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Introduction to Decision Making for Neutrosophic Environment "Study on the Suez Canal Port, Egypt"

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Abstract: Paper aims to use the programming codes in calculating the values of neutrosophic grades and their representation in proving the certainty and uncertainty associated with the data of navigational projects development in the Suez Canal, Egypt. Added to, we reach a more descriptive of the data in terms of certainty and uncertainty, and that is through the neutrosophic representation of both the total revenue and the revenues of the Suez Canal from the transit carriers and ships. Finally, we will present a study of the decision-making process regarding the better investment in the Suez Canal. Is it investing in the oil tankers or investing in cargo ships, as this is done based on neutrosophic data. This will be done by studying optimistic, pessimistic, and remorse entrances to the neutrosophic data, to see which oil tankers or cargo ships offer better returns to the Canal.

Keywords: Neutrosophic categories; neutrosophic analysis; Neutrosophic data; Suez Canal; Neutrosophic information models; Decision Making.

1. Introduction

In real-life problems, the data associated are often imprecise, or non-deterministic. Not all real data can be precise because of their fuzzy nature. Imprecision can be of many types: non-matching data values, imprecise queries, inconsistent data misaligned schemas, etc. The fundamental concepts of neutrosophic set, introduced by Smarandache in [2, 3] and Salama et al. in [2-19]. Decision-making method developed on the accuracy of the information resulting from the neutrosophic data processing. The data has converted from the classic situation using the neutrosophic technique, which helps in the process of decision-making. Thus, we can rank all alternatives and make a better choice according to the degrees of certainty, uncertainty, and impartiality. Paper is limited to the data for the ships crossing the Suez Canal Port, Egypt, such as the oil tankers, cargo ships, passenger ships and rescue ships from 1976 to 2019, because they are considered the most important main types that cross the Suez Canal, due to the nature and characteristics of each of them, and this requires special attention to that types of ships

2- 1. Preliminaries & Related Works

We recollect some relevant basic preliminaries, and in particular, the work of Smarandache in [2, 3] and Salama et al. [16]. The data was relied on the bulletins of the Suez Canal Authority Egypt, in [1].

2- Proposed frameworks

In 2014, Salama et al. [16] designed and implemented an object oriented programming [OOP] to deal with neutrosophic data operations.

The following are neutrosophic package class, some software algorithms and codes designed to generate neutrosophic data related to projects for the development of the navigation of the Suez Canal, Egypt:

1) The following diagram represent the neutrosophic structure.

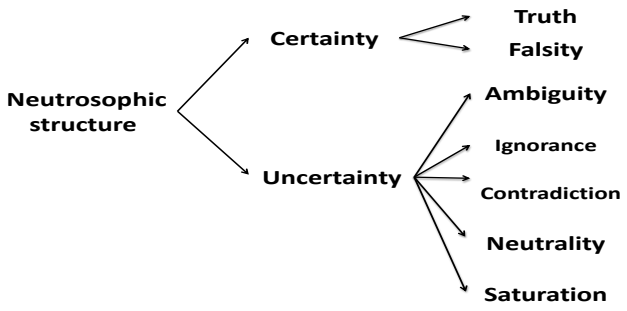

Figure 1. Neutrosophic Data Structure

2) The following diagram represent the neutrosophic Package

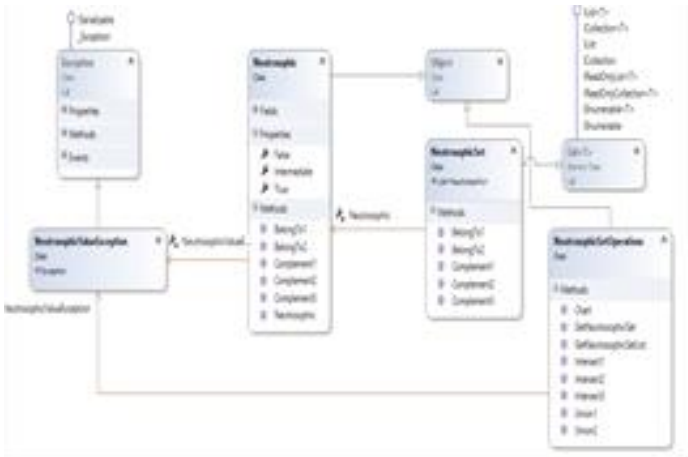

Figure 2: Neutrosophic Package Class Diagram.

3)The first input parameter to the neutrosophic variable has three-neutrosophic components membership function, indeterminacy and non-membership of data is illustrated in Figure 3.

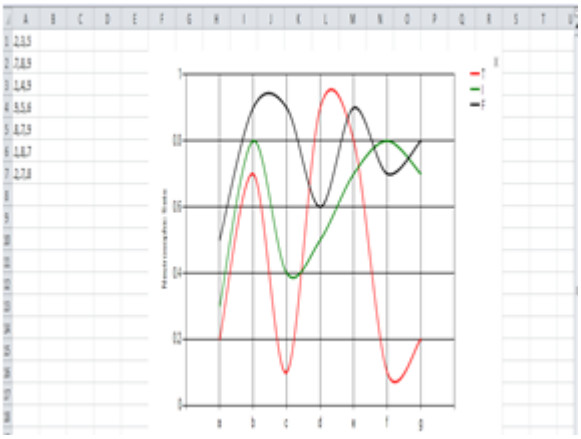

Figure 3: Neutrosophic Chart .

4) Some Neutrosophic codes

```
    using System;
using System.Collections.Generic;
using System.Linq;
using System.Text;
namespace RibbonCustomize
{
     class NeutrosophicValueException:Exception
     {
          public NeutrosophicValueException()
               : base("Neutrosophic value must be between 0 and 1")
          {
          }
     }
     class NeutrosophicSet:List<Neutrosophic>
     {
          public NeutrosophicSet Complement1()
          {
               NeutrosophicSet complementSet = new NeutrosophicSet();
               foreach (Neutrosophic n in this)
               {
                   complementSet.Add(n.Complement1());
               }
               return complementSet;
          }
          public NeutrosophicSet Complement2()
          {
               NeutrosophicSet complementSet = new NeutrosophicSet();
               foreach (Neutrosophic n in this)
               {
                   complementSet.Add(n.Complement2());
               }
               return complementSet;
          }
          public NeutrosophicSet Complement3()
          {
```

```
            NeutrosophicSet complementSet = new NeutrosophicSet();
            foreach (Neutrosophic n in this)
            {
                complementSet.Add(n.Complement3());
            }
            return complementSet;
        }
        public Boolean

BelongTo1(NeutrosophicSet nSet)
        {
            for (int i = 0; i < this.Count; i++)
            {
                if (!this[i].BelongTo1(nSet[i]))
                    return false;
            }
            return true;
        }
        public Boolean BelongTo2(NeutrosophicSet nSet)
        {
            for (int i = 0; i < this.Count; i++)
            {
                if (!this[i].BelongTo2(nSet[i]))
                    return false;
            }
            return true;
        }
    }

    class Neutrosophic
    {
        double t, i, f;

        public Neutrosophic(double t,double i,double f)
        {
            T = t;
            I = i;
            F = f;
        }
        public double T
        {
            get
            {
                return   Convert.ToDouble( Math.Round( t,4));
            }
            set
            {
                if (t < 0 || t > 1)
                    throw new NeutrosophicValueException();
                t = value;
            }
```

3- Neutrosophic Data Related to Projects for the Development of the Navigation Channel of the Suez Canal

In this section, software algorithms present the values of the neutrosophic grades (Membership, Indeterminacy, Non-membership) associated with the most important variables for the waterway development projects are introduced. Which in the future helps in the process of support and decision-making through the neutrosophic environment. The following tables represent for neutrosophic fuzzy data related to the development of Suez Canal projects.

3-1 Neutrosophic construction for the revenue of the oil tankers

The following table shows the neutrosophic functions membership, indeterminacy and non-membership for the revenue from oil tankers

membership	indeterminacy	non-membership
0.988740191	0.00461327	0.011259809
0.997541134	0.000366208	0.002458866
0.99372791	0.003386564	0.00627209
0.994747051	0.00352199	0.005252949
0.996362317	0.002416395	0.003637683
0.9992945	0.000439248	0.0007055
0.996371092	0.001113029	0.003628908
0.998656708	9.414E-05	0.001343292
0.996205932	0.002065225	0.003794068
0.996018585	0.003331682	0.003981415
0.998642595	0.001125642	0.001357405
0.997179889	0.001817804	0.002820111
0.997190918	0.00099931	0.002809082
0.99900649	0.000160861	0.00099351
0.998159997	0.001783886	0.001840003

0.998825512	0.000389082	0.001174488
0.999178991	9.72807E-05	0.000821009
0.997687655	0.000459245	0.002312345
0.997405507	0.001358576	0.002594493
0.996925695	0.000896872	0.003074305
0.998220312	4.8633E-05	0.001779688
0.99850752	0.00109835	0.00149248
0.999384376	0.000163505	0.000615624
0.999094749	0.000322558	0.000905251
0.999216422	0.00043813	0.000783578
0.999683732	0.00026184	0.000316268
0.999261561	0.000391302	0.000738439
0.998155283	0.000963051	0.001844717
0.998749522	0.000918046	0.001250478
0.997990694	0.000537374	0.002009306
0.997900945	0.000606896	0.002099055
0.99841285	0.000707733	0.00158715
0.998114783	0.001177655	0.001885217
0.998274559	0.001384855	0.001725441
0.998516734	0.000662619	0.001483266
0.998157819	0.001816153	0.001842181
0.998596055	0.000746927	0.001403945

0.999123659	3.86185E-05	0.000876341
0.999701164	0.000102857	0.000298836

3-2 Neutrosophic construction for the revenue of the casting cargo ships

The following table shows the neutrosophic functions membership, indeterminacy and non-membership for the revenue for casting cargo ships.

membership	**indeterminacy**	**non-membership**
0.979597358	0.011222455	0.020402642
0.99977598	0.000190899	0.00022402
0.987841221	0.011233986	0.012158779
0.988722391	0.004594681	0.011277609
0.999042398	2.94809E-05	0.000957602
0.996013645	0.003510839	0.003986355
0.993315242	0.001470175	0.006684758
0.999288912	0.000617127	0.000711088
0.997280058	0.001194023	0.002719942
0.997839878	0.001434591	0.002160122
0.999313108	0.000285615	0.000686892
0.998390123	0.000424146	0.001609877
0.998744516	1.66601E-05	0.001255484
0.996685415	0.002629738	0.003314585
0.999159935	0.000624388	0.000840065
0.999362719	0.000625203	0.000637281
0.998118538	0.00074875	0.001881462

0.999081238	0.000843198	0.000918762
0.998767326	0.000237711	0.001232674
0.996110421	0.00035633	0.003889579
0.996214035	0.001895643	0.003785965
0.997622584	0.001778035	0.002377416
0.997971546	0.001753866	0.002028454
0.996205565	0.001369003	0.003794435
0.99738413	0.002252678	0.00261587
0.99737923	0.00066253	0.00262077
0.99901595	0.000512284	0.00098405
0.998766167	0.001011506	0.001233833
0.999572232	0.000179547	0.000427768
0.99961459	0.000176656	0.00038541
0.9986817	0.000122479	0.0013183
0.998326458	0.000859449	0.001673542
0.998183893	0.000195493	0.001816107
0.99938128	0.000356578	0.00061872
0.999648021	0.000346284	0.000351979
0.998516736	0.000578491	0.001483264
0.99840945	0.000915206	0.00159055
0.998917136	6.82709E-05	0.001082864

0.999421069	2.40589E-05	0.000578931

3-3 Neutrosophic construction for the total revenue

The following table shows the neutrosophic functions membership, indeterminacy and non-membership for the total Revenue.

membership	**indeterminacy**	**non-membership**
0.99453	0.68563	0.00547
0.994298	0.258039	0.005702
0.999356	0.694458	0.000644
0.998015	0.759271	0.001985
0.998491	0.182653	0.001509
0.99755	0.842113	0.00245
0.999763	0.4457	0.000237
0.99826	0.747169	0.00174
0.999419	0.657663	0.000581
0.997668	0.176678	0.002332
0.999044	0.469494	0.000956
0.998904	0.408643	0.001096
0.999146	0.936579	0.000854
0.999439	0.72134	0.000561
0.998743	0.156889	0.001257
0.999089	0.752516	0.000911
0.999257	0.014837	0.000743

0.999994	0.553359	6.25E-06
0.998467	0.60711	0.001533
0.998461	0.670432	0.001539
0.998631	0.026247	0.001369
0.999688	0.585905	0.000312
0.99864	0.069339	0.00136
0.999698	0.843087	0.000302
0.99874	0.135408	0.00126
0.999383	0.682067	0.000617
0.999497	0.336895	0.000503
0.998713	0.076038	0.001287
0.99899	0.042053	0.00101
0.9991	0.299292	0.0009
0.9996	0.725316	0.0004
0.9998	0.08398	0.0002
0.9999	0.040729	1E-04
0.99994	0.497875	6E-05
0.99997	0.528715	3E-05
0.97811	0.4454	0.02189
0.9888	0.390296	0.0112
0.9999	0.715649	1E-04

0.99999	0.947433	1E-05
0.99999	0.243405	1E-05
0.999996	0.724688	4E-06
0.999998	0.512305	2E-06
0.999999	0.092309	1.5E-06

3-4 Neutrosophic construction for the oil tankers load sizes

The following table shows the neutrosophic functions membership, indeterminacy and non-membership for the oil tanker load sizes.

membership	**indeterminacy**	**non-membership**
0.999999683	1.67646E-07	3.1713E-07
0.999988666	4.86643E-06	1.13338E-05
0.999986858	1.139E-05	1.31419E-05
0.99999763	1.71931E-06	2.37026E-06
0.999998331	7.01436E-08	1.66936E-06
0.999994502	9.67939E-07	5.49785E-06
0.999999965	8.26009E-09	3.45204E-08
0.999995597	3.43245E-06	4.40344E-06
0.999992593	2.66158E-06	7.40721E-06
0.99999205	3.97483E-06	7.95034E-06
0.999995382	2.24479E-06	4.61806E-06
0.999996817	2.23691E-06	3.18252E-06
0.999996942	1.23941E-06	3.05795E-06
0.999994138	5.19437E-06	5.86174E-06

0.999994783	3.67107E-06	5.21695E-06
0.999998407	1.42519E-06	1.59336E-06
0.999999916	1.99228E-08	8.41154E-08
0.999998438	1.13182E-06	1.5621E-06
0.999994327	4.0787E-07	5.67272E-06
0.999994318	6.75615E-07	5.68204E-06
0.999988657	1.12072E-05	1.13432E-05
0.999999955	3.06172E-08	4.47353E-08
0.999997963	3.01945E-07	2.03699E-06
0.999987344	1.14491E-05	1.26559E-05
0.999995549	2.2139E-06	4.45134E-06
0.999992198	5.62777E-08	7.80226E-06
0.999994384	4.76185E-07	5.61551E-06
0.999994926	4.56611E-06	5.07413E-06
0.999994185	2.79521E-06	5.81518E-06
0.999993616	7.78117E-07	6.3837E-06
0.999995882	1.66929E-06	4.11835E-06
0.999996945	2.47541E-06	3.05471E-06
0.999993363	2.91819E-06	6.63674E-06
0.999997621	1.61063E-06	2.3791E-06
0.999994426	5.07718E-06	5.57402E-06

0.999994968	3.88646E-06	5.03216E-06
0.99999355	3.73223E-06	6.44966E-06
0.999998549	6.62626E-07	1.45134E-06
0.999998329	3.01809E-07	1.67063E-06
0.999996023	2.93175E-06	3.97664E-06
0.999995523	2.20011E-07	4.47681E-06
0.999995884	3.7598E-07	4.11594E-06
0.999996923	2.20412E-06	3.07715E-06

3-5 Neutrosophic construction for the sizes of tonnage of the cargo ships casting

The following table shows the neutrosophic functions membership, indeterminacy and non-membership of the sizes of tonnage for cargo ships casting.

membership	**indeterminacy**	**non-membership**
0.999980808	2.68364E-06	1.91925E-05
0.999975151	8.10953E-06	2.48487E-05
0.999998995	4.16959E-07	1.00491E-06
0.999995727	2.63953E-06	4.27268E-06
0.999979618	1.46253E-05	2.03821E-05
0.999988567	7.58596E-07	1.14333E-05
0.999984127	1.55296E-05	1.58727E-05
0.999988002	3.75304E-06	1.19978E-05
0.99999423	2.93423E-07	5.76964E-06
0.999982442	1.56162E-05	1.75578E-05

0.999999894	7.69112E-08	1.05778E-07
0.99999368	4.93127E-06	6.31956E-06
0.999989252	7.55723E-06	1.07479E-05
0.999993027	1.09647E-06	6.97259E-06
0.999996135	2.52924E-06	3.86463E-06
0.999994335	2.3808E-06	5.66547E-06
0.99999625	2.07892E-06	3.74972E-06
0.999996134	3.71619E-06	3.86632E-06
0.999997895	6.74216E-07	2.10478E-06
0.999988647	2.45364E-06	1.13533E-05
0.999993827	2.64785E-06	6.17332E-06
0.999993905	2.80495E-06	6.09518E-06
0.999997398	2.14679E-06	2.6023E-06
0.999991676	2.11799E-06	8.32415E-06
0.999996363	1.73944E-06	3.63679E-06
0.99999949	2.87001E-07	5.10254E-07
0.999999624	1.45097E-07	3.76357E-07
0.999997374	3.98441E-07	2.62619E-06
0.999992259	6.33327E-07	7.74082E-06
0.99999455	5.82952E-07	5.44981E-06
0.999999272	5.9419E-07	7.28466E-07

0.999992703	5.71205E-06	7.29738E-06
0.999999875	9.66849E-08	1.24589E-07
0.999990182	4.31384E-06	9.81787E-06
0.999999648	8.96058E-08	3.5191E-07
0.999993379	2.80686E-06	6.6212E-06
0.999993584	5.30479E-06	6.4156E-06
0.999998612	1.25861E-06	1.38826E-06

3-6 Neutrosophic construction for the total transit ship sizes

The following table shows the neutrosophic functions membership, indeterminacy and non-membership for the total transit ship sizes

membership	**indeterminacy**	**non-membership**
0.999990592	0.081595643	9.40827E-06
0.999993233	0.872542965	6.76657E-06
0.999997969	0.957965187	2.03095E-06
0.999996298	0.240681564	3.70197E-06
0.999996123	0.58812965	3.87712E-06
0.999994838	0.603066597	5.16243E-06
0.999995702	0.817902648	4.29796E-06
0.99999889	0.907832847	1.10985E-06
0.999996164	0.459277585	3.83603E-06
0.999995355	0.206840716	4.6451E-06
0.999995881	0.606598419	4.11885E-06

0.999997577	0.566837025	2.42347E-06
0.999999767	0.458398662	2.33325E-07
0.999998119	0.737134899	1.88071E-06
0.999996708	0.021642474	3.29234E-06
0.999996875	0.364123252	3.12526E-06
0.999999958	0.845535234	4.21479E-08
0.999995951	0.109050085	4.04896E-06
0.999994263	0.09590703	5.73726E-06
0.999998665	0.146926882	1.33461E-06
0.999996595	0.174293442	3.40508E-06
0.999998719	0.991957998	1.28056E-06
0.999995953	0.261600592	4.04712E-06
0.999998779	0.883490079	1.2211E-06
0.999999576	0.259355637	4.23945E-07
0.999997016	0.104312996	2.9843E-06
0.999995259	0.226220789	4.74055E-06
0.999999689	0.297662813	3.10824E-07
0.999999362	0.133707397	6.38072E-07
0.999999712	0.070726333	2.88346E-07
0.999998716	0.681388333	1.28386E-06
0.999999381	0.635096147	6.19429E-07

0.99999932	0.476381568	6.80231E-07
0.999996216	0.270553455	3.78429E-06
0.999997277	0.230908485	2.72295E-06
0.999998198	0.837658751	1.80196E-06
0.999996651	0.734244669	3.34864E-06
0.999999684	0.674576687	3.15575E-07

4 - Graphic Representation for Data in the Neutrosophic Environment

4-1 Neutrosophic functions of the Suez Canal revenues

The following graph shows the neutrosophic functions membership, indeterminacy and non-membership of the Suez Canal revenues from oil tankers

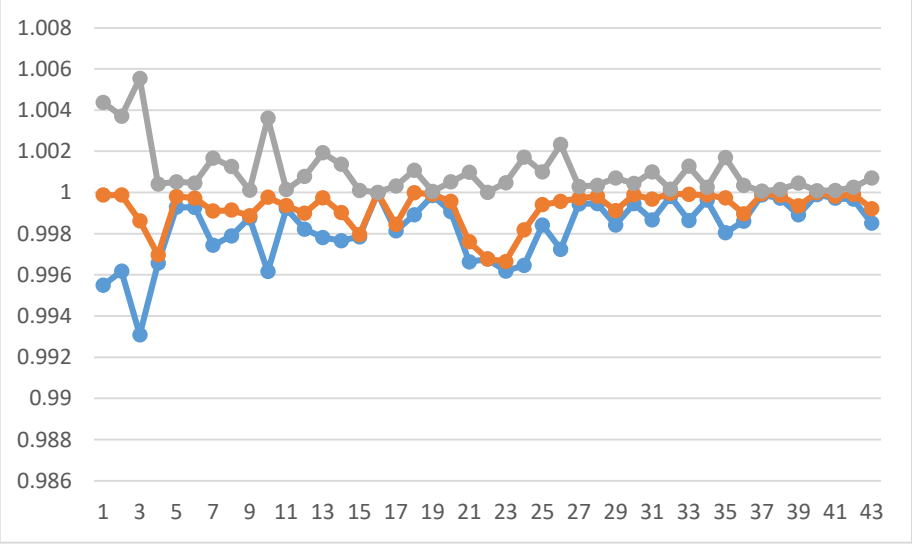

Fig.1, The neutrosophic functions of the Suez Canal revenue collected from oil tankers. (1976: 2019)

4 -2 Neutrosophic functions of the Suez Canal revenue collected from bulk cargo ships

The following graph shows the neutrosophic functions membership, indeterminacy and non-membership of the Suez Canal revenues received from bulk cargo ships.

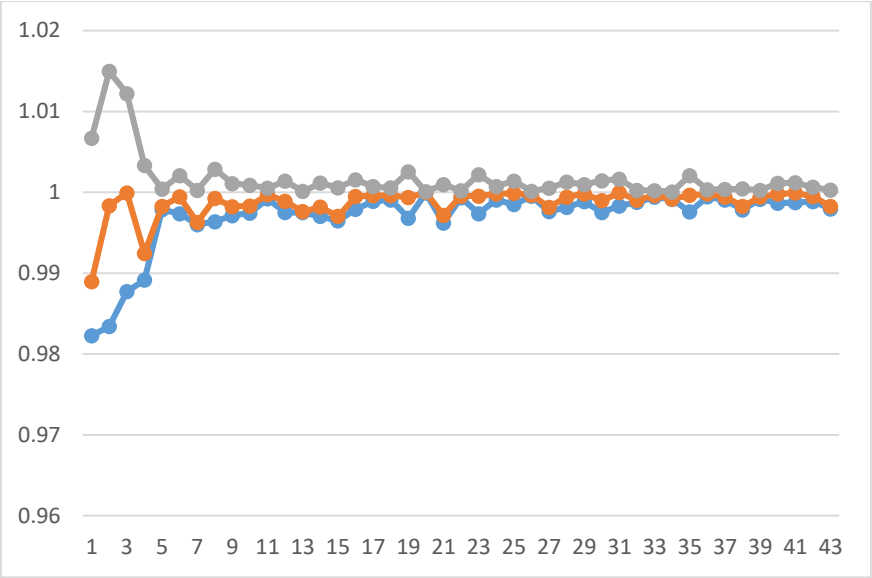

Fig.2. Neutrosophic functions of the Suez Canal revenue collected from bulk cargo ships. (1976: 2019)

4 -3 Neutrosophic functions of the Suez Canal revenue (total revenue)

The following graph shows the neutrosophic functions membership, indeterminacy and non-membership of the Suez Canal total revenue.

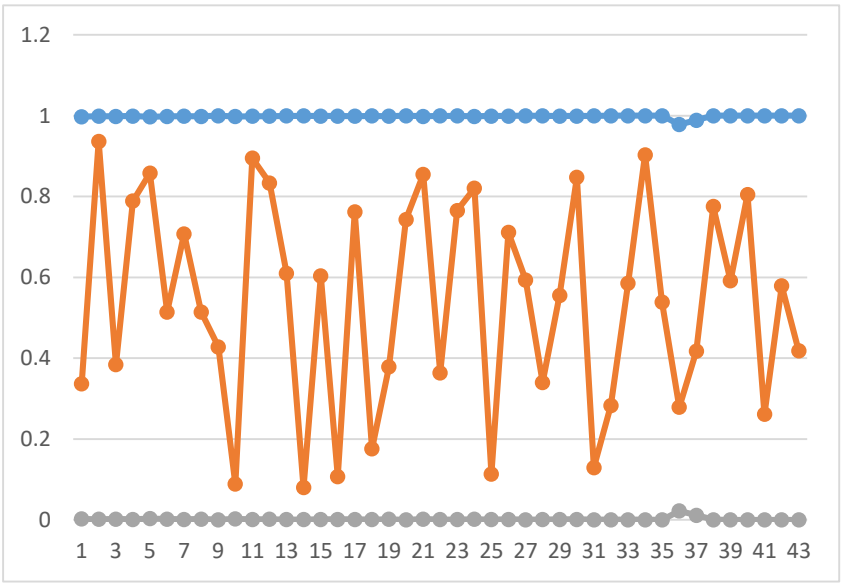

Fig.4. Neutrosophic functions of the Suez Canal revenues in million dollars (total revenue).

4 -4 Neutrosophic functions for volumes of shiploads

The following figure shows the neutrosophic functions membership, indeterminacy and non-membership of tonnage of tankers crossing the channel

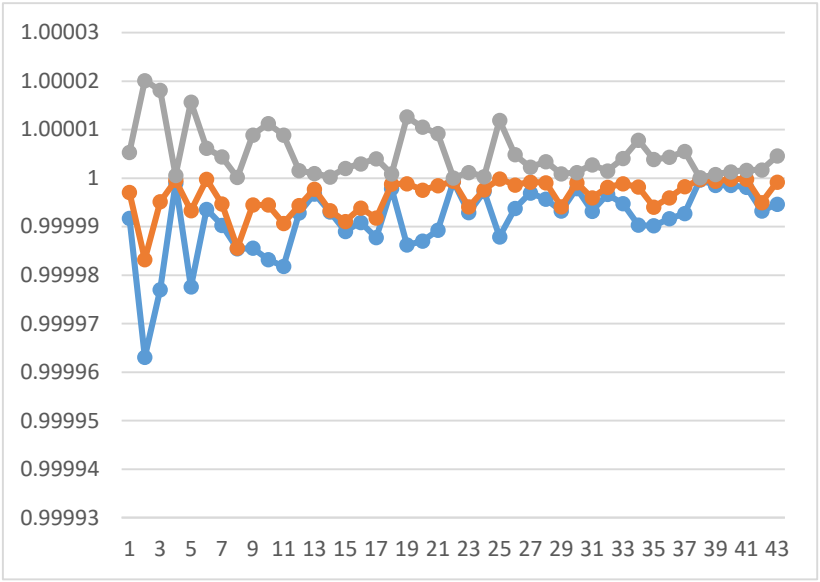

Fig.5. Neutrosophic functions for the volumes of tonnage of tankers crossing the channel.

4 - 5 Neutrosophic functions of tonnage of cargo vessels casting trans-channel

The following figure shows the neutrosophic functions membership, indeterminacy and non-membership of the tonnage of cargo ships for casting trans-shipment vessels.

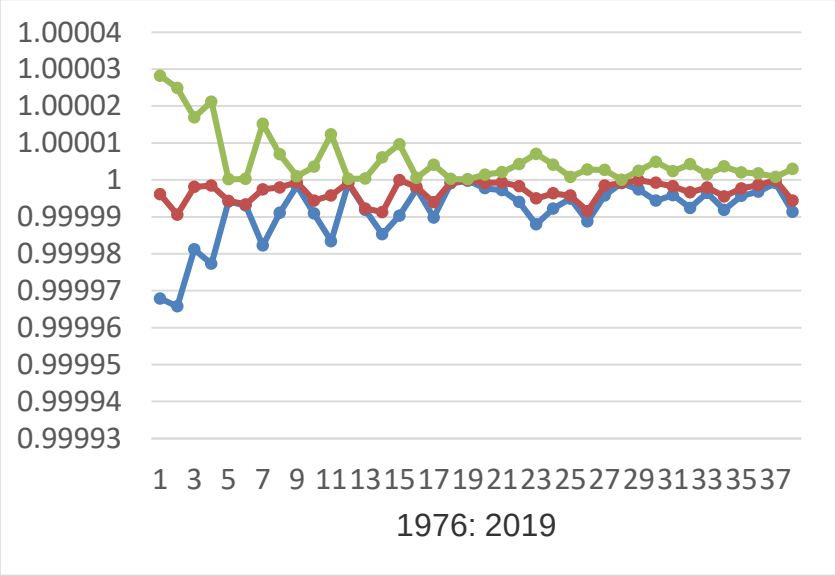

Fig.6. Neutrosophic functions of tonnage of cargo vessels casting trans-channel.

4 - 6 Neutrosophic functions of the tonnage of vessels transiting the channel

The following figure shows the neutrosophic functions membership, indeterminacy and non-membership of the sizes of tonnage of ships crossing the channel.

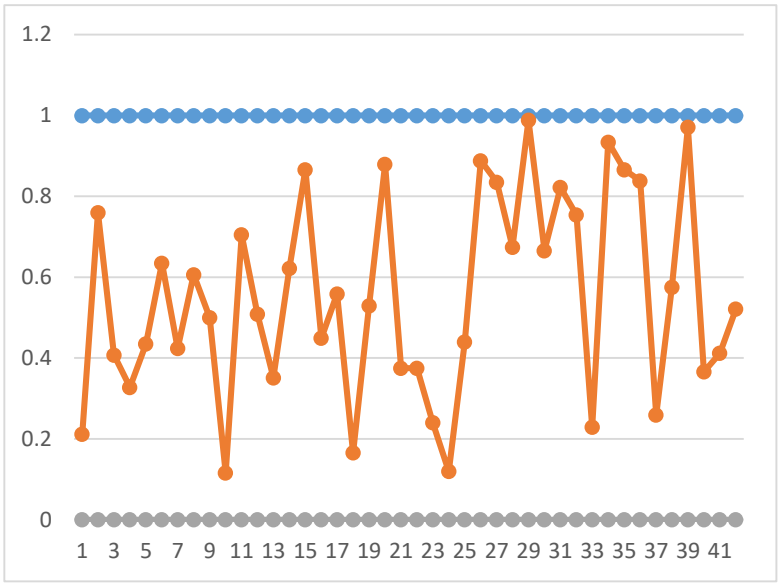

Fig.7. Neutrosophic functions of the sizes of tonnage of transit ships.

5 Decision Making for Neutrosophic Environment

Here we will present a study of the decision-making process regarding the better investment in the Suez Canal. Is it investing in oil tankers or investing in cargo ships, as this is done based on the previous neutrosophic data. This will be done by studying optimistic, pessimistic, and remorse entrances to the neutrosophic data, to see which oil tankers or cargo ships offer better returns to the Canal.

Study of entrances:

i. **The Optimistic entrance:**

We know that this entrance depends on evaluating the alternatives, in preparation for choosing the alternative that guarantees the best possible returns under optimistic natural states. Without any consideration for the pessimistic cases of this alternative. Which we express by the term (Max, Max). So that the first "Max" indicates the highest value, and the second "Max" denotes the optimistic natural state:

	Max Max
oil tankers	Max (0.999701164,0.000102857, 0.000298836) = 0.999701164
cargo ships	Max(0.99977598, 0.000190899, 0.00022402) = 0.99977598

Thus, according to the optimistic entrance, investing in the **cargo ships** is the best alternative considering that it includes the highest possible return, which is (0.99977598).

ii. **The conservative (pessimistic) entrance:**

We know that this entrance depends on evaluating alternatives. As a prelude to choosing the alternative, that guarantees the best possible returns in the light of pessimistic natural states.

Without regard for optimistic cases of that alternative. It is called the term (Max, Min), where "Max" means the highest value here, but it is related to the second part of the term "Min", which means the pessimistic natural state:

	Max Min
oil tankers	Max (0.988740191 ,0.00461327, 0.011259809) = 0.988740191
cargo ships	Max(0.979597358, 0.011222455, 0.020402642) =0.979597358

According to this entrance, investing in oil tankers is the best alternative, as it guarantees the highest possible return is (0.988740191).

iii. The entrance to remorse:

This entrance is not optimistic or pessimistic, but rather an intermediate entrance. It depends on the evaluation of the alternatives as a prelude to choosing the alternative that contains the least missed opportunities.

Choosing the most appropriate alternative in the light of this entrance requires creating a new matrix, as follows, we replace the alternative that achieves the highest value with a value of zero, given that there are no missed opportunities for this alternative.

	Highest neutrosophic return	**Lowest neutrosophic return**
oil tankers	(0.999701164,0.000102857, 0.000298836)	(0.988740191 ,0.00461327, 0.011259809)
cargo ships	(0.99977598, 0.000190899, 0.00022402)	(0.979597358, 0.011222455, 0.020402642)

	Highest neutrosophic return	**Lowest neutrosophic return**
oil tankers	(0.000074816,0.000088042, -0.000074816)	(0,0,0)
cargo ships	(0,0,0)	(0.009142833, -0.006609185, -0.009142833)

We subtract the highest value in the event of high return from the rest of the values present in this normal state. The same applies to the case of low return, and we subtract the highest value in the case of low return from the rest of the values found in this case.

Then now we create a short matrix that includes the highest missed opportunity values for each alternative, as follows:

	Missed opportunities
oil tankers	(0.000074816, 0.000088042, -0.000074816)
cargo ships	(0.009142833, -0.006609185, -0.009142833)

Consequently, according to this entrance, the appropriate alternative is oil tankers as it contains the least missed opportunities.

From the study of the previous three entrances in the light of the neutrosophic logic, we have different options for decision according to the entrances. This matter we can view positively as it enriches the decision-making process and is only a reflection of the circumstances of the decision-maker and the views that affect him.

Conclusion and Future Work:

Neutrosophic techniques as a generalization of crisp and fuzzy techniques that may better model imperfect information, which is omnipresent in any conscious decision making. In neutrosophic system, each attack is determined by membership, indeterminacy and non-membership degrees. In this paper, we have designed a program to generate neutrosophic grades for the most important variables of the waterway of the Suez Canal. In future studies we will design a statistical model to support and make decisions using the neutrosophic statistics. The future importance of the research paper is the use of neutrosophic in proposing a model for optimal decision-making in the neutrosophic environment.
The study aims at the possibility of proposing a general framework to support decision-making to maximize the profitability of the Suez Canal Authority by crossing ships using the neutrosophic analysis of navigation traffic data.
This is achieved through a set of objectives, as follows:

1. Neutrosophic analysis through the generation of organic functions with three degrees, for the navigation traffic in the Suez Canal.
2. Neutrosophic analysis of the numbers and volumes of tonnage of oil tankers transiting the Suez Canal through neutrosophic data.
3. Studying neutrosophic triple vehicles to predict future tanker and ship volumes.
4. Using the neutrosophic method to predict the value of revenues.

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