Analyzing Incidents in Militarized Interstate Disputes using Motifs in Temporal Networks

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Abstract. We present a temporal network analysis of militarized interstate dispute (MID) data from 1992 to 2014. MIDs progress through a series of incidents, each ranging from threats to uses of military force by one state to another. We model these sequences as a temporal conflict network, where nodes denote different states and directed edges denote incidents. We analyze temporal motifs or subgraphs in the conflict network to uncover the patterns by which different states engage in and escalate conflicts with each other. We find that different types of temporal motifs appear in the network depending on the time scale being considered (days to months) and the year of the conflict. The most frequent temporal motifs at a 1-week time scale correspond to different variants of two states engaging a third state, potentially escalating the conflict. Temporal motifs provide us with a more descriptive picture of patterns and progressions of MIDs than simply considering the number of incidents.

Keywords: Temporal Motifs, Dynamic Networks, Conflict Networks, Conflict Escalation.

1 Introduction

Militarized interstate disputes (MIDs) are conflicts between states that are not full-scale wars [1]. By analyzing past data on such disputes, we may discover some insights about how they escalate and de-escalate over time. Each dispute can be broken down into a series of smaller incidents, which provide us with additional information about the progression of the dispute.

In addition to analyzing these disputes in a tabular format, these MIDs can be modeled as a conflict network [2]. Each node in the network is a state, and each edge is a threat, display, or use of force one state directs toward another. We include the temporal dimension in this network to analyze how disputes and international relations change over time.

Different methods such as centrality measures [3], temporal community structures [4], and generative models [5, 6] can be used to analyze dynamic or temporal networks. In this paper, we use temporal motifs [7] to extract information from MIDs. In a temporal network, temporal motifs are defined as sequences of edges that complete within a time interval. Fig. 1 shows an example of temporal motifs in a conflict network. In the MID context, these can be used to analyze patterns of escalations.

We present an analysis of MID data from 1992 to 2014 using temporal motifs on conflict networks. We find that a variety of temporal motifs appear, depending on the time scale we consider, and different MIDs have different frequencies of temporal motifs. We also find that using temporal motifs can help us draw out more information about MIDs than just the raw number of incidents.

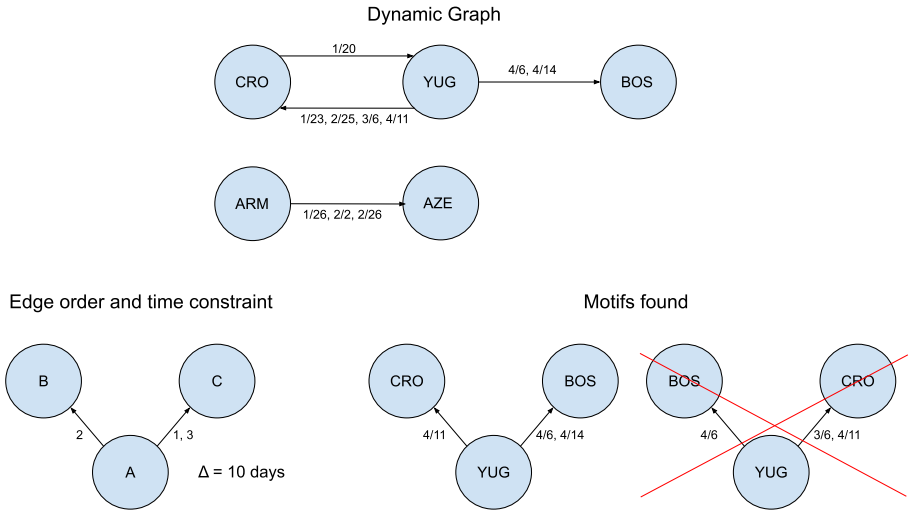

Fig. 1. Given a temporal network (top) and a temporal motif of interest (bottom left), we find one such instance of the motif (bottom right). The other crossed out one is not an instance despite matching the correct order of edges because the completion time exceeds the time limit of 10 days from first edge to last edge.

2 Materials and Methods

We are using the dataset MID 5.01 [1] compiled by the Correlates of War project. We use the incident-level data, which provides the date of each incident in a dispute from 1992 to 2014. Each incident represents a threat, display, or use of force one state directs toward another. We also consulted the narratives accompanying the MIDs.

We analyze this dataset using the Python package called DyNetworkX [8], which includes an implementation of a temporal motif calculating algorithm from [7]. The network for this dataset is built as an Impulse Directed Graph, which uses the start date of each incident. For a subgraph in the network to match a temporal motif, it needs to have the correct ordering of edges, and the time difference between the first and last edges needs to be within the completion time (e.g. 10 days in Fig. 1).

We first calculate all possible 3-edge temporal motifs, which are shown in Fig. 2, with maximum completion time of 7 days. By using this short time period, we focus on rapid escalations between countries rather than other long-term tactics. After that we calculate these motifs with different completion time intervals of [0, 3], (3, 7], (7, 30], and (30, 120] days to analyze the escalations at different level of intensities.

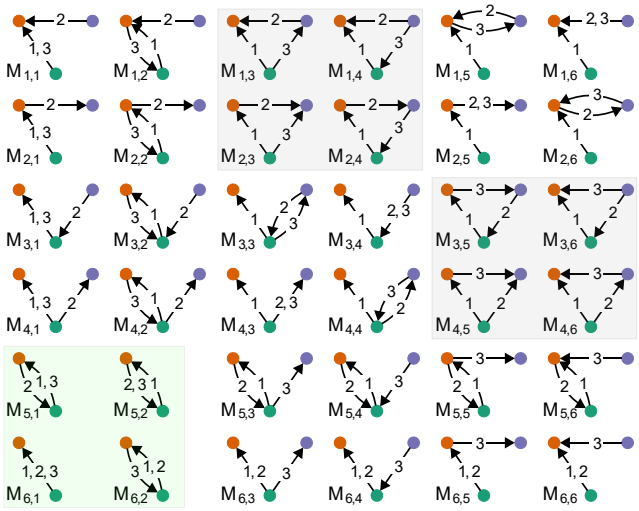

Fig. 2. All possible temporal motifs with 2 or 3 nodes and 3 edges (figure credit: [7]). Green and grey shaded boxes denote 2-node and triangle motifs, respectively. We denote the green, red, and blue nodes as roles 1, 2, and 3, respectively.

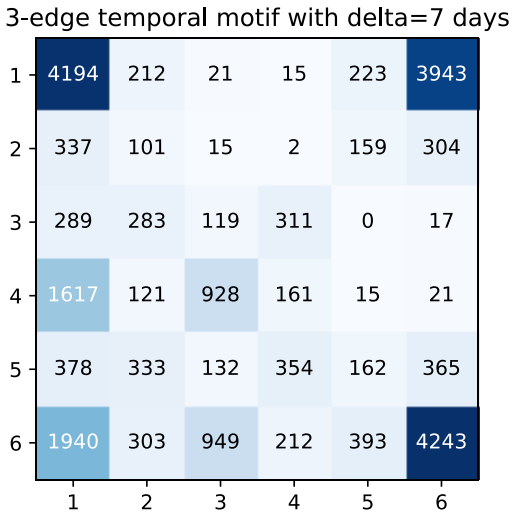

Fig. 3. Temporal motif counts with a delta of 7 days for each of the 2 or 3-node, 3-edge motifs.

3 Results

Fig. 3 shows the count of all 2 or 3-node and 3-edge temporal network motifs with a maximum completion time of 7 days from the constructed network. We use the notation M61 for the motif in row 6, column 1. The dominant motif counts we found are

- M61: 1 state initiates 3 incidents in a row with the same other state.
- M11, M16, and M66: 2 states initiate 3 incidents in total with the same other state.
- M41, M43, and M63: 1 state initiates 3 incidents in a row with 2 other states.

3.1 Disputes of Interest

We looked further into these motifs to determine which states are most involved in each motif and in which roles in the motifs. For all of the motifs in Fig. 2, role 1 means the green node, role 2 means the red node, and role 3 means the blue node. States are denoted by their 3-letter codes from the Correlates of War project [9].

Motif M61. From Fig. 4 we can see that the main participants in motif M61 are Israel dominating role 1, and Lebanon dominating role 2. The edges that Israel directs toward Lebanon account for about 11% of the incidents from 1992 to 2014. On the other hand, the proportion of edges in the opposite direction is only 0.5%, which implies that Lebanon rarely retaliates against Israel's threat. This can also be illustrated by the low count of M51, M52, and M62, which represent balanced reciprocity between the 2 countries. Most incidents appear to be Israeli attacks on Hezbollah guerillas in southern Lebanon, with the Lebanese not getting involved as frequently.

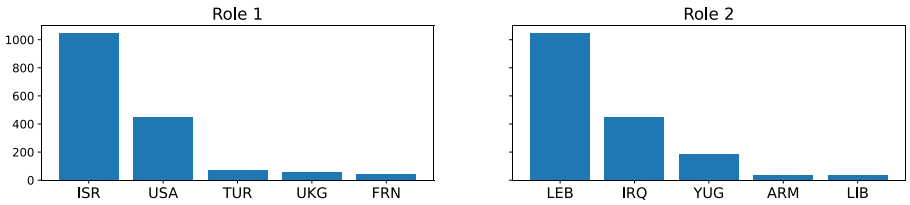

Fig. 4. Role of each country in Motif M61 (1 state initiates 3 incidents towards another state)

The next most frequent participants in motif M61 are the USA in Role 1 and Iraq in Role 2. Many incidents involved a show of force building up to the USA's invasion of Iraq. Other states also participated in this dispute, which shows up in other motifs.

Motifs M11, M16, and M66. We can see from Fig. 5 that Yugoslavia[1] is the most frequent participant in these motifs. It has high counts in role 2 of M11, M16, and M66, which shows that it received many threats from other states. The most frequent participant in roles 1 and 3 is the USA, which was involved in two main disputes that created these types of motifs: a dispute with Yugoslavia, where Germany, Turkey, the Netherlands, and Greece among others were also initiating incidents on the side of the USA; and a dispute with Iraq, where the United Kingdom and France among others were also initiating incidents on the side of the USA.

[1] Yugoslavia and Serbia may be conflated in this data set. There is no COW country code for Serbia, despite it being mentioned in some of the narratives.

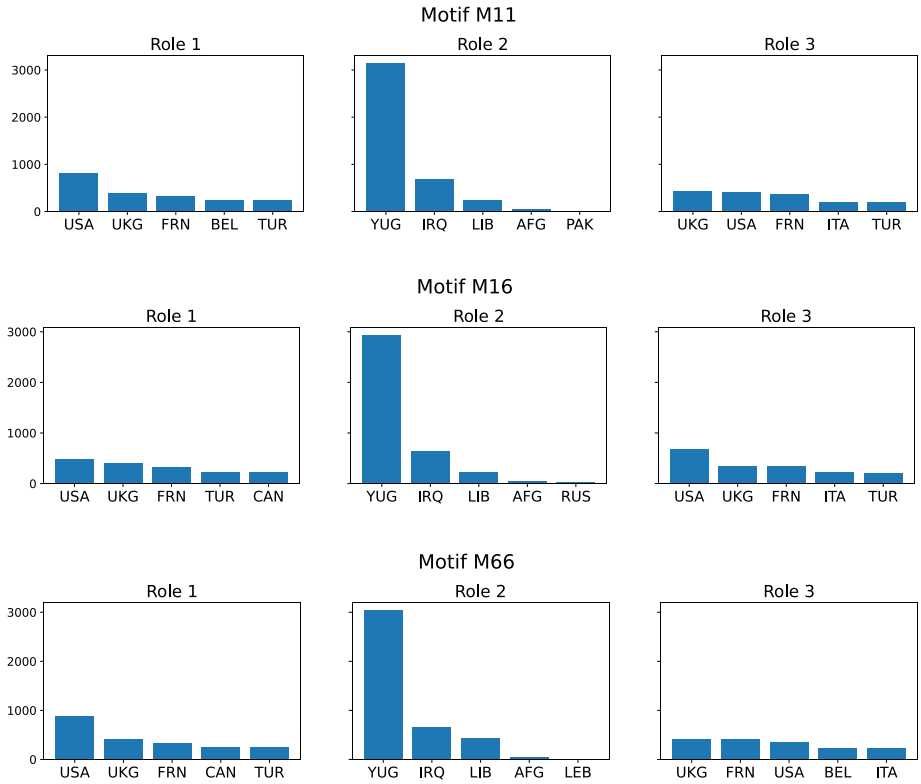

Fig. 5. Motifs M11, M16, and M66 (2 states initiate incidents towards 1 state)

Motifs M41, M43, and M63. From Fig. 6, the most frequent participant in these motifs is again Yugoslavia, and this time, in role 1, which shows that it initiated incidents towards many other states. Unlike the case of Israel and Lebanon for motif M61, only about 3% of the total edges in the network have Yugoslavia on either side. Even though Yugoslavia isn't involved in many incidents, when it is involved, it escalates fast and tends to bring in many other countries. By digging further into when the motifs M11, M16, M66, M41, M43, and M63 occur, we found that most of them are only in 1999 and 2000, which is shown in Fig. 7.

From the narratives for these actions, we find that they are the result of conflicts between Yugoslavia and Kosovo, which also had interventions from the North Atlantic Treaty Organization (NATO). We note that, in many cases from this dataset when many countries threaten others in the same incidents or vice versa, those threats do not necessarily happen at different times and with separate decisions from each of those countries. Those can be actions from joint military or international associations. An example is how NATO threatened Libya to end the civil war there. All countries in NATO are coded as threatening to Libya for approving the threat. In this case, the intervention of NATO increases the motif counts for Yugoslavia substantially.

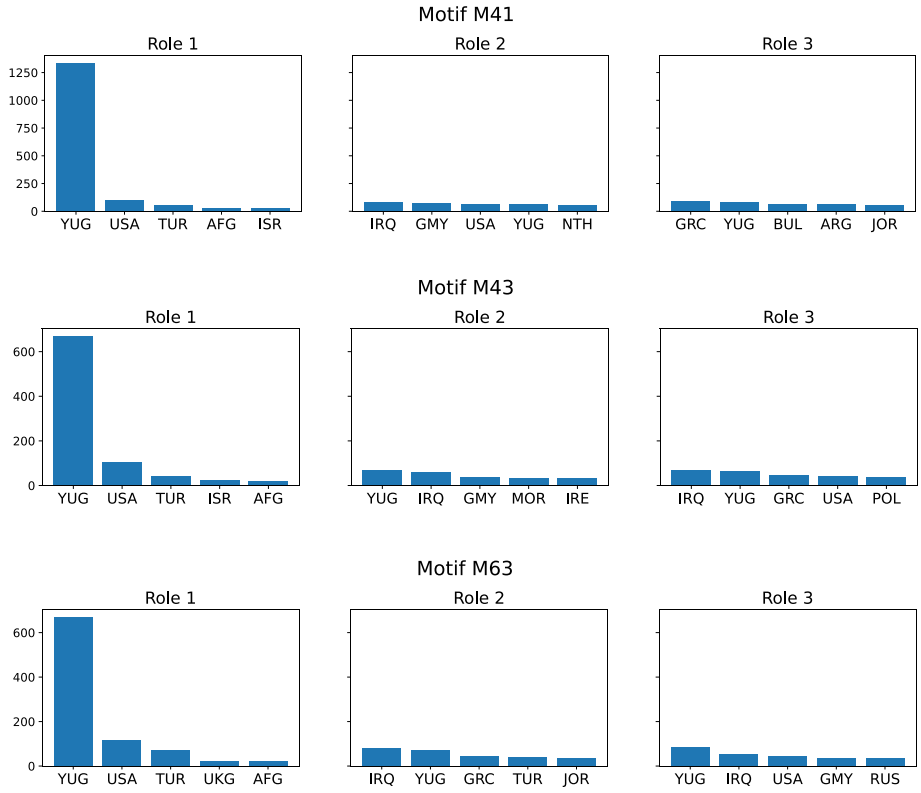

Fig. 6. Motifs M41, M43, and M63 (1 state initiates incidents towards 2 other states)

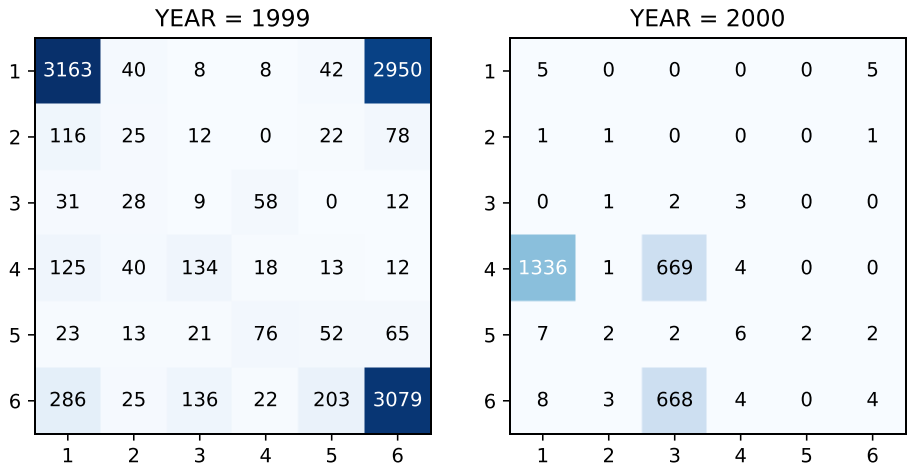

Fig. 7. Temporal motifs in 1999 and 2000, with delta = 7 days

Moreover, these motifs all lack reciprocity, which shows that there was not much immediate retaliation from the threatened country. If there were, other motifs such as M12 or M42 should also occur frequently. The fact that Yugoslavia was the center of these 2 groups of motifs shows that it took a while for Yugoslavia to retaliate back in 2000 after being threatened in 1999, as we can see in Fig. 7.

3.2 Temporal Motif Distributions at Different Completion Times

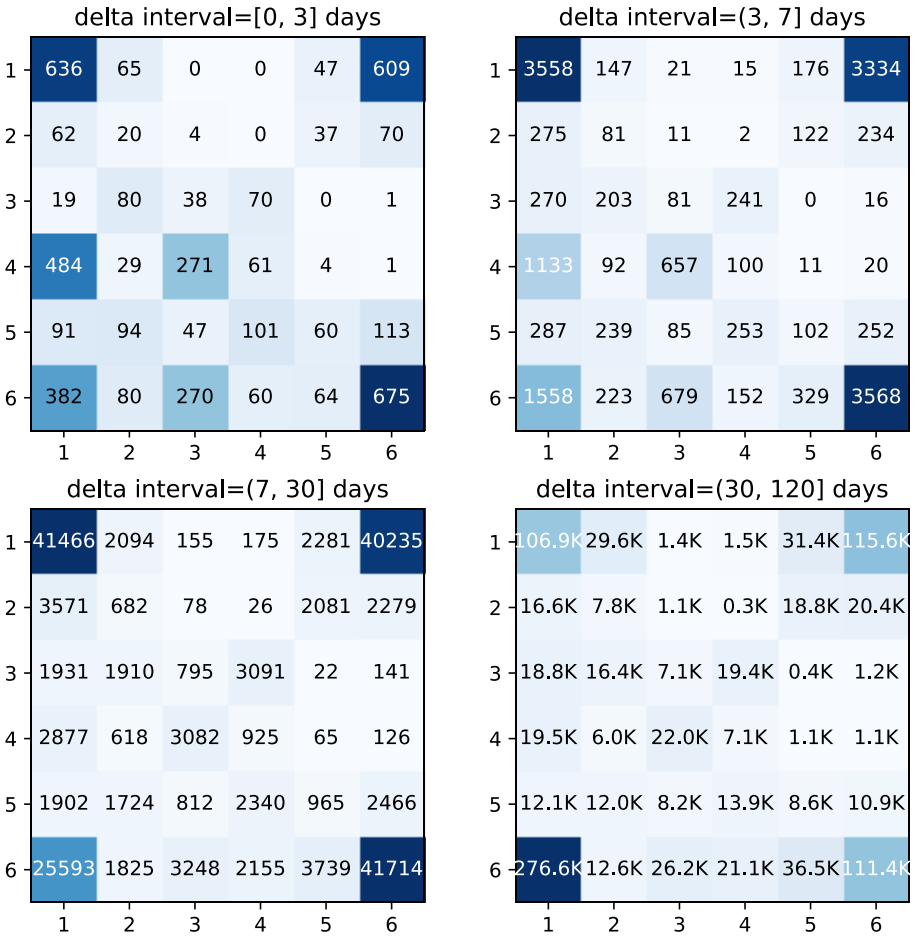

Fig. 8. Temporal motifs at each completion time interval

The smaller the completion time, the more rapid the escalation is. Fig. 8 shows the temporal motif distribution at different completion time intervals. We can notice that motifs M41, M43, and M63, which represent one state threatening many others, fade away in relative frequency as the completion time gets longer. This shows that this behavior can only occur when a state escalates quickly, and single-handedly engaging

in conflicts with many other states over a long time period is not an ideal tactic. However, the opposite is possible, which is also illustrated in Fig. 8, as the other dominant motifs remain dominant as the completion time increases.

3.3 Comparison with Analyzing Raw Edges

In the context of MIDs, temporal motifs with short completion times can be used to represent escalations. From the analysis above we can see that we are able to narrow down the network to when and where escalations occur by using temporal motifs. The size of the maximum completion time determines the rapidness or intensity of those escalations. The order of edge in those motifs determines what type of escalations they are, which is very beneficial to understand the behavior of each state. Besides, the distribution of these motifs shows the fundamental building blocks of the temporal network. Raw edge counts without those two attributes can only show an overview of history.

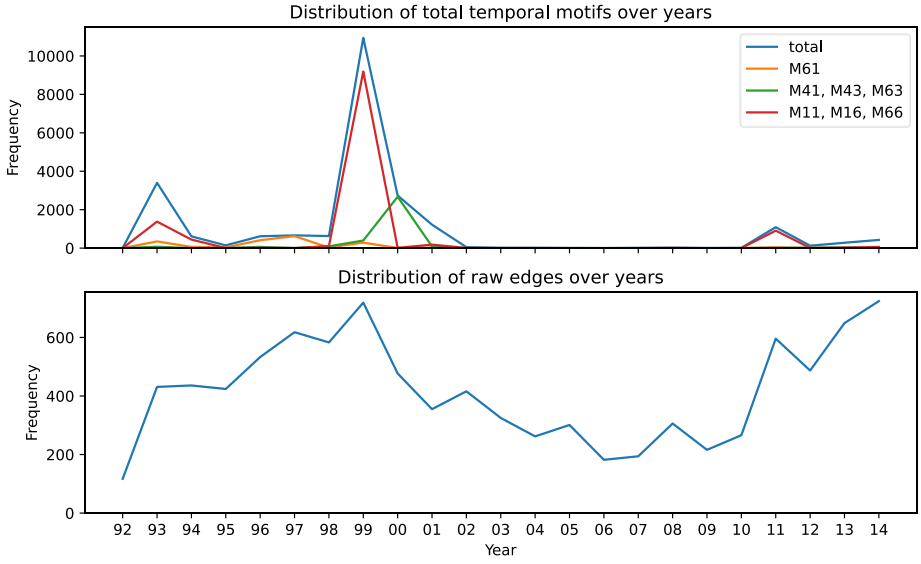

Fig. 9. Distribution of most frequent 3-edge temporal motifs (with a completion time of 7 days) vs raw edges over years

However, a quick analysis over raw edges can help us get the context that those motifs are in. Fig. 9 shows the distribution of temporal motifs and raw edges over the timeline of the dataset. We can notice that they have some correlations with each other (because more edges tend to lead to more motifs). However, that is not fully accurate for every year as we can see in the plots. From 1994 to 1998 and 2011 to 2014, even though there were a lot of incidents, the number of temporal motifs remains very low. This implies that those incidents happened over a long period and don't constitute any type of escalations. Moreover, we can observe that there are

spikes in the trend of temporal motifs whereas the trend of raw edges is more gradual. This can be explained by how one escalation tends to lead to another in a short time period then fades away altogether. Both trends show that the world was mostly at peace from 2002 to 2011 when there was a low number of incidents and almost no escalations.

4 Conclusion

In this paper, we illustrated how temporal motifs can be beneficial in analyzing militarized interstate disputes (MIDs). By representing escalations between states as temporal motifs, we investigated their intensities and patterns. We found that, somewhat surprisingly, there are not many reciprocated motifs. Instead, there are mainly motifs that show that one state threatens another multiple times and disputes between one state with many others. Not only can we find the motifs within the network, but we can also find the participants for each role of those motifs. From that, we were able to identify the roles of key states in MIDs, including Israel, Lebanon, Yugoslavia, and the USA. By varying the completion time, we found that the motifs that represent one state threatening many others can only occur in short completion times. We also compared analyzing temporal motifs and raw edges to show how they can complement each other. Temporal motifs show rapid escalations within the network, whereas raw edges can show the general view of the incidents.

One of the limitations of using temporal motifs is that the distribution is not robust to outlier incidents. The distribution shown in Fig. 3 can be misleading without any further investigation. Even though those are the motif counts for every state in the dataset, it doesn't necessarily show the general behavior pattern that every state follows. Instead, as we found out above, they are dominated by the incidents from Israel, Lebanon, and Yugoslavia. Another limitation is that we don't count edges within the same incident that happen on the same date as one happens after another. This problem is because the time resolution of the data is only day. Hence, this can create the potential loss of information and motifs count can be undercounted. However, since in many cases, those edges are a joint threat from many countries, they happen at the exact same time. Hence, the potential loss of information is reduced.

Another limitation concerns the accuracy of the dataset. A study in 2012 found that there are flaws within the dataset [10]. Moreover, without much expertise in international relations, we were not able to resolve the case of how Yugoslavia is coded in the dataset. Even though the country ceased to exist in 1992, there are still edges in the years after that. The narrative for a 1999 incident uses the name Yugoslavia in the description, whereas the 2013 one uses the name Serbia (even though that incident is still coded as YUG in the dataset). Moreover, Serbia is not in the dataset. Hence, we suspect that Yugoslavia and Serbia may be conflated.

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