

Spatio-temporal Distribution of Global Terrorist Attacks, Impact of War and Factors Influencing Deaths in Urban Terrorist Attacks, A Quantitative Analysis

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1 Research Question

Terrorist attacks have dominated the international news in recent decades. Different terrorist organizations have launched attacks against civilians to intimidate or coerce a larger audience to accept or satisfy their demands based on different ideologies of politics or religion. After 1970, 93% of terrorist attacks matching the above criteria occurred in cities around the world, which has had a considerable impact on modern urban life. In this study, we use quantitative methods to analyze the spatio-temporal patterns of terrorist attack occurrence since 1970, identify the determinants that influence the casualties of terrorist attacks in cities, and give our suggestions on counter-terrorism based on the conclusions of the quantitative analysis.

Firstly, we used K-means method to cluster the data of the locations where terrorist attacks occurred to detect the broad areas of terrorist attacks, and built a 3-dimensional spatio-temporal clustering model to find out the spatio-temporal patterns of terrorist attacks and provide corresponding explanations. Furthermore, we build multiple linear regression models and multiple mixed-effects regression models to analyze the impact of the state of total war on the number of terrorist deaths by combining data from the World Bank at the national annual level, demonstrating that war is the best catalyst for terrorism and that the worst order is better than no order in terms of counterterrorism. Finally, focusing on each of the terrorist attacks that occurred in the global cities, we built a logistic regression model to evaluate which factors have significant effects on whether the terrorist attack resulted in a fatality, and found a series of characteristics that significantly increase the risk of terrorist attacks, such as specific attack methods, weapons, and targets, which could also predict whether the attack would result in a fatality based on the relevant characteristics with the model accuracy of 78%.

2 Literature Review

Hasisi spatially clustered car terror attacks in Israel Palestine in his study(Hasisi et al., 2020), Piatkowska used time series to analyze hate crimes in the UK after a specific point in time(Piatkowska and Lantz, 2021), while Li analyze on the spatio-temporal evolution of terror attacks(Li et al., 2021), in this study we consider both spatial and temporal dimensions for clustering, looking at the distribution of terror attacks in a more global perspective and a 50-year time dimension. Santifort-Jordan in his research focused on suicide terrorist attacks (Santifort-Jordan and Sandler, 2014) analyzed the effect of national level data on the number of suicide attacks using linear regression, but the effect of factors on dependent variable may change with different observers, to capture these random effects we used In order to capture these random effects we therefore used a mixed effect linear regression model. In addition the authors used the number of suicide terrorist attacks as the dependent variable, but there are order of magnitude differences in the population of different countries, and it is obviously unreasonable to directly compare the number of terrorist attacks occurring in countries with billions of people with countries with millions of people, so we calculated the number of terrorist attack deaths per million people in our study based on population.

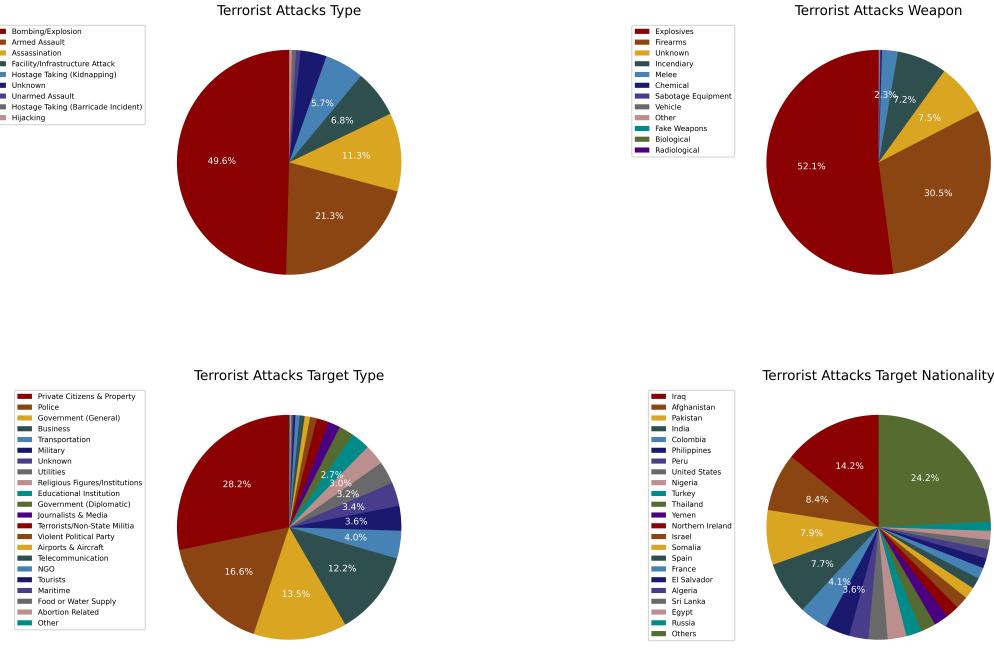


Figure 1: The distribution of terrorist attacks type, weapon used, target type and target nationality.

3 Data

In this study, we used The Global Terrorism Database™ (GTD) from the University of Maryland, which has recorded over 20 terrorist attacks or suspected terrorist attacks since 1970 to date based on reliable media information. We used the GTD provided criteria for filtering out uncontroversial terrorist attacks based on three criteria: First, the attack was motivated by the achievement of political, religious, or other societal goals rather than personal interests. Second, the attackers wanted to deliver their claims to a broader audience through violence, intimidation, or coercion. Finally, the attack itself exceeds the scope that is tolerated under the international laws of war, such as attacks committed against civilians.

As demonstrated in Figure 1, nearly half of the more than 160,000 terrorist attacks since 1970 have been bomb or explosive attacks, followed by armed attacks, with explosives and firearms being the most common weapons used in terrorist attacks. 28% of terrorist attacks were carried out against individuals in public places, with police (16.6%), government (13.5%) and business (12.2%) as the following most frequent targets. And top target nationalities most frequently attacked were Iraq, Afghanistan, Pakistan and India, with these four target nationalities accounting for nearly 40% of all terrorist attacks.

From Figure 2 and Figure 3, we can see that the number of terrorist attacks gradually began to rise since 1970, with a slight downward trend in the 1990s along with the collapse of the Soviet Union, and a rapid rise in the early 2000s with the beginning of the Iraq War, the number of terrorist attacks and deaths reached a peak in 2014 alongside the Syrian civil war and the expansion of ISIS in the Middle East, and then gradually declined, but the number of terrorist attacks remained at a high level until 2020.

Also, we used annual historical data from the World Bank for each country/region, including GDP, population, and unemployment rates to help us quantify the impact of war on terrorism.

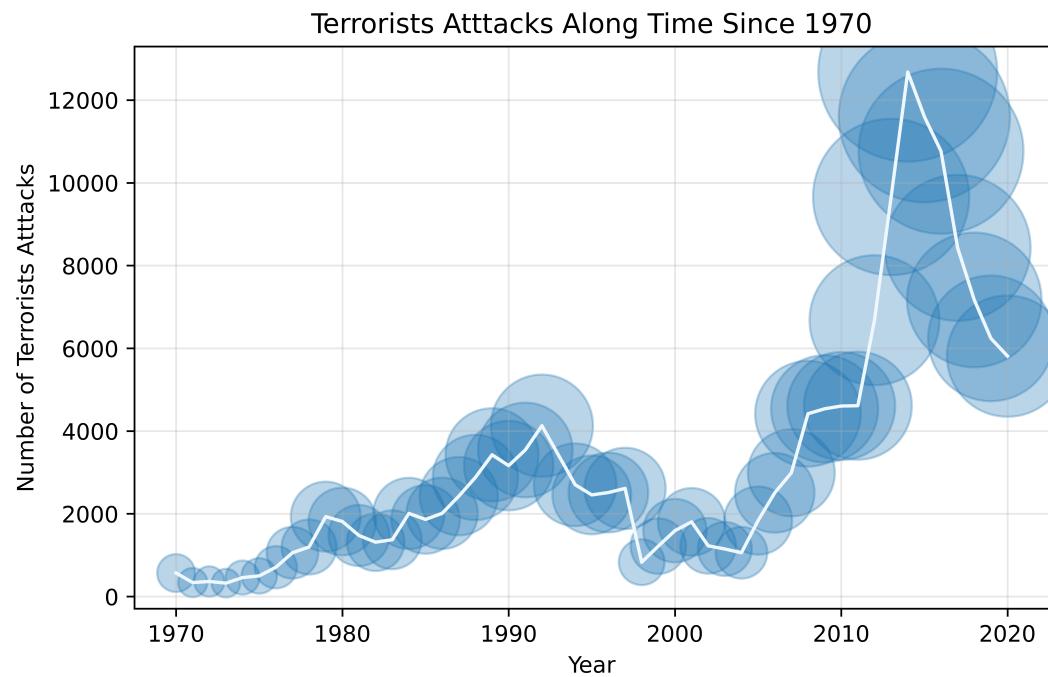


Figure 2: Number of terrorist attacks from 1970 to 2020.

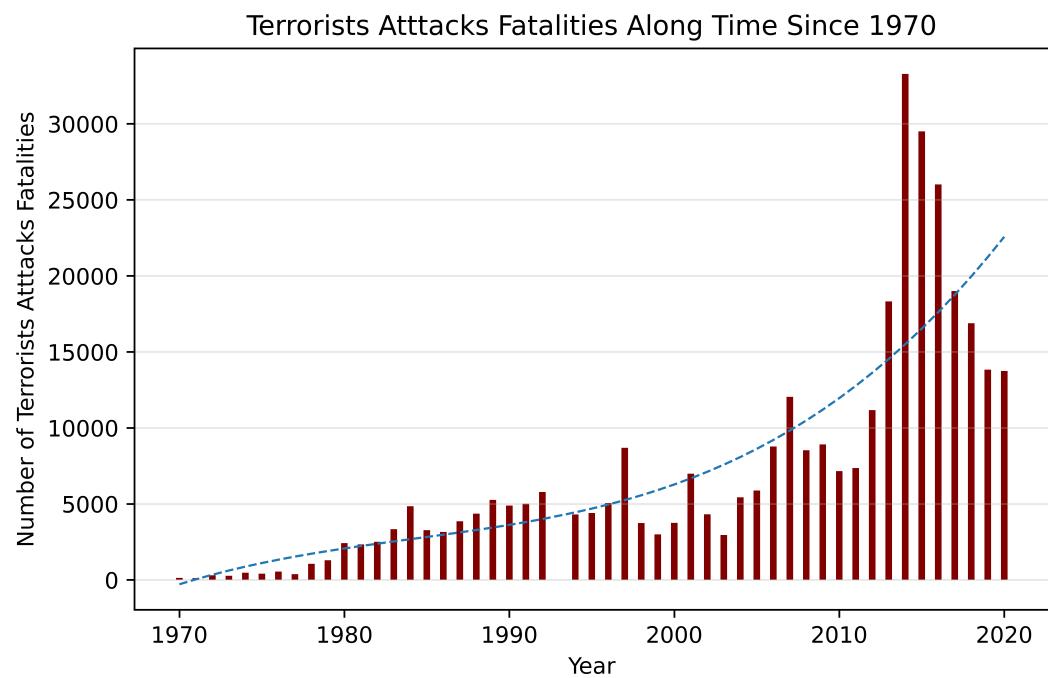


Figure 3: Number of death in terrorist attacks from 1970 to 2020.

4 Methodology

4.1 K-means Clustering

We use the latitude and longitude coordinates of all terrorist attacks to clustering using K-means approach to classify terrorist attacks into five hotspot areas in the spatial dimension for our analysis, by randomly assign all the points into 5 different clusters, calculate the centroid of each cluster, optimize the grouping of points, repeat this process until we get the final clustering.

4.2 DBSCAN Spatio-temporal Clustering

We found that terrorist attacks are clustered not only in spatial but also in temporal dimensions apparently, so we established a three-dimensional coordinate system of longitude, latitude, and time for each terrorist attack for spatio-temporal clustering. For latitude and longitude we define 1 degree as a unit, and 10 months as a unit in the time dimension. In other words we consider that a difference of 1 degree in latitude or longitude in space and 10 months in time have the same spatio-temporal distance. This setting is made by the author based on historical data, and possible flaws will be discussed in the limitation section. We applied the DBSCAN method to search for a cluster of at least 3000 terrorist attacks clustered within a sphere of 60 months (5 years) difference in time and 6 degrees around a point in latitude or longitude.

4.3 Mixed Effect Multiple Linear Regression

We developed a mixed effect model to examine the effect of whether a country is at full-scale war on the number of terrorist deaths per million people per year in a country. The main reason for using a mixed effect is that we found that whether a country is at full-scale war varies widely across countries. For example, there is an order of magnitude difference between the number of deaths per terrorist attack in Afghanistan during the Soviet War in Afghanistan (1979-1989) (185) and the U.S. War in Afghanistan (2001-2021) (49,971). Yemen, which is in a state of civil war, has about 7 terrorist deaths per million people in 2020, while Somalia, which is also in a state of civil war, has about 21.

$$Y_{ij} = X_{ij}\beta + Z_{ij}\mu_{ij} + \varepsilon_{ij}$$

$$\varepsilon_{ij} \sim \mathcal{N}(0, G)$$

Where Y_{ij} denote the number of deaths per million population in country i from terrorist attacks in year j . X_{ij} represent the characteristics of country i in year j , including per capita gdp and unemployment rate. β represents the fixed effect of the relevant feature. Z_{ij} represents the random effect characteristics, and μ_{ij} is the matrix capture the random effects. ε_{ij} represents the error term in the model.

4.4 Logistic regression

For terrorist attacks in cities, we built a logistic regression model to determine whether the terrorist attack would result in a fatality based on the type of terrorist attack, the type of weapon, the type of target and the area where it occurred, and whether it was a suicide attack. In the logistic regression we performed an exponential transformation of the multiple linear regression.

$$\ln\left(\frac{Y}{1-Y}\right) = \sum_k \beta_k x_k + \beta_0$$

Which Y denote the probability of death in the terrorist attack, and β_k capture the effect of the characteristics x_k include the weapon type, target type, etc on the dependent variable. We use 75% of the data to build the model and 25% of the data as the test set.

Global Terrorist Attacks K-means Clustering Map

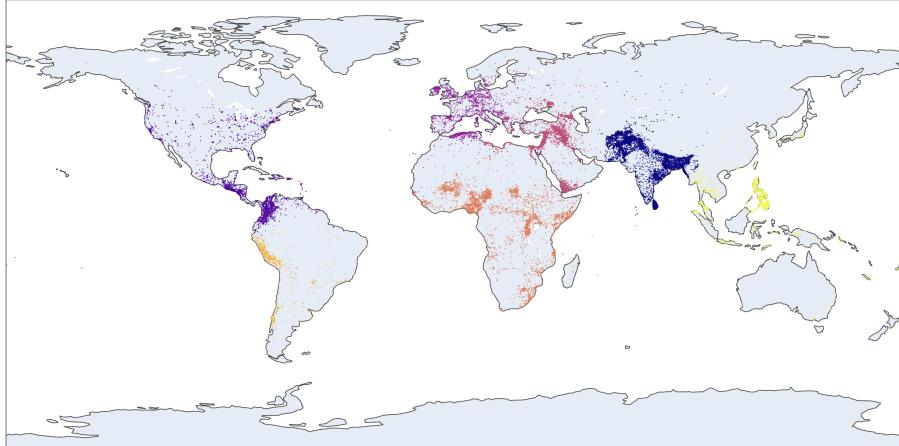


Figure 4: K-means clustering terrorist attacks from 1970 to 2020.

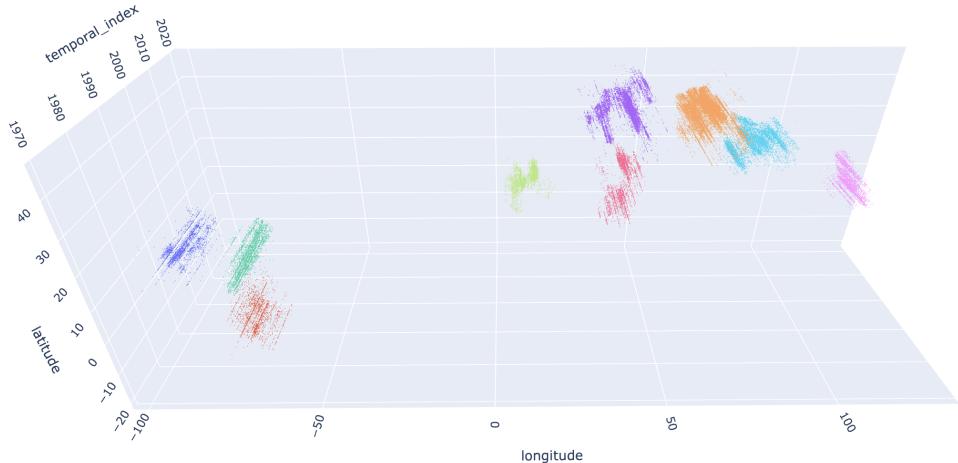


Figure 5: DBSCAN spatio-temporal clustering terrorist attacks from 1970 to 2020.

5 Results

We can cluster terrorist attacks since 1970 into five categories shown in the Figure 4, Middle East and Arabian Peninsula, Central and South Asia, Europe and North Africa, Sub-Saharan Africa, Southeast Asia, North and Central America, and Latin America. All of these regions have been or are in war or conflict, so we include temporal dimension to conduct a spatio-temporal clustering.

We identified 9 spatiotemporal regions with high clustering of terrorist attacks, 3 of which appeared in Latin America in the last century, including attacks in the lost decade of Peru mainly by left-wing terrorist groups such as Shining Path, MRTA, and terrorist attacks in the continuing civil wars in Colombia and Guatemala. The remaining 6 appear in this century and we find terrorist attack clusters highly correlated with the wars in Afghanistan (2001-2021), Iraq (2003-2011) and Syria (2011-present), Yemen and Somalia civil wars, and the Borg Haram insurgency in Nigeria. Terrorist attack clusters appearing in India and Pakistan, and the Philippines are mainly due to local separatist groups, leftist terrorist organizations, and religious extremist groups.

We find that most of the clustering occurs in countries and regions where there is an active major war,

Mixed Linear Model Regression Results						
Model:	MixedLM	Dependent Variable:	nkill_million			
No. Observations:	5043	Method:	REML			
No. Groups:	2	Scale:	122.7554			
Min. group size:	221	Log-Likelihood:	-19303.7141			
Max. group size:	4822	Converged:	Yes			
Mean group size:	2521.5					
	Coef.	Std.Err.	z	P> z	[0.025	0.975]
Intercept	-84.045	41.032	-2.048	0.041	-164.465	-3.624
gdp	-0.000	0.000	-2.119	0.034	-0.000	-0.000
year	0.050	0.019	2.627	0.009	0.013	0.087
unemployment	0.048	0.025	1.949	0.051	-0.000	0.096
major_conflict	Var 465.252	58.132				

Figure 6: Mixed Effect Multiple Linear Regression Results

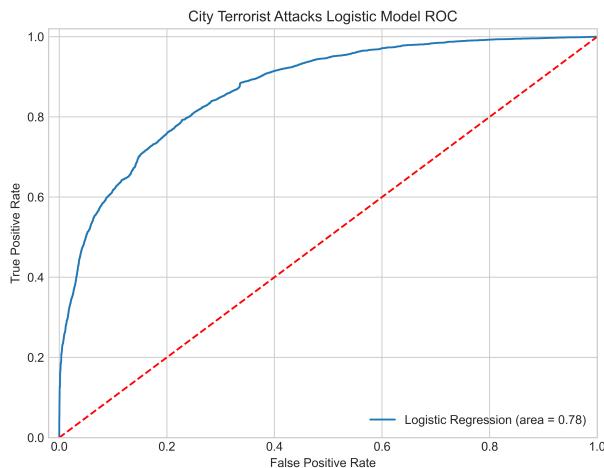


Figure 7: Logistic Regression Model ROC-Curve

so we build a mixed effect linear regression to estimate the effect of whether a country is at war or not on the number of terrorist deaths in that year, controlling for local GDP per capita and unemployment rate, and weighting the number of terrorist deaths per million based on the country's population in that year.

From the results of the model in Figure 4 we can find that random effect, whether the country was at war or not in that year, can explain $\frac{465.25}{122.76+465.25} = 79.12\%$ of the variation in dependent variable, the number of deaths per million people in the country that year.

The AUC of our logistic regression model is 0.78 shown in Figure 6, while the prediction accuracy of the model is approximately 78%, allowing us to determine whether the attack will result in a death based on the information related to the terrorist attack.

	Precision	Quantity
False	0.81	20162
True	0.75	17776
Overall	0.78	37938

Table 1: Predict results from the logistic model.

Meanwhile, we identified a series of factors that significantly correlated to the increased risk of death from terrorist attacks. If a terrorist attack is successfully conducted, it leads to an approximately a 27 times higher risk of death on average; if the terrorist attack is a suicide attack, it leads to a 101 times higher risk; compared to unarmed attacks, the risk of assassination is 88 times higher and the risk of explosion is 5 times higher; in terms of weapons for terrorist attacks, the risk of common explosives is reduced by 90% compared to vehicle bombs; compared to terrorist attacks against government , the risk of targeting military units is 196% greater than the former, and the risk of police units is 116% greater than the former.

6 Discussion

There are still some limitations in our study, first of all, the GTD data we used is missing from 1993 for physical reasons, and there is no definite global standard for terrorist attacks, each sovereign state classifies different organizations as terrorist organizations for their own considerations, for example, Hezbollah in Lebanon, which has been elected to the Lebanese parliament and participated in the formation of a coalition government, is classified as a terrorist organization by Western countries and The League of Arab States. These very different criteria greatly increase the difficulty of defining a terrorist attack, and thus our study may be considered to ignore relevant data or consider data that should not be considered.

We clustered the global terrorist attacks spatiotemporally, and the choice of relevant parameters is mainly based on historical data, e.g., we found that the majority of total wars lasted less than 5 years, so the time distance of the spatiotemporal clustering was set to 5 years, which may lead to bias that terrorist attacks appearing in a short period of time ignored due to total number of clusters did not reach the set minimum search points. On the other hand the prediction accuracy of our logistic regression is 78%, and some more advanced models such as decision trees can be employed in future study to build prediction models for terrorist attacks in cities, which can further improve the prediction accuracy.

7 Conclusions

Since 1970, terrorist attacks have expanded globally, and we have found that the vast majority of terrorist attacks cluster in war zones and wartime, with the number of terrorist attacks and deaths rising as wars occur, while whether or not a country is at state of war explains 79% of the annual fluctuations in the number of terrorist deaths per million people, so we believe that war is the best catalyst for terrorist attacks, and the best counter-terrorism measure is to end and avoid war.

With 93% of all terrorist attacks occurring in cities, we can predict with reasonable accuracy whether an attack in a city will result in a fatality based on perpetrator, weapon used, and target type. We also believe that more precautions should be taken in urban counterterrorism for specific weapons, such as car bombs, and more protection for high-risk targets, such as military units and police in cities, since the associated characteristics significantly increase the risk of fatalities in terrorist attacks.

8 Appendix

The relevant data and code can be found in the [Github repository](#).

Reference

- Hasisi, B., Perry, S., Ilan, Y., Wolfowicz, M., 2020. Concentrated and Close to Home: The Spatial Clustering and Distance Decay of Lone Terrorist Vehicular Attacks. *J Quant Criminol* 36, 607–645. <https://doi.org/10.1007/s10940-019-09414-z>
- Li, Z., Li, X., Dong, C., Guo, F., Zhang, F., Zhang, Q., 2021. Quantitative Analysis of Global Terrorist Attacks Based on the Global Terrorism Database. *Sustainability* 13, 7598. <https://doi.org/10.3390/su13147598>
- Piatkowska, S.J., Lantz, B., 2021. Temporal Clustering of Hate Crimes in the Aftermath of the Brexit Vote and Terrorist Attacks: A Comparison of Scotland and England and Wales. *The British Journal of Criminology* 61, 648–669. <https://doi.org/10.1093/bjc/azaa090>
- Santifort-Jordan, C., Sandler, T., 2014. An Empirical Study of Suicide Terrorism: A Global Analysis. *Southern Economic Journal* 80, 981–1001. <https://doi.org/10.4284/0038-4038-2013.114>