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Assessment of Barriers to Access Public Services for Immigrants in Ecuador using a NeutroAlgebra-based Model

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Abstract. As in other countries, public services in Ecuador are of great importance to ensure the effective functioning of society. Among these services, we have public housing, health, and education. These services are financed by the public treasury, which proceeds from taxes to citizens residing in the country, to specifically benefit these citizens. However, 2.21% of the Ecuadorian population is immigrant, mainly from Colombia and Peru, with a marked increase from Venezuela. This paper aims to analyze the situation of immigrants in Ecuador, in terms of theaccess to public services. Thus, 200 immigrants from Latin American and Caribbean countries who arrived in the Ecuadorian territory were interviewed in the last 4 years. We identified this sector of migration as the most vulnerable and, therefore, the greatest interest to our research. For this purpose, we use a new theory called NeutroAlgebra. NeutroAlgebra is an algebra that has at least one NeutroOperation or one NeutroAxiom, where some cases are indeterminate. Although NeutroAlgebra may seem to be only a mathematical theory with no practical application, there is a recent model of application of this theory in the study of immigrant barriers to public health services in Chile. A variant of this model is the one that we apply in our study because it has proven its usefulness.

Keywords: public services,migration, NeutroAlgebra, NeutroOperation, PROSPECTOR function.

1 Introduction

Public services are the set of activities and subsidies permitted, reserved, or required of public administrations by legislation in each state, and whose purpose is to respond to different imperatives of the functioning of society, and, ultimately, to promote the effective realization of personal and economic development, equality and social welfare. Usually, they are essential services, as taxpayers bear the costs through the State (Public Expenditure). They have a particularly significant presence in countries with mixed economies that follow political-economic models such as the social state or welfare state. It is often treated in international bodies as a fundamental element within the welfare state.

Generically, an essential service is an activity carried out by a public or private institution to satisfy a basic need of the society as a whole without wasting public resources. Consumers and users of public services are protected by the consumer protection act, to protect them against the service providers, such as gas, electricity, or phone, and it establishes that when the consumer claims faults in the service, the companies are obliged to register their claim by any means available.

In the daily life routine of any moderately developed society, we can find innumerable public services, from the oldest, such as the post office, to the most modern ones. The most well-known public services are, among others, the following: water supply, public library, education, electricity, emergency, gas, waste management, law, urban planning, order, health, social security, telecommunication, public transportation, sewage treatment, and public housing.

Today, thanks to technology we can also name a considerable number of modern companies, from radio stations and television stations to internet access companies among others that could fall under the definition of Public Service, although some disagree with their insertion in the same category.

On the other hand, the phenomenon of migration is the movement of a population that occurs from a place of origin to another destination and it brings with it a change of habitual residence in the case of individuals.

Immigrants are people who suddenly change to a society that is not their own and therefore require a degree of adaptation, they must find housing, work, access to social security and financial services, as well as education and health services. All these needs are part of the public services provided by the host countries, but they are designed to meet the needs of citizens residing in the country and not for immigrants. The latter usually present problems when arriving in the new country due to lack of documentation, xenophobia on the part of the native population, poor adaptation of the immigrant to the customs of the host country, etc., that is why immigration can affect the public service, although it must be recognized that immigrants are also a source of wealth within a society [1-4].

According to United Nations (UN) data corresponding to the year 2019, Ecuador has 381,507 immigrants, which represents 2.21% of the country's population. If we compare it with the rest of the countries we see that it is the 127th country in the world by percentage of immigration. Immigration to Ecuador comes mainly from Colombia, 50.21%, United States, 6.92%, and Peru, 3.54%. In recent years, the number of immigrants living in Ecuador has decreased by 17,561 people, or 4.4%, [5]. There has been a sharp increase in Venezuelan immigration with around 400,000 due to this neighboring country's political, economic, and social situation[6].

In the context of Good Living, the Constitution recognizes migration as a right, and therefore proposes not to identify any human being as illegal because of his or her migratory status (Art. 40 EPC) and, in the context of international relations (Title VIII), appeals to the "principle of universal citizenship" (Art. 416 EPC), [7].

The Constitution is the basis of the "National Plan for Good Living 2009-2013". This Plan includes the diagnosis on Human Mobility and Human Rights, which is generally in line with constitutional principles when referring to the exercise of rights, and the principle of universal citizenship, in which it is stated that firm steps have been taken to respect it.

Public policies on human mobility show us a model of social integration from a perspective of respect for Human Rights. Currently, foreign citizens do not require a visa to enter Ecuador for 90 days for tourism purposes; except citizens of the People's Republic of China, Afghanistan, Bangladesh, Eritrea, Ethiopia, Kenya, Nepal, Nigeria, Pakistan, and Somalia, who do require a visa.

In any case, when the stay is going to be longer than 90 days, they must approach the Department of the Ministry of Foreign Affairs to regularize their situation. Those who do not comply with this process must voluntarily leave the country or may otherwise be deported.

This study aims to analyze the barriers to public services faced by immigrants who migrated to Ecuador. To this end, we selected 200 immigrants who live in the country for a maximum of four years, and those who come from Latin American and Caribbean countries, including Colombians, Peruvians, and Venezuelans, were chosen. We believe that immigrants from First World countries may present a different situation to those whose countries of origin are selected for our study because those countries' political and economic realities are very different.

Within the services to be studied we select those that are essential for human life in modern societies, such as health, public transport, education, public housing, among others. An approach of Neutrosophy to assess migration phenomenon can be read in [8].

We apply a variation of the model that appeared in [9], which is a method based on NeutroAlgebra theory. In this model, the respondents evaluate on a scale from -10 to 10. A NeutroAlgebra is an algebra ([10-14]) which has at least one NeutroOperation or one NeutroAxiom (axiom that is true for some elements, indeterminate for other elements, and false for the other elements), [9, 15, 16]. Especially, this model uses a NeutroOperation based on uninorms, [17, 18] generated from the PROSPECTOR function defined for MYCIN, [19-21].

This paper has the following structure; section 2 exposes the main concepts used in this research like NeutroAlgebra. Section 3 contains the method we utilized for studying migrants' access to public services in Ecuador. The last section draws the conclusions of this paper.

2. NeutroAlgebra and PROSPECTOR function

Definition 1

([19]): Let X be a given nonempty space (or simply set) included into a universe of discourse U. Let <A> be an item (concept, attribute, idea, proposition, theory, etc.) defined on the set X. Through the process of neutrosophication, we split the set X into three regions [two opposite ones <A> and <antiA>, and one neutral (indeterminate) <neutA> between them], regions which may or may not be disjoint – depending on the application, but they are exhaustive (their union equals the whole space).

A *NeutroAlgebra* is an algebra that has at least one *NeutroOperation* or one *NeutroAxiom* (axiom that is true for some elements, indeterminate for other elements, and false for other elements).

The NeutroAlgebra is a generalization of *Partial Algebra*, which is an algebra that has at least one *Partial Operation*, while all its Axioms are true (classical axioms).

Definition 2

([19]): A function f: X → Y is called a *Partial Function* if it is well-defined for some elements in X, and undefined for all the other elements in X. Therefore, there exist some elements $a \in X$ such that $f(a) \in Y$ (well-defined), and for all other element $b \in X$ we have $f(b)$ is undefined.

Definition 3

([19]): A function f: X → Y is called a *NeutroFunction* if it has elements in X for which the function is well-defined (degree of truth (T)), elements in X for which the function is indeterminate {degree of indeterminacy (I)}, and elements in X for which the function is outer-defined {degree of falsehood (F)}, where $T, I, F \in [0,1]$, with $(T,I,F) \neq (1,0,0)$ that represents the (Total) Function, and $(T,I,F) \neq (0,0,1)$ that represents the AntiFunction.

Classification of Functions

i) (Classical) Function, which is a function well-defined for all the elements in its domain of definition.

ii) NeutroFunction, which is a function partially well-defined, partially indeterminate, and partially outer-defined on its domain of definition.

iii) AntiFunction, which is a function outer-defined for all the elements in its domain of definition.

Definition 4

([19]): A (classical) *Algebraic Structure* (or Algebra) is a nonempty set *A* endowed with some (totally well-defined) operations (functions) on *A*, and satisfying some (classical) axioms (totally true) - according to the Universal Algebra.

Definition 5

([19]): A (classical) *Partial Algebra* is an algebra defined on a nonempty set *PA* that is endowed with some partial operations (or partial functions: partially well-defined, and partially undefined). While the axioms (laws) defined on a Partial Algebra are all totally (100%) true.

Definition 6

([19]): A *NeutroAxiom* (or *Neutrosophic Axiom*) defined on a nonempty set is an axiom that is true for some set of elements {degree of truth (T)}, indeterminate for another set of elements {degree of indeterminacy (I)}, or false for the other set of elements {degree of falsehood (F)}, where $T, I, F \in [0,1]$, with $(T,I,F) \neq (1,0,0)$ that represents the (classical) Axiom, and $(T,I,F) \neq (0,0,1)$ that represents the AntiAxiom.

Classification of Algebras

i) A (classical) *Algebra* is a nonempty set *CA* that is endowed with total operations (or total functions, i.e. true for all set elements) and (classical) Axioms (also true for all set elements).

ii) A *NeutroAlgebra* (or *NeutroAlgebraic Structure*) is a nonempty set *NA* that is endowed with: at least one *NeutroOperation* (or *NeutroFunction*), or one *NeutroAxiom* that is referred to the set (partial-, neutro-, or total-) operations.

iii) An *AntiAlgebra* (or *AntiAlgebraic Structure*) is a nonempty set *AA* that is endowed with at least one *AntiOperation* (or *AntiFunction*) or at least one *AntiAxiom*.

Additionally, the PROSPECTOR combination function is defined in the PROSPECTOR expert system in the following way; it is a mapping from $[-1,1]^2$ into $[-1,1]$ with formula,[20, 22]:

$$P(x,y) = \frac{x+y}{1+xy} \qquad (1)$$

This function is a uninorm, [18, 19, 23, 24], with neutral element 0, thus it fulfills commutativity, associativity, and monotonicity. Here we respect the condition that $P(-1,1)$ and $P(1,-1)$ are undefined.

3 Study of immigrants' access to public services in Ecuador

This section contains the results of this investigation, for this we explain some characteristics of the method defined in [9].

First of all, for convenience $P(x,y)$ is extended to $\bar{P}(x,y)$ such that:

$\bar{P}(x,y) = P(x,y)$ for all $(x,y) \in [-1,1]^2 \setminus \{(-1,1),(1,-1)\}$,

$\bar{P}(-1,1) = \bar{P}(1,-1) = undefined$,

$\bar{P}(undefined, undefined) = undefined$.

$$\bar{P}(undefined, x) = \bar{P}(x, undefined) = \begin{cases} \text{undefined, if x} > 0 \\ \text{x, if x} \leq 0 \end{cases}.$$

Definition 7

([9]): Let S be a finite set defined as $S = \left\{(x,y): x,y \in \left\{\frac{k}{10}, undefined\right\},\ k \in \mathbb{Z} \cap [-10,10]\right\}$.

The operator $\odot$ is defined for every $(x,y) \in S$, such that:

1. If $\bar{P}(x,y)$ is not undefined, then $x \odot y = \frac{round(\bar{P}(x,y)*10)}{10}$, where *round* is the function that outputs the integer nearest to the argument.
2. If $\bar{P}(x,y)$ is undefined then $x \odot y = undefined$.
   Then $\odot$ is a finite NeutroAlgebra. This is because $\odot$ is commutative and associative for the subset of elements of S without any undefined component, but it is not associative otherwise.

E.g., if $a = -0.9$, $b = 0.8$, $c = undefined$, then $a \odot (b \odot c) = a$ and $(a \odot b) \odot c = -0.4 \neq a$, therefore associativity is a NeutroAxiom. Additionally, it is easy to ckeck that $\bar{P}$ is well-defined, it is commutative, 0 is the neutral element and also "undefined" is a neutral element for the negative values. Moreover, every element has an inverse.

Function *round* is used for guarantying $\odot$ is an inner operator.

For the sake of clarity, we use the elements of Tables 2 and 3 in [9] of Caley tables multiplied by 10. The idea is to output data in the same scale used in input data, i.e., from -10 to 10. See Tables 1 and 2, nevertheless, $\odot$ is still a NeutroAlgebra. Now it is based on Neutrosophic Off-uninorms ([25]) defined for offsets, [26-28].

$x \odot y$	**-10**	**-9**	**-8**	**-7**	**-6**	**-5**	**-4**	**-3**	**-2**	**-1**	**0**
-10	-10	-10	-10	-10	-10	-10	-10	-10	-10	-10	-10
-9	-10	-10	-10	-10	-10	-10	-10	-9	-9	-9	-9
-8	-10	-10	-10	-10	-9	-9	-9	-9	-9	-8	-8
-7	-10	-10	-10	-9	-9	-9	-9	-8	-8	-7	-7
-6	-10	-10	-9	-9	-9	-8	-8	-8	-7	-7	-6
-5	-10	-10	-9	-9	-8	-8	-8	-7	-6	-6	-5
-4	-10	-10	-9	-9	-8	-8	-7	-6	-6	-5	-4
-3	-10	-9	-9	-8	-8	-7	-6	-6	-5	-4	-3
-2	-10	-9	-9	-8	-7	-6	-6	-5	-4	-3	-2
-1	-10	-9	-8	-7	-7	-6	-5	-4	-3	-2	-1
undef.	-10	-9	-8	-7	-6	-5	-4	-3	-2	-1	0
0	-10	-9	-8	-7	-6	-5	-4	-3	-2	-1	0
1	-10	-9	-8	-6	-5	-4	-3	-2	-1	0	1
2	-10	-9	-7	-6	-5	-3	-2	-1	0	1	2
3	-10	-8	-7	-5	-4	-2	-1	0	1	2	3
4	-10	-8	-6	-4	-3	-1	0	1	2	3	4
5	-10	-7	-5	-3	-1	0	1	2	3	4	5
6	-10	-7	-4	-2	0	1	3	4	5	5	6
7	-10	-5	-2	0	2	3	4	5	6	6	7
8	-10	-4	0	2	4	5	6	7	7	8	8
9	-10	0	4	5	7	7	8	8	9	9	9
10	undef.	10	10	10	10	10	10	10	10	10	10

Table 1: Cayley table of $\odot$multiplied by 10.

$x \odot y$	**undef.**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**

-10	-10	-10	-10	-10	-10	-10	-10	-10	-10	-10	undef.
-9	-9	-9	-9	-8	-8	-7	-7	-5	-4	0	10
-8	-8	-8	-7	-7	-6	-5	-4	-2	0	4	10
-7	-7	-6	-6	-5	-4	-3	-2	0	2	5	10
-6	-6	-5	-5	-4	-3	-1	0	2	4	7	10
-5	-5	-4	-3	-2	-1	0	1	3	5	7	10
-4	-4	-3	-2	-1	0	1	3	4	6	8	10
-3	-3	-2	-1	0	1	2	4	5	7	8	10
-2	-2	-1	0	1	2	3	5	6	7	9	10
-1	-1	0	1	2	3	4	5	6	8	9	10
undef.	undef.	undef.	undef.	undef.	undef.	undef.	undef.	undef.	undef.	undef.	undef.
0	0	1	2	3	4	5	6	7	8	9	10
1	undef.	2	3	4	5	6	7	7	8	9	10
2	undef.	3	4	5	6	6	7	8	9	9	10
3	undef.	4	5	6	6	7	8	8	9	9	10
4	undef.	5	6	6	7	8	8	9	9	10	10
5	undef.	6	6	7	8	8	8	9	9	10	10
6	undef.	7	7	8	8	8	9	9	9	10	10
7	undef.	7	8	8	9	9	9	9	10	10	10
8	undef.	8	9	9	9	9	9	10	10	10	10
9	undef.	9	9	9	10	10	10	10	10	10	10
10	undef.	10	10	10	10	10	10	10	10	10	10

Table 2: Cayley table of $\odot$ multiplied by 10 (Continuation).

These are the questions asked to immigrants:

1. Immigrants find support networks upon arrival and during the first year of their stay in the country.
2. When immigrants arrive in the country, they are low vulnerable, with economic resources for their arrival and adaptation while accessing employment, with basic services for them and their family.
3. Immigrants are aware of the Ecuadorian labor market, the regularization process, general information about the country, recruitment processes, regulations, selection processes, rights and duties, and their benefits.
4. Immigrants arrive in Ecuador with complete studies, profiles that meet the requirements of employers, languages, and specific skills.
5. Immigrants' qualifications obtained in their countries of origin can be validated in Ecuador despite they are regulated professions; there is no lack of resources to cover the costs of validation or not lack of documents to advance the process of validation and homologation.
6. Immigrants have skills certification, the resources to cover the certification costs, know the fields of action of their skills, and know where the certification is obtained.
7. Immigrants arrive with no low work experience.
8. There are not extensive processes in Ecuador to access regularization and services.
9. Immigrants are aware of the existence of the Public Employment Service and its network of providers, of the mechanisms for access to employment, and the portfolio of job management and placement services.

10. Immigrant's adjustment processes are sufficient despite factors such as climate, culture, language, country structure, work patterns, and hourly intensity.
11. There are not situations that migrants face because of discrimination based on nationality, accent, gender, age, or disability.
12. From the institutional point of view, there is sufficient socialization about the regulations, there are not wasteful procedures of the financial sector and neither lack of social security due to non-opening of products.
13. There is an articulated and sufficient supply of services.
14. There is not a risk of loss of investment in migrants.
15. Immigrants have not difficulty accessing public transport due to fear of being arrested when they do not have up-to-date documents, fear of being attacked by xenophobia, for not having sufficient economic means to pay, not knowing the city, and not having a guide to help them.
16. Migrants have enough knowledge about the Ecuadorian health system.
17. They have access to the health system; they know where to go or who to tell them.
18. Migrants are well cared for by local doctors, who have no prejudices against them.
19. Migrants have easy access to medicines because they can afford them or because they have sufficient knowledge about them.
20. The children of school-age migrants have easy access to the education system; do not have limitations because of the level of education (more advanced or more backward than in their countries of origin), economic limitations, and legal limitations, among others.

The method that we use is as follows, which is the one introduced in [9]:

1. For each previous question, the opinion of the 200 selected migrants is collected. They are asked to rate each statement on a scale of 0 to 10 if they have a favorable or neutral opinion about access to public health from the point of view of the access that is measured. On the other hand, they are asked to evaluate on a scale of -10 to -1 if they have an unfavorable opinion.

2. Let us denote by v_{ij}, $(i = 1,2,\dots,200;\ j = 1,2,\dots,20)$ the evaluation of the i-th migrant on the j-th aspect.

   We calculate $\bar{v}_i = \left(\frac{\sum_{j=1}^{n^+} v_{ij}^+}{n^+}, \frac{\sum_{j=1}^{n^0} v_{ij}^0}{n^0}, \frac{\sum_{j=1}^{n^-} v_{ij}^-}{n^-}\right)$, where v_{ij}^+ are positive answers by i-th migrant about j-th aspects, v_{ij}^0 are neutral answers, so $\frac{\sum_{j=1}^{n^0} v_{ij}^0}{n^0} = 0$, and v_{ij}^- are negative answers. n^+, n^0, and n^- are the numbers of positive answers, neutral answers, and negative answers, respectively, where $n^+ + n^0 + n^- = 20$. This new treatment guarantees more accuracy in the results than simply calculating the arithmetic mean.

2.1. Then, we calculate $\hat{v}_i = round\left(\frac{\sum_{j=1}^{n^+} v_{ij}^+}{n^+}\right) \odot round\left(\frac{\sum_{j=1}^{n^-} v_{ij}^-}{n^-}\right)$, where the well-known round function is used. In case that both $round\left(\frac{\sum_{j=1}^{n^+} v_{ij}^+}{n^+}\right) = 10$ and $round\left(\frac{\sum_{j=1}^{n^-} v_{ij}^-}{n^-}\right)$ =-10, define $\hat{v}_i = -10$.

3. It is decided on two different situations:

3.1. If less than 30% of the respondents show contradictory results for each fixed j, that is, if there are 30 pairs or less of values $(-10,10)$ or $(10,-10)$, i.e., the combination function is "undefined" these values are eliminated for aggregating.

3.2. Otherwise, the j-th aspect is evaluated as "undefined" and it should be reviewed in more detail why there is such a contradiction.

4. When we have case 3.1. the aggregation of $\hat{v}_i$ is calculated by using $\odot$.

Let us note that even thougt it is not a classical algebra, but a NeutroAssociativity one, this is useful to explicitely consider the indeterminacy. In case of clearly contradiction in the pair (-10, 10), we used the term "undefined" instead of 0, in Tables 1,2. If only one of the evaluations is "undefined" the rest of the evaluations are also "undefined" or "negatives". Then, when more than 30% of that assesses are "undefined" we consider the total aggregation as "undefined", which indicates a clear contradiction in the final result. The way to resolve this problem is to reanalize the assesses.

Table 3 contains the grouped data of the results obtained for each question asked to the 200 migrants surveyed:

Question / Interval	[-10, -5)	[-5, 0)	[0, 5)	[5, 10]
1	8	26	74	92
2	28	28	77	67
3	31	40	55	74
4	38	40	60	62
5	5	10	31	154
6	5	7	33	155
7	48	45	61	46
8	55	50	59	36
9	17	26	76	81
10	5	8	88	99
11	85	70	33	12
12	58	57	28	57
13	40	63	43	54
14	16	18	80	86
15	6	44	15	135
16	18	2	61	119
17	22	52	53	73
18	20	55	69	56
19	39	7	46	108
20	97	62	2	39

Table 3: Grouped data on survey results.

After we applied the method, we obtained the value 10 as the final aggregation value. This means that the situation is more favorable than unfavorable; however, according to Table 3 some public services are not good for immigrants, e.g., education system and labor, and there exists discrimination.

Conclusion

This paper studied the situation of immigrants arriving in Ecuador. We surveyed 200 immigrants who came to the country from Latin American and Caribbean countries, in the last 4 years. NeutroAlgebra was used as a tool, which had been successfully applied in a similar problem; however,the used method was slightly changed in this paper to achieve greater accuracy. In addition, the Caley table of this NeutroAlgebra has been rescaled on a scale of -10 to 10, to match the scale used in the input data. The number of questions asked was 20. It was concluded that the situation is more favorable than unfavorable. Although from the data collected it can be inferred that not all services comply with this, such as employment and education; moreover, there is a degree of discrimination and xenophobia in the Ecuadorian population. We have showed from the definition of this NeutroAlgebra in Tables 1 and 2 that this is not an associative structure, due to the explicit precense of the term “undefined” and the combination of one “undefined” with a negative one is negative, nevertheless, we also showed that this term is useful for gaining in accuracy in the proposed method. When, more than 30% of the evaluations are contradictories, it is preferable that experts reconsider their evaluations. This is the advantage obtained with the cost of eliminating classical associativity.

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