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Neutrosophic Analytic Hierarchy Process for the Analysis of Innovation in Latin America

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Abstract. This paper analyzes the factors that are influencing the stagnation of innovation indicators in the Latin American region. To do this, an analysis is carried out to explore the existence of different groups of countries characterized by different levels of technological capacity and innovation. The elements to be analyzed during the study are obtained through the indicators evaluated in the Global Innovation Index, its 2020 edition, and the Analytic Hierarchy Process. The results show the existence of three groups of countries characterized by a different capacity for technological innovation, both in terms of technology policy and generation of technology and innovation, and technological preparation of society.

Keywords: Innovation, Latin America, WIPO

1 Introduction

Today, innovation is considered an imperative strategy to achieve economic development and is the best option to face the challenges of the future. You can innovate in products, processes, markets, or organizations [1]. [2] Defines innovation as having an idea about a process or a tool as new, but with relevant and substantial improvements. [3] Defines it as a solution of technological advance, achieved through cutting-edge technology. According to [4], it is: "the introduction of a new or significantly improved product (good or service), a new marketing method or a new organizational method, in internal company practices, workplace organization or external relations". Finally, [5] defines, in general terms, that innovation is the commercial application of an idea, which flows through three important stages: the idea, the development, and the introduction to the market.

There is a widely accepted belief that technological innovation is a fundamental variable to explain aspects such as competitiveness, growth rate, productivity, job creation, and well-being [6]. Different levels of technological development characterize countries and this is the main factor that reveals their different competitive patterns and their long-term economic divergence [7].

One of the most important references in this matter is the *Global Innovation Index* (GII). This report provides detailed values on innovation performance in various world economies. Its 80 indicators provide a broad vision of innovation, including the political environment, education, infrastructure, and market sophistication [1].

In recent years, there has been a strong political determination to foster innovation, including developing countries; it is a relatively new and promising trend towards democratization beyond a select number of economies and poles of competitiveness [8]. Unfortunately, Latin America remains stagnant relative to the average performance of global economies. The data provided by the Data Center for Intellectual Property Statistics of the World Intellectual Property Organization (WIPO) shows that from 2015 to 2019 there has been a decrease of 13% in patent applications from the Latin American region and the Caribbean. The crisis generated by the coronavirus disease (COVID-19) pandemic is expected to make this situation even worse.

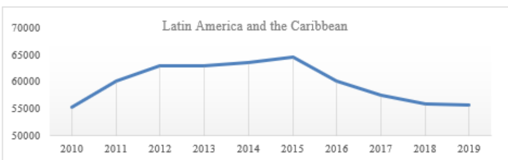

Figure 1: Indicator: Total patent applications. Region: Latin America and the Caribbean. Source: Intellectual Property Statistics Data Center of the World Intellectual Property Organization (WIPO)

The objective of this study is to analyze the factors that are influencing the stagnation of innovation indicators in the Latin American region. To do this, it is intended to carry out an empirical analysis that explores the existence of different groups of countries characterized by different levels of technological and innovation capacity, examining their main differences.

The study has been carried out using the data published in the Global Innovation Index (GII) in its 2020 edition, which contains a series of indicators that quantify the different aspects related to the technological innovation capacity of more than 130 countries. This work analyzes these data through two stages. The first consists of reducing a large number of indicators through the *Analytic Hierarchy Process* (AHP) to determine a reduced set of indicators based on which the different countries will subsequently be evaluated. Second, the selected indicators will be used to identify different groups of countries by analyzing these indicators.

Accordingly, the work has been organized as follows. In section 2, the indicators used to measure the technological innovation capacity of the different countries of the region are defined, while at the same time justifying their selection using the method described. Section 3 shows the analysis using the selected indicators and their result.

2 Case study

The capacity for technological innovation is related to different aspects such as the infrastructures that support industrial production and innovation activities, the formation of human resources, and the ability of nations to create, imitate, and manage a complex reserve of knowledge. advanced technology [9]. In this article, a series of indicators will be used that directly measure different relevant aspects of the technological innovation capacity of the Latin American countries included in the GII 2020. The advantage of using a battery of indicators is that it is thus possible to define the situation of each country, providing an easier understanding of the differences between them.

Professor Dutta launched the Global Innovation Index (GII) project in 2007 during his tenure at the European Institute of Business Administration (INSEAD). The objective was to find and determine metrics and methods that could better capture the richness of innovation in society, going beyond traditional measures of innovation such as the number of research articles and the level of expenditure on research and development (R&D) [10]. GII is not intended to be the final and definitive ranking of economies concerning innovation. Measuring the results of innovation and its impact remains difficult, so great emphasis is placed on measuring the climate and infrastructure for innovation and evaluating the related results [11].

The GII is based on two sub-indexes, the Innovation Input Sub-index and the Innovation Output Sub-index, each built around a total of 7 pillars. Each pillar is divided into three sub-pillars, which, in turn, are made up of several individual indicators.

Innovation Input Sub-index	Institutions
	Human resources and research
	Infraestructure
	Market sophistication
	Business sophistication
Innovation Products Sub-index	Knowledge and technology outputs
	Creative outputs

Figure 2: Global Innovation Index 2020. Source: Global Innovation Index Database, Cornell, INSEAD and WIPO, 2020

So the initial selection of the indicators to be evaluated is shown below:

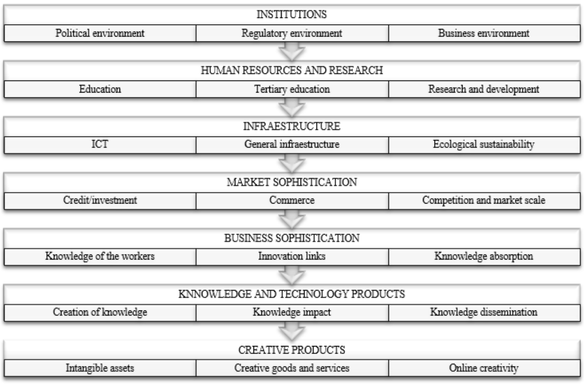

Figure 3. Innovation indicators to evaluate

Pillar 1: Institutions: captures the institutional framework of an economy.

- The political environment sub-pillar includes the political, legal, operational, or security risk index and the quality of public and civil services, the formulation and implementation of policies.
- The Regulatory Environment sub-pillar is based on two indexes intended to capture perceptions of the government's ability to formulate and implement cohesive policies that promote private sector development and to assess the extent to which the rule of law prevails.
- The Business Environment sub-pillar evaluates the cost of dismissal due to dismissal as the sum, in weeks of salary, of the cost of the notice requirements added to the severance payments due when dismissing a worker.

Pillar 2: Human resources and research: This pillar attempts to measure the human resources of economies.

- The first sub-pillar includes a combination of indicators aimed at capturing achievement at the primary and secondary education levels.
- The tertiary education sub-pillar aims to capture coverage (tertiary enrollment); Priority is given to sectors traditionally associated with innovation and the entry and mobility of tertiary education students.
- The sub-pillar on R&D measures the level and quality of R&D activities.

Pillar 3: Infrastructure:

- The ICT sub-pillar includes four indices, each on access, use, government online service, and citizens' online participation of ICT.
- The general infrastructure sub-pillar includes the average electricity production in GWh per capita; a composite indicator on logistics performance; and gross capital formation.
- The sub-pillar on ecological sustainability includes three indicators: it attempts to measure the environmental performance of the economies according to various criteria.

Pillar 4: Market sophistication: measures the availability of credit and the existence of an environment that supports investment

- The Credit sub-pillar includes a measure on the ease of obtaining credit
- The Investment sub-pillar includes the minority investor protection facility index. They analyze whether the market size corresponds to the dynamism of the market and provide a metric of concrete data on venture capital deals.
- The last sub-pillar addresses trade, competition, and market scale.

Pillar 5: Business sophistication - Try to assess how conducive innovation activities are.

- The first sub-pillar includes four quantitative indicators of workers' knowledge.
- The Innovation Links sub-pillar is based on both qualitative and quantitative data on collaboration between companies and universities in R&D, the prevalence of well-developed and deep clusters, the gross R&D expenditure promised by abroad as a percentage of GDP, and the number of agreements on joint ventures and strategic alliances.
- The sub-pillar on the absorption of knowledge will reveal how good economies are at absorbing and disseminating knowledge.

Pillar 6: Knowledge and technology products: This pillar covers all those variables that are traditionally believed to be the result of inventions and/or innovations.

- The first sub-pillar refers to the creation of knowledge. It includes accurate indicators that are the result of inventive and innovative activities: patent applications filed by residents both in the national patent office and internationally through the PCT; utility model applications submitted by residents at the national office; scientific and technical articles published in peer-reviewed journals; and the number of articles (H) of an economy that has received at least H citations.
- The second sub-pillar, on the impact of knowledge, includes statistics that represent the impact of innovation activities at the micro and macroeconomic levels.
- The third sub-pillar, on the dissemination of knowledge, includes statistics related to sectors with high-tech content or that are key to innovation.

Pillar 7: Creative Products

- The first sub-pillar on intangible assets includes statistics on trademark applications by residents and which economies have the most valuable brands.
- The second sub-pillar on creative goods and services includes powers to arrive at the creativity and creative outcomes of an economy.
- The third sub-pillar attempts to measure how innovation, production, and trade in digitized creative products and services are evolving in an innovation-based economy.

3 Conceptual framework of the neutrosophic AHP method

Before conducting the empirical study, it is convenient to reduce the set of indicators to a smaller number of dimensions. For this, the AHP method has been used in its neutrosophic variant since this method is designed to solve complex multi-criteria problems based on subjective assessments. Through its use, the indicators that best analyze the distribution of technological innovation among Latin American countries are identified, taking into account the region's particularities. In other words, those that best discriminate the level of technological innovation in these countries.

The result of the AHP is a hierarchy with priorities that show a global preference for each of the decision alternatives, so it will be used to prioritize the indicators that have the greatest impact on the problem under study. Below are the main definitions of neutrosophic logic and its application in the neutrosophic AHP.

Definition 1[12], [13]: The *Neutrosophic set* N is characterized by three membership functions, which are the truth-membership function T_A, indeterminacy-membership function I_A,and falsehood-membership function F_A, where U is the Universe of Discourse and $\forall x \in U$, $T_A(x)$, $I_A(x)$,$F_A(x) \subseteq]^-0, 1^+[$, and $^-0 \leq \inf T_A(x) + \inf I_A(x) + \inf F_A(x) \leq \sup T_A(x) + \sup I_A(x) + \sup F_A(x) \leq 3^+$. Notice that, according to the definition, $T_A(x)$, $I_A(x)$ and $F_A(x)$ are real standard or non-standard subsets of $]^-0, 1^+[$ and hence, $T_A(x)$, $I_A(x)$ and $F_A(x)$ can be subintervals of [0, 1].

Definition 2 [12], [13]: The *Single-Valued Neutrosophic Set* (SVNS) N over U is $A = \{<x; T_A(x), I_A(x), F_A(x)>: x \in U\}$c, where $T_A: U \rightarrow [0, 1]$, $I_A: U \rightarrow [0, 1]$, and $F_A: U \rightarrow [0, 1]$, $0 \leq T_A(x) + I_A(x) + F_A(x) \leq 3$.

The *Single-Valued Neutrosophic Number* (SVNN) is represented by N = (t, i, f), such that $0 \leq t, i, f \leq 1$ and $0 \leq t + i + f \leq 3$.

Definition 3[12], [14], [15]**:** the *single-valued trapezoidal neutrosophic number*, $\tilde{a} = \langle (a_1, a_2. a_3, a_4); \alpha_{\tilde{a}}, \beta_{\tilde{a}}, \gamma_{\tilde{a}} \rangle$, is a neutrosophic set on $\mathbb{R}$, whose truth, indeterminacy and falsehood membership functions are defined as follows, respectively:

$$T_{\tilde{a}}(x) = \begin{cases} \alpha_{\tilde{a}}\left(\frac{x-a_1}{a_1-a_1}\right), & a_1 \leq x \leq a_2 \\ \alpha_{\tilde{a}}, & a_2 \leq x \leq a_3 \\ \alpha_{\tilde{a}}\left(\frac{a_3-x}{a_3-a_2}\right), & a_3 \leq x \leq a_4 \\ 0, \text{otherwise} \end{cases} \quad (2)$$

$$I_{\tilde{a}}(x) = \begin{cases} \frac{(a_2-x+\beta_{\tilde{a}}(x-a_1))}{a_2-a_1}, & a_1 \leq x \leq a_2 \\ \beta_{\tilde{a}}, & a_2 \leq x \leq a_3 \\ \frac{(x-a_2+\beta_{\tilde{a}}(a_3-x))}{a_3-a_2}, & a_3 \leq x \leq a_4 \\ 1, & \text{otherwise} \end{cases} \quad (3)$$

$$F_{\tilde{a}}(x) = \begin{cases} \frac{(a_2-x+\gamma_{\tilde{a}}(x-a_1))}{a_2-a_1}, & a_1 \leq x \leq a_2 \\ \gamma_{\tilde{a}}, & a_2 \leq x \leq a_3 \\ \frac{(x-a_2+\gamma_{\tilde{a}}(a_3-x))}{a_3-a_2}, & a_3 \leq x \leq a_4 \\ 1, & \text{otherwise} \end{cases} \quad (4)$$

Where $\alpha_{\tilde{a}}, \beta_{\tilde{a}}, \gamma_{\tilde{a}} \in [0, 1]$, $a_1, a_2, a_3, a_4 \in \mathbb{R}$ and $a_1 \leq a_2 \leq a_3 \leq a_4$.

Definition 4 [12], [14], [15]**:** given $\tilde{a} = \langle (a_1, a_2, a_3, a_4); \alpha_{\tilde{a}}, \beta_{\tilde{a}}, \gamma_{\tilde{a}} \rangle$ and $\tilde{b} = \langle (b_1, b_2, b_3, b_4); \alpha_{\tilde{b}}, \beta_{\tilde{b}}, \gamma_{\tilde{b}} \rangle$ two single-valued trapezoidal neutrosophic numbers and λ any non-null number in the real line. Then, the following operations are defined:

1. Addition: $\tilde{a} + \tilde{b} = \langle (a_1 + b_1, a_2 + b_2, a_3 + b_3, a_4 + b_4); \alpha_{\tilde{a}} \wedge \alpha_{\tilde{b}}, \beta_{\tilde{a}} \vee \beta_{\tilde{b}}, \gamma_{\tilde{a}} \vee \gamma_{\tilde{b}} \rangle$
2. Subtraction: $\tilde{a} - \tilde{b} = \langle (a_1 - b_4, a_2 - b_3, a_3 - b_2, a_4 - b_1); \alpha_{\tilde{a}} \wedge \alpha_{\tilde{b}}, \beta_{\tilde{a}} \vee \beta_{\tilde{b}}, \gamma_{\tilde{a}} \vee \gamma_{\tilde{b}} \rangle$ (5)
3. Inversion: $\tilde{a}^{-1} = \langle ({a_4}^{-1}, {a_3}^{-1}, {a_2}^{-1}, {a_1}^{-1}); \alpha_{\tilde{a}}, \beta_{\tilde{a}}, \gamma_{\tilde{a}} \rangle$, where $a_1, a_2, a_3, a_4 \neq 0$.

Definitions 3 and 4 refer to the *single-valued triangular neutrosophic number* when the condition $a_2 = a_3$, [16]–[18]. For simplicity, we use the linguistic scale of triangular neutrosophic numbers, see Table 1 and also compare it with the scale defined in [19]. The analytic hierarchy process was proposed by Thomas Saaty in 1980 [20]. This technique models the problem that leads to the formation of a hierarchy representative of the associated decision-making scheme [21][22]. The formulation of the decision-making problem in a hierarchical structure is the first and main stage. This stage is where the decision-maker must break down the problem into its relevant components [22][24]. The hierarchy is constructed so that the elements are of the same order of magnitude and can be related to some of the next levels. In a typical hierarchy, the highest level locates the problem of decision-making. The elements that affect decision-making are represented at the intermediate level, the criteria occupying the intermediate levels. At the lowest level, the decision options are understood [13]. The levels of importance or weighting of the criteria are estimated using paired comparisons between them. This comparison is carried out using a scale, as expressed in equation (6) [25].

$$S = \left\{\frac{1}{9}, \frac{1}{7}, \frac{1}{5}, \frac{1}{3}, 1,3,5,7,9\right\} \quad (6)$$

We can find in [17] the theory of the AHP technique in a neutrosophic framework. Thus, we can model the indeterminacy of decision-making by applying neutrosophic AHP or NAHP for short. Moreover, equation 7 contains a generic neutrosophic pair-wise comparison matrix for NAHP.

$$\widetilde{\mathrm{A}} = \begin{bmatrix} \tilde{1} & \tilde{a}_{12} & \cdots & \tilde{a}_{1n} \\ \vdots & & \ddots & \vdots \\ \tilde{a}_{n1} & \tilde{a}_{n2} & \cdots & \tilde{1} \end{bmatrix} \quad (7)$$

Matrix $\widetilde{\mathrm{A}}$ must satisfy condition $\tilde{a}_{ji} = \tilde{a}_{ij}^{-1}$, based on the inversion operator of Definition 4. To convert neutrosophic triangular numbers into crisp numbers, there are two indexes defined in [19]. They are the so-called score and accuracy indexes, respectively, see Equations 8 and 9:

$$S(\tilde{a}) = \frac{1}{8}[a_1 + a_2 + a_3](2 + \alpha_{\tilde{a}} - \beta_{\tilde{a}} - \gamma_{\tilde{a}}) \quad (8)$$

$$A(\tilde{a}) = \frac{1}{8}[a_1 + a_2 + a_3](2 + \alpha_{\tilde{a}} - \beta_{\tilde{a}} + \gamma_{\tilde{a}}) \quad (9)$$

Saaty's scale	Definition	Neutrosophic Triangular Scale
1	Equally influential	$\tilde{1} = \langle(1,1,1); 0.50, 0.50, 0.50\rangle$
3	Slightly influential	$\tilde{3} = \langle(2,3,4); 0.30, 0.75, 0.70\rangle$
5	Strongly influential	$\tilde{5} = \langle(4,5,6); 0.80, 0.15, 0.20\rangle$
7	Very strongly influential	$\tilde{7} = \langle(6,7,8); 0.90, 0.10, 0.10\rangle$
9	Absolutely influential	$\tilde{9} = \langle(9,9,9); 1.00, 1.00, 1.00\rangle$
2, 4, 6, 8	Sporadic values between two close scales	$\tilde{2} = \langle(1,2,3); 0.40, 0.65, 0.60\rangle$ $\tilde{4} = \langle(3,4,5); 0.60, 0.35, 0.40\rangle$ $\tilde{6} = \langle(5,6,7); 0.70, 0.25, 0.30\rangle$ $\tilde{8} = \langle(7,8,9); 0.85, 0.10, 0.15\rangle$

Table 1: Saaty's scale translated to a neutrosophic triangular scale.

Step 1 Select a group of experts.

Step 2 Structure the neutrosophic pair-wise comparison matrix of factors, sub-factors, and strategies, through the linguistic terms shown in Table 1.

The neutrosophic scale is attained according to expert opinions [26]. The neutrosophic pair-wise comparison matrix of factors, sub-factors, and strategies are as described in Equation 7.

Step 3 Check the consistency of experts' judgments.

If the pair-wise comparison matrix has a transitive relation, i.e., $a_{ik} = a_{ij}a_{jk}$ for all i, j, and k, then the comparison matrix is consistent, focusing only on the lower, median, and upper values of the triangular neutrosophic number of the comparison matrix.

Step 4 Calculate the weight of the factors from the neutrosophic pair-wise comparison matrix, by transforming it to a deterministic matrix using Equations 10 and 11. To get the score and the accuracy degree of $\tilde{a}_{ji}$ the following equations are used:

$$S(\tilde{a}_{ji}) = 1/S(\tilde{a}_{ij}) \quad (10)$$

$$A(\tilde{a}_{ji}) = 1/A(\tilde{a}_{ij}) \quad (11)$$

With compensation by accuracy degree of each triangular neutrosophic number in the neutrosophic pair-wise comparison matrix, we derive the following deterministic matrix:

$$A = \begin{bmatrix} 1 & a_{12} & \cdots & a_{1n} \\ \vdots & & \ddots & \vdots \\ a_{n1} & a_{n2} & \cdots & 1 \end{bmatrix} \quad (12)$$

Determine the ranking of priorities, namely the Eigen Vector X, from the previous matrix:

1. Normalize the column entries by dividing each entry by the sum of the column.
2. Take the total of the row averages.

4 Application of the method

Following the logic of the method, we determined that the indicators whose behavior will be analyzed for their importance are: Regulatory environment, Business environment, Third cycle education, R&D, ICT, Credit, Creation of knowledge, and Knowledge Impact.

Pillars	Weighing	Indicators	Weight	Global
P1 Institutions	0.18	Political environment	0.162	0.029
		Regulatory environment	0.540	0.097
		Business environment	0.298	0.054
P2 Human Resources	0.15	First and second cycle education	0.168	0.025
		Third cycle education	0.416	0.062
		R&D	0.416	0.062
P3 Infrastructure	0.09	ICT	0.564	0.051
		General infrastructure	0.218	0.020
		Ecological sustainability	0.218	0.020
P4 Market sophistication	0.10	Credit	0.564	0.056
		Investment	0.218	0.022
		Trade, competition and market scale	0.218	0.022
P5 Business sophistication	0.07	Knowledge of workers	0.333	0.023
		Innovation Links	0.333	0.023
		Knowledge absorption	0.333	0.023
P6 Knowledge and technology products	0.32	Knowledge creation	0.416	0.133
		Knowledge impact	0.416	0.133
		Dissemination of knowledge	0.168	0.054
P7 Creative Products	0.08	Intangible assets	0.564	0.045
		Creative goods and services	0.218	0.017
		Online creativity	0.218	0.017

Table 2: Summary of the global evaluations of the evaluated indicators

5 Analysis of the results

In this section, an analysis of the innovation capacity of Latin American countries is carried out according to the indicators determined in the previous section.

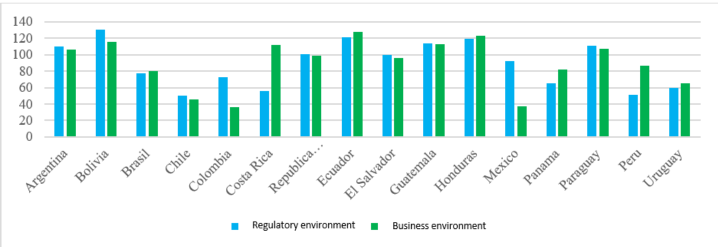

Figure 4. Behavior (ranking) of the P1 indicators in Latin American countries.

As can be seen in Figure 4, both indicators have very similar behavior in the countries analyzed. It is observed that only three are located among the top 60 worldwide concerning the regulatory environment indicator. With regard to the business environment, only Chile, Colombia, and Mexico are among the top 60, which offers a measure of the lack of ease that exists among the rest of Latin American countries to start a business and to resolve insolvency.

In general, the region has institutional frameworks that are weakly focused on achieving adequate levels of protection and incentives for innovation.

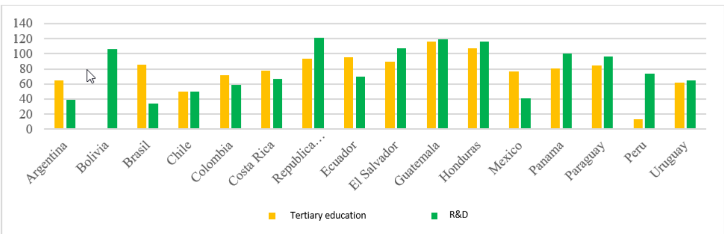

Figure 5: Behavior (ranking) of the P2 indicators in Latin American countries.

Regarding coverage (tertiary enrollment) in sectors traditionally associated with innovation, only Chile and Peru are in favorable positions; the rest are between the average, except for Guatemala and Honduras, which are in positions above 100. It is noteworthy that even though few countries in the region are among the top 60 with respect to tertiary education, the quality of R&D activities in several countries (Argentina, Brazil, Chile, Colombia, Costa Rica, Ecuador, Mexico, Peru, and Uruguay) allow locations in the ranking below 80. Only the Dominican Republic, El Salvador, Guatemala, and Honduras are in positions above 100.

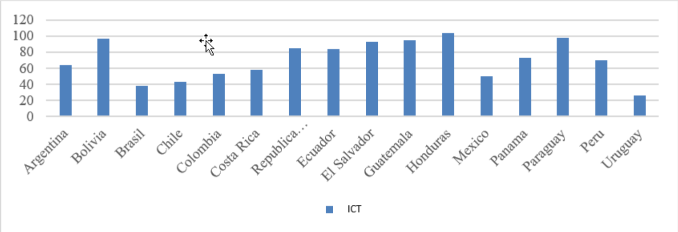

Figure 6. Behavior (ranking) of the ICT indicator in Latin American countries.

In general, access to ICTs, their use, the government's online service, and the online participation of citizens in the region are highly variable. Countries such as Brazil, Chile, Colombia, Mexico, and Uruguay have better results in this regard than other Latin American countries. On the other hand, it is generally observed in the region that it is relatively easy to obtain credits for innovations. The cases of Peru, Panama, and Colombia are noteworthy, which are among the top 40 in the world in terms of this indicator.

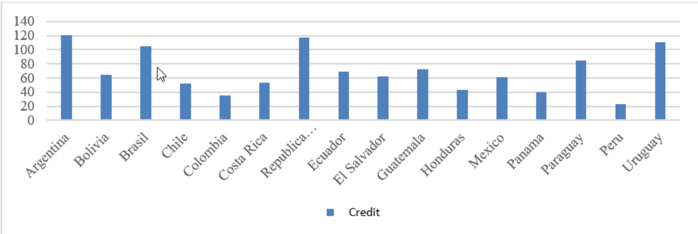

Figure 7. Behavior (ranking) of the Credit indicator in Latin American countries.

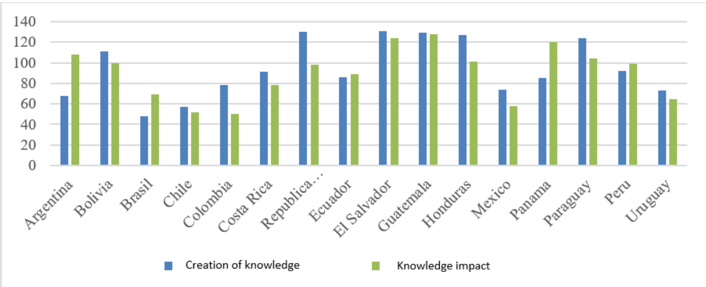

Figure 8. Behavior (ranking) of the P6 indicators in Latin American countries.

In the period analyzed, patent applications filed by residents both in the national patent office and internationally through the PCT, utility model applications filed by residents in the national office, scientific and technical articles published in peer-reviewed journals have made Brazil and Chile stand out from the rest by being located among the top 60 worldwide. However, in general, this indicator did not perform well in the region. The Knowledge impact made it possible to obtain slightly better results, but the impact of innovation activities at the micro and macroeconomic levels is still insufficient to position the countries of the region favorably.

In general, it can be verified that the region is characterized by scarce investments in R&D, an incipient use of IP systems is observed, and the disconnection between the public and private sectors in prioritizing R&D and innovation. The deficient and bureaucratic regulatory framework, the existence of poorly financed public administrations and without resources, the low levels of education and consequently the low number of scientific publications, the Latin American model of staying with small companies and the incipient culture to promote the use of trademarks do not favor innovation activity. Only a few countries in the region exceed the average: Brazil, for example, has an R&D intensity comparable to some European economies, such as Portugal and Spain. Chile, Uruguay, and Brazil, on the other hand, are high producers of scientific papers.

Finally, and according to what has been analyzed, it can be concluded that the innovation performance of the region can be divided into three groups: First, the regional leaders: Chile, which is the most innovative economy in the region, 54 of the world ranking, followed by Mexico (55) and Costa Rica (56). Second, an intermediate group of six economies, mostly from South America and upper-middle-income, except for Uruguay and Panama with high incomes: Brazil (62), Colombia (68), Uruguay (69), Panama (73), Peru (76), and Argentina (80). The third group is made up of 7 economies that are in the top 110.

Conclusions

Carrying out this work allowed the development of an investigation on the differences in the capacity for technological innovation between Latin American countries. The results show the existence of 3 groups characterized by different levels of technological innovation. The differences shown between them were determined from 8 indicators obtained from the GII 2020:

- Regulatory environment,
- Business environment,
- Tertiary education,
- R&D,
- ICT,
- Credit,
- Creation of knowledge and Knowledge Impact.

The versatility of the neutrosophic AHP method can be verified as an effective tool in the discrimination of information to rank these indicators.

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