.995</b>

**Step 3:** Now, the divergence degree ( $div_j$ ) for each criterion  $C_j$  is determined by Eq. 4. The results are shown in Table IV.

**Step 4:** Then, the entropy weight ( $w_j$ ) for each criterion  $C_j$  is determined by Eq. 5. The results are presented in Table IV.

**TABLE IV**  
**DIVERGENCE AND ENTROPY VALUES IN THE CASE STUDY**

	1/C1	C2	C3	1/C4	C5	C6	C7	C8	C9	C10	1/C11	C12	1/C13
<b>Divergence</b>	0.0512	0.0003	0.0001	0.0359	0.0318	0.0488	0.0078	0.0014	0.0050	0.0021	0.0365	0.0010	0.0052
<b>Entropy-weight</b>	0.2254	0.0012	0.0006	0.1581	0.1401	0.2148	0.0344	0.0061	0.0222	0.0091	0.1609	0.0045	0.0227

In this part, the entropy-weight method application was concluded. The classification obtained by a weighted sum is then described and discussed in the following section. average is then used to obtain the ranking. The ranked results are shown in Table V.

**IV. RESULTS AND DISCUSSION**

Decision matrix values (Table II) are recalculated considering the weights of the criteria (Table 5). A weighted

**TABLE V**  
**RANKING OF THE STUDIED COUNTRIES**

Country	1/C1	C2	C3	1/C4	C5	C6	C7	C8	C9	C10	1/C11	C12	1/C13	Sum Pond
Chile	0.0204	1.3E-04	5.6E-05	0.0273	0.0233	0.0353	0.0041	0.0007	0.0028	0.0011	0.0137	0.0005	0.0027	0.1320
Uruguay	0.0249	1.2E-04	5.6E-05	0.0113	0.0251	0.0398	0.0036	0.0006	0.0025	0.0010	0.0118	0.0005	0.0031	0.1243
Bolivia	0.0488	1.1E-04	5.3E-05	0.0124	0.0117	0.0081	0.0029	0.0006	0.0018	0.0008	0.0297	0.0004	0.0020	0.1193
Peru	0.0197	1.2E-04	5.4E-05	0.0247	0.0124	0.0158	0.0041	0.0006	0.0024	0.0010	0.0262	0.0004	0.0023	0.1097
Argentina	0.0306	1.2E-04	5.6E-05	0.0108	0.0127	0.0326	0.0034	0.0007	0.0022	0.0009	0.0110	0.0005	0.0024	0.1079
Paraguay	0.0290	1.2E-04	5.6E-05	0.0231	0.0106	0.0107	0.0035	0.0006	0.0020	0.0008	0.0176	0.0004	0.0019	0.1003
Brazil	0.0197	1.2E-04	5.6E-05	0.0078	0.0142	0.0224	0.0033	0.0007	0.0024	0.0009	0.0080	0.0004	0.0021	0.0821
Ecuador	0.0074	1.2E-04	5.6E-05	0.0134	0.0110	0.0156	0.0034	0.0006	0.0020	0.0009	0.0201	0.0004	0.0022	0.0772
Venezuela	0.0137	1.2E-04	5.6E-05	0.0175	0.0060	0.0195	0.0020	0.0005	0.0016	0.0007	0.0118	0.0005	0.0019	0.0759
Colombia	0.0112	1.2E-04	5.6E-05	0.0099	0.0131	0.0152	0.0042	0.0006	0.0025	0.0010	0.0111	0.0004	0.0022	0.0715

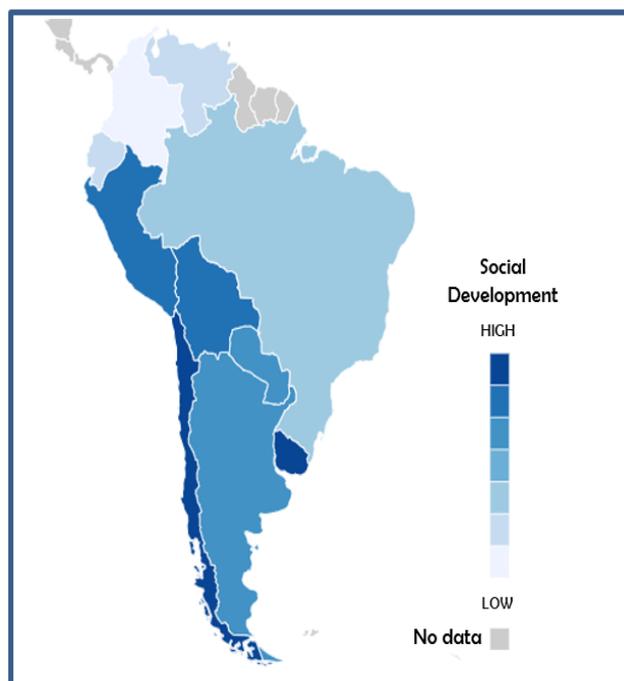
The data for the production of an informative map on a scale of colours was obtained from Table VI (Fig. 1). The countries in lead colour are those that were not taken in the case study. The informative map was created using the web application MapInSeconds [36] with dates of social development ranking [10].

Chile, which is the country with the greatest in the result, is represented by a dark blue colour and Colombia, which turned out to be last in the ranking, is represented as a light sky blue colour. In addition, in first place of our ranking is Chile with the highest global indexes among the countries studied, in contrast to Venezuela, penultimate in the ranking and with the lowest global indexes, as shown in Table VI.

**TABLE VI**  
**COMPARISON CHILE AND VENEZUELA**

	World Happiness Index <sup>1</sup>		Global Innovation Index <sup>2</sup>		Global Competitiveness Index <sup>3</sup>	
	Score	Rank	Score	Rank	Score	Rank
Chile	6.652	20	38.41	44	4.64	33
Venezuela	5.250	82	22.32	120	3.27	130

<sup>1</sup> Data is obtained of World Happiness Report 2017 [8].  
<sup>2</sup> Data is obtained of The Global Innovation Index 2016 [31].  
<sup>3</sup> Data is obtained of The Global Competitiveness Report 2016-2017 [32].



**Fig. 1 Informative map of the Social Development**

In the second place is Uruguay with a higher GDP per capita, greater transparency in the face of corruption and a lower index of gender inequality. In addition, Colombia, the last in the ranking has the second highest public debt added to the second highest population density for the countries studied [37], point out in their article that the loans obtained by international financial institutions have brought with them social, economic and political consequences, among which mention: increase in the sale of assets and large companies to corporations international, increase in taxes, bankruptcy of national farmers, increase in poverty rates, reduction of investment in health and education, privatization of public services, among others.

These results were obtained from the application of the method in the countries taking into consideration the criteria established for this study, it was used for the method of plant selection [10] or prioritization of strategies in SMEs [38].

In the report 'Human Development Index' published by UNDP, the progress achieved in a country is measured in three fundamental aspects of human development: enjoy a full and wholesome life, receive access to education and a dignified quality of life. The organization indicates that this index was conceived in order to highlight that the expansion of the people' opportunities should be the most important criterion for evaluating development results [7].

**TABLE VII  
HUMAN DEVELOPMENT INDEX RANK FOR  
COUNTRIES STUDIED**

Country	HDI rank in the world <sup>1</sup>
Argentina	45
Bolivia	118
Brazil	79
Chile	38
Colombia	95
Ecuador	89
Paraguay	110
Peru	87
Uruguay	54
Venezuela	71

<sup>1</sup> Data is obtained of Human Development Report 2016 [7].

Table VII shows the ranking for the countries studied in this paper regarding the HDI, then in Table VIII a comparison was made between the Human Development Index and the Social Development Index, result of this work.

**TABLE VIII  
COMPARISON HDI AND SOCIAL DEVELOPMENT**

Country	HDI countries studied Rank <sup>1</sup>	Social Development Rank <sup>2</sup>
Argentina	2	5
Bolivia	10	3
Brazil	5	7
Chile	1	1
Colombia	8	10
Ecuador	7	8
Paraguay	9	6
Peru	6	4
Uruguay	3	2
Venezuela	4	9

<sup>1</sup> Data is obtained of Human Development Report 2016 [7].

<sup>2</sup> Data is obtained of this study.

The contrast between both indices is small for some countries, as in the case of Chile where the range is the same, but for other countries the contrast is high, for example the cases of Bolivia and Venezuela.

It should be consider that the HDI report is for the year 2015 since UNDP prepares these reports every 5 years. In addition, in the ECLAC report, "Social Panorama of Latin America" prepared by the Social Development Division and the Statistics Division, the statistics produced on the inequality of income of individuals and households, the evolution of poverty, stand out and its determinants, and the effects of pension systems on equality and its relationship with the dynamics of the labour market, its results and conclusions, unlike our study, give a general look for South America, seeking as much as we contribute to development of the country [29].

The social developing in each country is very dynamic and inconstant. This fact makes that the governments of countries demand current social information, in order to make policies decisions to improve social indicators in each country. Particular, in South America there are many social conflicts, which requires a prompt solution [9].

Consequently, this study showed a ranking from South America countries considering the criteria selected. However, this ranking could change if other criteria are used. In addition, there are others methodologies to stablish a ranking based on criteria previously determined; this aspect also could generate different results for this type de studies.

## V. CONCLUSIONS

For the countries of South America, the impact on development indicators has a significant impact on the social development ranking and on the economic growth of each country. For example, Uruguay, second in the development ranking, with the highest GDP per capita among all the countries studied with 15,226 dollars, Chile, which is first in the ranking, has the best indices among the countries in terms of world indices such as: Global Innovation Index, World Happiness Index and Global Competitiveness Index.

The social welfare, that is the purpose of these statistics and measurements, can be achieved by improving the standard of living of the inhabitants from each country, through the creation of projects aimed at satisfying the primary needs of vulnerable groups, new strategies at different levels of society for continuous improvement, significant proposals, improvements in the financial sector, in production systems, in social policies, in revenues. In addition, inequality, lack of inclusion, are social problems that bring negative consequences for all development processes, and that can be induced in their reduction with sustained investment in the education and health sector. The results of this study could change according to other context or by applying of other method.

Finally, the entropy-weight method applied in this study could be used to perform other types of studies, in which there is information to analyse, in order to obtain an informative ranking.

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