Journal of Intelligent Systems and Internet of Things
Vol. 12, No. 01, PP. 158-163, 2024
DOI: https://doi.org/10.54216/JISIoT.120112

A Neutrosophic Multicriteria Analysis of Economic Recovery Systems

Carlos Wilman Maldonado Gudiño[1, *], Maria Fernanda Jara Campoverde[2], Maria Belen Carlosama Ponce[2], Marina Abdurashidova[3]

[1]Regional Autonomous University of the Andes, Ecuador
[2]Luis Leoro Franco Educational Unit, Ecuador
[3]Tashkent State University of Economics, Uzbakistan

Email: ui.carlosmaldonado@uniandes.edu.ec; mariaferjarac@gmail.com; ci.mariabcp91@uniandes.edu.ec; m.abdurashidova@tsue.uz

Abstract

The article investigates the neutrosophic multicriteria analysis of the post-pandemic economic recovery, an intricate and multi-dimensional problem, which persistently affects several nations in a globalized setting with high levels of uncertainty. This study delves into how recovery measures including policies and strategies should be developed and implemented considering the newly emerging complexities that characterize the modern world and its politics. The main concern is the absence of any tools that may seek to correlate the various factors that are necessarily involved in any recovery process, all of which have variable post- pandemic economic, social, and political conditions. In addition, there is clearly an importance of this issue since it has been so timely for governments and/or organizations to look for strategies and policies that would ensure a just and environmentally sound reconstruction phase. By providing a neutrosophic multicriteria analysis that has not been applied before in this context, the paper contributes to the existing literature by outlining various factors involved in economic recovery such as fiscal policy and health and social measures. This study takes the neutrosophic perspective and forms of analysis to explore the various uncertainties and heterogeneous views concerning economic strategies, thus enabling an intricate analysis of the strategic options put forth. The findings emphasize the necessity for a creative and cross-cutting strategy towards the reconstruction of the economy, emphasizing the fact that the solutions must be dynamic to the changing circumstances. Making an academic contribution, this research not only proposes a new theoretically based framework for the understanding of recovery, but also has practical recommendations that may help in formulating policies that are more robust and effective in times of crises.

Received: August 17, 2023 Revised: November 24, 2023 Accepted: March 11, 2024

Keywords: Neutrosophic multicriteria analysis; Multicriteria decision making; Unbiased logic; Unbiased populations; Indicators; Behavior; Data sets; Economic recovery; Expert evaluation

1. Introduction

Evaluation, measurement, and control are important for both government and private industry. Publication of indicators related to industrial activity is important in the decision-making process, especially in promoting government policies and financial support. It is necessary to classify indicators that reflect the dynamics of enterprises more frequently than the GDP that is published quarterly, to evaluate the results over time [1].

Real-time monitoring of economic activity is essential for governments, the financial sector and the private sector, providing them with the tools they need to respond appropriately to economic cycles. The Non-Oil Economic Activity Index (IAE-NP) is an important statistical tool for understanding business behavior in Ecuador and is calculated monthly and quarterly from VAT Form 104 data according to approved methods [2].

The short-term financial stability of the last decade was based on a more efficient fiscal policy, [3] indicating a direct relationship between tax rates and economic growth, influenced by periods of expansion, boom, bust and recession, as an indication of an epidemic.

Taxation plays a key role in Ecuador's public finances, but they warn that an increase in tax collection does not guarantee effective tax administration [4]. According to the International Standard Industrial Classification, oil-related companies are not included in the IAE-NP calculation process.

The epidemic affected sectors such as trade, tourism, and manufacturing, leading to unemployment and slower economic growth [5]. During the pandemic, difficulties in implementing digital solutions and accessing financial services affected investment and business development.

It is said that with the outbreak of the new coronavirus epidemic, companies are facing new management and innovation challenges to overcome the financial crisis. This means rethinking their objectives and operations. The study of post-pandemic economic recovery is essential to understand the challenges and opportunities faced by countries and industries, develop effective public policies, and promote sustainable and inclusive recovery. In addition, based on the analysis of the IAE-NP and its components, the development of the industry in the country can be clearly and simply analyzed [6].

2. Related work

This study is based on the use of the MDMC approach to achieve the proposed objectives. This approach simplifies the original problem, allowing to consider complex real-world situations and make decisions in specific situations [7-10].

Table 1: Single-digit neuron number (SVNN).

definition	**SVNS**
Extreme Preference (ExP)	(1,0,0)
Very Very Liked (VVP)	(0.9, 0.1, 0.1)
Highly Recommended (VP)	(0.8,0.15,0.20)
Favorite (P)	(0.70, 0.25, 0.30)
Equal Priority (EC)	(0.50, 0.50, 0.50)
Not recommended (NP)	(0.35, 0.75, 0.80)
I don't like it at all (VNP)	(0.20, 0.85, 0.80)
I don't like it at all (VVNP)	(0.10, 0.90, 0.90)

Source: [13]

ID card 2. Let Ek be the specific number of neurons of the decision maker for problem type k. Then the weight of the decision maker can be written as: [11] :

$$\psi_k = \frac{1-\sqrt{[(1-T_k(x))^2+(I_k(x))^2+(\mathrm{F}(x))^2]/3}}{\sum_{k=1}^{p}\sqrt{[(1-T_k(x))^2+(I_k(x))^2+(\mathrm{F}(x))^2]/3}} \quad (1)$$

In the decision-making process, it is important to make decisions at the group level. In group decision-making, the judgments of all the individual decision makers need to be aggregated into a single integrated neural decision matrix. This can be achieved using the Joint Neutrosophistication and Weighting (SVNWA) [12].

ID card 3. ([12]) Let D $^{(k)}$ = (di $_j$ $^{(k)}$) mxn The single-valued neutron decision matrix of decision maker k, $\psi = (\psi_1\psi_2, \dots, \psi_p)^T$ let each be the weight vector of the decision maker,$\psi_k \in [0,1], D = (d_{ij})_{mxn}$

$$d_{ij} = \langle 1 - \prod_{k=1}^{p}\left(1 - T_{ij}^{(p)}\right)^{\psi_k}, \prod_{k=1}^{p}\left(I_{ij}^{(p)}\right)^{\psi_k}, \prod_{k=1}^{p}\left(F_{ij}^{(p)}\right)^{\psi_k}\rangle \quad (2)$$

Definition 4. Suppose A and B are single-digit neutron numbers (SVNN) and the normalized Hamming distance between them is :

$$d(A,B)\frac{|TA-TB|+|IA-IB|+|FA-FB|}{3} \quad (3)$$

Definition 5. Let A = (TA , IA , FA) SVNN, then the complement of SVNNA is :

$CA = ({}^{FA}, 1- IA , TA).$ (4)

A systematic process

To analyze the articles, existing databases in the country were searched.

- **Tourism (T):** Travel restrictions and border closures have led to a significant decline in domestic and international tourism, negatively affecting the revenues of hotels, restaurants, travel agencies and other tourism-related services.

- **Retail (RM):** Lockdowns and social distancing measures have forced many stores and retailers to close temporarily or permanently. This is especially true for stores and retailers that cannot quickly adapt to online sales or delivery services.

- **Informal sector:** Many informal sector workers, such as street vendors and self-employed workers, are facing financial difficulties due to lower demand for goods and services and lack of access to government support measures.

- **Manufacturing (IM):** Supply chain disruptions and lower demand for products have impacted manufacturing, particularly industries such as textiles, footwear and electronics.

- **Construction (C):** Lockdowns and travel restrictions have halted many construction projects, affecting construction companies and industrial workers.

Economic recovery should be used in the decision-making process and as a source of principles for evaluating production lines. In this way, alternative solutions to the problem can be analysed from the same perspective. The study was designed using four evaluation criteria that were presented to policy makers and validated. During the analysis, the experts agreed to give each criterion the same weight (each weight value w = 0.25).

The following criteria will be used to conduct this survey:

- **Employment levels:** Assess the ability of relevant industries to recover employment levels lost during the pandemic, taking into account the quantity and quality of jobs restored.

- **GDP growth by sector:** Analyzes GDP growth or decline in the sectors most affected by the pandemic and compares current data with pre-health crisis levels.

- **Output growth rate:** Examine the rate of output recovery in relevant industries, taking into account factors such as production capacity, market demand and resource supply.

- **Investment and financing:** Assess sources of investment and financing in relevant areas, including capital flows, credit availability, and government financial assistance.

3. Discuss

Table 2 shows the scores assigned to each decision based on its relative importance in the issue in question.

Table 1: Classification of decision makers according to their importance.

language assessment	SVNN	numerical value
Very important	(0.9; 0.1; 0.1)	0.22
Moderately important	(0.5; 0.5; 0.5)	0.14
Very important	(0.9; 0.1; 0.1)	0.22
Very important	(0.9; 0.1; 0.1)	0.22
excellent	(0.75; 0.25; 0.20)	0.2

Source: Home page.

The decision maker uses formula (2) to evaluate the specific design separately based on each selected attribute or evaluation criterion, and then transforms it to obtain the overall design decision matrix as shown in Table 3.

Table 2: Report on electoral decisions.

Employment level	**Growth of Sectoral GDP**	**Growth rate of The production**	**Investment and financing**
(0.61424; 0.38376; 0.33486)	(0.67429;0.32371;0.28374)	(0.7626; 0.2374; 0.2081)	(0.7237; 0.2743; 0.2319)
(0.33633;0.44347;0.42667)	(0.3;0.3;0.3)	(0.36731;0.43269;0.41301)	(0.3;0.3;0.3)
(0.68696;0.31304;0.2988)	(0.34297;0.47088;0.43333)	(0.47187;0.34413;0.3313)	(0.6024; 0.4096; 0.3789)
(0.69071;0.30929;0.29323)	(0.61623;0.38377;0.33244)	(0.47187;0.34413;0.3313)	(0.3673;0.4327;0.413)
(0.3;0.3;0.3)	(0.33633;0.44347;0.42667)	(0.3;0.3;0.3)	(0.7443;0.2333;0.2333)

Source: Own elaboration.

All the selected criteria are useful criteria. That is, except for criterion 4, they should be maximized so that the resulting criteria matrix matches the usual matrix shown in Table 3. This allows determining the matrix Pj (Bi, Br) with respect to Gj . This calculation can be performed using the linear function proposed in (4). In this case, assuming q = 1 and ip = 0, matrices P 1 to P 4 are formed.

$$P_1 = \begin{vmatrix} & B_1 & B_2 & B_3 & B_4 & B_3 \\ B_1 & 0.0000 & 0.0000 & 0.0187 & 0.0199 & 0.0000 \\ B_2 & 0.0239 & 0.0000 & 0.0426 & 0.0438 & 0.0000 \\ B_3 & 0.0000 & 0.0000 & 0.0000 & 0.0012 & 0.0000 \\ B_4 & 0.0000 & 0.0000 & 0.0000 & 0.0000 & 0.0000 \\ B_3 & 0.0484 & 0.0243 & 0.0671 & 0.0683 & 0.0000 \end{vmatrix}$$

$$P_2 = \begin{vmatrix} & B_1 & B_2 & B_3 & B_4 & B_3 \\ B_1 & 0.0000 & 0.0000 & 0.0000 & 0.0000 & 0.0000 \\ B_2 & 0.0721 & 0.0000 & 0.0102 & 0.0492 & 0.0244 \\ B_3 & 0.0619 & 0.0000 & 0.0000 & 0.0390 & 0.0142 \\ B_4 & 0.0229 & 0.0000 & 0.0000 & 0.0000 & 0.0000 \\ B_3 & 0.0476 & 0.0000 & 0.0000 & 0.0247 & 0.0000 \end{vmatrix}$$

$$\boldsymbol{P_3 = \begin{vmatrix} & B_1 & B_2 & B_3 & B_4 & B_5 \\ B_1 & 0.0000 & 0.0000 & 0.0000 & 0.0000 & 0.0000 \\ B_2 & 0.0683 & 0.0000 & 0.0000 & 0.0000 & 0.0000 \\ B_3 & 0.1198 & 0.0515 & 0.0000 & 0.0000 & 0.0225 \\ B_4 & 0.1198 & 0.0515 & 0.0000 & 0.0000 & 0.0225 \\ B_5 & 0.0973 & 0.0290 & 0.0000 & 0.0000 & 0.0000 \end{vmatrix}}$$

$$\boldsymbol{P_4 = \begin{vmatrix} & B_1 & B_2 & B_3 & B_4 & B_5 \\ B_1 & 0.0000 & 0.0000 & 0.0000 & 0.0000 & 0.0000 \\ B_2 & 0.0827 & 0.0000 & 0.0364 & 0.0290 & 0.0815 \\ B_3 & 0.0463 & 0.0000 & 0.0000 & 0.0000 & 0.0451 \\ B_4 & 0.0537 & 0.0000 & 0.0074 & 0.0000 & 0.0525 \\ B_5 & 0.0012 & 0.0000 & 0.0000 & 0.0000 & 0.0000 \end{vmatrix}}$$

The overall preference index can be obtained by formula (6), as shown in the table, Пand then the input, output and net flow of each option can be obtained, as shown in table 4.

$$\Pi = \begin{vmatrix} & B_1 & B_2 & B_3 & B_4 & B_5 \\ B_1 & 0.000 & 0.000 & 0.005 & 0.005 & 0.000 \\ B_2 & 0.062 & 0.000 & 0.022 & 0.030 & 0.026 \\ B_3 & 0.057 & 0.013 & 0.000 & 0.010 & 0.020 \\ B_4 & 0.049 & 0.013 & 0.002 & 0.000 & 0.019 \\ B_5 & 0.049 & 0.013 & 0.017 & 0.023 & 0.000 \end{vmatrix}$$

Table 3: Inputs, outputs and net substitution flows.

No	□□	□□	□
N1	0	1,000	-1.000
N2	1	0.000	1,000
N3	0.691	0.036	0.654
N4	0.555	0.167	0.388
N5	0.703	0.150	0.553

Source: personal information.

In this analysis, positive and negative flows represent advantages and disadvantages compared to other options. In this sense, based on the results of the analysis, we can know:

Ecuador's various industries can be divided into the following categories in order of economic recovery:

1. Processing

2. Construction

3. Sleeves

4. Travel services

5. Informal sector

Analyzing Ecuador's economic recovery, industries such as manufacturing and construction show growth, which benefited from the national and international demand for their products and services and were able to adapt to the new conditions caused by the pandemic. The manufacturing industry, in particular, has shown greater resilience to the health crisis, restructuring supply chains and focusing on the production of essential and high-demand goods. The construction sector shows signs of recovery thanks to infrastructure investments and government development projects.

At the same time, businesses and tourism face significant challenges as they recover. While there are signs that domestic demand is improving and domestic tourism is picking up, ongoing uncertainty and travel restrictions have limited the full recovery of these industries. Finally, the informal sector was the hardest hit, with a slow recovery due to vulnerability to social distancing measures and lack of access to government finance and support. Overall, while some sectors are showing signs of recovery, Ecuador’s economy still faces significant challenges to achieving a full recovery.

4. Conclusion

Looking at Ecuador's economic recovery, sectors such as manufacturing and construction are showing growth. These industries were able to adapt to the new conditions brought about by the pandemic and benefited from domestic and international demand for products and services. In particular, the manufacturing industry has shown remarkable resilience during the health crisis by transforming supply chains and focusing on the production of essential and high-demand goods. The construction sector has also recovered thanks to infrastructure investments and government development projects. However, businesses and tourism continue to face significant challenges in the recovery process. Although domestic demand has recovered significantly and domestic tourism has picked up, continued uncertainty and travel restrictions have prevented a full recovery in these industries. Meanwhile, the informal sector has been the hardest hit, with a slow recovery due to vulnerability to social distancing measures and lack of government funding and support. Overall, Ecuador's economy still faces major challenges in achieving a full recovery, although some sectors are showing good signs of recovery.

Funding: “This research did not receive external funding”

Conflicts of interest: “The authors declare that they have no conflict of interest.”

References

[1] D. Gillian, G. Camilo, RP De Souza, T. Diaz and C. Frazao, Multicriteria analysis in medical care: selecting the most appropriate emergency classification system, pp. 1-16, 2020.

[2] J. Aznar and F. Guijarro, New evaluation methods: multicriteria models . Polytechnic University of Valencia, 2012

[3] S. Bernal and D. Niño, "Multicriteria models used in decision making can be represented by Ishikawa diagrams", 2018. [Online].

[4] Nasser al-Din, A. Azar, A. Rajabzadeh, and A. Afsar, "Implementing collaborative decision making in emergency response: New default configuration capabilities in PROMETHEE," Rev. International 38, p. 101221, 2019.

[5] S. Singh, S. K. Verma, and A. Tiwari (2020) "New approach for finding critical nodes using ELECTRE method." Int J. Mod B , Volume 34, Issue September 2020

[6] T. Arar, S. Karaoglan, and K. Dirik, Office location selection using fuzzy AHP and VIKOR, revised edition. International Journal of Information and Decision Sciences , Volume 11, Issue 1, Pages 36–54, 2019.

[7] P. Biswas, S. Pramanik, and B. Giri, "TOPSIS Method for Multi-Attribute Collaborative Decision Making in a Unified Neutrosophistic Environment ." Application , Volume 27, Issue 3, March 3, 2016.

[8] D.K. Sen, S. Dutta, and S.S. Mahapatra, "Extending TODIM for Decision Making in Fuzzy Environments: A Case Study of an Experimental Industrial Robot Selection Study," Science, Management and International Services Review , Vol. 26, No. 2, pp. 238~276;

[9] M. C. Ilie, I. F. Borcosi, and I. Ciocan, "Improving power quality by a four-wire shunt active power filter," *Energies*, vol. 14, no. 7, p. 1951, Apr. 2021. DOI: 10.3390/en14071951.

[10] Patini, NC (2012). "Successful Austerity Policies in the United States, Europe, and Japan" (IMF Working Paper 12/190). International Monetary Fund.

[11] Biga, F. (2022). "E-commerce and consumer habits during the coronavirus pandemic in Mexico: Journal of Administration and Social Sciences, 119-134".

[12] C. P. Cisneros Zúñiga, R. C. Jiménez Martínez, and L. R. Miranda Chávez, "Neutrosophic Analytic Hierarchy Process for the Control of the Economic Resources Assigned as Alimony," *Neutrosophic Sets and Systems*, vol. 37, no. 1, pp. 37–44, 2020.

[13] R. Minasny, B. P. Malone, and A. B. McBratney, "Digital mapping of soil carbon," *Advances in Agronomy*, vol. 163, pp. 1–47, 2020. DOI: 10.1016/bs.agron.2020.06.002.