Analysis of the Venezuelan migratory impact on the economic development of Santo Domingo city, a neutrosophic cognitive map approach

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Abstract. In the most recent years, there has been a massive Venezuelan emigration to Santo Domingo city in Ecuador. This phenomenon has affected the local economy as well as the society of the city. This paper aims to study the economic impact of Venezuelan emigration to the city of Santo Domingo since a Neutrosophic Cognitive Map (NCM) approach. The advantage of using NCMs is that the causal relationships between the variables that influence the phenomenon under study are established and ranked in order of their importance. This allows determining which are the elements related to the Venezuelan migration to the Ecuadorian city of Santo Domingo that most impact the city economically, and if this impact is positive or negative for citizens and migrants. Finally, decision-makers will be provided with valuable information to take the necessary measures, where those favorable trends are reinforced and the unfavorable ones are reversed, always that humanitarian policies were dictated.

Keywords: Migration, local economy, employment, cognitive maps, neutrosophic cognitive maps.

1 Introduction

Ecuador has not been characterized as a country with an immigrant tradition compared to other countries of the American continent such as Mexico or Brazil. However, in the last decade, Ecuador has gone from being a country of emigrants to one that receives immigrants. The number of migrants in Ecuadorian territory has increased since the principle of universal citizenship recognized in the Constitution of Montecristi in 2008. According to the 1990 census, there were 65147 foreigners in Ecuador, in 2001 the number increased to 104130, while in 2010 the number was 325356.

Although there are no exact figures for the number of Venezuelans living in the country, according to data from the Civil Organization of Venezuelans in Ecuador, there exist approximately 28347 Venezuelans in the nation who mainly live in the cities of Quito, Guayaquil, Cuenca, and Ibarra.

In the press conference held at the Palais des Nations in Geneva, William Splinder, the spokesperson of United Nations High Commissioner for Refugees (UNHCR) said that many Venezuelans are moving on foot in a journey for days and even weeks in precarious conditions. Many of them are left without resources to continue their journey and are forced to live in difficult conditions in public parks, resorting to begging and other harmful mechanisms to meet their daily needs. It has been identified that about 20 percent of newcomers show specific protection needs and other vulnerabilities, including women and children at risk, single-parent families or persons with disabilities, who need urgent assistance. Women and girls account for 40 percent of newcomers and face serious risks of sexual violence, including survival and trafficking sex. Xenophobic reactions to the exodus have been observed in some sectors; see [1-4].

Emigration should be analyzed from two points of view, the social one linked to human rights, because with the sustenance of their work they intend to "help" the relatives who stayed in Venezuela, which leads to an increase

in the human tragedy that these aspects are linked to, and secondly the benefits obtained to the economic perspective in Ecuador when there exist labor sectors that are not of the pleasure of Ecuadorians, but that the presence of Venezuelan emigrants, mainly young people, helps to generate benefits for the company's owners who decide to rely on their services since their costs are minimized, especially if they are informally hired.

The purpose of this investigation is to analyze the impact of the massive migration of Venezuelans in Ecuador over the last two years, especially the economic impact in the city of Santo Domingo. We must recognize that the study we are doing would be superficial if other variables, such as political and social, were not included. In particular, we propose to carry out this analysis through the application of neutrosophic cognitive maps where the causal relationships between different characteristics related to Venezuelan migration are linked. We select the use of neutrosophy to incorporate some causal relationships among aspects that may be indeterminate, mainly since at the moment of the research there was no certainty of the degree of relationship between them, although they are essential for this study.

The neutrosophic logic theory is based on Neutrosophy and generalizes fuzzy sets and fuzzy logic theory; see [5-7]. A Neutrosophic Cognitive Map (NCM) is a Cognitive Map where indeterminacy is explicitly included in causal relations evaluations, see [8]. NCMs are based on neutrosophic logic to represent uncertainty and indeterminacy in cognitive maps([9]), thus, it extends Fuzzy Cognitive Maps ([10]). An NCM is a directed graph such that at least one edge is indeterminate and it is depicted by using dotted lines, see [11]. This kind of representation allows dealing with indeterminacy. In this paper, we apply the static tools of NCM for the study.

There exist different approaches to mathematically model the migratory flow between countries. Usually, these are dynamic models, since migratory flows change over time. Among those models there are Markov chains, for example in [12] the migration process is modeled using the multistage network equilibrium model of human migration. In [13] a model called "Discrete-time model for a substance motion in a channel of a network" is developed, which among its proposed applications is the modeling of human migratory processes, especially the interaction between migrants and the native population.

In [14, 15] a review of human migration models is made. Among the mathematical models, in addition to those based on the Markov chain, there are others based on natural and social phenomena, such as the Gravity Model based on the Newtonian theory of universal gravitation, migration modeling based on adaptation to climate change, model of agent migration adaptation to rainfall change, economic models, as well as statistical models based on time-series and multiple regression analysis. In [16] a multiclass human migration network equilibrium model is designed and a calculation algorithm is proposed. None of the aforementioned models explicitly considers indeterminacy as part of them. An interesting exception appears in [17], where the Iadov technique is used to study the migratory phenomenon in Ecuador. On the other hand, we intend to specifically study the migration impact on the local economic situation and not the behavior of the migratory flow.

On the other hand, there is extensive experience in the application of FCM to study sociological phenomena. In [18] the FCM is applied to incorporate social science scenarios in integrated assessment models. Khan and Quaddus [19] use the FCM to study causal relationships among relevant domain concepts. In [20] the situation of the social and personal life of employees of private companies is analyzed. On the other hand, Tsadiras in [21] compares the inference capacity of FCM based on binary, trivalent and sigmoid functions. An interesting generalization would be to replace the FCM by NCM, once the indeterminacy is included, to obtain more accurate models.

Also, some NCM-based models are used for modeling social phenomena. In [22] the criminal situation in Nigeria and the factors related to this phenomenon are studied, with the support of NCMs. In [23] the reasons for suicide are studied using this tool. Mondal and Pramanik ([24]) use it to study the social situation of a discriminated minority in India, the hijras group, in [25] the problem of construction workers in a region of India is studied using NCM, and Vasantha-Kandasamy and Smarandache ([26]) study through this tool the social situation of migrant workers who are carriers of HIV/AIDS. These constitute the most recent approaches to study social phenomena by NCM. In particular, NCMs allow us to model not only uncertainty, as Markov chains or FCMs do, but also incorporate the indeterminacy of decision-making, and it does so through the subjective assessment of experts, which makes the difference of tools based on classical statistics. The methods used above are based on the dynamic study of the variables, which reach an equilibrium point. In this paper, the static analysis is performed, which is algorithmically simpler.

As we have previously pointed out, Venezuelan migration in Ecuador has had an impact on the local population, including the economically. This study is motivated by the need to measure appropriately, which is intuitively known by the opinion issued by the Ecuadorian citizens, which is the rejection of Venezuelan emigrants, and the humanitarian situation in which they find themselves. For this reason, the authors of the paper consider that the main contribution of this investigation is that it determines what the true humanitarian situation of these migrants is and how they influence the local economy. Therefore in some way, it will reverse any circumstance

that it is not following humanism or that damages the prosperity of the citizens, to designing effective public policies ([27-30]). NCMs have the advantage that they are tools that model the causal relationships between the variables that are measured, in addition to incorporating the indeterminacy because of the relationships between two or more variables are unknown.

We should point out that other more general neutrosophic theories have proven are effective in solving decision-making problems, such as plithogenic sets, that could be considered to replace classic neutrosophic sets in a possible future investigation similar to this, see [31].

This paper is divided into the following sections; Section Preliminaries contains the basic concepts related to Neutrosophic Cognitive Maps. Section Results summarizes the results of the investigation on the economic impact of the Venezuelan migration to Santo Domingo city. The paper finishes with the section of Conclusions.

2 Preliminaries

This section summarizes the most important definitions and techniques associated with NCM. Concepts like neutrosophic logic, neutrosophic numbers, neutrosophic cognitive maps and static indices of NCM are described.

Definition 1. ([6-7]) Let X be a universe of discourse. A *Neutrosophic Set* (NS) is characterized by three membership functions, $u_A(x), r_A(x), v_A(x) : X \to \,]^-0, 1^+[$, which satisfy the condition $^-0 \leq \inf u_A(x) + \inf r_A(x) + \inf v_A(x) \leq \sup u_A(x) + \sup r_A(x) + \sup v_A(x) \leq 3^+$ for all $x \in X$. $u_A(x), r_A(x)$ and $v_A(x)$ denote the membership functions of truthfulness, indetermination, and falseness of x in A, respectively, and their images are standard or non-standard subsets of $]^-0, 1^+[$.

The *Single-Valued Neutrosophic Set*, which is defined below, was created to apply NS to real problems.

Definition 2. ([6-7]) Let X be a universe of discourse. A *Single-Valued Neutrosophic Set* (SVNS) A on X is an object of the form:

$$A = \{\langle x, u_A(x), r_A(x), v_A(x)\rangle : x \in X\} \quad (1)$$

Where $u_A, r_A, v_A : X \to [0,1]$, satisfy the condition $0 \leq u_A(x) + r_A(x) + v_A(x) \leq 3$ for all $x \in X$. $u_A(x), r_A(x)$ and $v_A(x)$ denote the membership functions of truthfulness, indetermination, and falseness of x in A, respectively. For convenience a *Single-Valued Neutrosophic Number* (SVNN) will be expressed as A = (a, b, c), where a, b, c $\in [0,1]$ and satisfies $0 \leq a + b + c \leq 3$.

Neutrosophic Logic (NL), extends fuzzy logic, in such a way that given a logical proposition P, it is characterized by three components; see [5]:

NL(P) =(T, I, F) (2)

Where component T is the degree of truthfulness, F is the degree of falsity and I is the degree of indetermination. The degree of indeterminacy is considered an independent component.

The results of the static analyses in NCMs are given in form of neutrosophic numbers, which are numbers with the algebraic structure a+bI, where I = indetermination; see Definitions 3 and 4.

Definition 3. ([32-36]) Let R be a ring. The *neutrosophic ring* $\langle R \cup I\rangle$ is also a ring, generated by R and I under the operation of R, where I is a neutrosophic element that satisfies the property $I^2 = I$. Given an integer n, then, n+I and nI are neutrosophic elements of $\langle R \cup I\rangle$ and in addition $0 \cdot I = 0$. Also, the inverse of I $I^{-1}$is not defined.

For example, a neutrosophic ring is $\langle \mathbb{R} \cup I\rangle$ generated by the ring $\mathbb{R}$.

An operation over $\langle R \cup I\rangle$, especially with I is the following:

I+I+...+I = nI.

Definition 4. A *neutrosophic number* N is defined as a number as follows ([37, 38]):

N=d+I (3)

Where d is the *determined part* and I is the *indeterminate part* of N.

Let $N_1 = a_1 + b_1 I$ and $N_2 = a_2 + b_2 I$ be two neutrosophic numbers, then some operations between them are defined as follows:

1. $N_1 + N_2 = a_1 + a_1 + (b_1 + b_2)I$ (Addition),
2. $N_1 - N_2 = a_1 - a_1 + (b_1 - b_2)I$ (Difference),
3. $N_1 \times N_2 = a_1 a_2 + (a_1 b_2 + b_1 a_2 + b_1 b_2)I$ (Product),
4. $\frac{N_1}{N_2} = \frac{a_1 + b_1 I}{a_2 + b_2 I} = \frac{a_1}{a_2} + \frac{a_2 b_1 - a_1 b_2}{a_2(a_2 + b_2)} I$ (Division).

A *neutrosophic matrix* is a matrix whose components are elements of $\langle R \cup I\rangle$.

Since this, it is possible to generalize the operations between vectors and matrices on R to the ring $\langle R \cup I\rangle$.

A *neutrosophic graph* is a graph with at least one neutrosophic edge linking two nodes, i.e. an edge where there is indetermination on the connection of two nodes, see [39-41].

A *neutrosophic cognitive map* (NCM) is a neutrosophic graph used to represent causal reasoning, see [7, 37, 38].

Neutrosophic Cognitive Maps extend cognitive maps and fuzzy cognitive maps since it includes the possibility of indetermination. See for instance Figure 1, where the connections of nodes v_4 to v_2, v_5 to v_2 and v_1 to v_5 are represented by dashed lines, which means that there is indeterminacy in these connections.

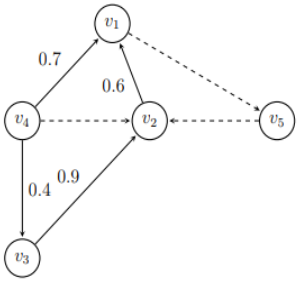

Figure 1. Example of Neutrosophic Cognitive Map.

To build an NCM we have to collect the evaluations of k experts. The *collective adjacency matrix* of the experts is calculated as follows ([7]):

$$E = \mu(E_1, E_2, \ldots, E_k) \quad (4)$$

Where μ is an aggregation operator, usually the arithmetic mean.

Centrality measures are calculated as neutrosophic numbers obtained from the adjacency matrix of the NCM. These measures are:

Outdegree, denoted by $od(v_i)$, is calculated as the sum by rows of the absolute values of a variable in the neutrosophic adjacency matrix. It measures the degree of accumulated force of the existing connections of the variable. See Equation 5:

$$od(v_i) = \sum_{j=1}^{N} |c_{ij}| \quad (5)$$

Indegree, denoted by $id(v_i)$, is calculated as the sum by columns of the absolute values of a variable in the neutrosophic adjacency matrix. It measures the degree of accumulated force of the variables that arrive at the given variable. See Equation 6:

$$id(v_i) = \sum_{j=1}^{N} |c_{ji}| \quad (6)$$

The *Total Degree*, which is denoted by $td(v_i)$, is calculated by the sum of indegree and outdegree. See Equation 7:

$$td(v_i) = od(v_i) + id(v_i) \quad (7)$$

A de-neutrosophication process was proposed by Salmeron and Smarandache ([42]) and can be applied to give a final order. This process provides a range of numbers for centrality using as a base the maximum and minimum values of $I = [a_1, a_2] \subseteq [0, 1]$, based on Equation 8, see [7, 42]:

$$\lambda([a_1, a_2]) = \frac{a_1 + a_2}{2} \quad (8)$$

The next step when the previous indices are calculated is to establish an order of preference among the variables. Thus, given $A = [a_1, a_2]$ and $B = [b_1, b_2]$, the preference is defined as follows:

$$A \succ B \Leftrightarrow \lambda(A) > \lambda(B) \quad (9)$$

That is to say, A is preferred over B if and only if $\lambda(A) > \lambda(B)$.

The nodes are classified according to the following rules:

- Transmitting variables: They have positive or indeterminate outdegree and null indegree.
- The receiving variables: They have an indeterminate or positive indegree, and null outdegree.
- Ordinary variables: They have both non-null indegree and non-null outdegree.

3 Results

This section exposes the results of applying NCMs to study the economic impact of the Venezuelan migration to Santo Domingo city. NCMs are proven tools for social studies, in this research, we will use static analysis of NCMs. Additionally, the classification rules for the nodes given above allow determining the dynamic relationships between the studied variables, since the variables that influence the others or those that are influenced by the others are identified, also the degree of such influence is given.

The variables we study are the following:

V_1: Immigrant's labor experience.
V_2: Immigrant's kind of job.
V_3: Immigrant's time of residence in Ecuador.
V_4: Immigrant has a family in Venezuela.
V_5: Immigrant has suffered from discrimination.
V_6: Immigrant's motive for migrating.
V_7: Local Economy of Santo Domingo.

We based our analysis in experts' opinions, a survey applied to Venezuelan's migrants, the interviews made to the main Santo Domingo's political authorities, among others. The last punctuations were made by three experts, who assessed the current situation of the Venezuelan' immigrant. Figure 2 shows the neutrosophic graph of the NCM after the relationships among these variables were evaluated, whereas the adjacency matrix can be seen in Table 1.

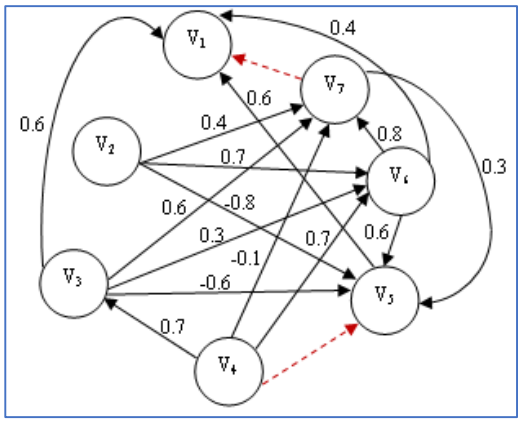

Figure 2: Pictorial representation of the NCM. Red and dashed lines represent indeterminate relationships.

Variable	V_1	V_2	V_3	V_4	V_5	V_6	V_7
V_1	0	0	0	0	0	0	0
V_2	0	0	0	0	-0.8	0.7	0.4
V_3	0.6	0	0	0	-0.6	0.3	0.6
V_4	0	0	0.7	0	I	0.7	-0.1
V_5	0.6	0	0	0	0	0	0
V_6	0.4	0	0	0	0.6	0	0.8
V_7	I	0	0	0	0.3	0	0

Table 1: Adjacency matrix of the causal relationships among every pair of variables.

From Table 1, we can calculate the static indexes of the NCM, i.e., outdegree, indegree, and the total degree of the neutrosophic adjacency matrix, according to formulas 5, 6 and 7, respectively; see Table 2.

Variable	*outdegree*	*indegree*	*Total degree*
V_1	0	1.6+I	1.6+I
V_2	1.9	0	1.9
V_3	2.1	0.7	2.8

V_4	1.5+I	0	1.5+I
V_5	0.6	2.3+I	2.9+I
V_6	1.8	1.7	3.5
V_7	0.3+I	1.9	2.2+I

Table 2: Indegree, outdegree, and the total degree of the neutrosophic adjacency matrix.

Results in Table 2 are converted to intervals in case the value contains symbol I, next to the de-neutrosophication function λ is applied according to Equation 8, and finally an order of preference among the variables is established, see Equation 9.

Variable	Final Value	$\lambda(V_i)$	Order of preference
V_1	[1.6, 2.6]	2.1	5
V_2	1.9	1.9	7
V_3	2.8	2.8	3
V_4	[1.5, 2.5]	2	6
V_5	[2.9, 3.9]	3.4	2
V_6	3.5	3.5	1
V_7	[2.2, 3.2]	2.7	4

Table 3: Total degree, de-neutrosophicated and ordinal number of every variable.

Table 3 indicates that the order of preference of the variables is the following:
$V_6 \succ V_5 \succ V_3 \succ V_7 \succ V_1 \succ V_4 \succ V_2$.

As can be seen, the variables corresponding to "Immigrant's motive for migrating" (V_6), "Immigrant's suffered from discrimination" (V_5) and "Immigrant's time of residence in Ecuador" (V_3), are the ones with the most impact on the city's economy. On the other hand, the variables "Immigrant's kind of job" (V_2) and "Immigrant has a family in Venezuela" (V_4) are classified as transmitters; therefore although they are the least important, they influence the other variables. Finally, the variable "Immigrant's labor experience" (V_1) is influenced by the others as it is a receiving variable. In the next section, the results and the measures to be taken will be explained in more detail.

Conclusion

This paper was dedicated to studying the local economic impact of the Venezuelan migration to Santo Domingo city in Ecuador. We used Neutrosophic Cognitive Maps as the method to study this impact. Three experts, a survey to the immigrants, official data, among others, served as the source for the evaluation based on seven socio-economic variables, viz., "immigrant's labor experience", "immigrant's kind of job", "immigrant's time of residence in Ecuador", "immigrant has a family in Venezuela", "immigrant has suffered from discrimination", "immigrant's motive for migrating", and "local economy of Santo Domingo". The most influential factor is "immigrant's motive for migrating", later we have "immigrant has suffered from discrimination", "immigrant's time of residence in Ecuador", and "local economy of Santo Domingo". Thus, the motif for migrating is a powerful cause to take into account for studying the situation of those people. Because the main motif of them is the economic situation, then, it is frequent they suffer from discrimination by the native citizens, the time of residence in Ecuador of most of them is less than two years and the local economy has been impacted by these variables. The influence on the economy is positive in the sense that Venezuelans immigrants have jobs not wanted by the Ecuadorian citizens; however, the negative impact is that many of them have not jobbed, thus, they become a social problem. We recommend to Santo Domingo's political authorities they consider helping those people, mainly in placing them in jobs or giving them social assistance.

The authors think that because of the importance of this phenomenon future studies deserve to be developed in that delve even deeper into the variables that influence the local economic impact of Venezuelan migration. It is proposed to repeat the study after a sufficient time of having applied the measures by the city government about this phenomenon. In such a case, we could use again the static analysis of the NCMs, or the dynamic analysis as in [24, 25]. This study of the situation could be combined with Venezuelan migration forecast models, which would allow predicting future behaviors of the economic situation of the city. An interesting approach would be to apply plithogenic decision methods that make it possible to better capture the complex nature of the phenomenon.

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