Analyzing Network Relations Through Network Theory

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Abstract:

The project aims to identify key players that influence the connections between nations in the context of International Relations by employing network analysis techniques like degree centrality, community detection, and leveraging the growing volume of data on international relations. We used the alliance and sanctions data to determine the changes in relationships from 1975 to 2010. In this way, our study highlights the importance of network science in understanding the dynamics and patterns of global relations and its potential for informing policy decisions to promote peace and stability in the world. Furthermore, our study's use of advanced network analysis techniques enabled us to identify the most central and influential players in the international arena. Additionally, our findings suggest that international relations are becoming increasingly complex and interconnected, highlighting the need for ongoing analysis and attention to these relationships. Ultimately, our study contributes to a deeper understanding of the complexities of global relations and provides insights that can inform policy decisions to promote peace, stability, and cooperation in the world.

Introduction:

Motivation and Literature Review:

As global ties continue to strengthen, studying the foundational principles and patterns that influence their operation becomes increasingly important. Studying these configurations allows us to quantify or reproduce them and better understand how to create and maintain effective global alliances. A network-based approach can be useful in uncovering patterns in the complex relationships between countries and their effect on global politics.

A study by Wang et al. (2019) analyzed international trade data and found evidence of "global trade communities" that were characterized by strong intra-community ties and weaker inter-community ties [1]. Similarly, a study by Ward and Gleditsch (2008) found that alliances between nations tend to form along regional and ideological lines. These studies show that a network analysis approach can help us understand the underlying patterns and factors that contribute to successful collaborations between countries.

Proposal:

The following are the research questions for this study:

1)How can a network analysis approach help us understand the complex relationships between countries and their effect on global politics?
2)Are there any noticeable patterns in the military alliance and sanction networks, and how have they changed over time?
3)What factors contribute to the imposition of sanctions?

The following hypotheses will be tested:

Hypothesis 1:
The modularity of the military alliance and sanction networks will reveal clusters of countries with shared political, economic, or geographic interests.
Hypothesis 2:
The imposition of sanctions is more likely to occur in regions with high levels of political instability, economic inequality, or security threats.
Hypothesis 3:
The structure of the military alliance and sanction networks will change over time in response to shifting geopolitical dynamics, such as the rise or fall of superpowers, changes in global economic trends, or the outbreak of armed conflicts.

Method:

- **Modularity (Community Detection):**
  - Modularity is a measure of the extent to which a network can be divided into distinct communities or modules.
  - Here modularity refers to the degree to which countries with similar interests or characteristics form clusters or communities within the alliance and military sanctions networks. The modularity metric is used to identify these communities and can be visualized through node color in the network graphs, with nodes of similar color indicating membership in the same community or module.
  - Essentially, modularity measures the tendency of nodes in a network to form groups or clusters that are more tightly connected to one another than to nodes in other groups or clusters.
- **Degree Centrality:**
  - Degree centrality is a network analysis metric that measures a node's number of connections in a network. In the context of your project, degree centrality is used to analyze the alliance and military sanctions networks to determine the importance of a country in terms of the number of alliances or sanctions it has with other countries.
  - A node with a high degree centrality has more connections than other nodes, indicating that it is more important and influential in the network. The degree centrality metric can be calculated as the number of edges incident to a node divided by the total number of nodes in the network minus one.
- **In-degree Centrality:**

- In-degree centrality refers to the number of military sanctions that a country receives from other countries in the network.
- Specifically, it measures the number of incoming edges to a node in the military sanctions network, indicating the number of other countries that have placed military sanctions against that country.
- A higher in-degree centrality for a country suggests that it is a more frequent target of military sanctions from other countries, and therefore may have a higher level of conflict or disagreement with other countries in the network.

- **Out-degree Centrality:**
  - Out-degree centrality is a measure of a node's importance in a network based on the number of outgoing edges it has.
  - In the context of your project, out-degree centrality measures the number of military sanctions a country has imposed on other countries.
  - A country with a high out-degree centrality in the military sanctions network has placed more sanctions on other countries than any other country, indicating its key role in implementing international sanctions.
  - The United States, for example, has a high out-degree centrality in the network of military sanctions, suggesting it has imposed more sanctions on other countries than any other country.

- **Eigen Vector Centrality:**
  - Eigenvector centrality is a measure of the importance of a node in a network based on the concept of eigenvectors.
  - In simple terms, it considers the connections of a node to other well-connected nodes in the network and assigns a score based on the importance of those nodes. A node with high eigenvector centrality is considered to be connected to other important nodes in the network.
  - In the context of your project, eigenvector centrality was used to identify the nodes with the highest influence and connections to other significant nodes in the network.

Tools:

- **Gephi**
- **Networkx- Python library**

Data:

Alliance Data: The "Correlates of War Formal Interstate Alliance Dataset 1816-2012" is the dataset utilized in this project. The Correlates of War website offers this dataset for public download and is regularly updated.

Sanctions Data: We collected the military sanction data points from the Global sanction database. This dataset consists of data from 1960 to 2020, but we are considering data from 1975 to 2010.

Pre-processing:

We have used Pandas profiling to find duplicates and missing values from the records. Then we separated the military data from overall sanctions data using Python libraries like numpy and pandas.

Results:

Attributes	Alliance data	Military Sanction data
Nodes	180	214
Edges	1694	868
Average path length	2.315	2.728
Average Clustering Co-efficient	0.375	0.071
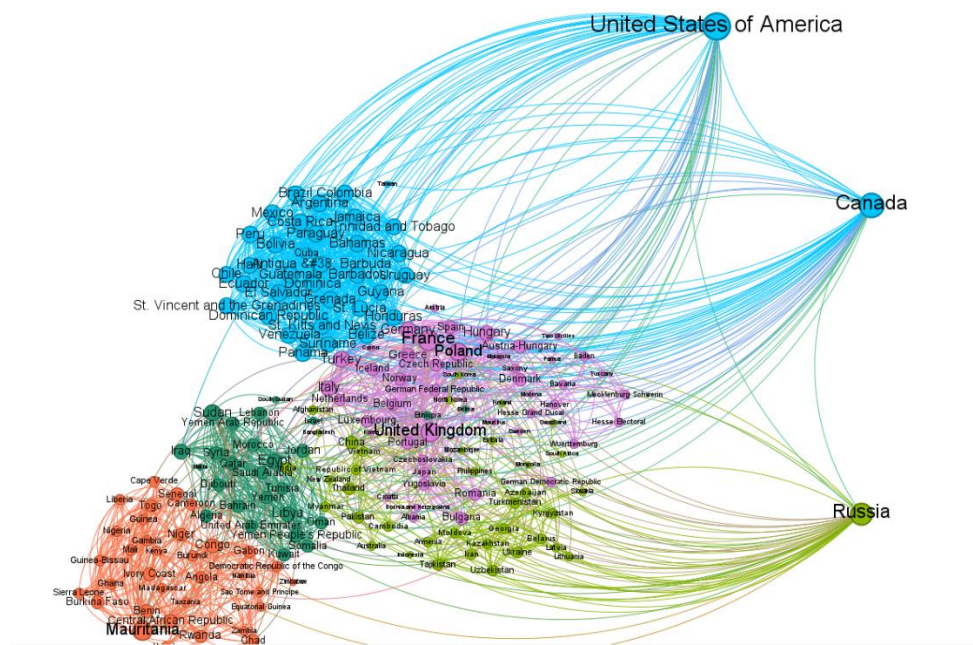
Fig.1 Alliance network 1975-2010

Nodes size: Degree Centrality
Node color: Modularity
Edges size: Weights (Duration of years)

Observation:

1. The United States of America formed the most alliances with other countries in the alliance network based on its high degree of centrality in the network.
2. The United States has a high betweenness centrality in the alliance network, indicating that it acts as an important link between various groups of countries.
3. According to the community structure of the alliance network, countries tend to establish alliances with other countries that are geographically close by or that share common interests.

4. Due to its high degree of centrality within the highly interconnected community, Russia acts as a hub and holds a key place in alliances.
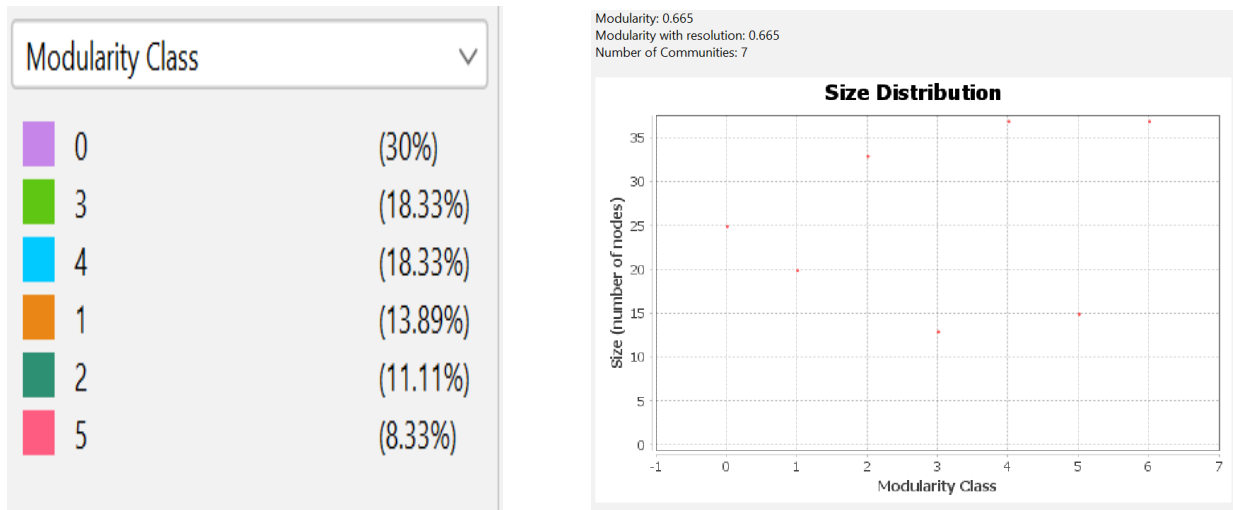
Fig.2 Communities formed for Alliance data

Fig.3 Map representation of neighboring countries   *Fig4. Gephi representation of communities*

Observations:

1. The network shows a community structure based on the geographical closeness of countries, demonstrating the impact of geographical considerations on the network's creation.
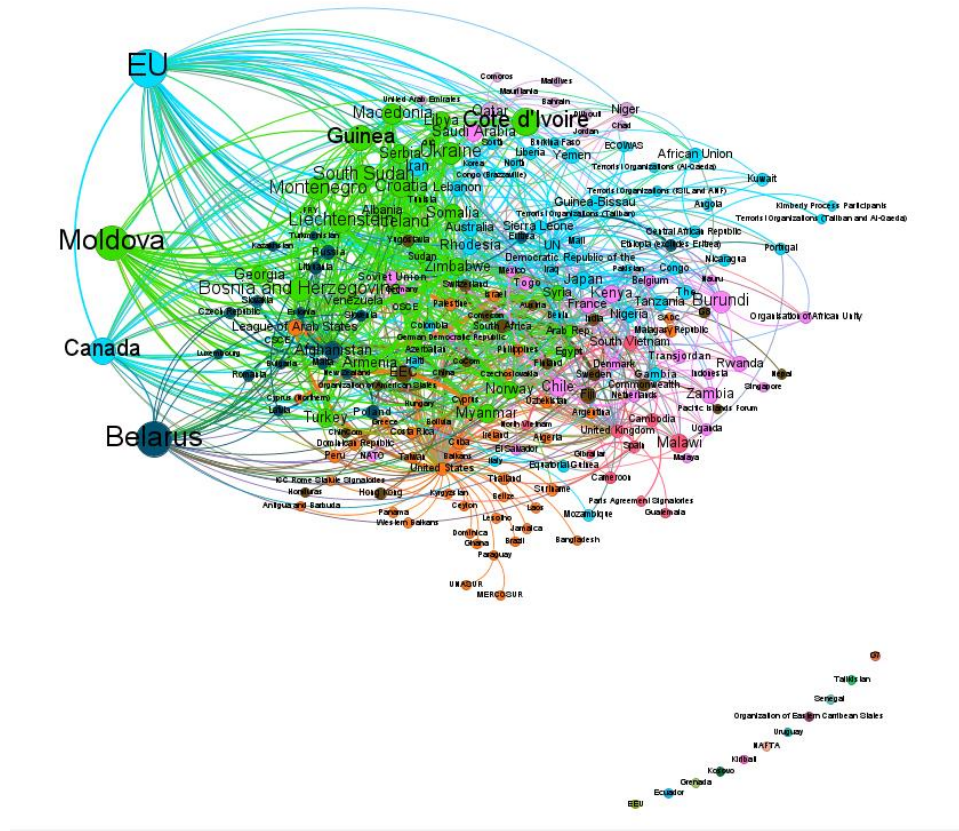
Fig.5 Military sanctions network1970-2010

Nodes size: In-Degree Centrality
Node color: Modularity
Edges color: Types of objectives for sanctions
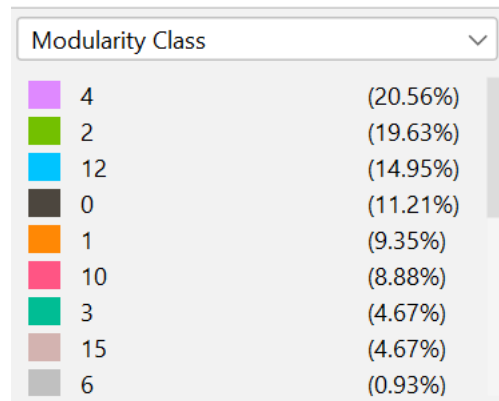**Edge size**: Weights (Duration of years)

trade	(38.82%)
financial	(29.15%)
arms	(15.67%)
travel	(7.72%)
other	(6.34%)
military	(2.3%)

Fig.6 Edge type based on the objective of the military sanction
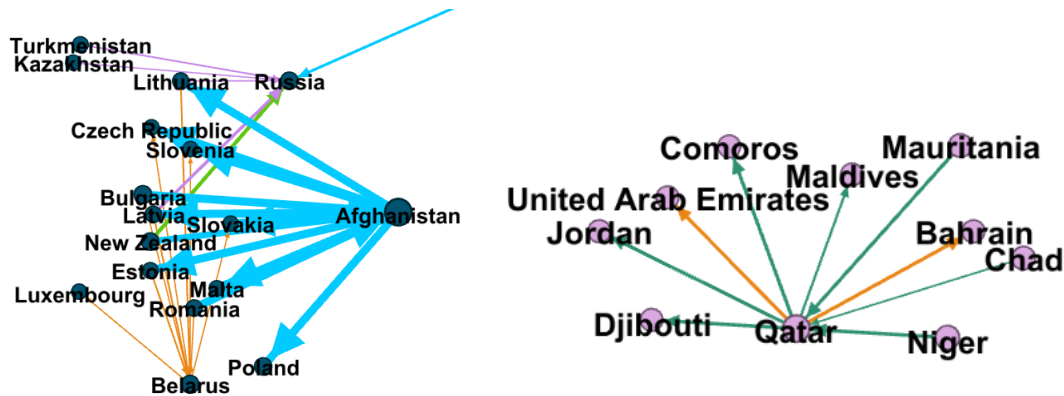
Observations:

1. The European Union is the subject of military sanctions from a number of countries, as shown by the in-degree centrality, emphasizing the network's strategic importance.

2. A few countries exist without any military sanctions, which shows that these countries have successfully avoided any confrontations or disagreements and have preserved constructive diplomatic ties.

Modularity Class		
■	4	(20.56%)
■	2	(19.63%)
■	12	(14.95%)
■	0	(11.21%)
■	1	(9.35%)
■	10	(8.88%)
■	3	(4.67%)
■	15	(4.67%)
■	6	(0.93%)

Fig.7 Communities formed for Military sanctions

1. The 19 communities were detected using the community detection algorithm, and the lack of connections between some of the countries was detected using the community detection algorithm, and the lack of connections between some of the countries indicates that there are no sanctions between them.

Fig.8 Military sanctions communities

Observation:

1. The out-degree centrality reveals the community structure within the network of military sanctions.
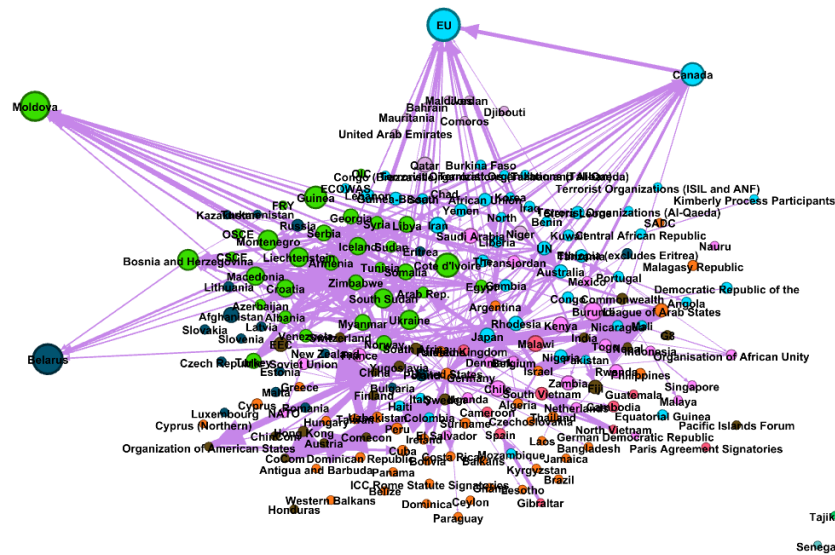2. The edge partitions show that Afghanistan has more arms restrictions against other nations.

Fig.9 Common objective representation in Military Sanction

Observation:

1. According to network analysis, trade is the network's most common objective of military sanctions.
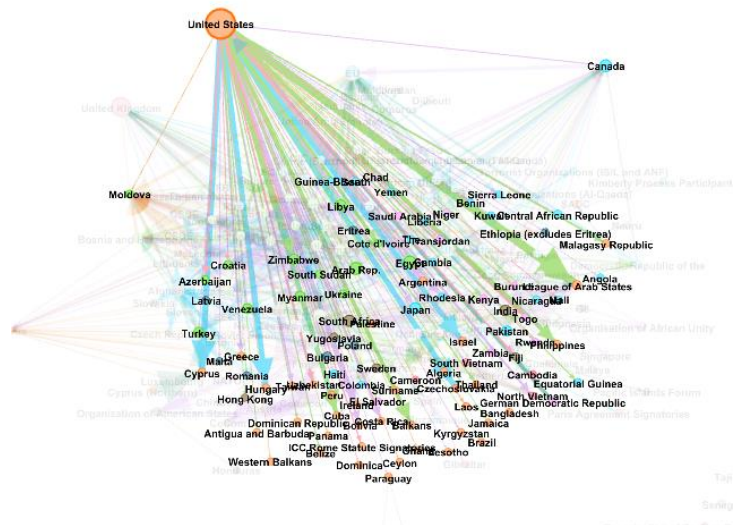

*Fig.10 Overall Military Sanctions Graph Out-degree*

Observation:

1. The United States has a high out-degree centrality in the network of military sanctions, indicating it has placed more sanctions on other countries than any other country. This shows that the USA is a key player in the network and has a big say in implementing international sanctions.

Fig.11 Sanctions 1975-1990
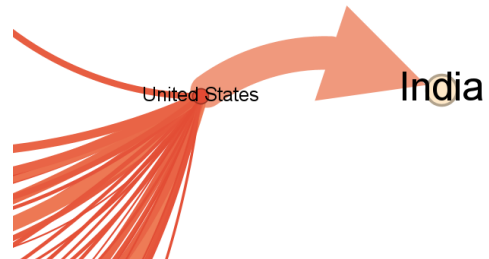
Fig.12 Sanctions 1995-2010

Observations:

1. The sanctions graph shows that there were no sanctions between the United States and India from 1975 to 1990. However, from 1995 to 2010, the USA imposed sanctions on India as a result of nuclear testing in 1998.
2. The weight of the edge indicates the total duration of the sanction, and it is shown that the USA's sanction on India was one of the longest, highlighting the gravity and importance of the incident that prompted the imposition of the sanction.
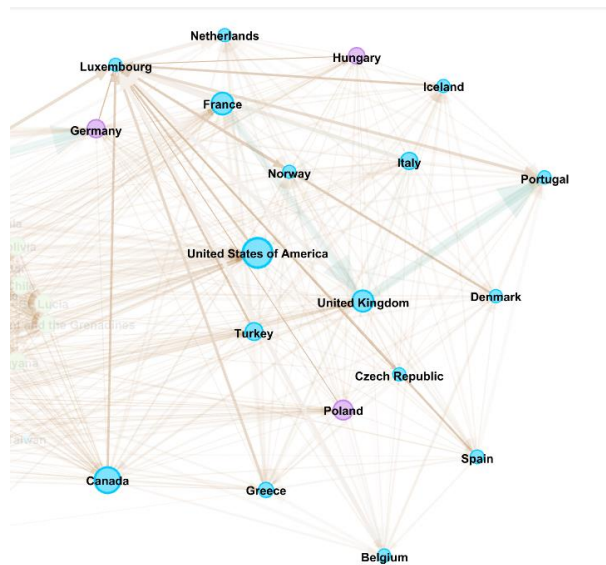
Fig.13 NATO Alliance Countries

Observations:

1. The edge weights in the alliance graph show how equally important connections are between NATO member nations.

2. According to the community structure in the graph, countries frequently create alliances with other countries that have comparable military and political goals.

Fig.14 Representation of Shanghai Cooperation Organization (SCO)

Observation:

1. This alliance network features a distinct community structure, with the Shanghai Cooperation Organization's members constituting a separate community within the larger alliance network. The countries include China, Russia, Kazakhstan, Kyrgyzstan, Tajikistan, Uzbekistan, and Pakistan.
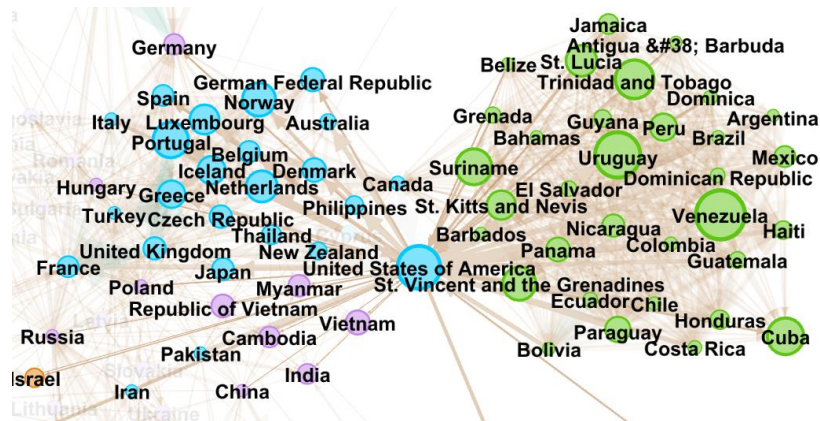

Fig.15 Eigenvector representation

Id	Label	Eigenvector Cent... ∨
90	Venezuela	1.0
89	Uruguay	0.899733
88	United States of America	0.834308
87	Trinidad and Tobago	0.719453
91	Cuba	0.663998

Fig.16 Tabular Eigenvector representation

Nodes size: Eigenvector Centrality

Observation:

1. The two nodes with the highest eigenvector centrality in the network are Venezuela and Uruguay, showing close ties to other significant nodes.
2. The United States has more connections to other communities in the network and is connected to both nodes.
3. As a result of their close ties to the United States, Uruguay, and Venezuela are expected to exert more influence within the network.

Discussion & Conclusion:

Network analysis is an effective method that can help us in comprehending the complex connections between countries and how they affect international politics. Network analysis can provide a visual depiction of the patterns of cooperation and conflict that appear in the international political arena by depicting countries as nodes and their interactions as edges. This method allows us to pinpoint the key players in the networks of alliances and sanctions as well as how they affect one another's foreign policy choices.

According to our research, the community structure of the alliance network reflects the proximity of countries geographically and their similar interests. This lends credence to the idea that countries join together because of shared geographic interests. For instance, we noticed that countries in Asia tended to develop alliances with other Asian nations, but countries in Europe tended to form alliances with other European countries. This implies that countries are more inclined to create coalitions with other countries that share their culture and experience comparable security risks.

We also discovered that regions with high levels of political unrest, economic disparity, or security threats are more likely to impose sanctions. This lends credence to the idea that these elements influence the application of punishments. According to our findings, the United States put sanctions on India following its nuclear tests. Additionally, we discovered that the primary goal of military sanctions was trade, which suggests that nations frequently employ sanctions to safeguard their economic interests.

Lastly, we observed that throughout time, the structure of the military alliance and sanction networks varies in reaction to evolving geopolitical factors, such as the emergence or waning of superpowers, shifts in global economic trends, or the escalation of armed wars. This lends credence to the idea that these networks' structures are dynamic and change over time. For instance, we noticed that the early 1990s Soviet Union collapse resulted in a rearrangement of the alliance network as former Soviet Union allies sought new ties.

Our analysis emphasizes the significance of network analysis as a tool for comprehending the complex connections between countries and their impact on international politics. We can learn more about the power relations between countries and the possible effects of these interactions

on global politics by analyzing the patterns of cooperation and conflict that arise in the international political sphere.

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