Research on the Prediction of world nuclear weapons Quantity based on Topsis Comprehensive Evaluation method

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Abstract. First, based on the data collected, the countries that have ever possessed nuclear weapons are screened, and the nuclear bomb stockpiles of each country in the last 20 years are counted, and the change in the total number of nuclear weapons of each country is found, and the most change in the nuclear weapon stockpile of the United States in 20 years is obtained. Immediately afterwards, the number of nuclear tests by country was added up by year and the five years with the highest number of nuclear tests worldwide were 1962, 1958, 1968, 1966 and 1961. Subsequently, the stockpile of nuclear bombs and the number of nuclear tests were selected as measures of nuclear weapons research activity, and the Topsis model (Technique for Order Preference by Similarity to Ideal Solution) was used to obtain a score for each country to determine the level of activity, with the United States ultimately having the highest level of activity. Finally, the speed of transition from disregard to possession of nuclear weapons is found, and the final ranking gives the country with the fastest transition speed, again giving the fastest transition speed for the USA.

Keywords: Nuclear weapons Quantity, Topsis Model, Comprehensive Evaluation, Prediction

1. Introduction

Nuclear weapons are among the most powerful weapons ever developed by man, and the explosion of a nuclear bomb and its radiation range can destroy a city [1-3]. Since the world's first nuclear bomb came into view in 1945, nuclear weapons entered a period of rapid development, reaching its peak during the US-Soviet Cold War, when people became generally aware of the immense destructive power of nuclear weapons and began to limit the number of nuclear bombs to prevent their proliferation [4]. In the pursuit of a nuclear-free 21st century, it is necessary to collect descriptive statistics on the nuclear weapons of all countries in the world and, based on these data, to predict the total number of nuclear weapons in the world and in each country in the future, and before the number of nuclear weapons is zeroed out, to further develop mathematical models of the locations of nuclear weapons explosions and to further determine the threat of nuclear weapons to the planet on which humanity depends [5-8]. Based on the background information identified in the abstract and the data already collected on the web, the following questions were finally addressed [9].

TOPSIS method (Technique for Order Preference by Similarity to Ideal Solution) can be translated to approximate ideal solution sorting method, domestic often referred to as the good and bad solution distance method. TOPSIS method is a commonly used comprehensive evaluation method, which can make full use of the information of the original data, and its results can accurately reflect the gap between the evaluation schemes. In order to give a ranking of the many schemes, after all schemes are given, an ideal optimal solution and the worst solution in the system of all schemes can be constructed from these data. TOPSIS's idea is to evaluate, through certain calculations, the combined distance between any solution in the scheme system and the optimal and the worst solution. If a solution is closer to the ideal optimal solution and further away from the worst solution, it is reasonable to think that the solution is better. What is the ideal optimal solution and the worst solution? In simple terms, the ideal optimal solution is that the index values of the ideal optimal scheme are taken to the optimal value of the evaluation index in the system, and the worst solution is that the index values of the ideal worst scheme are taken to the worst value of the evaluation index in the system.

Question 1: Basic data analysis

Based on the information collected and reviewed, the following information was collated and descriptive statistics were compiled: 1(a) Countries that have ever possessed nuclear weapons; 1(b) States with the largest change in the total number of nuclear weapons in the last twenty years; 1(c) the five years with the highest number of nuclear tests; 1(d) countries with the most active nuclear weapons research in the last ten years; 1(e) The country that has made the fastest transition from not being considered to possessing nuclear weapons.

Question 2: Predicting the number of nuclear weapons

2(a) Develop a suitable mathematical model to predict the number of nuclear weapons in the future and the countries that will have them in the next hundred years. 2(b) Predict the trend in the number of nuclear weapons over the next one hundred years and the total number of nuclear weapons in the world and in each country in 2123.

2. Establishment and solution of problem model

2.1. Model establishment and solution of problem 1

2.1.1 Solving problem 1(a)

Firstly, the nuclear weapons data of each country over the past years is imported into excel, and then the data with status 3 (0- do not consider possessing nuclear weapons, 1- consider possessing nuclear weapons, 2- pursue or start to manufacture nuclear weapons, 3- possess nuclear weapons) is screened out using excel's screening function. Then excel is used to check the screened countries, as shown in Figure 1. Countries that have ever possessed nuclear weapons include Pakistan, China, North Korea, Russia, France, the United States, South Africa, Israel, India, and the United Kingdom.

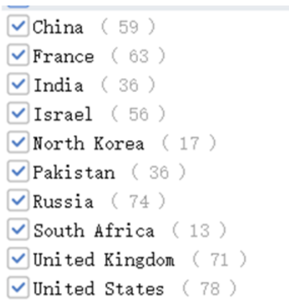

Figure 1. States that once possessed nuclear weapons

2.1.2 Solving problem 1(b)

Firstly, the nuclear bomb inventory of each country in the past 20 years was calculated using excel, and then the maximum and minimum nuclear bomb quantity of each country in the past 20 years were calculated using excel PivotTable to obtain the absolute growth or reduction of the nuclear bomb quantity of each country in the past 20 years. The results are shown in Table 1.

Table 1. Changes in nuclear weapons stockpiles by country (partial)

Country	Minimum value	Minimum value	Absolute value
Pakistan	165	26	139
North Korea	35	0	35
Russia	10114	4300	5814
France	350	290	60
United States	10457	3708	6749
South Africa	0	0	0
Israel	90	76	14
India	160	23	137
Britain	280	180	100
China	350	235	115

2.1.3 Solving problem 1(c)

Using the python platform to read the worksheet data recording the number of nuclear tests, the number of nuclear tests of various countries in the same year is summed up to get the total number of nuclear tests each year. After the results are obtained, the total number of nuclear tests each year is sorted from largest to smallest. The final results are shown in Table 2 1966 and 1961.

Table 2. Five years with the highest number of nuclear tests in history

Year of nuclear tests	Number of tests
1962	178
1958	116
1968	79
1966	76
1961	71

2.1.4 Solving problem 1(d)

Establishment of the model:

We think there are two measures of activity: the size of each country's nuclear stockpile and the number of tests each country has conducted. So we use Topsis model to get the score of each country and judge the activity by the score. The specific steps are as follows: Firstly, excel is used to extract the nearly ten years' data of the reserve scale and nuclear test table, and the data is imported into matlab in the form of a matrix. Since both the amount of storage and the number of nuclear tests are positively correlated with activity, there is no need for positive processing [10]. Then, each set of data is standardized according to formula (1) to remove dimensional effects.

Solution of the model: For each element of Z:

$$Z_{ij} = \frac{x_{ij}}{\sqrt{\sum_{i=1}^{n} x_{ij}^2}} \quad (i = 1,2,\cdots,9\,,\, j = 1,2) \tag{1}$$

In formula, S: Scores for each country; X: The matrix in the warp direction; Z: The standardized matrix for X. Using the scoring formula (2)-(4) :

$$\min Z = [\min\{Z_{11}, Z_{21}, \cdots, Z_{91}\} \quad \min\{Z_{12}, Z_{22}, \cdots Z_{92}\}] \tag{2}$$

$$\max Z = [\max\{Z_{11}, Z_{21}, \cdots, Z_{91}\} \quad \max\{Z_{12}, Z_{22}, \cdots Z_{92}\}] \tag{3}$$

$$S = \frac{|Z - \min Z|}{|Z - \min Z| + |Z - \max Z|} \tag{4}$$

The score for each country was calculated, and then ranked from highest to lowest. The final result was: the United States was the most active.

2.1.5 Solving problem 1(e)

With the help of the worksheet data that recorded the status of each country's nuclear weapons in python platform, we cycled through each country and recorded the time interval that each country began to transition to possessing nuclear weapons. After sorting by the length of time interval, we found that the United States completed the transition from 1939 to 1945, with the fastest speed.

2.2. Establishment and solution of problem 2 model

2.2.1 Problem 2 (a) is solved

(1) Establishment of model

We processed the data of countries' attitudes towards nuclear weapons and plotted the curve of the relationship between different states over time, as shown in the figure below. The pessimistic view is that countries without manufacturing capacity will not have nuclear weapons in the future (Figure 2).

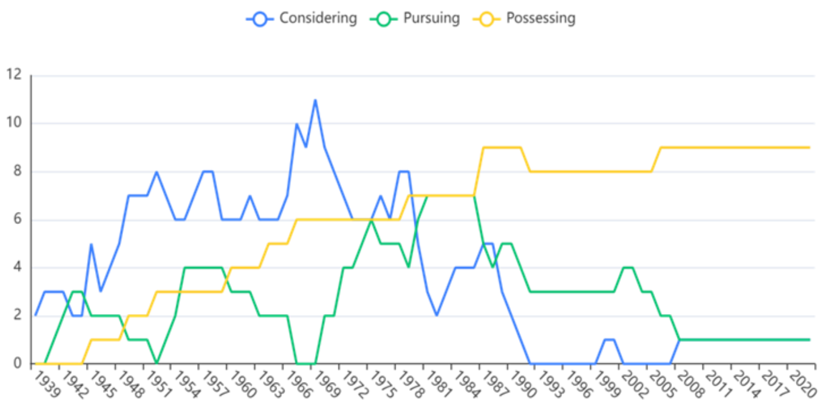

Figure 2. Total number of different attitudes towards nuclear weapons

For countries with manufacturing capabilities, we plotted the number of nuclear weapons stockpiles over time. According to the characteristics of different curves, the rationality of different models is analyzed, and the optimal time series model is selected to predict the number of nuclear weapons in the future.

According to the characteristics of the sequence diagram, nuclear weapon states are divided into three categories, and three kinds of time series models are applied for prediction respectively. We take one example of each type for specific explanation, and other countries are similar. Therefore, the mathematical model of nuclear bomb prediction can be established. The specific steps are as follows:

(1) We found that the sequence diagrams of 4 nuclear states (Russia, France, the United States and the United Kingdom) all meet the following characteristics: ① with a certain linear trend. ②Based on the current economic and political landscape of the world and people's attitudes towards nuclear weapons, the linear trend will gradually weaken. Take France for example (Figure 3).

Figure 3. Number of nuclear weapons in France over the years

Therefore, we build a time series model to predict the number of nuclear bombs in the four nuclear states in the next 100 years, and use the damping trend model in the exponential smoothing model for specific operations, in which the damping trend model is shown as follows:

$$\begin{cases} l_t = \alpha x_t + (1-\alpha)(l_{t-1} + \phi b_{t-1}) \\ b_t = \beta(l_t - l_{t-1}) + (1-\beta)\phi b_{t-1} \\ \hat{x}_{t+h} = l_t + \left(\phi + \phi^2 + \cdots + \phi^h\right) b_t \end{cases} \tag{5}$$

α: Horizontal smoothing parameter; β: Smoothing parameters of trends; ϕ:Damping parameter ($0<\phi\leq 1$) . Notice that if $\phi = 1$, then the damped trend model at this point is the Hult linear trend model. For values between 0 and 1, ϕ has a damping effect on the trend.

Then, spss software was used to draw the forecast charts for the next 100 years of these four countries. The damping trend model of spss time series prediction was selected to obtain the forecast charts of these four countries, also taking France as an example, as shown in Figure 4 and Figure 5.

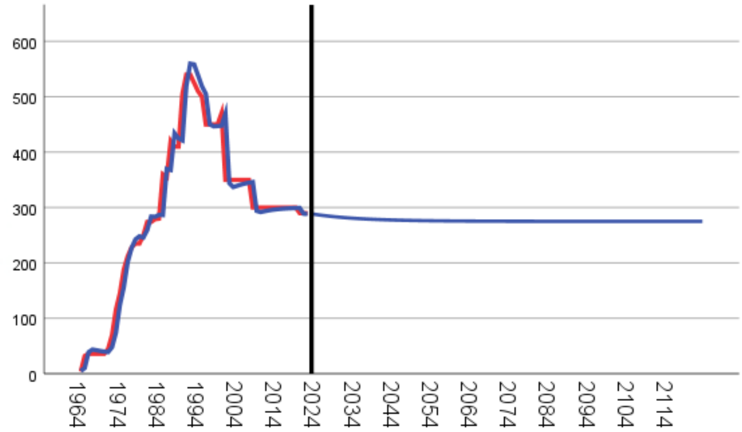

Figure 4. Projection of future nuclear weapons in France

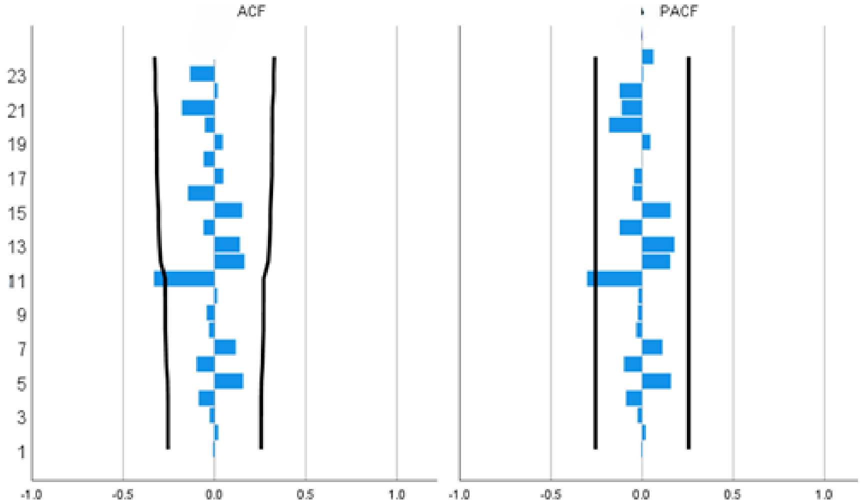

Figure 5. Prediction of ACF in France and visualization of PACF

It can be seen that the residual ACF and PACF do not exceed the upper and lower limits too much within a reasonable range.

To sum up, the French decay trend model is in line with expectations.

(2) We find that the sequence diagrams of Pakistan, Israel, India and China meet the following conditions: ①The image does not contain seasonality .② there is a clear linear trend. Take China as an example, as shown in Figure 6.

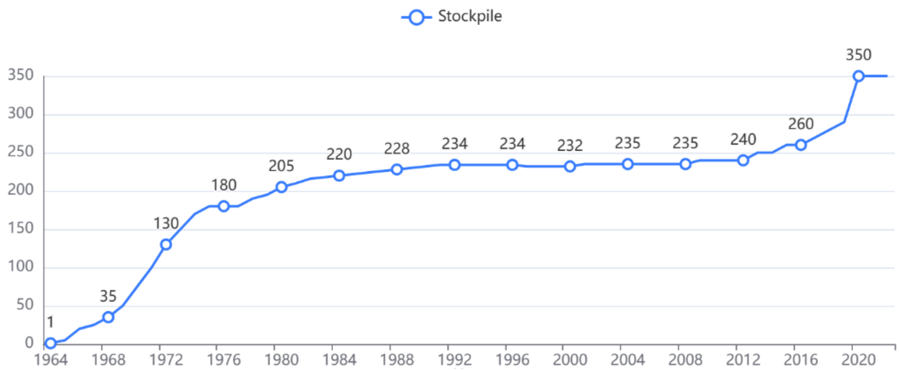

Figure 6. Number of nuclear weapons in China over the years

Therefore, we build a time series model to predict the number of nuclear bombs in the four nuclear states in the next 100 years, and use the Hout linear trend model in the exponential smoothing model for specific operations:

Then, spss software was used to draw the forecast charts for the next 100 years of these four countries, and Brownian linear trend model in spss time series forecast was selected to obtain the forecast charts for these four countries, also taking China as an example, as shown in Figure 7 and Figure 8.

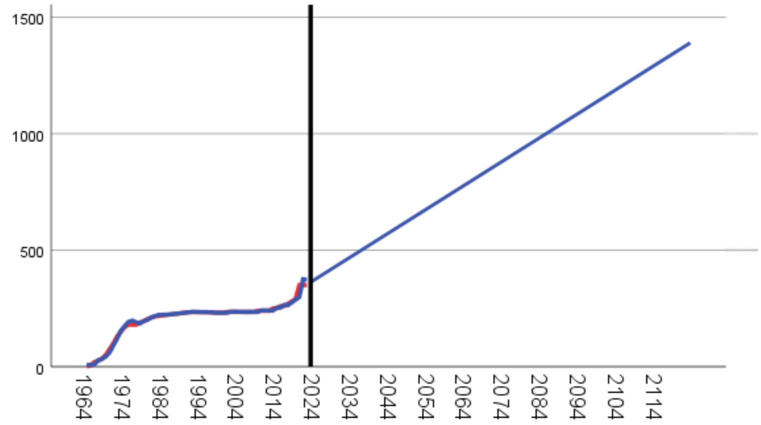

Figure 7. Forecast of the future number of nuclear weapons in China

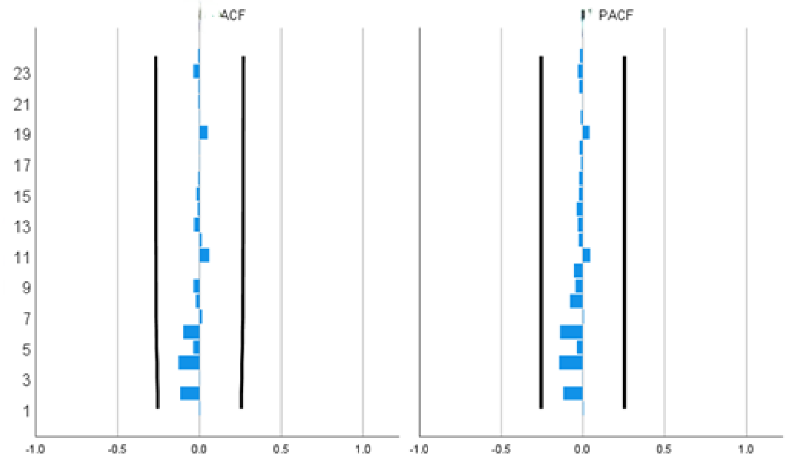

Figure 8. Prediction of ACF in China and visualization of PACF

As can be seen from the figure above, the residual ACF and PACF do not exceed the upper and lower limits within a reasonable range.

To sum up, the Brownian linear trend model of China is in line with expectations.

(3) We found that the sequence maps of the two nuclear states (South Africa and North Korea) all meet the following characteristics: ①Seasonality is not included. ②without trend. In the case of North Korea, the number of nuclear weapons over the years is shown below(Figure 9).

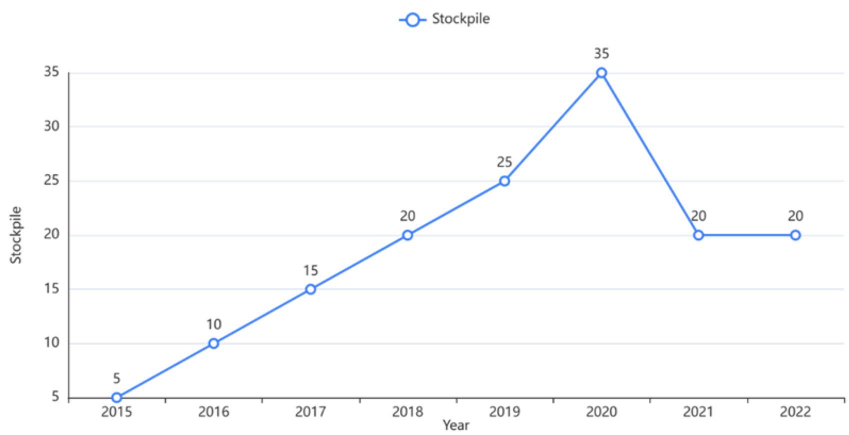

Figure 9. Number of nuclear weapons in North Korea over the years

So we set up a simple exponential smoothing method to predict the number of nuclear bombs in the next 100 years for these two nuclear states, again using North Korea as an example(Figure 10).

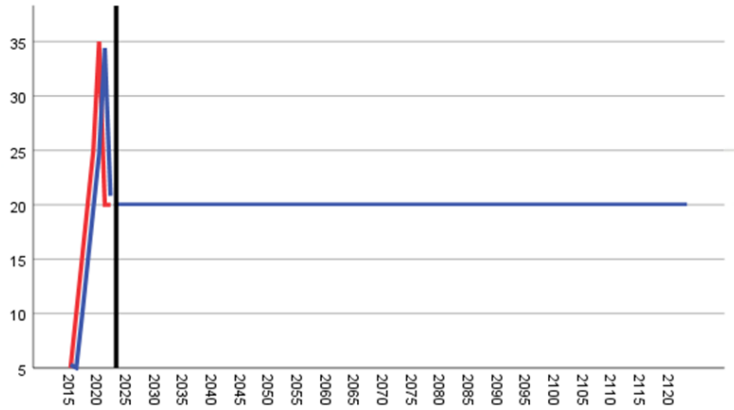

Figure 10. Forecast of the future number of nuclear weapons in North Korea

Figure 11 Forecast ACF of North Korea and visualization of PACF

It can be seen from Figure 11 that the residual ACF and PACF do not exceed the upper and lower limits or even lie in the middle within a reasonable range.

To sum up, the simple exponential smoothing model of North Korea meets expectations.

We believe that the future global nuclear bomb change is naturally equal to the sum of the predicted values of the 9 countries with nuclear bombs. spss is used to draw the global nuclear bomb change and obtain the predicted data of global nuclear bomb change:

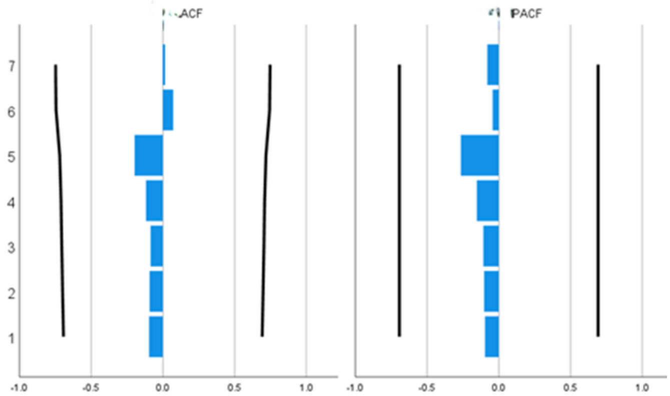

Figure 11. Forecast ACF of North Korea and visualization of PACF

It can be seen from Figure 11 that the residual ACF and PACF do not exceed the upper and lower limits or even lie in the middle within a reasonable range.

To sum up, the simple exponential smoothing model of North Korea meets expectations.

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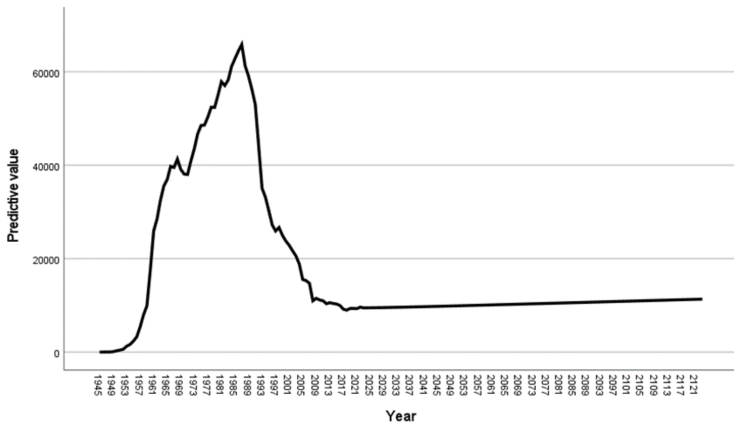

Figure 12. Time nuclear bomb change prediction 1

a asks the mathematical model built above, the country forecasts are: Russia, France, the United States, the United Kingdom, Pakistan, Israel, India, China, North Korea.

2.2.2 Solving Problem 2 (b)

(1) The trend prediction of world nuclear bombs in the next 100 years can be obtained from the mathematical model of Q a, and the trend chart can be drawn with spss (Figure 13).

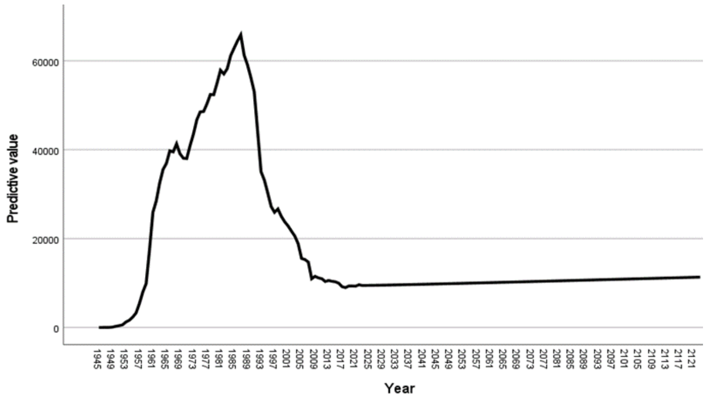

Figure 13. Forecast of nuclear bomb changes in the world 2

(2) The number of nuclear bombs in the world in 2123 can be put into the independent variable of 2123 by the mathematical model created by Q a, and the result can be obtained: by 2123, the predicted total number of nuclear bombs in the world is 11,332.

(3) The countries with nuclear bombs in the future are Russia, France, the United States, the United Kingdom, Pakistan, Israel, India, China and North Korea. The rest thought they would never have a nuclear bomb, so the number was zero. We apply the mathematical model created in Question a to these 9 countries, and draw the forecast chart and data table of each country by using spss. The following takes the United States as an example, and the forecast chart is shown in Figure 14:

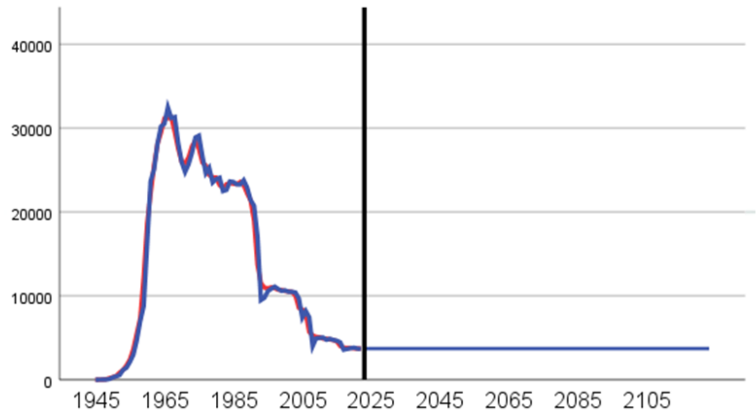

Figure 14. Projection of the future number of nuclear weapons in the United States

3. Conclusion

First, based on the data collected, the countries that have ever possessed nuclear weapons are screened, and the nuclear bomb stockpiles of each country in the last 20 years are counted, and the change in the total number of nuclear weapons of each country is found, and the most change in the nuclear weapon stockpile of the United States in 20 years is obtained. Immediately afterwards, the number of nuclear tests by country was added up by year and the five years with the highest number of nuclear tests worldwide were 1962, 1958, 1968, 1966 and 1961. Subsequently, the stockpile of nuclear bombs and the number of nuclear tests were selected as measures of nuclear weapons research activity, and the Topsis model(Technique for Order Preference by Similarity to Ideal Solution) was used to obtain a score for each country to determine the level of activity, with the United States ultimately having the highest level of activity. Finally, the speed of transition from disregard to possession of nuclear weapons is found, and the final ranking gives the country with the fastest transition speed, again giving the fastest transition speed for the USA.

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