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Summary Sheet

In our paper, we construct a mathematical model which can be used to deal with problems about a country's fragility.

Our approach consists of four main models.

- The multi-Fuzzy-AHP-SEM model is used to determine the country's fragility. The base of this model is the FSI. By using the AHP, we can calculate the country's fragility index. The state will be identify by the fuzzy mathematics method and the SEM will show how the climate change influence the country's fragility.
- The GM(1,1) Model can be used to predicted the country's future.
- The Climate- Mitigate Model can point out which country has the most potential country to drive the intervention against the climate change and calculate the cost of mitigation.
- The Improved mode. In order to use our model to bigger or smaller state, we change the factor which influent state fragility to make our model more useful.

In our paper, we design a multi-Fuzzy-AHP-SEM model to determine country's fragility, which presented as the CFI between 0 to 10, point t out the state of country and show how the climate change will influent the country's fragility. Take Afghanistan and Egypt as an example, through our calculation, the CFI of Afghanistan is 8.1787, which shows that Afghanistan is a fragility country. While the CFI of Egypt is 6.8865, which shows that Egypt is a vulnerable country. After that we make an assumption that there is no climate change, we found that the FSI of Afghanistan become 7.9633, which means that the climate change will increase the fragility of state. Then we define the two tipping point of CFI is 3 and 7, which can be recognize the three state. We use our GM(1,1) model to show that Egypt will become the fragility between 2018 and 2019. Our Climate-Mitigate model point out the America is the country which has the most potential country to drive the intervention against the climate change and the cost of intervention is about $ 40 million. Finally we analysis the strength and weakness of our model and improve the model to make sure that it can be used in city or continents.

Key Words: State Fragility, Fuzzy Mathematics, AHP, SEM

Content

I. Introduction

In order to indicate the origin of country's fragility problems, the following background is worth mentioning.

1.1 What is country's fragility

A country's fragility is means that where the state government is not able to, or chooses not to, provide the basic essentials to its people. It is showed that the fragility of country is affect by many factors: society, economics and so on.

1.2 The approach to determine country's fragility

Now there is lots of approaches to determine a country's fragility, included the CIFP index which is built by Carleton University, the FIS which is built by The Fund for Peace. All of these is built with the principle of the three aspect of the country's functions: authority, capacity and legitimacy.

1.3 How the climate change influence the country's fragility

A country's fragility may increase the vulnerability of a country's population to the impact of such climate shocks as natural disasters, decreasing arable land, unpredictable weather and increasing temperatures. Non-sustainable environmental practices, migration and resource shortages, which are common in developing sates, may further aggravate states with weak governance.

1.4 What we do in our research

In our research, we try to take the consideration of the climate change into the fragility's evaluation, which only considered in the CIFP, to construct a time series to predicts the country's future and improve our model to be used in bigger or smaller states such as the city or the continents.

1.5 Assumption

- The economic is the most important things in country's fragility.
- There are three main methods for the evaluation of natural resource depletion: present value method, net price method and user cost method.
- The data we got is real.

II. The multi-Fuzzy-AHP-SEM model

2.1 Our considerations

In order to add the climate change into the model, we firstly try to find the approaches that evaluate in the world to evaluate a country's fragility. We find two main methods : FSI and CIFP. The FSI, which is built by The Fund for Peace, take four main factors into considerations including cohesion, economic, political and

social. The CIFR add two more factors, the population and environment, into model. But those index are less concerning about the climate change even the CIFR has evaluate the environment.

But we still get somethings important: we can develop the model of FSI by adding the factor of climate change. By using this methods, we can only evaluate climate change which can save us lots of work. And after we get the date which evaluate the climate change, we use the AHP to determines our own country's fragility index.

When it comes to the how climate change increase fragility through direct means or indirectly as it influences other factors and indicators, we are going to use the SEM model to calculate the weight between all factors and the country's fragility index. And we will use the fuzzy mathematics method to point out when a state is fragile, vulnerable, or stable.

2.2 Evaluate the climate change——Data Processing

We choose three factors: per capita water resources, per capita carbon emissions, Per capita arable land, to describe the climate. After we collect the time-series date of three factors, we calculate the three factor's rate of change to describe the climate change. It is showed followed:

$$\text{the rate of change} = \frac{x_t - x_{t-1}}{x_{t-1}}$$

The x can be referred to per capita water resources, per capita carbon emissions, Per capita arable land, while the t donates the year of the data.

For some special data, such as the per capita water resources which is measured every five years, we use the spline interpolation method to calculate the missing data.

To be simple, the RCC_t donates per capita carbon emissions' rate of change in the t year, the RCL_t donates per capita arable land's rate of change in the t year, the RCW_t donates per capita water resources' rate of change in the t year.

According to Central Limit Theorem, the RCC_t, RCL_t, RCW_t can be transformed into a series of number ${N^t}_X$ which is subjected to standard normal distribution by using the formula below:

$${N^t}_X = \frac{X - \overline{X}}{\sigma / \sqrt{n}}$$

The X can be referred to RCC_t, RCL_t, RCW. The n donates the number of the country or the number of data, and the σ donates to the standard deviation of data.

Then we can use the 3σ rule to transform the ${N^t}_X$ to the score which between 0

to 10. According to 3σ rule, we believed that ${N^t}_X$ are mainly distributed in the range of -3 to 3. For the three factor we choose, they all are the positive factors, so using the function below to transform the ${N^t}_X$ to the score.

$$Score^t{}_X = \begin{cases} 0 & {N^t}_X \le -3 \\ \frac{5}{3}{N^t}_X - 5 & -3 < {N^t}_X < 3 \\ 10 & {N^t}_X \gg -3 \end{cases}$$

2.3 The Country's Fragility Index（CFI）

We use the multi-AHP to calculate the country's fragility index. In order to consider the direct influence and indirect influence of the climate change, we design the structure below:

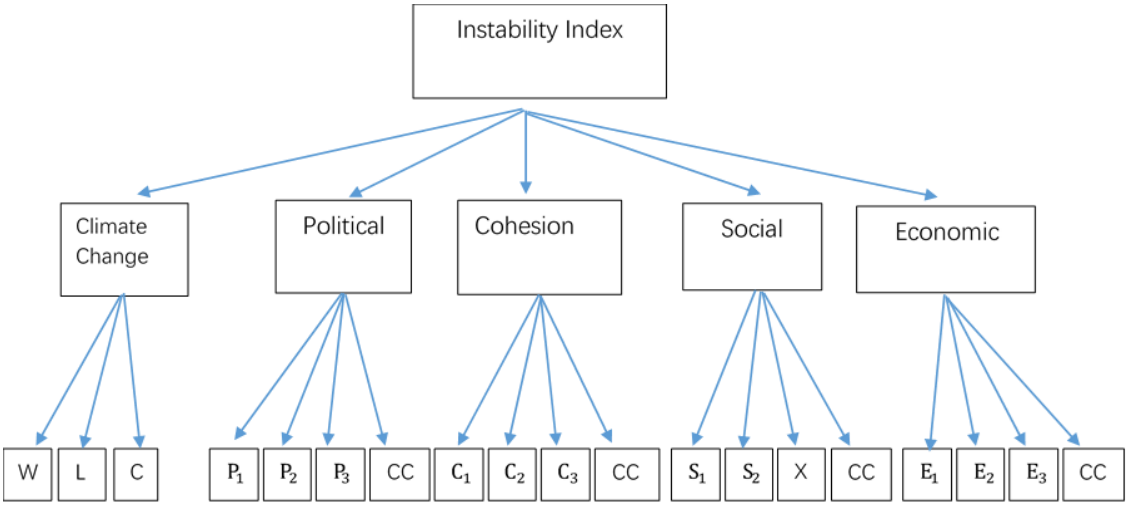

Fig.1 The structure of multi-AHP

In the Fig.1, the W in scheme layer donates the soccer of the per capita water resources' change which is calculated with the method in 2.2. The L in in scheme layer donates the soccer of per capita arable land's change, while the C in scheme layer donates the soccer of per capita carbon emissions' change. The CC in scheme layer donates the Climate Change in criterion layer. The P_1 donates the score of State Legitimacy, the P_2 donates the score of Public Services, the P_3 donates the score of Human Rights. The C_1 donates the score of Security Apparatus, the C_2 donates the score of Factionalized Elites, the C_3 donates the score of Group Grievance. The S_1 donates the score of Demographics, the S_2 donates the score of Refugees and IDPs, the X donates the score of the External Intervention. The E_1 donates the score of Economic Decline, the E_2 donates the score of Uneven Development, the E_3

donates the score of Human Flight. And the $P_1, P_2, P_3, C_1, C_2, C_3, S_1, S_2, X, E_1, E_2, E_3$ in scheme layer can be seem in http://fundforpeace.org/fsi/indicators/ and their data can be found in http://fundforpeace.org/fsi/data/.

In our method, we will use AHP for 6 times to calculate the whole weight in the Fig.1 including the five times in scheme layer and one time in criterion layer. Now we just explain one of them in details, the other is the same.

Look at the Fig.2 which we use as an example. For the AHP, the most important things is to construct the Judgment Matrix. The Judgment Matrix we constructed for the Fig.2 are as follows:

$$\begin{pmatrix} 1 & 2 & 1 & 5 \\ \frac{1}{2} & 1 & \frac{1}{2} & 4 \\ 1 & 2 & 1 & 6 \\ \frac{1}{5} & \frac{1}{4} & \frac{1}{6} & 1 \end{pmatrix}$$

The biggest characteristic root of matrix A:

$$\lambda_{max}^{A} = 4.0211$$

The characteristics of the vector is:

$$W_A = (-0.6411, -0.3613, -0.6682, -0.1092)^T$$

Then we take the consistency check:

Random consistency index: $R.I. = 0.9$

$$C.I. = \frac{\lambda_{max} - n}{n-1} = 0.007$$

$$C.R. = \frac{C.I.}{R.I} = 0.0078 < 0.1$$

Thus the test get through, which means the Judgment Matrix is passes.

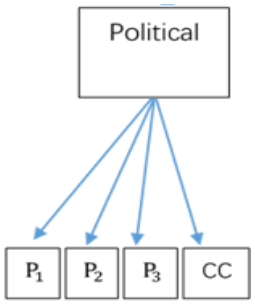

Fig.2 The Structure of the criterion layer political

The other five Judgement Matrix , $R.I.$ and $C.R.$ is showed below:

For the scheme layer Cohesion:

$$Cohesion = \begin{pmatrix} 1 & 2 & 1 & 5 \\ \frac{1}{2} & 1 & \frac{1}{2} & 4 \\ 1 & 2 & 1 & 5 \\ \frac{1}{5} & \frac{1}{4} & \frac{1}{6} & 1 \end{pmatrix},$$

$$R.I. = 0.9,$$

$$C.R. = \frac{C.I.}{R.I} = 0.0103 < 0.1.$$

For the scheme layer Cohesion:

$$Social = \begin{pmatrix} 1 & 1 & 2 & 1 \\ 1 & 1 & \frac{1}{2} & 1 \\ \frac{1}{2} & 2 & 1 & \frac{1}{2} \\ 1 & 1 & 2 & 1 \end{pmatrix},$$

$$R.I. = 0.9,$$

$$C.R. = 0.0923 < 0.1.$$

For the scheme layer Economic:

$$Economic = \begin{pmatrix} 1 & 2 & 1 & 5 \\ \frac{1}{2} & 1 & \frac{1}{2} & 4 \\ 1 & 2 & 1 & 6 \\ \frac{1}{5} & \frac{1}{4} & \frac{1}{6} & 1 \end{pmatrix},$$

$$R.I. = 0.9,$$

$$C.R. = 0.0078 < 0.1.$$

For the scheme layer Climate Change:

$$Climate\ Change = \begin{pmatrix} 1 & 2 & 1 \\ \frac{1}{2} & 1 & \frac{1}{2} \\ 1 & 2 & 1 \end{pmatrix},$$

$$R.I. = 0.58,$$

$$C.R. = 0 < 0.1$$

For the General objective Country's fragility index:

$$Country's\ fragulity\ index = \begin{pmatrix} 1 & \frac{1}{4} & \frac{1}{5} & \frac{1}{5} & \frac{1}{6} \\ 4 & 1 & 1 & 1 & \frac{1}{2} \\ 5 & 1 & 1 & 1 & \frac{1}{2} \\ 5 & 1 & 1 & 1 & \frac{1}{2} \\ 6 & 2 & 2 & 2 & 1 \end{pmatrix},$$

$$R.I. = 1.12,$$

$$C.R. = 0.0063 < 0.10$$

From the the consistency check above, it is clear that our Judgment Matrix is correct. By using the Judgement Matrix, we got six formulas below which can be used to calculate the country's fragility index:

$$\begin{aligned} CC &= 0.4W + 0.2L + 0.4C \\ P &= 0.3602P_1 + 0.2032P_2 + 0.3755P_3 + 0.0614CC \\ E &= 0.4466E_1 + 0.1917E_2 + 0.1105E_3 + 0.2511CC \\ C &= 0.3642C_1 + 0.2064C_2 + 0.3642C_3 + 0.0652CC \\ S &= 0.2865S_1 + 0.2098S_2 + 0.2137X_1 + 0.2865CC \\ CFI &= 0.0467CC + 0.1907P + 0.3628E + 0.1999C + 0.1999S \end{aligned} \quad \cdots (1)$$

The CFI donates the country's fragility index. While the other score expect CC can be find in the http://fundforpeace.org/fsi/data/, which is calculated by The Fund for Peace.

2.4 Identify the state

We identify the state by fuzzy mathematics method. We firstly to see how The Fund for Peace identity a state. Then we find the Fig.3.

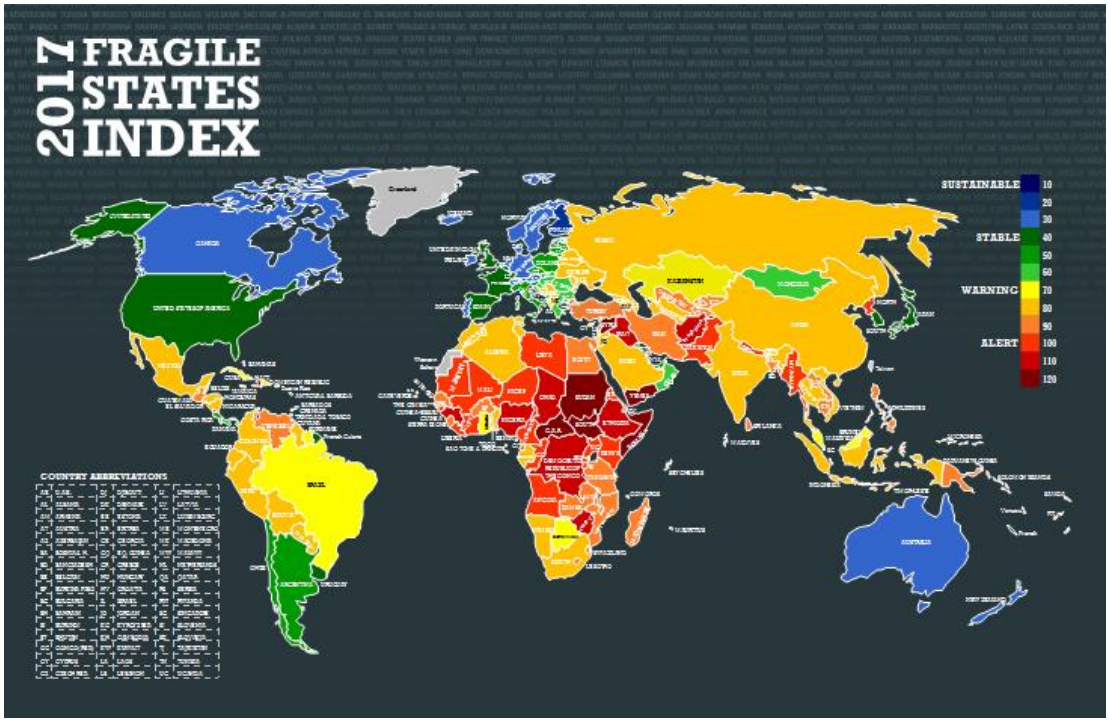

Fig.3 The Heat Map of FSI 2017 (http://fundforpeace.org/fsi/analytics/fsi-heat-map/)

Exactly it is hard to find that the state is fragile, vulnerable, or stable. It can be all the state according to data. But in the Fig.3, we find there is always some fuzzy areas, which is between fragile area and vulnerable area. So we try to use the fuzzy mathematics method to identify it.

After we study FSI heat map during 2006 to 2017, we construct three membership function below, which is used to identify the state:

$$Fragile=\begin{cases}0 & 0<CFI\le 5\\ 2(\dfrac{CFI-5}{4})^2 & 5<CFI\le 7\\ 1-2(\dfrac{CFI-9}{4})^2 & 7<CFI\le 9\\ 1 & 9<CFI\le 10\end{cases} \quad \cdots\cdots\cdots (2)$$

$$Stable=\begin{cases}1 & 0<CFI\le 2\\ 1-2(\dfrac{CFI-2}{2})^2 & 2<CFI\le 3\\ 2(\dfrac{CFI-4}{2})^2 & 3<CFI\le 4\\ 0 & 4<CFI\le 10\end{cases} \quad \cdots\cdots\cdots (3)$$

$$Vulnerable=1-Fragile-Stable=\begin{cases}0 & 0<CFI\le 2\\ 2(\dfrac{CFI-4}{2})^2 & 2<CFI\le 3\\ 1-2(\dfrac{CFI-2}{2})^2 & 3<CFI\le 4\\ 1 & 4<CFI\le 5\\ 1-2(\dfrac{CFI-9}{4})^2 & 5<CFI\le 7\\ 2(\dfrac{CFI-5}{4})^2 & 7<CFI\le 9\\ 0 & 9<CFI\le 10\end{cases} \quad \cdots (4)$$

The three membership functions can show us which state the country is after we calculate. For three number calculated by the functions, the country's state is the same to the state which the biggest number belongs to.

2.5 How the climate change influent the FSI

We want to find that how the climate change influent the State Fragility, which is the same to the problem that how the climate change influent the FSI. But in the AHP, we can't calculate the indirectly influence between climate change and FSI. So we use the SEM to show the weight between all factors and the country's fragility index.

The SEM, Structural Equation Modeling, can be used to path analysis. In our model, we collect the fifteen factors, $P_1, P_2, P_3, C_1, C_2, C_3, S_1, S_2, X, E_1, E_2, E_3, W, L, C$ with the FSI of one country in 10 years. Exactly, because the FSI only present in 10

years so we only can use 10 data for SEM. But with time goes by, we can get more and more data so the result will be more accurate. We construct the structure below to do the SEM in SPSS.

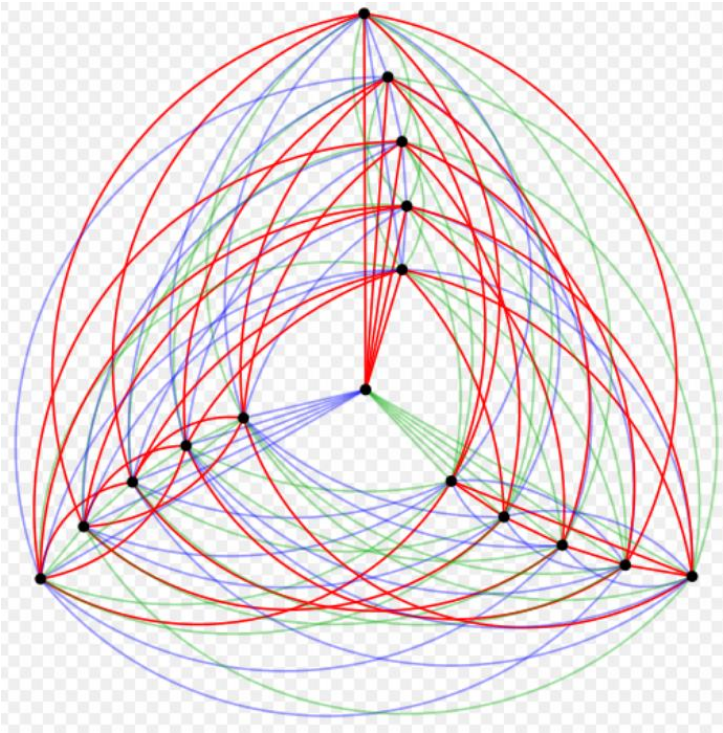

Fig.4 The Structure of SEM for 16 point

In the Fig.4, every color line means the weight between the two point, while the point stand for $P_1, P_2, P_3, C_1, C_2, C_3, S_1, S_2, X, E_1, E_2, E_3, W, L, C$, FSI.

To simply the model, if the number of the weight is smaller than 0.01, we believe that the two factors has no relevant.

2.6 Empirical in fragility country

Now we use our model to evaluate a top 10 fragility country in the FSI. We choose the Afghanistan as our example. Then we get the table followed:

Table.1 The score of Afghanistan in 2017

C1	C2	C3	P1	P2	P3	E1	E2	E3	S1	S2	S3	W	L	C
10	8.6	8.4	9.1	9.9	8.5	8.3	7.5	8.2	9.3	9.8	9.7	7.58	6.01	4.38

According to our formulas (1), which can be used to calculate CFI, we calculate the CFI of Afghanistan is 8.1787. Then according to formulas (2) (3) (4), we have the results followed:

$$Stable(Afghanistan) = 0$$

$$Vulnerable(Afghanistan) = 0.9156$$

$$Fragility(Afghanistan) = 0.0844$$

$$Fragility(Afghanistan) > Vulnerable(Afghanistan) > Stable(Afghanistan)$$

So the state of Afghanistan is fragility.

Then we use the data to show how the climate change influent the FSI by using the SEM in SPSS, we get the weight in the Fig.5

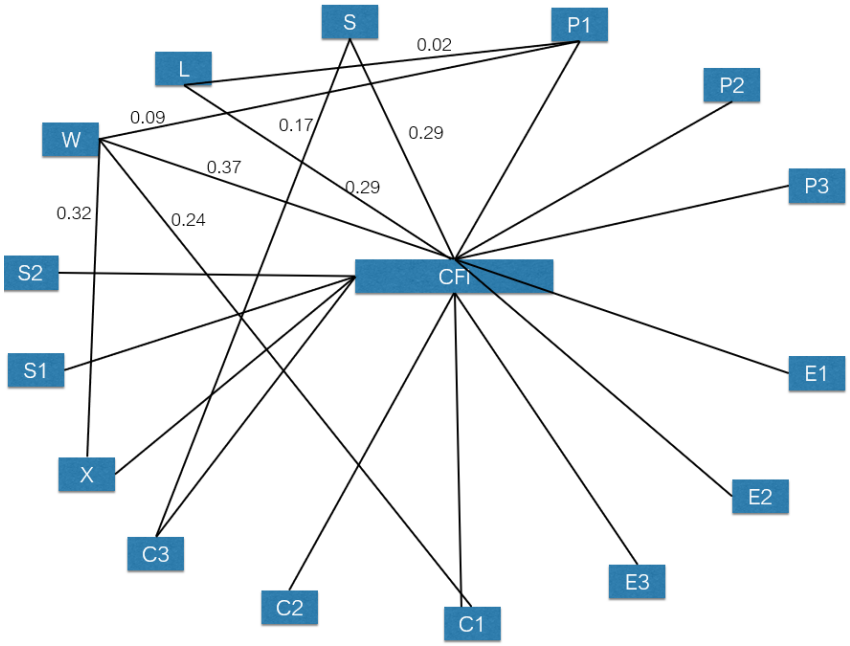

Fig.5 The weight between the factors

In the Fig.5, we just draw the weight which is related to the climate change, because the figure is too complex. We can see that the three factors of climate change not only directly influent the CFI, but also influent the CFI by influent the factor P_1, C_1, X, and the weight are 0.32,0.09 and 0.24.

Now we also concern about without the climate change, what will happen to Afghanistan. In our model, without the climate change means that the score of W,L,S are 5. Because our factor is the rate of change. If the climate never change, they only can get the 5 of score. Then we calculate the FSI, Now the FSI become 7.9633, it still the fragility country but the FSI is higher than before. So it is showed that without the climate change, the country will be much more stable.

III. The GM(1,1) Model

3.1 The multi-Fuzzy-AHP-SEM model Empirical in vulnerable country

Now we use our model to evaluate a country which is not the top 10 in the FSI. We choose the Egypt as our example. Then we get the table followed:

Table.2 The score of Egypt in 2017

C1	C2	C3	E1	E2	E3	P1	P2	P3	S1	S2	S3	W	L	C
8.1	8.8	8.8	8.2	6	4.7	8.2	4.9	9.8	7.1	7.3	7.9	6.008	6.326	4.013

According to our formulas (1), which can be used to calculate CFI, we calculate the CFI of Afghanistan is 6.8858. Then according to formulas (2) (3) (4), we have results followed:

$$Stable(Egypt) = 0$$

$$Vulnerable(Egypt) = 0.5584$$

$$Fragility(Egypt) = 0.4416$$

$$Vulnerable(Egypt) > Fragility(Egypt) > Stable(Egypt)$$

So the state of Egypt is vulnerable.

Then we use the data to show how the climate change influent the FSI by using the SEM in SPSS, we get the weight in the Fig.6

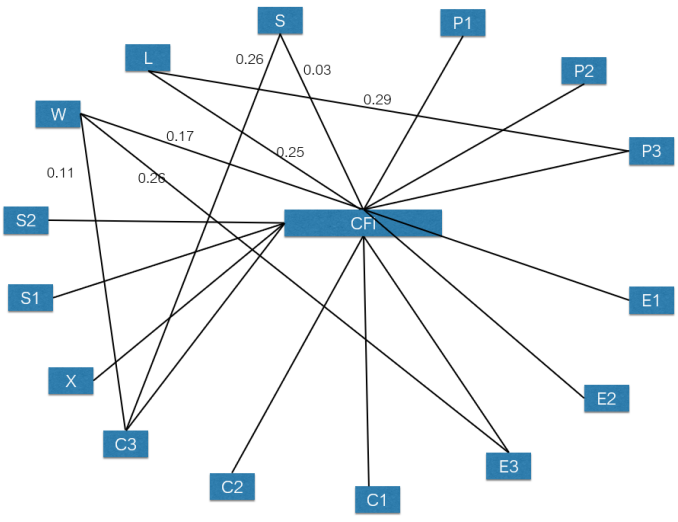

Fig.6 The weight between the factors

In the Fig.6, we just draw the weight which is related to the climate change, because the figure is too complex. We can see that the three factors of climate change not only directly influent the CFI, but also influent the CFI by influent the factor P_3, C_3, X, and the weight are 0.11 and 0.29.

Now we are interested in when the Egypt will become a fragility country.

3.2 The tipping point of CFI

Before we make a prediction of Egypt's future, we should define the tipping point of FSI, which is useful.

To calculate the tipping point, we should focus on the formulas (2) (3) (4), which is used to define the state.

Considering the tipping point between vulnerable sate and stable sate first, it must have the formulas exited when the CFI is transforming from vulnerable sate to stable sate:

$$Stable(CFI) = Vulnerable(CFI) = \frac{1}{2} \qquad Fragility(CFI) = 0$$

So it is easy to calculate that the tipping point of CFI between vulnerable sate and stable sate is 3.

The same to the tipping point between vulnerable sate and fragility sate, the following formulas will exited.

$$Fragility(CFI) = Vulnerable(CFI) = \frac{1}{2} \qquad Stable(CFI) = 0$$

So it is easy to calculate that the tipping point of CFI between vulnerable sate and stable sate is 7.

3.3 when the Egypt will become a Fragility country

If we want to know when the Egypt will become a fragility country, we should construct a prediction model.

In our methods, we use the gray prediction model to predict the five kinds of data: the score of Climate change, Economic, Political, Cohesion, Social. Now we will introduce the whole process of using the gray prediction model with the example of the Economic-score's prediction.

In order to predict the future score of the indicators, we use gray prediction model(GM(1,1)) based on available data. The original economic score of Egypt can be seem in the Table.3

Table.3 The original economic score

Year	2008	2009	2010	2011	2012
Economic Score	6.6493	6.6082	6.3811	6.2849	6.5599
Year	2013	2014	2015	2016	2017
Economic Score	6.8292	6.7622	6.6591	6.7677	6.6559

We use GM(1,1) model to calculate the predictive score, we should make sure that the error between the actual score and the predictive score is small. So the table.4 shows the error on available data.

Table.4 the error between the actual score and the predictive score of Egypt's Economic

Year	2008	2009	2010	2011	2012
Actual Score	6.6493	6.6082	6.3811	6.2849	6.5599
Predictive Score	6.6493	6.4601	6.4975	6.5352	6.5731
Relative Error(%)	0	0.0224	0.0182	0.0398	0.002
Year	2013	2014	2015	2016	2017
Actual Score	6.8292	6.7622	6.6591	6.7677	6.6559
Predictive Score	6.6113	6.6496	6.6882	6.727	6.766
Relative Error(%)	0.0319	0.0166	0.0044	0.006	0.0165

From the relative error we can see that the model is reliable, so we can use it to predict future economic score of Egypt:

Table.5 The Predictive Score of Egypt's Economic

Year	2018	2019	2020	2021	2022
Economic Score	6.6493	6.8488	6.8845	6.9244	6.9646
Year	2023	2024	2025	2026	2027
Economic Score	7.005	7.0456	7.0865	7.1276	7.169

So for the other four factors we have some tables to show the error and the predictive data.

Table.6 The error between the actual score and the predictive score of Egypt's Political

Year	2008	2009	2010	2011	2012
Actual Score	8.053	7.8801	7.653	7.7393	8.22
Predictive Score	8.053	7.869	7.9102	7.9516	7.9932
Relative Error(%)	0	0.0014	0.0336	0.0274	0.0276
Year	2013	2014	2015	2016	2017
Actual Score	8.2442	8.3766	8.223	8.0324	7.953
Predictive Score	8.035	8.077	8.1193	8.1618	8.2045
Relative Error(%)	0.0254	0.0358	0.0126	0.0161	0.0316

Table.7 The Predictive Score of Egypt's Political

Year	2018	2019	2020	2021	2022
Political Score	8.053	8.2905	8.3339	8.3775	8.4213
Year	2023	2024	2025	2026	2027
Political Score	8.4654	8.5097	8.5542	8.5989	8.6439

Table.8 The error between the actual score and the predictive score of Egypt's Cohesion

Year	2008	2009	2010	2011	2012
Actual Score	7.12	7.1914	7.3534	7.4969	7.9188
Predictive Score	7.12	7.2795	7.4313	7.5862	7.7444
Relative Error(%)	0	0.0123	0.0123	0.0119	0.022
Year	2013	2014	2015	2016	2017
Actual Score	7.8641	8.3044	8.344	8.4653	8.3151
Predictive Score	7.9058	8.0706	8.2389	8.4106	8.5859
Relative Error(%)	0.0053	0.0282	0.0126	0.0065	0.0326

Table.9 The Predictive Score of Egypt's Cohesion

Year	2018	2019	2020	2021	2022
Cohesion Score	7.12	8.9477	9.1342	9.3246	9.519
Year	2023	2024	2025	2026	2027
Cohesion Score	9.7174	9.92	10	10	10

Table.10 The error between the actual score and the predictive score of Egypt's Cohesion

Year	2008	2009	2010	2011	2012
Actual Score	6.7631	6.8635	6.6333	6.5653	6.6161
Predictive Score	6.7631	6.6565	6.6452	6.634	6.6227
Relative Error(%)	0	0.0302	0.0018	0.0105	0.001

Year	2013	2014	2015	2016	2017
Actual Score	6.4518	6.5179	6.4132	6.6784	6.7648
Predictive Score	6.6115	6.6003	6.5891	6.578	6.5668
Relative Error(%)	0.0248	0.0126	0.0274	0.015	0.0293

Table.11 The Predictive Score of Egypt's Social

Year	2018	2019	2020	2021	2022
Social Score	6.7631	6.5446	6.5335	6.5225	6.5114
Year	2023	2024	2025	2026	2027
Social Score	6.5004	6.4894	6.4784	6.4674	6.4565

Table.12 The error between the actual score and the predictive score of Egypt's Climate Change

Year	2008	2009	2010	2011	2012
Actual Score	5.5254	5.3366	5.0285	5.3107	5.339
Predictive Score	5.5254	5.1966	5.2022	5.2079	5.2136
Relative Error(%)	0	0.0262	0.0345	0.0194	0.0235

Year	2013	2014	2015	2016	2017
Actual Score	4.8162	5.4438	5.0826	5.3424	5.2737
Predictive Score	5.2193	5.2249	5.2306	5.2363	5.2421
Relative Error(%)	0.0837	0.0402	0.0291	0.0199	0.006

Table.13 The Predictive Score of Egypt's Climate Change

Year	2018	2019	2020	2021	2022
Climate Change Score	5.5254	5.3366	5.0285	5.3107	5.339
Year	2023	2024	2025	2026	2027
Climate Change Score	4.8162	5.4438	5.0826	5.3424	5.2737

After we calculate the predictive score of Egypt's Climate change, Economic, Political, Cohesion, Social, we can get the predictive FSI of Egypt which is showed in the Table.14.

Table.14 The Predictive FSIof Egypt

2018	2019	2020	2021	2022	2023	2024	2025	2026	2027
6.9807	7.4735	7.473	7.5335	7.6067	7.6122	7.7184	7.7199	7.8085	7.8462

According to the result of 3.2, the tipping point of CFI between vulnerable sate and stable sate is 7. From the Fig.4, we can easily find that Egypt will become a fragility country between 2018 and 2019.

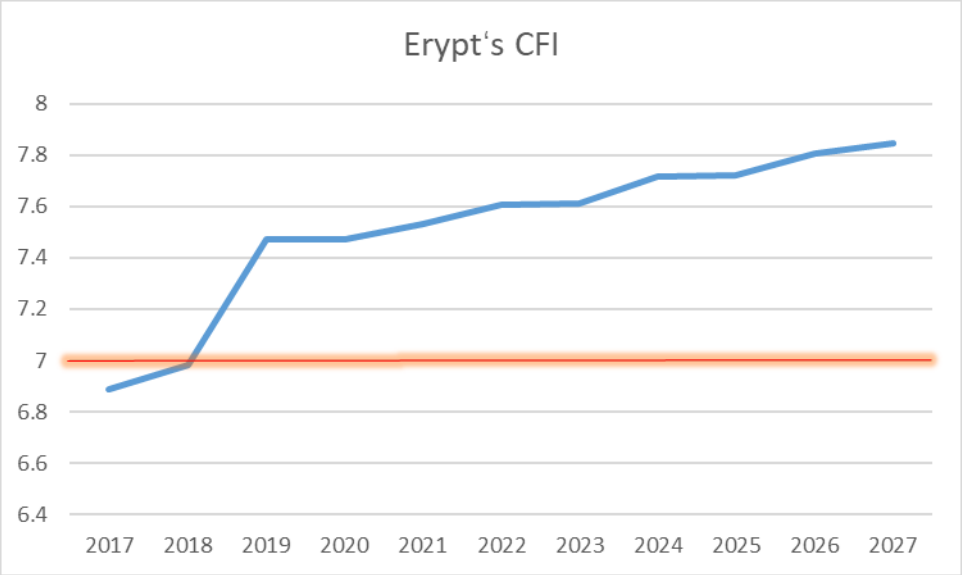

Fig.7 The Predictive CFI of Egypt

IV. The Climate- Mitigate Model

4.1 Mitigate the risk of climate change

Once we find that the climate change will affect the state of country, there must be some measurement taking to prevent it. But which country can be the best one to do.

According to our considerations, we think a country who is the best one to do it has a great should have a good economic condition and the bad climate-change condition. Assume that there is a country which has a bad economic condition and climate-change condition, even it is important to making the climate-change condition better, but they don't have money to do it.

So we define the PI as the potential index of country who driven the interventions.

The formulas of PI is showed as followed:

$$\mathrm{PI} = \frac{Climate\ Change}{Economic}$$

The Climate Change in the formulas donates the score of the climate change, while the Economic donates the score of economic. Now the problem that find the country which can drive the interventions efficiently transforms into a planning issues:

$$\max \quad PI$$

After we deal with this problem by lingo, we find the best country who can drive the interventions efficiently is American and China. Then we try to analysis the situation in America.

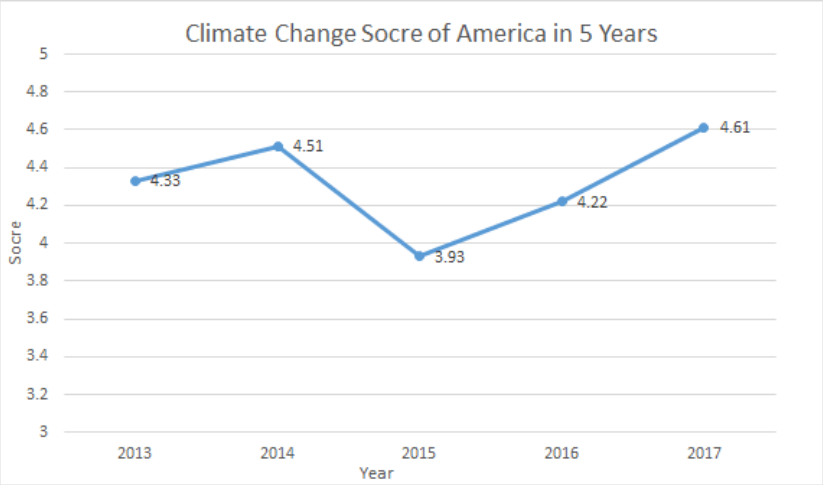

Fig.8 The Climate Change Score of Egypt in 5 years

It is no doubt that America has the most powerful economic conditions. As we can see in the Fig.5, in the 5 years the climate change score of America is increasing more and more faster. So America has necessary and ability to drive the interventions to mitigate the risk of climate change to prevent the country become fragility country.

4.2 The effect of human interventions

Human intervention has a very important impact on national vulnerability, such as man-made carbon dioxide removal, which can solve the climate problem most directly -- excessive greenhouse gases in the air; The artificial circulation of urban water resources -- can promote the water resources to participate in the cycle more quickly. These two are mutually reinforcing, and they play an important role in mitigating climate risk.

Then we are focus on the cost of human interventions with two approach: water resource consumption and the governance of carbon emissions.

4.3 The Cost accounting method for water resource consumption

For non-renewable resources, resource usage is the cost reduction, but the water resources and resource, belong to the renewable resources, in addition to the deep groundwater, the other can be use of water resources can be constantly updated with the water cycle system, therefore, water resource depletion cost analysis can be based

on the basis of two aspects, one is water use, water consumption reduction. From the perspective of value analysis, there is only useful for human and scarcity of goods is the exchange value, that more than a certain range, the number of items of exchange value will be very low and close to zero, the water resources also have the same nature, Take China as an example， China's total water resources 2 trillion m3, groundwater resource volume is about 0.8 trillion m3.According to the internationally recognized surface water resource development utilization rate 40% calculation, surface water resources.

Using water resource value and water resource consumption to evaluate the cost reduction of water resources can be expressed through the following formula:

$$V_w = D_w \bullet P_{ws}$$

Where: V_w is the cost of water consumption; D_w is water consumption reduction; P_{ws} is the value of water resources per unit.

4.4 The Cost governance of carbon emissions

There are three main methods for the evaluation of natural resource depletion: present value method, net price method and user cost method. On our natural resources based on the analysis of the stock valuation theory and method, thoroughly discusses the depletion of natural resources appraisal method and its application, summarizes the user cost method, and discuss its application in practice, using the method of carbon cost of governance.

And the total cost of intervening in the climate comes from both, and for the cost of CO_2 , we're going to generate cost allocation by combining the cost of emission reduction and the probability temperature program. The temperature prediction of any known path is due to geophysical uncertainties. If there is no any serious mitigation measures (currently global carbon price less than $1 per ton of carbon dioxide emissions per ton of CO_2 equivalent emissions (tCO_2e^{-1}), limit warming to within 2 ℃ possibility is basically zero. However, a carbon price of about $20 tCO_2e^{-1} keep under 2 at the university of California in our model can increase the probability of 50%, and the price of carbon will reach more than $40 tCO_2e^{-1}. At the university of California, the target rate is more than 66%

4.5 The Cost of America’s interventions

We simply make the assumption that there is only two parts of the Cost of America’s interventions, which is mentioned in 4.3 and 4.4. Then we can easily calculate the cost of America’s interventions is about $ 40 million.

V. The Improved Model

5.1 The Strength and Weakness

Comparing to the FSI, our model concern about the weight of every factors which is more accurate to reality. Adding the climate change into consideration makes the model more complete. The multi-fuzzy-AHP-SEM model is linear model which make the calculation easier than other model.

But there are some problems in the model: Our model will not completely work on smaller "states" (such as cities) because the indicators we choose to determine country's fragility is not suitable for other "states". Take city as an example, cities' urbanization level is various. For those cities whose urbanization is in a high level (such as New York City), their arable land cannot reflect the impact of climate change. Because arable land of these cities will maintain in a low level but it doesn't mean these cities are fragile. Instead they are likely to be stable cities.

5.2 The Improved Model

Exactly if we want to make our model to be used in city or continents, we should re-choose the factor that may influence the FSI. The factor we choose this time should shows the own character of the special area.

For the continents, our model may be still used because the three factors of climate change can be measured. For the city, we want to change the factor L into air pollution marker, such as PM2.5 or others. Because some city may give up the agriculture but it is still stable because of it's business or industry. And the Urban structure replaces the uneven economic development(E2). Because for a city the uneven economic development is not so clear. But a good urban structure can have great influence on economic.

VI. Conclusion

In our paper, we design a multi-Fuzzy-AHP-SEM model to determine country's fragility, which presented as the CFI between 0 to 10, point t out the state of country and show how the climate change will influent the country's fragility. Take Afghanistan and Egypt as an example, through our calculation, the CFI of Afghanistan is 8.1787, which shows that Afghanistan is a fragility country. While the CFI of Egypt is 6.8865, which shows that Egypt is a vulnerable country. After that we make an assumption that there is no climate change, we found that the FSI of Afghanistan become 7.9633, which means that the climate change will increase the fragility of state. Then we define the two tipping point of CFI is 3 and 7, which can be recognize the three state. We use our GM(1,1) model to show that Egypt will become the fragility between 2018 and 2019. Our Climate-Mitigate model point out the America is the country which has the most potential country to drive the intervention against the climate change and the cost of

intervention is about $ 40 million. Finally we analysis the strength and weakness of our model and improve the model to make sure that it can be used in city or continents.

VII. References

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