NOVA School of Business and Economics

Data Visualization

From attacks to insights – A visual analytics study of terrorism, economics and governance

Prof. João Moura Pires

Group 17

António Marques dos Santos – 71212

Simon Anthofer – 71078

Vanessa Weiss – 73217

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1. ABSTRACT

This paper visualizes global patterns or terrorism from 1997 - 2017 to question the widespread perception that the world is becoming increasingly dangerous and to explore how terrorism risk relates to economic development and governance quality of a country.

The data on terrorism provided by the Global Terrorism Database together with the World Bank World Development Indicators and the Corruption Perception Index build the basis for the analysis of terrorist attacks and casualties. The analysis is structured around three analytical questions: (AQ1) how terrorist attacks and casualties have evolved globally and by region since the late 1990s; (AQ2) where terrorism risk is most concentrated once adjusted for population, and how high-, medium- and low-risk countries differ in economic indicators; and (AQ3) whether improvements or deteriorations in governance quality are associated with systematic changes in terrorism intensity.

To address these questions, interactive Tableau dashboards combining time-series plots, choropleth maps, coordinated scatterplots with regression summaries and a dynamic case-study map has been developed. The visuals show that global terrorism risk has not risen steadily over time but is driven by peaks in a few conflict-heavy regions. Furthermore, high-risk countries differ from low-risk ones more clearly in some indicators (e.g. military expenditure) than in others (e.g. income). In addition, better governance is on average associated with lower terrorism, though this relationship is heterogenous and strongly context dependent.

2. INTRODUCTION

Terrorism continues to shape global politics, security policies and daily news. Although the news is not reporting large attacks on a daily basis, a consistent threat is perceived by the society and as soon as an attack is reported it will cover the headlines for weeks and drives governments to review or change their policies. Analyzing the motives and impact of past events as well as monitoring current developments is important to help governments to think about measures for prevention. A deeper understanding of how radicalization happens, how the security of a country and its citizens can be ensured and how the media influences the public opinion are topics which still require further discussion and leaves terrorism a highly relevant topic.

The goal of this paper is to build tools that will enable the reader of this paper to answer the analytical questions on terrorism addressed in this research. For this purpose, three complimentary datasets, each adding specific information to investigate the influences that drive terrorism are selected. The Global Terrorism Database (GTD), maintained by the University of Maryland records individual terrorist incidents worldwide from 1970 to 2021. This dataset will build the basis for the research and is supplemented by the World Bank's World

Development Indicators (WDI), focusing on institutional and governance indicators as well as the Corruption Perceptions Index (CPI), providing a detailed overview of external governance metrics. The focus of the research is to answer how terrorist attacks and resulting casualties in different countries have developed over the past 20 years, if there are any countries which casualty figures are disproportionately high in relation to the size of the population and if there are any economic indicators which could explain the greater risk as well as if the improvement in government quality and the control of corruption may be associated with a decline in terrorist incidents over time.

To answer these questions, the datasets have been preprocessed, and appropriate variables have been selected to build meaningful and effective visualizations in Tableau. The visualizations were essential for moving beyond intuitive impressions about terrorism towards a more evidence-based interpretation. Global and regional time-series plots showed dramatic spikes rather than a steady worldwide increase in risk. Scatterplots with regression lines clarified the impact socioeconomic indicators on terrorism. Finally, the governance scatterplots and dynamic country maps revealed the relationship between governance quality and terrorism. Together, these visuals structured the analysis, exposed outliers, and supported more context-sensitive conclusions than tables or summary statistics alone would allow.

The remainder of this paper is organized into three sections, starting with the introduction of the analytical questions. Based on the selected questions the dashboard design for each of the questions is described, including the technical solutions, use of further analysis using Tableau and how the visuals are implemented to answer the analytical questions. The findings of this research are summarized in the last part with an overall conclusion.

3. ANALYTICAL QUESTIONS (AQ)

3.1 AQ1 – Is the world really becoming increasingly dangerous?

How have terrorist attacks and casualty figures developed in different countries over the past 20 years, and to what extent does this long-term trend contradict the perception that "the world is becoming increasingly dangerous"?

Following the daily global news can give the impression that the world is becoming increasingly violent and dangerous. News related to terrorist attacks receive an extraordinary attention by the media because it is most often associated with a high number of casualties and creates a moment of shock as well as strong emotions for the viewer. The special attention leads many people to believe a rare and specific attack may be a real risk for themselves in their daily lives. AQ1 is challenging this perception by analyzing data on terrorism attacks and their casualties from 1997 to 2017 across multiple regions and countries. By comparing figures on terrorist attacks and casualties (per million people) it can be shown whether citizens are facing a higher

risk of being affected by an attack or not. The analysis is also reviewing if there have been any changes from the beginning of the 20-year period and if today's risk is lower than in the past. Lastly the global spread of terrorist attacks and casualties are analyzed to identify any regional trends.

3.2 AQ2 – Where is terrorism risk concentrated, and how does it relate to economic measures?

Are there certain countries where terrorist attacks figures are disproportionately high in relation to the size of the population? And how do these high-risk countries compare to low-risk countries in terms of economic indicators?

Even if global averages suggest that terrorism is a rare cause of death, the individual risk can be much higher or lower in a subset of countries. AQ2 zooms in on this heterogeneity. First, we identify *high-risk* (top 20), *middle-risk* (middle 20) and *low-risk* (bottom 20) countries based on country-level averages of *Attacks per Million – Country Avg* over the period between 1997-2017. These per-capita measures for the 60 countries in total adjust for population size and are derived from *total attacks* and *population counts*. We then compare these risk groups along several economic development proxies drawn from the merged terrorism–WDI dataset. Economic development is proxied by *GDP per Person – Country Avg* (computed from GDP Current Us divided by population), as well as *Military Expenditure % – Country Avg*, *Research and Development Expenditure % – Country Avg*, *Agricultural Land % – Country Avg*, *Population Density – Country Avg*, and *Inflation Annual % – Country Avg*.

3.3 AQ3 – Does better governance quality go hand in hand with less terrorism?

Are improvements in government quality and the control of corruption associated with a decline in terrorist incidents over time at the country level?

Public debates about terrorism and security often assume that strengthening the state – improving governance quality, reducing corruption and making institutions more effective – will automatically make societies safer. Governments justify institutional reforms partly on these grounds, but it is not obvious that this expectation is borne out in practice, especially when reforms are gradual, uneven or occur in conflict-prone environments. AQ3 addresses this gap by examining whether countries that improve their governance also experience lower terrorism intensity once we adjust for population size. Using a combination of global cross-country comparisons and dynamic case-study evidence, we relate a composite index of governance quality (based on the six World Governance Indicators, including control of corruption, normalized to 0–100) to average and changing levels of terrorist attacks and casualties per million inhabitants over 1997–2017. By comparing both levels and changes in governance with

per-capita terrorism measures, we can ask whether institutional strengthening is systematically associated with sustained reductions in terrorism risk, or whether in many cases violence persists despite better formal institutions. In this way, AQ3 complements AQ1 and AQ2: while they document how terrorism risk has evolved over time and how it is distributed across countries, AQ3 investigates whether long-run improvements or deteriorations in governance help explain why some states become safer whereas others remain trapped in high-risk environments.

4. DASHBOARD DESIGN

4.1 Dashboard 1 – AQ1

Dashboard 1[1] (*AQ1 - Figure 1)* is composed by three visuals which aim to answer AQ1 and provide a detailed understanding on how terrorism attacks and casualties have developed from 1997 to 2017 and if there are any specific countries or regions which experienced an increase in numbers from the first 5 years (covering 1997-2003) and the last 5 years of the period (2012-2017). The visuals support the critical view on the statement stated on top of the dashboard "Is the world becoming increasingly dangerous?", making the reader critically think if the perception of an ever more dangerously world that the media is producing is supported by the present data on terrorism.

On the top left, the overall Global Trend (*AQ1 - Figure 2)* of *average attacks per million* and *average casualties per million* for all countries is presented. The per-capita measures for the 60 countries in total adjust for population size and are derived from *total attacks* and *population counts*. The legend labelled as *Measure* and a filter for *Year,* allow the user to gain a general overview of the trend pattern worldwide. The top right vertical line chart represents the Regional Trend *(AQ1 - Figure 3)* and provides a break-down of following identified regions for this analytical question: *Americas, Asian Pacific, Eastern Europe and Central Asia, Middle East and North Africa, Sub-Sahara Africa and Western Europe*. *Average attacks per million* and *average casualties per million* are the main variables shaping this graph. They are distributed on a dual axis and the filters for *Year, Country* and *Region* can be applied to this graph. By hovering over the lines, the tooltip provides additional information on the *average attacks/casualties per million* for each region.

Lastly the bottom visual shows the stability of *average casualties per million*, broken down by region and country (*AQ1 - Figure 4).* Lastly the bottom visual shows the stability of *average casualties per million*, broken down by region and country. To compute the change in casualty figures the first 5 years (covering 1997-2003) of the 20-year period have been subtracted by the

[1] https://public.tableau.com/views/DataVisualizationG17_AQ1/AQ1-Dashboardtobegraded?:language=de-DE&:sid=&:redirect=auth&:display_count=n&:origin=viz_share_link

last 5 years of the period (2012-2017) have been resulting in a new calculated field *Changes in casualties per million* which is used to generate the values for the y-axis. The legend *Change Category* presents the colors used to encode whether the number of casualties from terror attacks of a country has *decreased* (green), *increased* (red) or has *not changed or very low* (grey). Similarly to the Region Trend visual the filters for *Year, Country* and *Region* can be applied to this measure.

4.2 Dashboard 2 – AQ2

Dashboard 2[2] (please see AQ2 - Figure 1) is designed to answer AQ2 by helping the reader see where terrorism risk is concentrated once adjusted for population size, and how high-risk countries differ economically from medium- and low-risk countries. On the left, a large interactive choropleth map displays average *Attacks per Million – Country Avg* (1997–2017) for all countries, with a legend labelled *Range Measure* and filters for *Region* and *Risk group* so users can focus on specific parts of the world or only on high-risk countries. A compact control panel at the top groups the Risk group, Region and Scatter View selectors, so different perspectives on the data can be explored with a few clicks. On the right-hand side, a parameter called "Scatter View" controls the x-axis of a scatterplot, switching between economic indicators such as *GDP per Person – Country Avg*, *Military Expenditure % – Country Avg*, *Research and Development Expenditure % – Country Avg*, *Agricultural Land % – Country Avg*, *Population Density – Country Avg* and *Inflation Annual % – Country Avg*, while fixed *Attacks per Million – Country Avg* remains on the y-axis. Hence, those different views reveal whether high-risk countries tend to be poorer, more inflation-prone and more densely populated than low-risk countries, and whether some economic indicators correlate more strongly with terrorism intensity than others. Point shapes encode the *Risk group*, point color represents the *Country correlation (*Pearson r between annual attacks per million and the chosen indicator for that country*)* over time, and a trend line summarizes the overall association. The Tooltips show the underlying values per country and the regression equation, R^2 and p-value for the overall trendline. Interactive actions link both views: selecting a country on the map filters the scatterplot to the same subset, and selecting points in the scatter highlights the corresponding countries on the map. Together, the coordinated map and scatter allow users to identify where terrorism risk is highest, how these countries are positioned in the economic indicator space, and whether attacks in each country tend to move together with the chosen indicator or not.

4.3 Dashboard 3 – AQ3

Dashboard 3[3] is designed to answer AQ3 by showing how governance quality and terrorism intensity relate to each other in both levels and changes across countries. The AQ focuses on a

[2] https://public.tableau.com/shared/GSSZ42FFD?:display_count=n&:origin=viz_share_link
[3] https://public.tableau.com/app/profile/ant.nio.santos/viz/DataVisualizationG17_AQ3/DataVisualizationG17_AQ3?publish=yes

subset of 30 countries: the 10 with the largest positive change in governance quality, the 10 with the largest negative change, and the 10 with the smallest change over time. The Dashboard allows to combine for this countries: (i) a change-versus-change view comparing how governance and terrorism evolved between two periods (1997–2006 vs. 2007–2017), (ii) a cross-sectional view of the long-run relationship between governance and terrorism, and (iii) a dynamic map following a small set of case-study countries over time.

The first element shows a change-versus-change scatterplot *(AQ3–Figure 1)* with the change in governance quality on the x-axis and the change in terrorist attacks per million inhabitants on the y-axis. Governance change was measured using the six normalized Worldwide Governance Indicators[4], as the difference in a composite governance index between the two periods, while terrorism change is defined as the change in average attacks per million inhabitants. Countries are represented by colors indicating whether they belong to the top 10 improvers (green), middle 10 (yellow) or bottom 10 decliners (red). The usage of reference lines at zero on both axes creates four quadrants, allowing the reader to easily identify countries that improved or deteriorated in governance and whether this coincided with higher or lower terrorism.

The second component is a cross-sectional scatterplot of long-run levels *(AQ3–Figures 2–5)*. The x-axis shows average governance quality over 1997–2017 (Gov_Q_Avg_97_17, on a 0–100 scale), and the y-axis shows average terrorist attacks per million inhabitants over the same period on a log scale. Each dot is a country, with size reflecting average casualties per million. Horizontal and vertical reference lines mark global averages, partitioning the space into "high/low governance" and "high/low attacks" areas, while a fitted curve summarizes the overall association in each view. The full-sample scatter *(AQ3–Figure 2)* displays all countries, whereas *(AQ3–Figures 3–5)* filter separately to the top 10 improvers, middle 10 and bottom 10 decliners, so that the reader can see how the same variables behave within each governance-change group.

The third component is a dynamic map of five case-study countries *(AQ3–Figure 6*), selected to provide a small but informative sample from all three governance-change groups: Georgia and Indonesia (top improvers), Sri Lanka (middle group), and Thailand and Greece (bottom decliners). These cases were chosen because they cover all three categories, have complete data for 1997–2017, and are geographically relatively close (Europe and Asia), which facilitates visual comparison on a single map. Data are aggregated into two-year bins, and for each country–bin combination the average governance index and average attacks per million are computed. Country color encodes the change in governance relative to the previous bin, while the size of the yellow circle represents the log of average attacks per million. This temporal

[4] Voice and Accountability; Political Stability and Absence of Violence/Terrorism; Government Effectiveness; Regulatory Quality; Rule of Law; Control of Corruption.

perspective makes it possible to visually track how governance and terrorism co-evolve within specific countries, complementing the cross-country patterns shown in the scatterplots.

5. CONCLUSIONS

5.1 AQ1 – Conclusion

Global Trend of attacks and casualties

Global attacks and casualties per million show spikes in specific periods (2007 and 2014) which can easily lead to the interpretation that in fact the world is becoming more dangerous. But looking at the visualization, it can be identified that there is no simple continuous trend acknowledgeable in the past 20 years. Specific and clearly impactful events mislead the perception and a clear downwards trend can be seen after the year 2014. Further analysis of the latest data from 2017 onwards would support the understanding if the average of attacks and casualties may have already dropped below the level of the year 2010.

Regional Trend of attacks and casualties

A more detailed look at the different regions provides additional insights into highly effected regions such as the Middle East and North Africa as well as to some extend Eastern Europe and Central Asia. These two regions reveal as the most significantly impacted regions in the past 20 years with increased average numbers of attacks and casualties in different periods of time. The remaining regions in comparison are impacted only minor with an average of attacks per million remaining below a threshold of 4 attacks per million people.

The Global and Regional Trend suggest that the increase in global counts is driven by a small number of conflict heavy regions, and no worldwide rise is supported by the visualized data. When normalized by population, for many people in many countries, the risk has not systematically increased. This contradicts the initial statement that “the world is becoming increasingly dangerous”. This observation is finally confirmed by comparing the average number of casualties between 1997-2003 and 2012-2017. A clear outlier can be detected easily and when further filtering for the region Middle East and North Africa, Iraq can be identified as the country with the highest increase in casualties with an average of 604,6 million casualties per million people from 1997-2003 to 2012-2017.

Role of visualization

The visualizations used in this dashboard have provided a clear understanding of global and regional trends over a specific period and allowed the viewer to quickly spot regions or time spans for further investigation and a deeper insight into specific events. The used colors for the change in casualties between 1997-2003 and 2012-2017 clearly indicate that there is one major

outlier which is ultimately affecting all visualizations on the dashboard and therefore needs to take into consideration when trying to answer the question “Is the world becoming increasingly dangerous?”

5.2 AQ2 – Conclusion

1. Indicators with little or inconsistent global association

GDP per person: The regression line is almost flat ($R^2 \approx 0.01$, $p \approx 0.28$), so income levels do not systematically predict terrorism intensity; rich countries such as Qatar can have very low attack rates and strong negative within-country correlations ($r \approx -0.94$) as we can see in *AQ2 - Figure 7.*

Population density: High-risk countries tend to be of medium to high density, but many very dense countries remain low-risk; overall there is no strong global relationship ($R^2 \approx 0.06$, $p \approx 0.01$), though outliers like Malta ($r \approx 0.59$) show that rising density has coincided with more attacks in specific cases. Malta in *AQ2 - Figure 8* lies on the regression line.

Inflation annual %: Globally the trend line is slightly downward with very low explanatory power, implying that higher average inflation does not consistently go along with more terrorism. At country level the picture is mixed: Ghana exhibits a strong positive correlation ($r \approx 0.98$), Germany a moderate negative one ($r \approx -0.46$), and Angola combines very high inflation with only a weak link to attacks. But what we can derive from the scatter is, that most high-risk countries have almost the same inflation rates while in the low-risk countries the rates differ more from each other (please compare density in *AQ2 - Figure 9*). Angola experienced the highest inflation in between 1997-2017, see *AQ2 - Figure 3*.

2. Indicators with modest systematic patterns

Military expenditure %: Across high-/low-risk countries the trend line slopes upward ($R^2 \approx 0.24$, $p \approx 0.001$), indicating that higher military spending is associated with somewhat higher attack intensity, though the effect is moderate. Extreme outliers we can derive from *AQ2 - Figure 10* in both directions are Israel, Iraq and China. Cases like Mali ($r \approx 0.85$) show that periods of rising military expenditure and increasing attacks can go hand in hand, while Iraq has high spending and high attack rates but only a weak positive correlation ($r \approx 0.19$). Comparing to the GDP, Saudi Arabia is investing most heavily into its military, see *AQ2 - Figure 4.*

3. Indicators with weak negative relationships

R&D expenditure %: The cloud of points is diffuse, but the trend line slopes slightly downward ($R^2 \approx 0.05$, $p \approx 0.02$), so more R&D is weakly associated with fewer attacks on average. Yet country-level correlations differ: Morocco shows a very strong negative relationship ($r \approx -0.98$),

see *AQ2 - Figure 11*. Countries relatively invest more into R&D are the Nordic states in the EU followed by Japan and the USA, see *AQ2 - Figure 5*.

Agricultural land %: For all countries combined, agricultural land share has almost no explanatory power (very shallow negative slope, $R^2 \approx 0.02$, $p > 0.1$) and risk groups are spread across the full range. Restricting the view to high-risk countries produces a steeper negative slope ($R^2 \approx 0.15$, $p \approx 0.09$), hinting that among these countries more agrarian economies may experience somewhat lower attack rates, see *AQ2 - Figure 12*. The agricultural land map can be found in *AQ2 - Figure 6*.

5.3 AQ3 –Conclusion

Global relationship between governance and terrorism

The global link between governance quality and terrorism *(AQ3–Figure 2)* shows a clear but imperfect negative association between average governance quality (1997–2017) and terrorist attacks per million inhabitants: high-governance countries tend to cluster in a low-risk area, while many low-governance states face higher attack rates. The Relation Between Governance & Attacks graphic *(AQ3–Figure 1)* adds a dynamic perspective by relating changes in governance to changes in attacks between 1997–2006 and 2007–2017. The slightly downward-sloping line indicates that governance improvements are, on average, associated with reductions in attacks, but the strong dispersion of points reveals substantial heterogeneity. The filtered views by governance-change group *(AQ3–Figures 3–5)* reinforce this: Top 10 improvers, Middle 10 and Bottom 10 decliners all display overlapping ranges of terrorism intensity, suggesting that good governance lowers risk on average but is neither a sufficient nor a necessary condition for low terrorism levels.

Country-level dynamics in the case studies

The 2-year-bin map *(AQ3–Figure 6)* illustrates how these patterns play out within individual countries. Georgia and Indonesia, both Top 10 improvers, combine rising governance scores with relatively low or declining attacks per million, exemplifying the “good governance–low terrorism” trajectory. However, Sri Lanka exhibits a different pattern, with assaults peaking at about 8.8 per million before declining despite very slight gains in the governance. As for Greece and Thailand both show reductions in governance along with increase in terrorism. These divergent routes demonstrate how, depending on the history of the conflict and the local environment, comparable improvements in governance can have quite different results

Role of visualization for AQ3

Overall, the AQ3 visuals reveal patterns that would be difficult to detect from tables alone. The scatterplots summarize the average global association and the overlap between governance-

change groups, while the dynamic map clarifies the timing and magnitude of shifts within specific countries. Together, they support a nuanced answer to AQ3: institutional quality matters for terrorism risk, but its effect is context-dependent, and improvements in governance are more effective when they are accompanied by broader progress in managing underlying conflicts.

6. REFERENCES

Dashboard 1 (AQ1)

Dashboard 2 (AQ2)

Dashboard 3 (AQ3)

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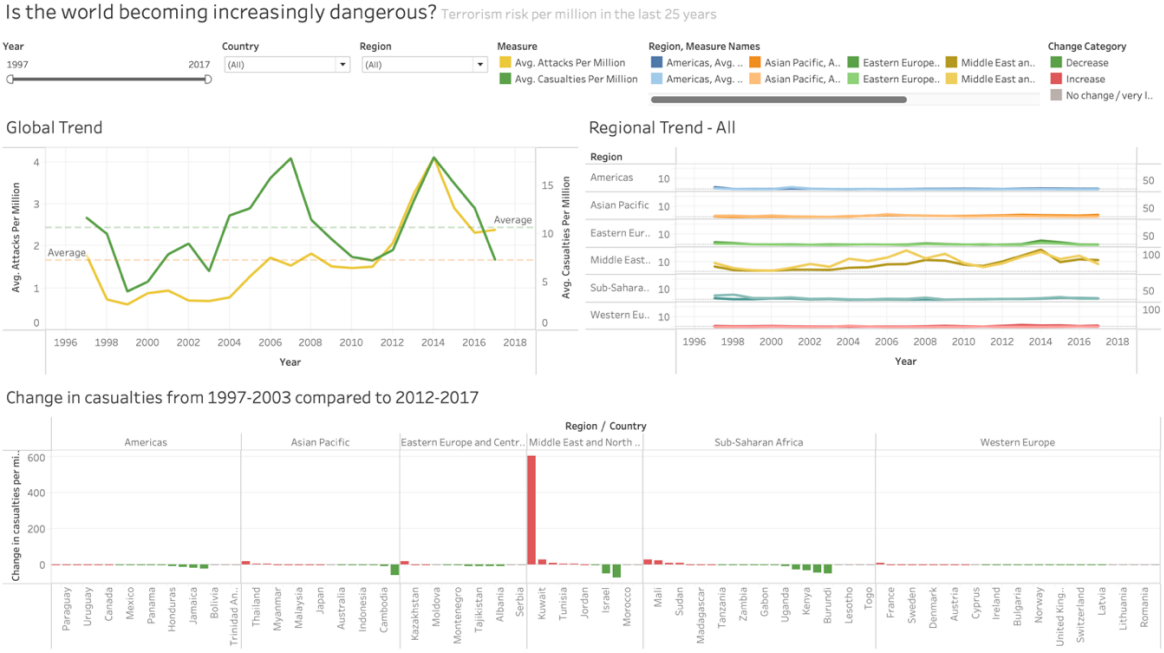
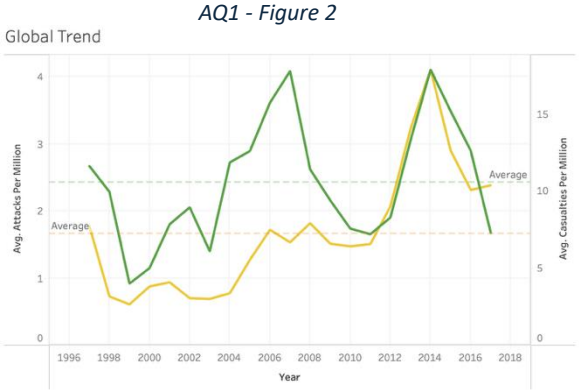
7. APPENDIX

AQ1 - Figure 1



AQ1 - Figure 2



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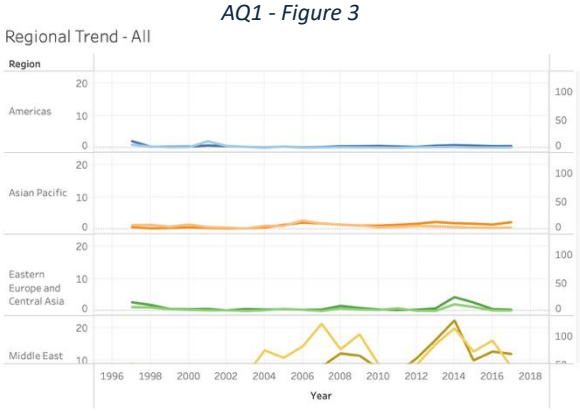
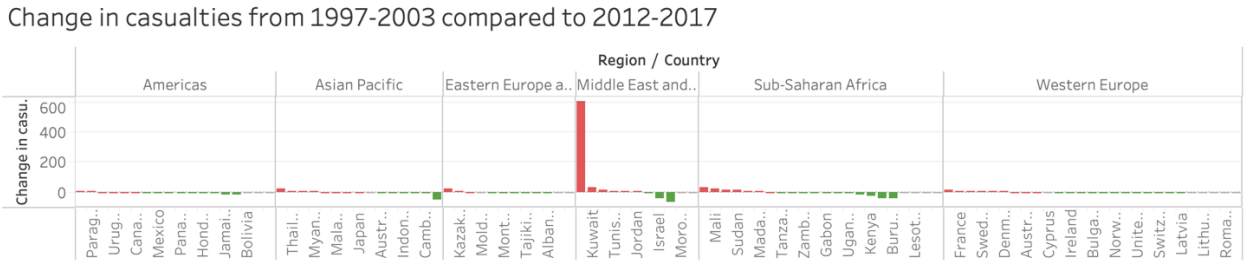


AQ1 - Figure 4



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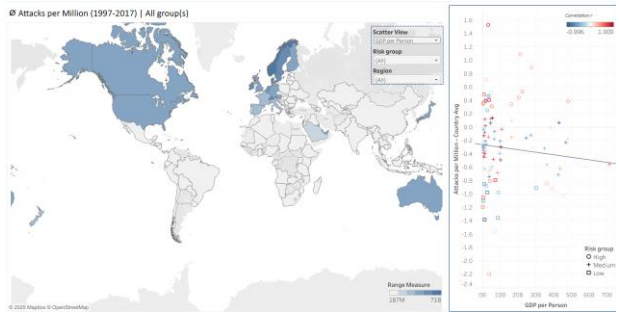
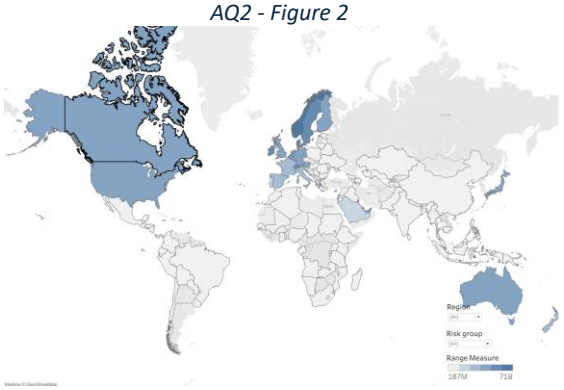
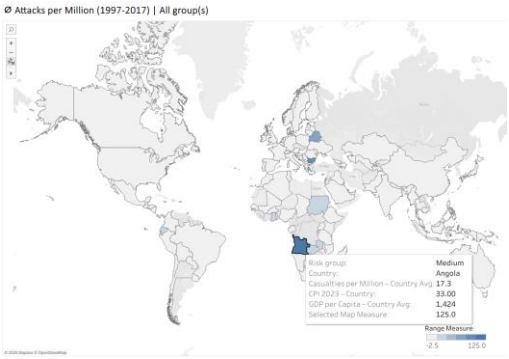
AQ2 - Figure 1



AQ2 - Figure 2



AQ2 - Figure 3



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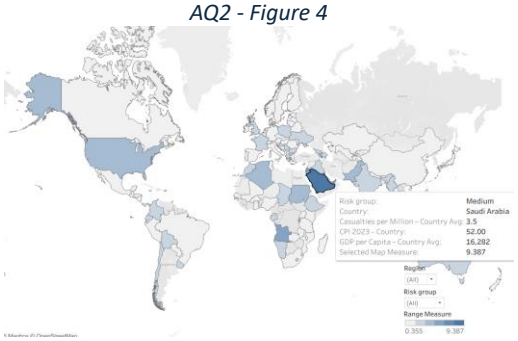
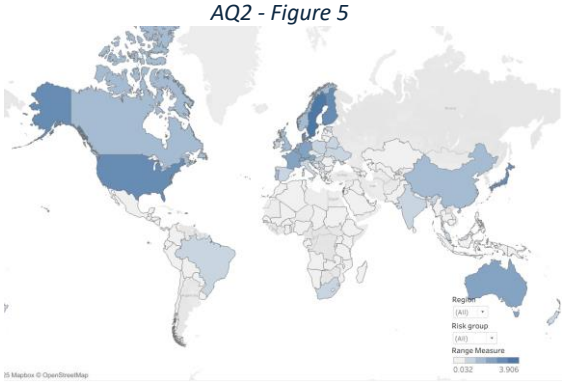
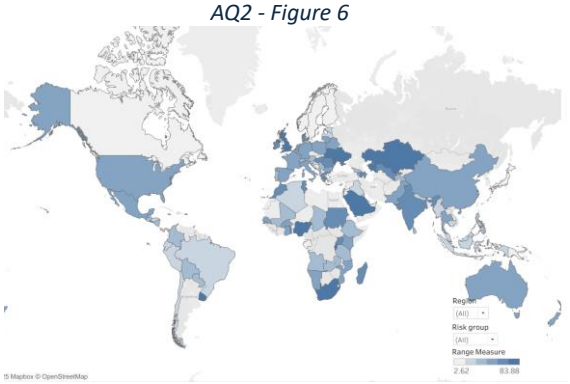


AQ2 - Figure 5



AQ2 - Figure 6



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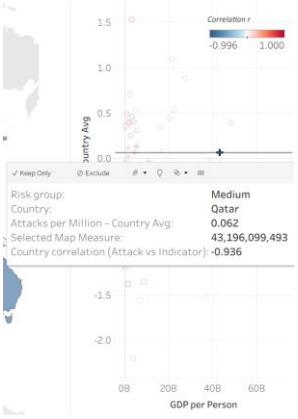
AQ2 - Figure 7



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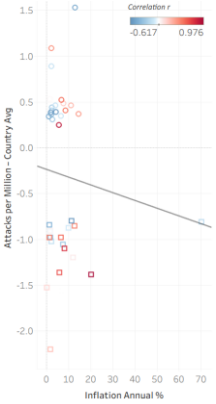

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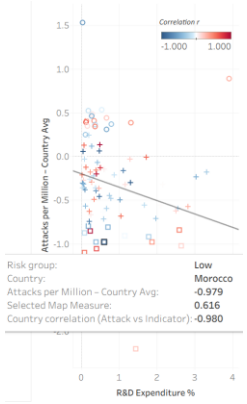
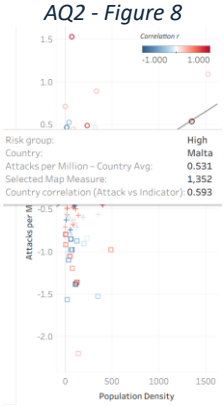


AQ2 - Figure 8



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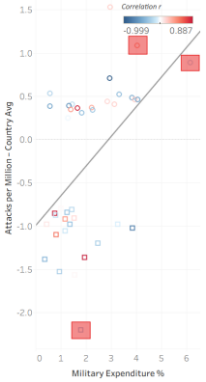
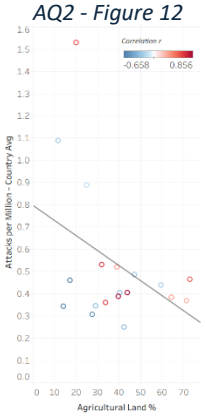
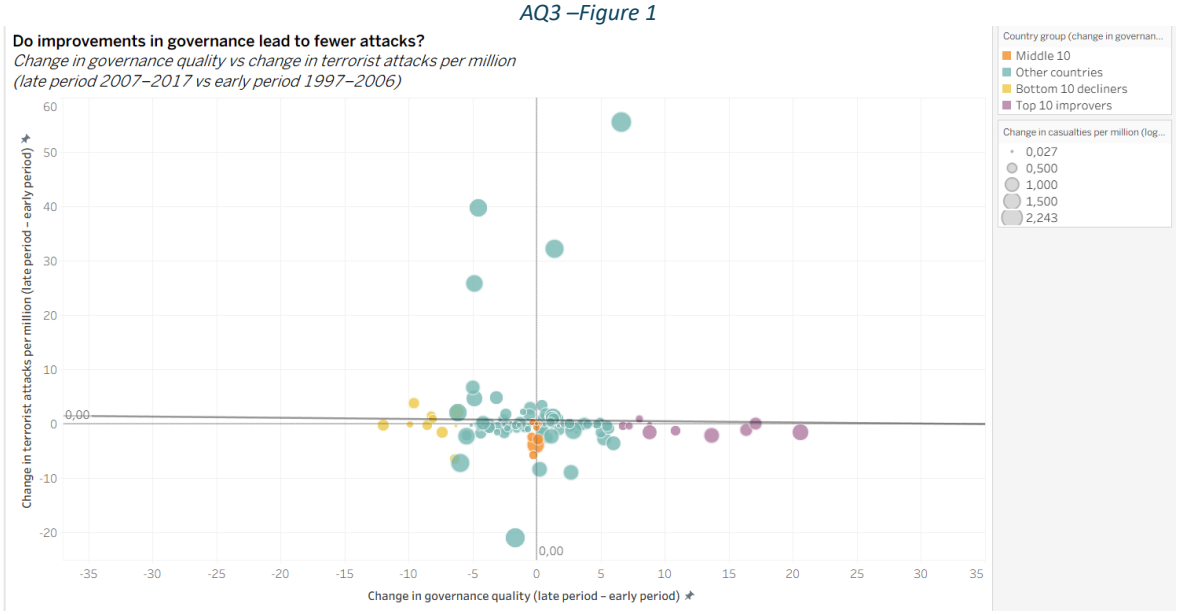


AQ2 - Figure 12



AQ3 –Figure 1



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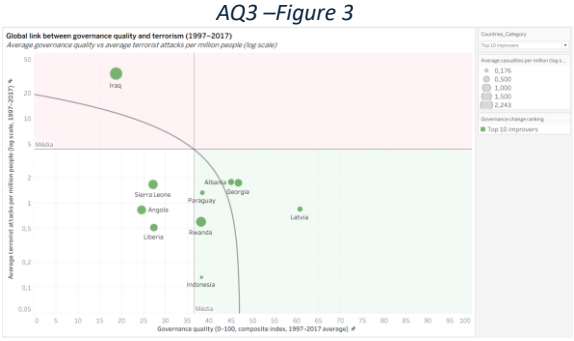
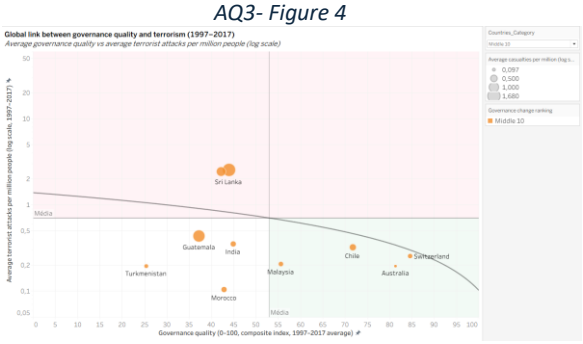
AQ3-Figure 2

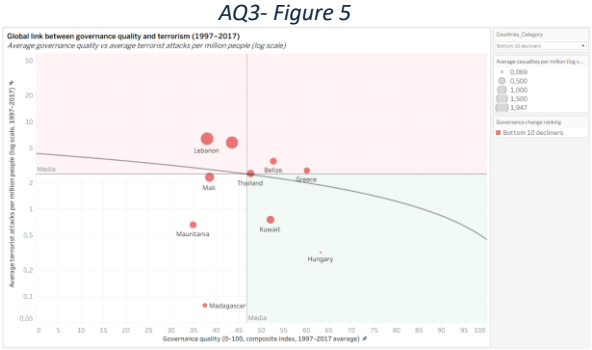
AQ3 –Figure 3



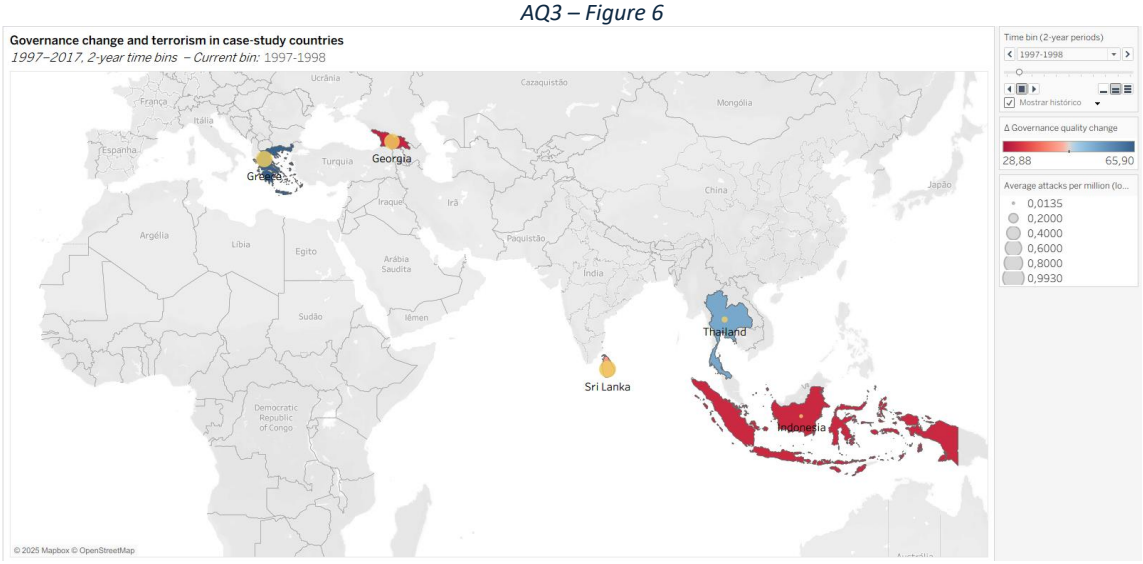
AQ3- Figure 4



AQ3- Figure 5



AQ3 – Figure 6



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