Research on Risk Prediction of Modern Terrorist Attack Cooperation Event Based on Time Series

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ABSTRACT

In-depth study on the cooperative characteristics of modern terrorist attacks and prediction of their development trend is helpful to control risks, strengthen regional security management and improve the effectiveness of counter-terrorism. Based on the data of 192,212 terrorist attacks from 1970 to 2018 provided by the Global Terrorism Database, this paper selects cooperative terrorist attacks, analyzes their distribution regions, proportion changes and other characteristics, and further constructs the cooperative network of terrorist organizations, and finds that the connection relationship continues to become complicated. By constructing a time series model, this paper predicts the trend change of the risk of cooperative terrorist attacks, and obtains the theoretical prediction of two small increases in cooperative terrorist attacks in 10 years. Finally, the risk management of dealing with terrorism cooperation is put forward.

Keywords: *contemporary terrorism; cooperation; terrorist organization networks; ARIMA model; risk prediction*

1. INTRODUCTION

Since the 1970s, contemporary terrorism has evolved as an ideology and controlling ideology that organically mobilizes, gathers, and plans numerous terrorist attacks that injure innocent people and seriously threaten to challenge the contemporary socio-political order and security.

Due to the commonality of ideology and political objectives, terrorist organizations generally cooperate with each other to maintain development, and gradually evolve into a network-like structure [1]. Based on the network of terrorist organizations, terrorist organizations can bifurcate or converge under different conditions, and the evolution of the network over time is complex and unpredictable [2]. The study of terrorist networks reveals that they have the typical small-world effect and scale-free characteristics of complex networks [3]. Under this structure, a large number of collaborative terrorist attacks have occurred, posing a serious obstacle to the international fight against terrorism. At present, research on the current situation and development history of terrorist networks has achieved certain results, but the research work on the prediction of the risk of the occurrence of terrorist organization cooperation events is still relatively lacking. By studying the evolution and development characteristics of cooperative events and cooperation of terrorist organizations, we can grasp the dynamic characteristics of cooperative development of terrorism and effectively guide the management of anti-terrorism risk of deradicalization.

This paper will focus on analyzing the current distribution, proportion, development and other characteristics of cooperative terrorist attacks based on the relevant data involved in terrorist incidents, and making model fitting predictions for their development, so as to study the future development of the cooperative terrorist attack situation of terrorist organizations and give theoretical opinions on anti-terrorist prevention in response to the cooperation of terrorism.

2. DATA SOURCES AND RESEARCH METHODS

2.1 Data sources

This paper applies the Global Terrorism Database (GTD) maintained by researchers at the University of Maryland's National Consortium for the Study of Terrorism and Counterterrorism. The database, which extracts data primarily from media articles, defines

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terrorism as "the threatened or actual use of illegal force and violence by a non-state actor to attain a political, economic, religious, or social goal through fear, coercion, or intimidation." The database is considered to be the most comprehensive database covering terrorist attacks in the world today. This paper collates and analyzes the data of 192,212 terrorist attacks and their related information in the database between 1970 and 2018. First, we extract the required elements from the database and construct a collection of attack elements, mainly including the time of occurrence, place of occurrence, organizer, and type of terrorist attack. At the same time, 2232 incidents belonging to cooperative terrorist attacks, i.e. terrorist attacks involving no less than two organizations, were screened according to the organizations responsible for carrying out the attacks among them.

2.2 Research Methodology

This paper uses Gephi software to construct and extract parameters for the relational network of cooperative terrorist attacks, and draws conclusions by comparing and summarizing these data with corresponding visual presentations. ARIMA model is a time series model proposed by Box-Jenkins in 1970 [4], which is a non-stationary time series using difference to make it into a stationary series after determining the parameters p and q required for the model to determine the model to model the series, after which the original series is obtained by inverse transformation, fitting the model. The optimal model can be obtained by experimentally optimizing the model prediction results for different parameters. The model prediction equation is given in equation (1).

$$y_t = \theta + \varphi_1 y_{t-1} + \varphi_2 y_{t-2} \cdots \varphi_p y_{t-p} + \varepsilon_t - \theta_1 \varepsilon_{t-1} \cdots \theta_q \varepsilon_{t-q} \quad (1)$$

y_t are the sample values, φ_i (i =1, 2,…, p) and θ_j (j =1, 2,…, q) are the model parameters, and ε_t are the white noise sequences obeying independent normal distribution N (0 , δ). p, d, and q are the parameters of the model [5].

This paper uses python programming to model collaborative terrorist attacks and obtain ARIMA time series models of their development, so as to conduct predictive analysis in the hope that the analysis can understand to grasp the characteristics and development dynamics of collaborative terrorist attacks.

3. ANALYSIS OF TERRORIST ORGANIZATION NETWORK COOPERATIVE DEVELOPM-ENT

To highlight the trend of concentrated distribution of cooperative terrorist attacks, a location word cloud map (Figure 1) is constructed using the locations of the events. It can be seen that the countries with more occurrences include: South and Central Asian countries such as India, Philippines and Pakistan, West Asian countries such as Israel and Iraq, and South American countries such as Colombia, Concentrated in central Asia, South Asia, West Asia, Central Africa, north South America and other regions.

Figure 1: Word cloud map of regions where cooperative terrorist attacks occur (photo credit: original)

Also, by comparing the characteristics of the overall terrorist attack distribution, it is found that the regions where cooperative terrorist attacks are concentrated are subsets of the regions where overall terrorist attacks occur intensively. However, some of the regions where overall terrorist attacks occur intensively, such as Europe and the United States, do not belong to the regions where cooperative terrorist attacks occur intensively. These regions are developed areas and do not have large terrorist groups gathered, and terrorist attacks in these places do not form larger groupings, so they are not conducive to cooperative terrorist attacks. Most of the regions where cooperative terrorist attacks are concentrated are less developed, and most of them are politically unstable and war-torn, which is conducive to the emergence and development of terrorist organizations, and some of the bases of large terrorist organizations are concentrated in these regions (Islamic State is mainly in the Middle East, Taliban is mainly in Central Asia, etc.). Such regions are able to form more complex cooperative networks, which can also breed the growth of small terrorist organizations and provide sufficient conditions for the development of cooperative terrorist attacks.

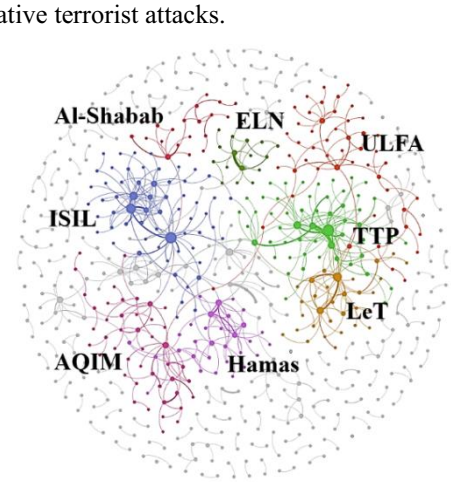

Figure 2: Terrorist Organization Cooperation Network (photo credit: original)

In this paper, the participants involved in collaborative terrorist attacks are extracted, and terrorist organizations that have common participation in terrorist attacks are set to have connections, so as to construct the connection network. The terrorist organization linkage matrix is imported into the software Gephi to obtain the linkage network as in Figure 2. Intuitively, it is found that the main network shows the trait of a nebula, forming a network system including eight larger groups and many smaller groups, and the names of the largest terrorist organizations in the range of eight groups are marked as follows: Islamic State of Iraq and the Levant (ISIL) in the blue network, Tehrik-i-Taliban Pakistan (TTP) in the lime green network, Lashkar-e-Taiba (LeT) in the brown network, Al-Qaeda in the Islamic Maghreb (AQIM) in the pink network, Islamic Resistance Movement (Hamas) in the purple network, Al-Shabab in Somalia, Ejército de Liberación Nacional (ELN) in the dark green network, and the United Liberation Front of Assam (ULFA) in the orange network. As a whole, the network of terrorist organization links is complex, mostly in the form of groups connected to each other exist, the center of the group is generally a larger terrorist organization, and there are intricate relationships between groups and groups. In the network system, the blue network involves the most nodes, the network system is the most massive, and the other networks connected are also the most numerous, visually showing the development of the Islamic State-centered terrorist organization network is large.

In order to observe the changes of terrorist organization relationship network, this paper sets every five years as a small interval, and visualizes the terrorist organization relationship network for each interval, as shown in Figure 3. The study calculates the amount of network feature correlation based on the network constructed above, so as to analyze the trend of network topological features (simplifying the year to 7f0 for 1970, 00 for 2000, and the rest in the same way).

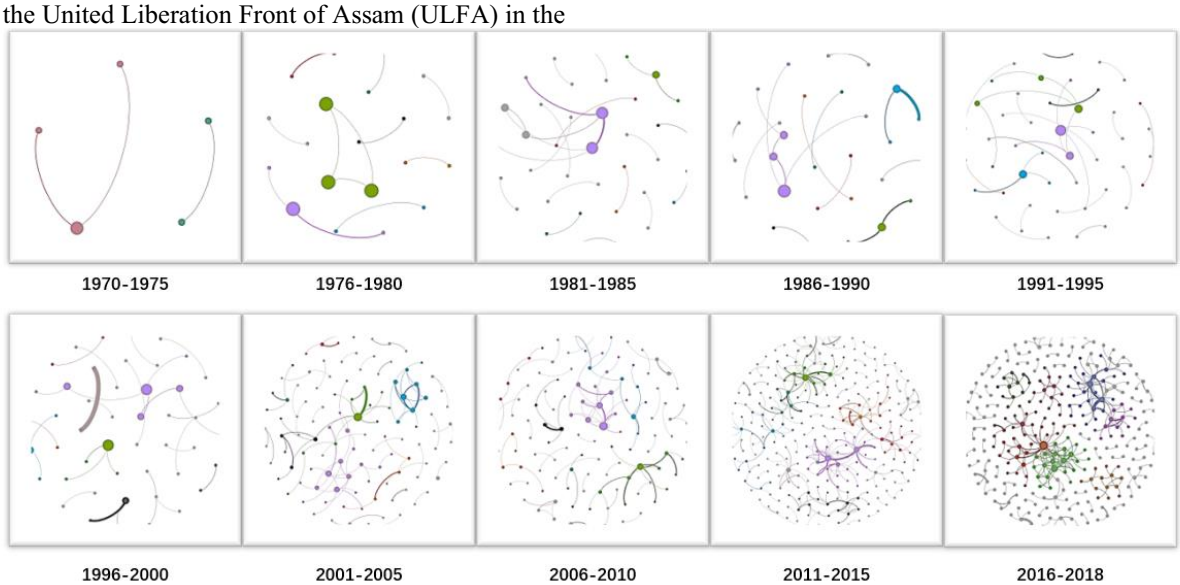

Figure 3: Map of changes in terrorist organization contact networks (photo credit: original)

The average degree and the average weighted degree mainly measure the average of the number of other nodes connected to the network nodes. From the data, it is clear that the average degree and the average weighted degree in this network only decreased from 1991 to 1995, and the rest of the interval had a relative increase, the number of partnerships of terrorist organizations increased.

The network diameter is the maximum value of the distance between any two nodes; the graph density indicates the actual number of edges of the network nodes divided by the maximum possible number of edges. It mainly measures the overall size and completeness of the network. The network diameter increases from 2 to a level of about 10, which indicates to some extent that the network volume is increasing and more nodes are involved. The relative decrease in graph density indicates that some of the nodes in the network are not directly connected, showing a certain degree of sparseness in the cooperative relationship, which is consistent with the nature of presenting multiple cooperative groups in the network.

Modularity indicates the degree of network community segmentation, and it is generally considered that the higher the value the better the network community segmentation, taking values in the range [-0.5,1). This network modularity is relatively stable at a high level after increasing from 0.375 to about 0.8 from 1976 to 1980, indicating that the cooperative group corresponds to a better community segmentation.

The connection component is used to indicate the largest set of interconnected nodes in the network and can show the size of the largest group in the network. The

network connection component only decreases from 1986 to 1990, and the rest of the interval shows an increase, from 2 to 55 overall, expanding more than 20 times, indicating that the size of the largest group in the network increases rapidly.

The average path length refers to the average of the shortest paths between all nodes in the network, which demonstrates the so-called "small world" effect and reflects how the nodes are embedded in the network. In terms of data variation, this feature is cyclical in nature, with some ups and downs, but generally rises from about 1 to about 3, which also reflects the expansion of the transmission of cooperative relationships.

It can be found that the network of terrorist organizations cooperating in terrorist attacks shows an overall trend of increasing complexity, with more and more organizations involved in the network and increasing complexity of the connection network. In particular, from 15-18 years, compared to the network graphs of previous intervals, this interval, although corresponding to only three years of data and according to previous data indicating a decrease in the number of terrorist attacks as well as the percentage of cooperative airstrikes, the network of terrorist organization cooperation has developed to a very dense level. This suggests that even though the number of terrorist attacks worldwide has increased or decreased with each year, the collaboration of terrorist attacks is continuously strengthening and its network of connections is tending to become more and more dense and complex.

4. RISK AND MODLE ANALYSIS OF COOPERATIVE TERRORIST ATTACK

This paper collates both terrorist attacks and collaborative terrorist attacks. Based on the change in the number of terrorist attacks per year and the percentage of cooperative terrorist attacks in the overall, a line graph is drawn in Figure 4.

Overall, the number of terrorist attacks showed an upward trend from 1970 to 2014, with some ups and downs in some years. after 2014, the number curve gradually decreased, corresponding to the fact that terrorist attacks were somewhat suppressed due to the increased global counter-terrorism efforts, and many terrorist groups led by ISIS received a huge compression after 2014, but still at a high level.

The corresponding curve of the percentage of cooperative terrorist attacks has a smooth trend of change in volume from 1970 to 1992, but four peaks of growth in 1993, 1998, 2003, and 2016, respectively, and the corresponding overall terrorist attacks are instead at a low point at the time of the four peaks, indicating that when terrorism is suppressed, terrorist organizations tend to adopt cooperative terrorist incidents. Based on this, a superficial analysis of the reasons for the growth peaks.

In 1992, the Security Council adopted a resolution concluding that Libya was harbouring terrorists and imposing sanctions against it. In 1993, there was a sudden decline in overall terrorist attacks, while at the same time, there was a spike in collaborative terrorist attacks [6]. In 1998, the percentage of collaborative terrorist attacks peaked again, but the number of terrorist attacks and fatalities declined that year, in part due to the increased attention paid to terrorism worldwide and the increased international cooperation in counterterrorism. In 2001, following the 911 attacks, the United Nations adopted a series of counterterrorism documents [7]. In 2001, after the 911 attacks, the United Nations adopted a series of counter-terrorism documents, which led to an unprecedented increase in national counter-terrorism efforts and a crackdown on terrorist groups, which led to a clear trend toward collaborative terrorist attacks, with a peak in 2003 [8].

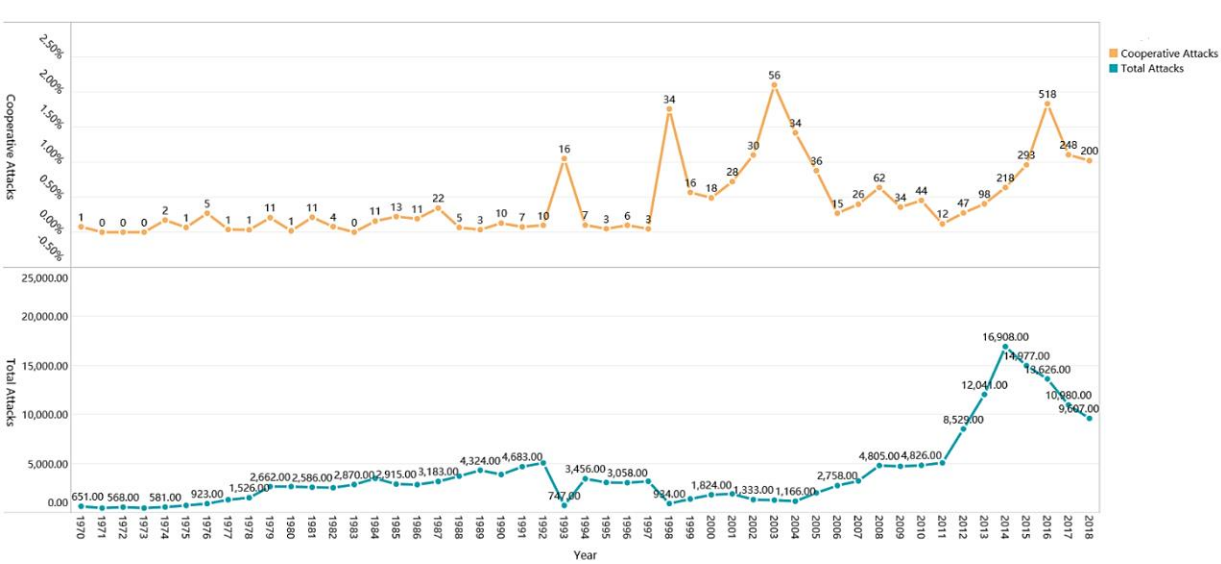

Figure 4: Line graph comparing the change in the number of cooperative and overall terrorist attacks (photo credit: original)

The global financial crisis in 2008, the widening gap between rich and poor in developing countries, and the worsening of terrorism, the rapid rise of the Islamic State, formerly partly derived from the Iraqi branch of al-Qaeda, after the withdraw of U.S. forces from Iraq in 2011. The overall terrorist threat rose. With the late defeat of ISIS and the continued loss of base areas, related terrorism has been suppressed [9].

In order to study and analyze the future trend of collaborative terrorist attacks more deeply, it is necessary to predict their situations.

4.1 Processing of data on the percentage of collaborative terrorist attacks

In this paper, ARIMA time series model is used to fit and predict the cooperative terrorist attacks. In constructing the ARIMA model, the three parameters p,d,q related to the model need to be determined to construct the fitted model.

Since the existing data are not smooth enough, we need to perform the difference operation to get a smooth time series, differencing order d is set to 1.

4.2 Determine the model parameters

The autocorrelation plots show the autocorrelation coefficients at lags 1 to 5 exceed the confidence bounds, and the values of the autocorrelation coefficients shrink to 0 after order 5. The partial autocorrelation coefficients at lags 1 to 4 exceed the confidence bounds. And both plots decay to zero after nth order.

So, there are the following models to choose from: ARMA (0, 1) moving average model with order q=1; ARMA (5, 0) autoregressive model with strata p=5; ARMA (5, 1) mixed model, etc. In this paper, AIC, BIC, and HQ criteria are used for model selection. The smaller the indicator means the better the model parameters, and ARMA (5, 0) is obtained as the best model.

4.3 Model testing

Testing autocorrelation on the residuals generated by the ARMA (5, 0) model revealed that the continuous residuals were not autocorrelated.

The D-W test was performed on the model and the D-W test value is calculated to be 2.05. The model does not have first-order autocorrelation.

4.4 Model testing

Comparing the curves drawn by the fitted model with the original data model, it can be seen that the model can be fitted to approximate and can better explain the data changes, especially the development peaks and troughs can make better predictions. At the same time, the data changes show a certain cyclical nature, reflecting the data trend presented by the development of the percentage of cooperative terrorist attacks in the overall terrorist attacks. The cooperative terrorist attack proportion prediction model is adopted for risk prediction.

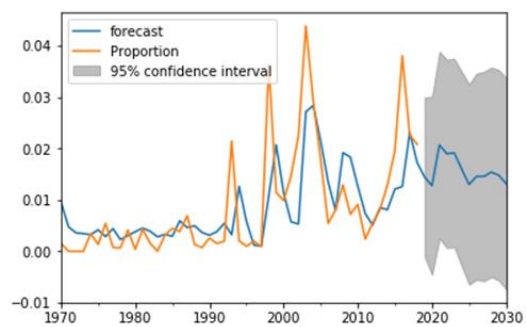

Figure 5: Collaborative Terrorist Attack Share Forecast for the Next Years (photo credit: original)

Setting the forecast interval to 2018 to 2030 and making the forecast to get the results, it can be seen that the share situation may reach a trough in 2020 and then see a small increase again, after which it decreases again. A much smaller one with a small peak again around 2027. This illustrates the cyclical trend in the development of cooperative terrorist attacks, where terrorist organizations may adopt more cooperation to maintain their influence and International security risk will increase.

5. CONCLUSION AND RECOMMENDATIONS

5.1 Main Conclusions

First, collaborative terrorist attacks are more concentrated in the Middle East, South Central Asia, and other regions. On balance, Europe and the United States are not where cooperative terrorist attacks are concentrated. Cooperative terrorist attacks mainly occur in unstable areas and areas where large terrorist organizations exist, where it is easier for terrorist organizations to work together to carry out terrorist attacks.

Second, cooperative networks are becoming increasingly complex around the core. While there has been a downward trend in terrorist attacks in recent years after some of the core organizations of the network have been struck, the relationships of the cooperative network have maintained a continuing trend of complexity, and they radiate around the core of the organization.

Third, there is a significant trend toward the risk of terrorist cooperation. Along with the development of terrorist organizations, cooperation has become an important means for more and more terrorist organizations to develop and grow or maintain their influence. In this paper, we analyze and predict the risk of collaborative terrorist incidents. The nature of collaborative terrorist attacks, which rise sharply during the overall low point of terrorist attacks, indicates their role in maintaining terrorist organizations. According to this paper's prediction, the occurrence of collaborative terror attacks may again usher in another cyclical risk peak in the next decade.

5.2 Suggestions

First, counter-terrorism cooperation needs to focus on concentrated regions. Today's large terrorist organizations, including Al Qaeda and ISIS, have been subjected to continuous global counterterrorism efforts. However, the network of terrorist organizations still has a large scale, and the terrorist organizations with cooperative relationships are located in their base areas to carry out extensive cooperative terrorist attacks, and are likely to expand again. Therefore, it is necessary to strengthen the global counter-terrorism efforts in the face of the large scale of terrorist organizations.

Second, there is an urgent need to combat the cooperation of counter-terrorism by striking the core organizations. Terrorist networks tend to expand around the core terrorist organizations, and eliminating the core terrorist organizations is a better initial measure to combat counterterrorism cooperation.

Third, the fight against counter-terrorism cooperativeness should be eradicated from point to point. After grasping the law of the development of terrorist organization networks, efforts should be made to reduce the interaction between organizations and the role of help to improve the effectiveness of the fight against terrorist organizations. Follow the vine, focus on the whole, maintain the fight against other nodes in the network of terrorist organizations, and reduce the possibility of collaborative terrorist attacks to enter a low point and then go back to high.

Based on the data of terrorist attacks in the Global Terrorism Database from 1970 to 2018, this paper conducts a systematic study to gain insight into the development status and trends of collaborative terrorist attacks. In order to facilitate uniform quantification and analysis, this paper mainly studies the number of cooperative terrorist attacks, and does not consider other connected behaviors among terrorist organizations, such as financial assistance, technology sharing, and personnel mobility, etc. The cooperation relationship thus defined has certain limitations in itself.

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REFERENCES

[1] Feng Weiguo, Lan Di, Gou Zhen (2018). Exploring the Frontier Issues of Counter-terrorism and De-extremism. China University of Political Science and Law Press: Serving Northwest China's Stable Development and National Security Research Series. 373.

[2] Fu Julei, Sun Duoyong, Xiao Jin, Wang Shouyang (2013). A Review of Terrorist Organization Network Research Based on Social Network Analysis Theory. Systems Engineering Theory and Practice. 2177-2186.

[3] Jin Xiaozhe (2020). Terrorism and Counterterrorism Cooperation in Southeast Asia in the Post-Islamic State Era. Southeast Asia Studies. 40-64,154-155.

[4] LI Benxian, Li Mengjun, Fang Jinqing, Yang Jinxin (2013). Spatio-temporal Evolution Law of Terrorist Organization Network. Journal of Automation. 770-779.

[5] Rao J. N. K., Box G. E. P., Jenkins G. M. (1972). Time Series Analysis Forecasting and Control. Econometrica. 40(5).

[6] Li Zhichao, Liu Sheng (2019). Comparison of Forecasting Based on ARIMA Model, Gray Model and Regression Model. Statistics and Decision Making.38-41.

[7] Wang Wulin, Lin Yao, Xu Zonghuang, Zeng Xianjun, Wang ChengXuan (2021). A Study on the Hazard Evaluation and Spatial and Temporal Evolution of Global Terrorist Attacks from 2000-2018. Human Geography. 36(05):92-100.

[8] Wang Xiumei (2020). Global Terrorist Crimes: Situation, Response and Law Enforcement Cooperation. Jurisprudence. 165-179.

[9] Wang Zhen (2022). From "Fellow Travelers" to "Deadly Adversaries": The Evolution of the Perception of Islamic Extremism in the U.S. Foreign Strategy Community. West Asia Africa. 3-30,156.