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Analysis of the Fragile States Index based on FUND Model

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Abstract: Climate change has recently started emerging as a global threat, with clearly noticeable consequences like global warming. In some cases, climate change can even pose a threat to the very existence of a country. Therefore, this paper discusses how the climate change has an effect on fragile states index by using the FUND (Climate Framework for Uncertainty, Negotiation, and Distribution) model. Through the data of climate change, this model can explain the impact of climate change on fragile states index while calculating it.

Keywords: Fragile states index; Climate change; FUND model

1. Introduction

Climate change has already taken place and will continue into the foreseeable future, which will have an impact on the fragile states index on different time scales. As a result, how to minimize the adverse impact of climate change on Fragile States Index is the primary task. In recent years, many scholars have established a variety of pricing models to study the related climate change and Fragile states index.

Fund for peace organization[1] provided the rank of fragile states every year through a specific indicator system which some of the indicators are related to climate change; Schwartz[2] et al theoretically analyzed an abrupt climate change scenario and its implications for united states national security; Targeting to the main problem that quantify climate change, David Anthoffa [3] build FUND model to study it; Dwqjz [4] present a few climate potential factors which have influence on climate fragility; Theisen [5] et al theoretically illustrate that climate change is a driver of armed conflict. In this paper, FUND model based on climate change indicator system is proposed to study the problem of fragile states index.

2. Establishment of Comprehensive FUND Model

2.1. Basic idea

Build an indicator system and then combine with the fragile states index in FUND FOR PEACE organization website. Then use the FUND model to calculate the value of each indicator we find. Sum them up to get the final fragile states index which not only includes climate change but also have the policy and other effects into consideration.

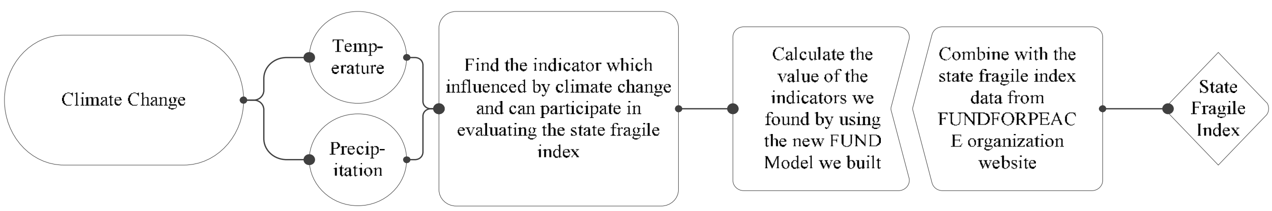

Figure 1. Flow Chart of the Whole

2.2. Establishment of indicator system

The index system we built by reviewing the literature on the impact of climate change is as follows:

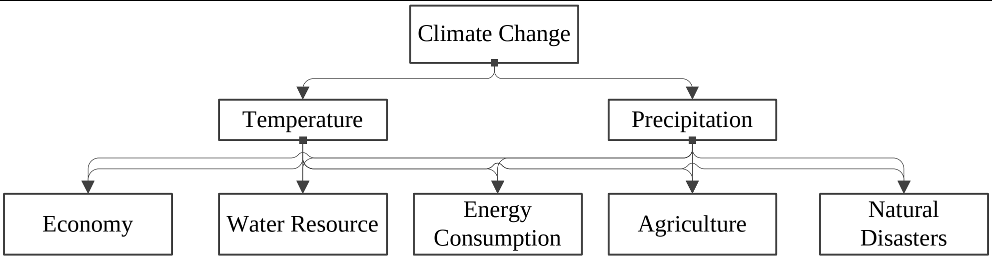

Figure 2. The Index System We Built

The simple scarcity (or neo-Malthusian) model of conflict assumes that if climate change results in a reduction in essential resources for livelihood, such as food or water, those affected by the increasing scarcity may start fighting over the remaining resources. Therefore, the indicators which will endanger people's livelihood are the main course climate change can have on a country. In other words, we only need to chase down the factors related to people's livelihood to represent the influence climate change can cause to increase the fragility. It is fair to say that, the indicators we chose contain every part of the needs of people to live a life or the things of life threatening. Hence, it is valid to consider these five factors as the indicators which can participate in evaluating the fragile states index.

Through the analysis of researchers, we can see that fragile states index can be influenced by the economy, society, policy, cohesion ability of people and so on while the climate change can have an effect on agricultural development, water resources, energy consumption and bring about natural disasters. In order to be able to explain how climate change affects the indicators associated with fragile states index, we find FUND Model (Climate Framework for Uncertainty, Negotiation, and Distribution) to quantify climate change.

2.3. Establishment of FUND model

FUND Model assumed that climate change is influenced by the emission of CO2 then it will go a further step to influence the agricultural development, water resources and other aspects. However, since we already have found the temperature and rainfall data of every country in the world directly on the internet which can represent the climate change, take emission of CO2 to analyze the climate change will be unnecessary.

In conclusion, we need and only need to analyze what impact will climate change have on the economy, agriculture, water resources, energy consumption, and natural disasters. Therefore, we collect the following formula for research:

2.3.1. Agriculture

The influence of climate change on agriculture at time t in region r are divided into two parts: impacts due to the rate of climate change A_t^r ; impacts due to the level of climate change $A_t^l : A_t = A_t^r + A_t^l$

For the impact of the rate of climate change (i.e. the annual change of climate) on agriculture, the assumed model is: $A_t^r = a\left(\frac{dT_t}{0.04}\right)^2 + \left(1-\frac{1}{10}\right)A_{t-1}^r$

where: A_t^r : denotes damage in agricultural production as a fraction due the rate of climate change by time and region; dT_t : denotes the change in the regional mean temperature (in degrees Celsius) between time t and $t-1$.

The model for the impact due to the level of climate change is: $A_t^l = d^l T_t + d^q T_t^2$

A^l : denotes the damage in agricultural production as a fraction due to the level of climate change by time and region; d^l and d^q are parameters, that follow from the regional change (in percent) in agricultural production for a warming of 2.5◦C above today or 3.2◦C above pre-industrial and the optimal temperature (in degree Celsius) for agriculture in each region.

2.3.2. Water resources

The impact of climate change on water resources follows:

$$W_t = a Y_t + (1-t)^{t-2000} y_t^{0.85} P_t^{0.85} T_t + \frac{T_t}{10}$$

where: W_t : denotes the change in water resources at time t in region r.

2.3.3. Energy consumption

Energy consumption can be split into two parts: heating and cooling. But as mentioned before, the greenhouse gas is a universal problem which is also heating our air temperature. In this circumstance, it is more complicated than just energy consumption. To simplify our model, and to get a relatively stable result we hereby calculate cooling energy consumption only. The model is:

$$SC_t = \frac{a Y_t T_t^{1.5} y_t^{0.8} P_t}{\prod AEET_t}$$

where: SC_t : denotes the increase in expenditure on space cooling at time t in region r ;

$AEET_t$ is a parameter. It is the Autonomous Energy Efficiency Improvement, measuring technological progress in energy provision; the global average value is about 1% per year in 1990, converging to 0.2% in 2200; its standard deviation is set at a quarter of the mean.

2.3.4. Natural disaster

We have a lot of disasters in the world while not all the disaster can contribute to the fragile states index, fortunately. Most of them are inland disasters (drought, flood and so on). However, the resilience quantification is arguable. Thereby, we will not give an exact number to the parameter but a range for the parameter to change to fit in the reality which can improve the accuracy of the formula. The mortality TM due to an increase in the intensity of natural disaster (hurricanes, typhoons) follows:

$$TM = b P_t \left(y_t^{0.501} \right) \left[\left(1 \pm 0.005 T_t \right)^3 - 1 \right]$$

where: TM is the mortality due to tropical storms (in people per year) at time t in region r.
b is the current mortality (as a fraction of population).

2.3.5. Economic damage

The climate change can not directly cause the economic damage except the climate can actually take money away. Hence, climate change in an indirect way to influence the country economy by causing disasters. Besides, the disasters can not only bring about a direct pecuniary loss but also lead violence to the house. The economic damage TD due to an increase in the intensity of tropical storms (hurricanes, typhoons) follows:

$$TD = a Y_t y_t^{-0.514} \left[\left(1 + 0.005 T_t \right)^3 - 1 \right]$$

where: TD is the damage due to tropical storms at time t in region r. a is the current damage as fraction of GDP.
The relationship between indicators are as follows:

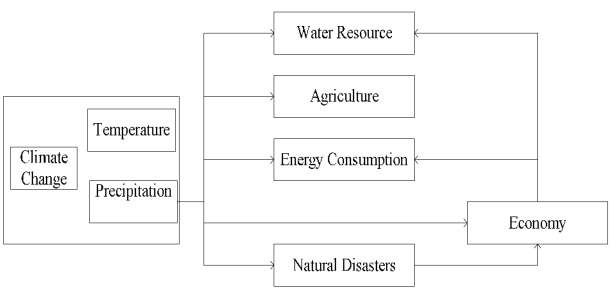

Figure 3. The Relationship between Indicators

The disasters cannot only bring about the direct pecuniary loss but also lead violence to the house to have effect on the economy.
The freshwater resources are limited which means the economy plays a key role in determined whether people or country have the access to the resources or not.
The energy (Coal, oil and so on) we can use is actually more finite than water resources which means economy plays a more important part in energy consumption.
Combining with the formula we mentioned above we can get the value of each indicator. However, fragile states index cannot determine by climate change. We need to take other factors into account such as the rationality of the policy and the livelihood quality of people. With the data of the twelve indicators we find in FUND FOR PEACE organization website, we decided to combine these two aspects together to optimize the fragile states index which can become more accurate.
Nonetheless, the original data we calculated by the model above is messed up. Considering we need to combine the data we obtained from our model and the data we get from the website to comprehensively calculate the final Fragile states index. Therefore, we get the value we calculated and the value we get from the website normalized under the same formula by IBM SPSS Statistics 24 software. In this way, we can add the values altogether to get a fair fragile states index.

3. Calculation and Result Analysis

3.1. Model features

The model can perfectly combine the climate change to fragile states index.
The model includes a set of indicator system to calculate the specific value of each indicator influenced by climate change.
Literally, this model made it to quantitative climate change to a certain extent.

3.2. Results

Climate change can directly influence other related factors to produce an excessive effect which can indirectly influence fragile states index. Consequently, we can split the situation into four states:
If a country has both stable climate change and stable political state, we assume that this country is a stable country and the fragile states index is pretty low.
If only one of the two aspects is satisfied then we assume that this country is vulnerable which means it can be helped to become stable through policy and human interference way (helped by the other stable indicator system).
When the above two situations are in conflict, it is obvious that the country is fragile, with a low adjustable coefficient and high risk.
The indicators we found in FUND FOR PEACE organization website in combination with the indicator system we built is standardized by SPSS software. And then, the sum is calculated as the final fragile states index in the order from 2006 to 2015.
And as the conclusion we showed above, we can see that the climate has an influence on fragile states index by an

indirect way through having an effect on the indicator value to influence the final fragility!

4. Test of the Model

In order to test the correctness of the model, we take Sudan as an example to test the model. The accuracy of our model can be concluded by comparing the fragility value calculated by our model to the fragility value in the FUND FOR PEACE website which we assumed that is the real fragility value.

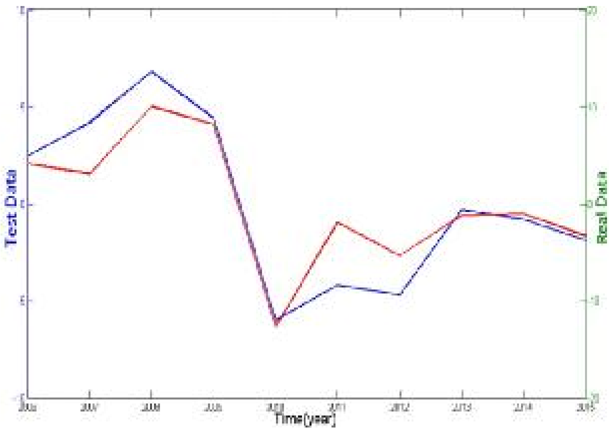

Figure 4. The Relationship between Test Data and Real Data

Conclusion: from the figure above, it can be concluded that the trend of the fragility value we calculated with the trend of the real fragile states index we obtained in FUND FOR PEACE website is 90% match, which shows that the accuracy of our model is credible.

5. The Application of the Model

The model we built above can be used here to figuring out why the climate change can contribute to the fragile states index is the breakthrough to lower fragility. Thereby, we choose Sudan as a research object. Climate data of Sudan is obtained virtual of the globe climate website which includes the temperature data and precipitation data. Then principal component analysis is used here to process the data by SPSS. And combine with the FUND model we mentioned above to get the fragile states index. Therefore, fig.5 and fig.6 can be obtained.

5.1. Analysis

According to the following figure, it is concluded that fragility is positively correlated with the economy, that is, the degree of fragility is relatively high when the economic index is high. The fragility changes with the economy.

According to the following figure, it is concluded that temperature and economic losses are reversed, namely, the higher the temperature, the more severe the economic loss and the low economic elasticity.

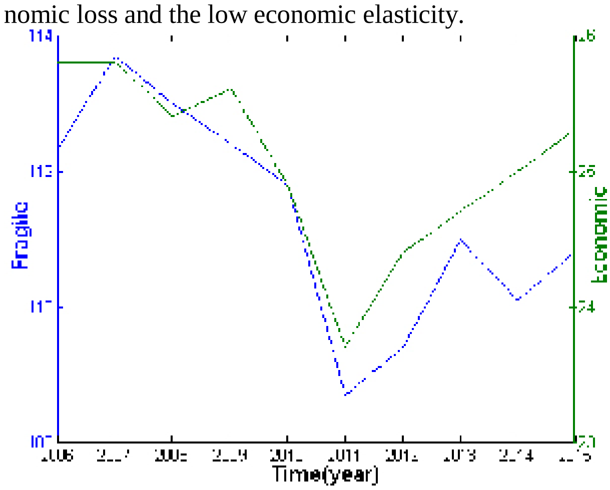

Figure 5. The Relationship between Fragile with Economy

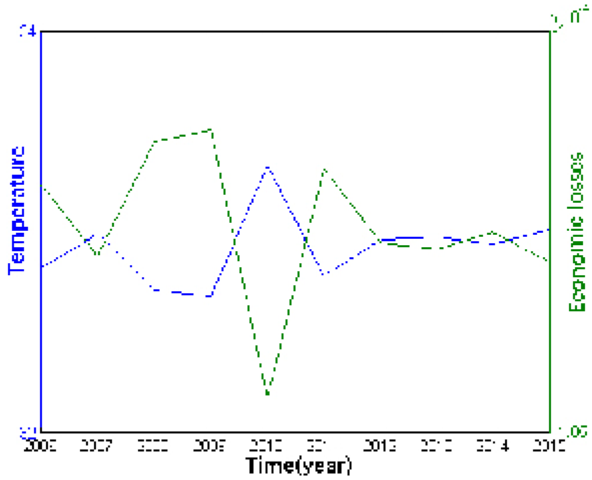

Figure 6. The Relationship between Temperature with Economy Losses

5.2. Results

Combine with the conclusion we obtained above, we think that: The economy is highly related to fragility; Temperature affects economic loss which means, temperature correspondingly affects the whole economic development.

To show in what way(s) the state may be less fragile without the effects, it is very important that we find out the things can really define the effects. As the conclusion we draw above, we can know that the dynamic state is how the climate change has an influence on the economy and then to contribute to the fragile states index. In this way, we let the climate change approaching zero to find out whether the state may be less fragile without the effects of climate change. Therefore, we take the mean value of temperature to take place the value of temperature, all of it. So as the precipitation. Then we calculate the fragile states value by the model we built. The two Fragile states index calculated by our model are shown as follows:

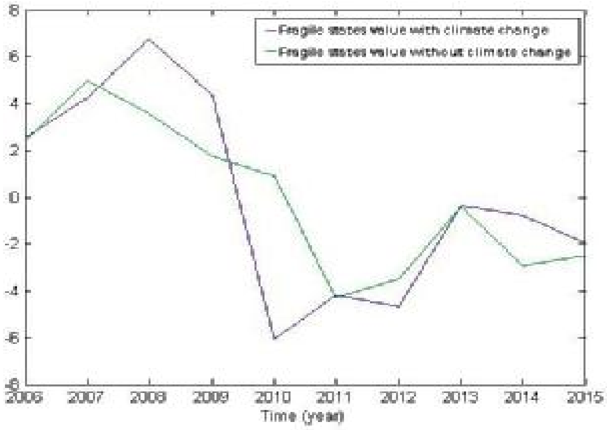

Figure 7. The Analysis of Fragile States

As a result, it is believed that the economy is in a better state when the climate does not change. In the case of economic stability, other indicators have little flexibility to deal with national fragility.

6. Conclusions

First of all, the model we built is quite flexible, and it can be divided into many useful parts. The model can be used to get the specific number of fragile states index which can be very helpful to assistant a country to improve itself.

However, by the time of calculating the final fragile states, we simply sum all the fragility value up which is relatively inaccurate. When we sum the value up it represents that we assume the country fragility is divided into two parts and these two parts are equal to country fragility which is not. However, the result of the proportion we obtained is quite different with the reality we expected. But if this problem can be solved, a more accurate result will be obtained.

As you can see, there are two indicator systems for measuring the fragility of counties. Moreover, the two systems have cross indicators. And the cross indicators will be calculated in two different values. Therefore, we can set two matrices to contain the different indicator value from different indicator system.

Then, normalize the value under the same rule and equalize the two different values by matrix change (Or in another way to equalize the two different values). At last, we can get the proportion of the climate change in the fragility of countries.

References

[1] Fragile States Index: http://fundforpeace.org/fsi/

[2] Schwartz, P. and Randall, D. An Abrupt Climate Change Scenario and Its Implica- tions for United States National Security, October 2003.

[3] David Anthoffa and Richard S.J. Tolb, c,d. The Climate framework for uncertianty, Negotiation and Distribution (FUND), Technical Description, Version 3.9 September 16, 2014

[4] Dwqjz,Study on related theories and methods of climate change vulnerability assess-ment[DB/OL], https://wenku.baidu.com/view/6a834fe819e8b8f67c1cb90c.html

[5] Theisen, O.M., Gleditsch, N.P., and Buhaug, H. Is climate change a driver of armed conflict? Climate Change, April 2013, V117 (3), 613-625.