Using Network Analysis and News Sentiment to quantify Geopolitical Changes

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ABSTRACT

In this study to explore shifts in international relations from 2015 to 2023, we employed network analysis and global news article sentiment, leveraging the Global Database of Events, Language, and Tone (GDELT) in conjunction with the World Press Freedom Index. We investigated the reciprocity of countries, focusing on the United States and China's role in the global international order and observe a modestly declining global political centrality of the United States juxtaposed with China's rising influence, underscoring a potential shift towards a multipolar global order. Additionally, we studied the impact of significant political events on international relations, event-related polarization in global news coverage and regional differences in media sentiment at the hand of the Russian-Ukrainian conflict that started on February 24th, 2022, revealing regional variability pertinent to the war. Our research underscores the utility of digital news archives in understanding global political dynamics and provides suggestions for further exploration into the intricacies of global news media and politics.

1 INTRODUCTION

The global international order has in the past decades undergone several significant transformations. From the Cold War era which manifested itself in history as an inherently bipolar world, in which the two superpowers of that era, the United States and the USSR, competed for world hegemony in the years following World War II. To the decades following the dissolution of the USSR which marked a unipolar moment lead by the victorious US allowing it as the sole superpower to exert unparalleled influence over international affairs shaping world politics, economics or culture and facilitating the proliferation of Western ideologies. More recent developments, however, e.g. the formation of the intergovernmental organization *BRICS* in 2010 and its expected expansion to six new members from January 2024 [3] or the Chinese-led *One-Belt, One-Road* initiative launched in 2013 [9] challenge that post-Cold War international order and US world hegemony [8].

To aid in the study of such changes in international relations and affairs, the political sciences have traditionally relied on event-based data to describe the interaction between political actors—be it nation-states or influential individual groups. Such events summarize an action performed by one actor upon another [13], thus modelling their interaction in a specific context. Consequently, a series of events between two actors can then be used to analyze their relationship over time. Helped in recent decades by the increasing digitization of global news, access to news sources has faciliated the research and analysis of international relations, both of historical contexts, for understanding current conflicts as well as for predicting future micro- or macro-political developments. Among the most extensive such event databases is the open-source *GDELT Project* [10] with its *GDELT 2.0 Event Database* which collects and

makes available millions of news articles from global media outlets that are automatically annotated to describe an event that includes its actors, action and overall sentiment as extracted from the news article. These data may offer both coarse and nuanced insights into both significant and subtle shifts in international relations and affairs.

In this work, we will thus investigate potential and subtle changes in international relations using event data from global news. We will use network analysis to represent the relationship of individual nations over time, identify significant players and analyse reactions to and the impact of significant world events on international relations. More specifically, we will try to answer the following questions:

I. Can we quantify the relationship between countries using news articles and thereby observe changes in international relations over time?

II. How are these changes influenced by events?

In ensuing sections, we will present the data (Section 2) used in this work, followed by the methodology (Section 3) conceived to model the relationship between involved actors and the results (Section 4) obtained. Finally, we will briefly discuss limitations (Section 5) of our work before concluding (Section 6).

2 DATA

The project relies on the Global Database of Events, Language, and Tone (GDELT) as its primary data source. GDELT continuously monitors global news coverage in over 100 languages, updating every 15 minutes, categorizes news articles with various attributes, and stores them in their databases. Complementing this, we incorporate data from the World Press Freedom Index to enrich our analysis.

2.1 GDELT

Our study is based on political news articles spanning from 2015 to 2023 sourced from the GDELT project [12]. Specifically, we are using the GDELT 2.0 Event Database stored on Google Cloud Platform [11]. The database collects so-called events that are extracted from sociopolitical news articles published worldwide. An event is a record stored in an expanded version of the dyadic CAMEO format [16], capturing two actors and the action performed by *Actor1* upon *Actor2* [13]. Each record is represented in a number of fields capturing various attributes of the event.

Table 1 presents an example event with all irrelevant fields omitted. In this example, an Italian delegate (`Actor1CountryCode == "ITA"`) had a telephone call (`EventCode == 041`) with a representative from France (`Actor2CountryCode == "FRA"`). The value of `NumMentions` indicates that this event was mentioned in two news articles within a 15-minute time frame, with the tone averaged by these articles being 0. The `SOURCEURL` contains a link to the first

article that featured this event. And indeed this article is from a Serbian media outlet covering the French Interior Minister's plans to visit Italy to discuss the migrant crisis with his Italian counterpart following the arrival of thousands of migrants on Lampedusa, as confirmed by the French presidency after a call between French President Emmanuel Macron and Italian Prime Minister Giorgia Meloni.

To measure the sentiment of an article, GDELT identifies positive and negative words in the document and calculates the overall tone of the text by calculating the positive and negative sentiment in it. The tone score range is from -100 (extremely negative) to +100 (extremely positive) but most of the values reside between -10 and +10, with 0 indicating neutral [1].

Finally, it is important to note that each event in the dataset typically involves three parties: Actor1 and Actor2 country and the country of the media outlet that reported the event with the latter potentially coinciding with either the Actor1 or Actor2 country.

As already mentioned, the event database resides on Google Cloud. We have implemented a script to retrieve data for the years from 2015 to 2023. It is accessible in our GitHub repository [1], which is included alongside this report.

Before conducting any analysis, we filter raw datasets as follows:

(1) Exclude all non-country actors: if a value in `Actor1CountryCode` or `Actor2CountryCode` field is not a three-letter country code (ISO alpha-3 code), remove the entry;
(2) Filter out records with `Actor1CountryCode == Actor2CountryCode`.

2.2 World Press Freedom Index

Several factors, e.g. the political, legal or socio-cultural situation in a country, may influence what and how media in that given country report on world events. To this end, the apparent press freedom of a country may give an indication as to the degree of trustworthiness of news reporting stemming from that country. Thus, to more accurately reason on and interpret potential findings from our analysis, we augment our event dataset with information on the apparent freedom of press in individual countries, more specifically when investigating concrete events and global reactions to it (see Section 4).

For this purpose, we use the *World Press Freedom Index (WPFI)* which is published annually by the non-governmental organisation *Reporters sans Frontières (RSF)* [14]. To determine the freedom of press of countries, RSF relies on partner organisations, journalists and media workers, human rights and legal experts in individual countries to respond to a questionnaire pertaining to their country's freedom of press situation. In its latest methodology, the questions in the WPFI cover five contextual indicators, i.a. political, economical or socio-cultural, to assess the press freedom of countries in a range from 0-100, whereby a score of zero indicates the worst and a score of 100 the best possible situation for the press and journalists in that country. Finally, based on these individual indicators an overall score is determined which all contextual indicators contribute to equally. A qualitative classification of countries based on the determined overall scores can be found in Table 4 of the Appendix.
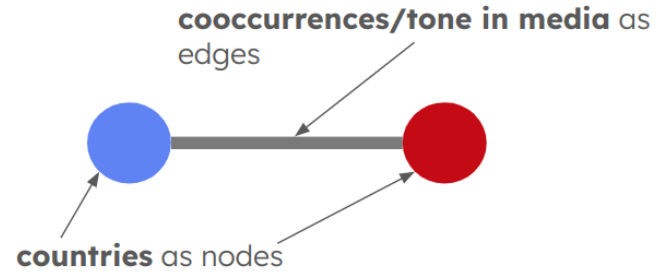
Figure 1: Nodes and Edges

It must be noted that because the methodology by which the score is assessed has changed in 2022, we limit the use of WPFI data to the analysis of global events occurring in a specific year, as scores before and after the methodological change may not be fully comparable.

3 METHODOLOGY

In its core our project employs network analysis, a technique to study relationships between various actors. We have chosen this methodology for several reasons:

(1) Network analysis is a great tool to generate a human-readable representation for large amounts of data;
(2) Once the network is built, there are numerous approaches to measure it, such as quantifying the importance of nodes or identifying communities;
(3) Network analysis is a helpful tool to guide investigations of data by revealing interesting patterns. It provides the freedom to pick a question and delve deeper into the intricacies of the network to find answers revealing how and why something works in a certain way.

3.1 Creating networks

In social network analysis, nodes typically represent people, while edges represent various forms of interactions or relationships between them. We use the same idea but put countries in the nodes of the network. We define edges in two different ways (see illustrative example in Figure 1 and further details below).

As described above, an entry of the dataset captures an action performed by Actor1 upon Actor2, where Actor1 and Actor2 are *distinct* countries. For a pair of nodes, i.e. a pair of countries, say, country A and country B, we calculate a value that represents the strength of the relationship between country A and country B and use it as the weight of the undirected edge between A and B.

- **Co-occurrence edge**: Count the number of dataset entries, where Actor1 is either country A or country B, and Actor2 is also country A or country B, and weight them by `NumMentions`. After normalization, obtain the edge indicating how often an event occurred with both countries A and B involved. The larger the value of an edge, the more intense the relationship between the pair of countries is. A value of zero indicates the absence of a relationship.
- **Tone edge**: Calculate the average tone (mean value of `AvgTone`) weighted by `NumMentions` of all events, where

GLOBALEVENTID	SQLDATE	Actor1CountryCode	Actor2CountryCode	EventCode	NumMentions	AvgTone	SOURCEURL
1127378316	20230917	ITA	FRA	041	2	0	Original article here

Table 1: Example event from the GDELT Event Database

Actor1 is either country A or country B, and Actor2 is also country A or country B. After applying a linear transformation function to restrict the range of values to non-negatives, obtain the edge that represents the averaged tone of mentions of the events with both country A and B involved. The higher the value, the more positively the countries are aligned. An edge weight of zero indicates an extremely negative relationship between this pair of countries.

3.2 Measuring networks

Betweenness Centrality. Betweenness Centrality measures how often a node occurs in the shortest path between two other nodes in the network, where the lowest possible value is 0 and the maximum value depends on the network topology and cannot be specified a priori. Depending on the methodology chosen, we interpret a high or low centrality differently. In the case of the co-occurrence network e.g., we interpret the centrality value assigned to each node as a measure of influence associated with the country: the larger the value, the more involved and active the country is in the political landscape.

Modularity. Modularity is a metric used to identify communities within a network. It operates on the premise that nodes in the same community are significantly more interconnected with each other than with the rest of the nodes. The algorithm begins with each node in its own community, then iteratively attempts to merge communities in a way that minimizes the modularity score, denoted as Q. The algorithm terminates when no further merges are possible that would reduce the score. The modularity score Q ranges from -1 to 1, with higher scores indicating a more pronounced community structure within the network.

3.3 Example and Interpretation

Figure 4 illustrates a network based on the co-occurrence of actors in the dataset in 2015. It displays the subset of all nodes with a betweenness centrality of ≥ 0.0018. The nodes are sized corresponding to their betweenness centrality, where a larger node size correlates to a higher centrality. Additionally, nodes in the network are coloured according to their affiliation with a given community as determined via its modularity. Various algorithms exist to arrange nodes in a network and reveal their relationship visually. To this end, a force-directed algorithm [6] can be used to attract nodes with higher edge weights—corresponding to a greater co-occurrence in events—or conversely, repulse nodes to highlight the bilateral relationship between countries.

4 RESULTS

Our analysis of global events from the years 2015 to 2023 unveil insights into which actors have potentially shaped international relations most, how individual actors reacted to significant events
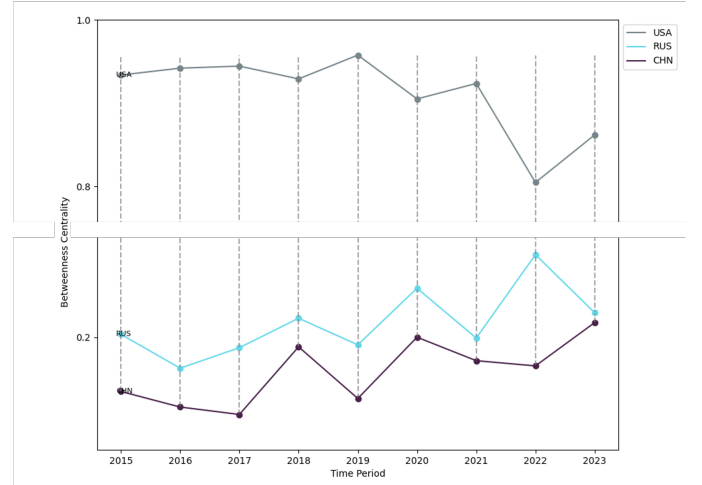
Figure 2: Annual Betweenness Centrality of the three superpowers USA, Russia and China.

and how an actor's opinion may have changed in its course. In the following paragraphs, we will thus detail our findings that are based on supplementary analyses of the data in addition to the network analysis performed.

4.1 Key Players

Using the centrality of nodes, which in the networks of this work reflects the global political influence and importance of individual countries, we find that with an average *betweenness centrality* of 0.9124 the United States is the single most significant global player. Its property of lying most frequently on the shortest path of any two nodes in the network highlights the US' role as the global leader and its engagement in affairs or actions with a great number of other countries. Given that the post-Cold war international order has been dominated by the US, this finding is hardly surprising. What stands out, on the other hand, is the observable decline of centrality of the US in the examined period from 2015 to 2023 (see Figure 2). Its percentage decline of -7.71% is contrasted by the rapid increase of centrality of 61.58% by China as illustrated in Table 5. In the last six years of that period alone, China's centrality more than doubled (103.4%), while Russian and US centrality increased and decreased by 22.5% and -8.75% respectively in the same period. This suggests a perceptible rise of China as a regional and global power [8, 9] that increasingly and more frequently interacts with countries around the globe, effecting a change of the unipolar international order to a multipolar one.

		Tone		Topic Count		Topic Share		Score	
		F-statistic	p-value	F-statistic	p-value	F-statistic	p-value	F-statistic	p-value
Period	Before	1.16	0.88	40.16	4.0e-08	66.36	1.3e-13	-	-
	After	9.88	0.042	43.16	9.6e-09	51.73	1.6e-10	-	-
Press Freedom	-	11.66	0.02	54.72	3.7e-11	64.11	3.9e-13	63.86	4.4e-14

Table 2: Kruskal-Wallis test results for regional and press freedom-based comparison in the period before and after the commencement of the Russian-Ukrainian war on February 24th, 2022

4.2 Key Events

We are interested also in investigating the effect of major events on bilateral relations of involved and uninvolved actors. To make the analysis more tangible, we focus on observing the tone spread and its changes within a narrow timeframe surrounding the commencement of the Russian-Ukrainian conflict on February 24th, 2022.

4.2.1 Event-related Polarization. We examine potential global polarization in relation to the Russian-Ukrainian war and changes in attitude towards involved actors based on the share of news reporting on the war of each country and their tone of reporting. Figure 5 illustrates the change in tone and share of event-related reporting in the period from January to April 2022 for all countries present in the dataset for that year. To reduce the impact of countries that have a large number of news reporting, we calculate the share of event-related reporting, i.e., the start of the Russian-Ukrainian war, in relation to the overall news output from a country instead. We use the tone as defined in Section 3.1 to gauge the polarization caused by the event. We employ simple statistical analysis to identify differences across the periods before and after the war (see Table 6). The observable shift in tone in Figure 5 manifests itself with a mean change of 11% in higher negativity in global news reporting, while the share of event-related news reporting, referred to as *topic share* saw an increase of 80% after the war started. To further investigate regional differences viz., between Africa, Americas, Asia, Europe and Oceania, pertinent to tone and topic share, we used the Kruskal-Wallis test (see Table 2) to explore the relationship between the variables used in the data. We observe that in the period prior to the start of the war no significant differences between regions w.r.t to tone can be identified ($p = 0.88$). By contrast, the period after the war's start indicates more significant differences in tone ($p = 0.042$) for event-related reporting across various regions providing compelling evidence for regional differences in their response to and perception of the event. Test results for the topic share suggest significant variation in regional event-related reporting both before ($p = 1.3e{-}13$) and after ($p = 1.6e{-}10$) the start of the war. In this regard, European news saw the highest mean topic share (24.7%) in the period after the war, suggesting local news outlets emphasized the war in their news coverage most prominently.

While this finding may be the result of several factors, one possible explanation for it might be Europe's geographical proximity to the war. But because Oceania has the second highest topic share (19.5%) and is geographically furthest away from this event, we cannot confidently determine geography to explain this observation.

An alternative explanation may, thus, lie in the press freedom observed in the different regions. We, therefore, perform an analogous analysis using a country's press freedom score as assessed in the World Press Freedom Index [14]. A visualization of the data under analysis and the calculated correlation of its variables are shown in Figure 6 and 7 respectively. Interestingly, the results indicate that there exists a moderate positive correlation of 0.305 between the topic share and score variables, suggesting that news reporting from countries with higher freedom of press scores have, in the case of the Russian-Ukrainian war, a tendency to more event-related coverage. The significance of the observed moderate correlation between topic share and score is corroborated by $p = 9.7e{-}05$ using Spearman's measure for rank correlation. Finally, Europe and Oceania have the highest and second highest mean freedom of press score, 72.8 and 70.2 respectively, thus, reinforcing our hypothesis that a region's score may explain the intensity of event-related reporting, i.e. topic share.

4.2.2 Tone Spread. In this subsection, we examine the tone spread of media from different countries across various types of events. We limit our analysis to Russian and Ukrainian media, considering them as the media outlets of directly involved parties. Additionally, to capture not only the reactions from 'insider' perspectives but also those from countries not directly involved in the conflict, we include a similar tone analysis for a selected set of other influential countries' media as shown in Figure 8 in the Appendix.

Figure 3 illustrates the mean average tone of Russian and Ukrainian media categorized according to event codes. For the sake of visualization, the bar plots feature the top 10 most frequent event codes in the two months preceding and following the inflection point. The solid orange and green bars represent the mean average tone of Russian and Ukrainian media, respectively, *in events involving any countries as actors*. Conversely, the semi-transparent bars depict the mean average tone *in events solely involving Russia and Ukraine as actors*.

The bar plot corroborates two hypotheses:

(1) Russian and Ukrainian media exhibit significantly more negativity in events exclusively involving Russia and Ukraine.
(2) Negativity intensified following the onset of the military conflict.

Table 3 summarizes the data depicted in the graph. Descriptive statistics are computed for *all* events occurring from January to April 2022 (not solely the top 10 frequent ones depicted in Fig. 3). Notably, before the outbreak of the war, Russia tended to display more positivity in events solely involving Russia and Ukraine compared to those involving other countries, whereas Ukraine exhibited

the opposite trend. However, after the conflict commenced, both countries demonstrated increased negativity in their coverage of events involving both of them, as opposed to other events. Additionally, it is noteworthy that the mean average tone of Russian media covering events with solely Russia and Ukraine involved as actors remained unchanged after the conflict began, while the tone of Ukrainian media considerably worsened.

5 DISCUSSION

In this subsection, we will investigate the similarity of the two methodologies, *tone* and *co-occurrence*, chosen to create a network and delineate limitations that we have identified in our work.

5.1 Comparing Approaches

As a measure of similarity to compare the networks obtained by the two approaches, where the first one measures edges of the network based on co-occurrences and the other based on the average tone, we use the *Betweenness Centrality*, as defined in Section 3.2, of individual countries assigned to them in the respective approaches. For this purpose, we rank countries by their centrality in the two networks and calculate their rank difference. We register a significant change in the rank of a country, if this difference exceeds a predefined threshold. Conversely, a country whose rank from one approach to the other is within the defined threshold, we consider it to be within an acceptable limit of difference. We deliberately opted for a threshold of five ranks to err on the side of conservatism.

Testing the two approaches discloses a notable difference of an annual average of 94% of all countries that undergo a significant change in the ranking. As an illustrative example, the United States have the highest betweenness centrality in the co-occurrence network, while in the tone network the Maldives rank highest. While this finding is surprising, it may be the manifestation of several factors.

Third-Party Opinion. Using the average tone of news articles to construct a network is influenced by what can be referred to as *observer bias*. As the article to an event may be written by a third, uninvolved party to the event, the tone assigned to the event between actor *A* and *B*, thus, not necessarily reflects the tone of the actual engagement between actor A and B, but rather what the third-party opines. We conjecture that as a result we obtain different results for our tone versus co-occurrence networks.

To address this flaw, future work could weight the average tone assigned to an event by the press freedom score assigned to the country of origin of the news outlet reporting on an event. As an indicator for the apparent trustworthiness of news coming from a country, news reporting originating from a country that performs better in the World Press Freedom Index [14] could be given a higher weight in the calculation of the weighted average tone of a specific event as a compensatory measure.

Positive Relations. Although the differences in assigned betweenness centralities may be the result of aforementioned *observer bias*, they do not necessarily imply superiority of one approach of the other. Because distinct approaches are used to calculate the weight of edges between two nodes in the network—indicative of the strength of bilateral relations—trivially different countries may

receive varying values across the two approaches. Importantly, a high centrality in the co-occurrence network is indicative of a country that frequently engages in events with other countries without any indication as to the apparent tone of that interaction. On the other hand, a high centrality in the tone network is indicative of a country that cultivates many positive relations, therefore augmenting the study of bilateral and international relations with an additional dimension. Future work may, thus, investigate further the relations of countries based on the tone of their relations as opposed to only their intensity.

5.2 Limitations

Apart from the differences in interpretation, additionally we highlight the following methodological and theoretical limitations.

Simplified Actors. The GDELT dataset provides more fine-grained information on actors than the subset of data that we employed in this work. In this regard, actor information surpasses the simple affiliation with a country and may include information on non-governmental organizations, movements or actors such as rebel groups or independent military actors. Because we do not disassociate actors at this level of detail and presume an affiliation to the official government by using solely the CountryCode with which an actor has been coded, we make assumptions that may oversimplify or approximate the relationship between countries.

For instance, our approach attributes an entry in the dataset that involves a rebel group from country *A* that is engaged in an event *E* in country *B* to the official government of country *A* instead of to the rebel actors that are involved in or are the perpetrators of that event. Actions of independant individuals or non-governmental groups may, thus, explicitly influence the relationship of their country's government to third countries. While in some instances actions of independent actors may indeed influence bilateral relations of that country, this is not always the case.

In order to increase modelling accuracy of international relations, future iterations of this work would need to distinguish between actions of different types of actors e.g., rebel versus governmental actors.

News-as-a-Proxy. While we have shown in Section 4 that our approach is sensitive to significant events e.g., the start of the war between Russia and Ukraine in late February 2022, corroborating that events coded from news articles indeed constitute a good proxy for modelling the true relationship between any two countries is more laborious. Firstly, using news articles as a proxy trivially only allows for de-classified information to ever be coded into events between two countries. Information that is not publicly available or has not e.g. been leaked to news outlets or independent journalists cannot be reported on, hence will not be reflected in datasets such as that of the GDELT project. Thus, clandestine interactions between actors to shape the relationship of two countries cannot be considered in a modelling approach that employs news as a proxy for the relationship of countries. Secondly, though more fundamentally, the question of whether news or media can generally act as a proxy for estimating international relations and whether there exists a reciprocal media-politics relation must be answered. In this regard, various theories exist to draw attention, amongst others, to
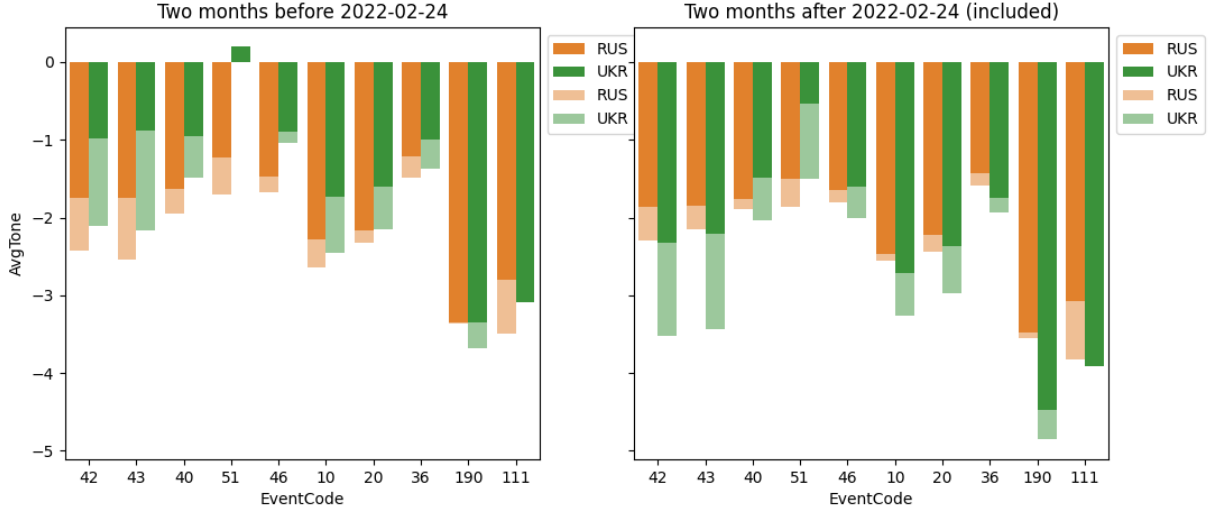
Figure 3: Tone spread of Russian and Ukrainian media before/after the start of the Russian-Ukrainian conflict. For the event code meanings refer to A.6.

| | | Before | | After | |
		RUS	UKR	RUS	UKR
All events	mean	-2.99	-2.31	-2.68	-2.96
	min	-12.96	-7.38	-7.55	-10.13
	max	2.76	6.81	1.63	3.95
Events Russia-Ukraine actors only	mean	-2.72	-2.55	-2.72	-3.38
	min	-7.44	-10.43	-7.45	-8.55
	max	2.14	3.6	2.72	2.37

Table 3: Descriptive statistics for tone spread analysis on all events from January to April 2022; Fig. 3 features top 10 most frequent events from that period of time. RUS and UKR columns denote Russian and Ukrainian news outlets respectively.

the relationship between media and politics and its influence on political decision-making and vice-versa [2, 5, 7].

In [2], Bennett posits that mainstream media does not operate entirely independently in shaping narratives but rather echoes the debates and perspectives prevalent among political elites by *indexing* its views on particular issues to those debated in official political or governmental circles. Importantly, Bennett argues that non-official viewpoints are often only included in that index if they reflect opinions already being discussed in official circles. Thus, a higher agreement on a particular issue in political or governmental circles is mirrored in the news media by more uniform reporting on that issue. The process of mediatization of politics, by contrast, influences political decision-making [15], whereby due to higher independence of news media from political institutions, politics is said to increasingly follow the *news media logic* as opposed to a *political logic*. As a result of this emancipation process the news media follows their own as opposed to party-affiliated interests, thus the setting of the agenda and framing of newsworthy issues is driven by self-interest of news media. Consequently, political

actors need to adjust their views and behaviour to what the news media logic dictates.

While effects of mediatization on politics [4, 7] are manifold, we conclude that because politics has an interest in influencing the news media agenda with issues dear to them and it may also adopt issues that have been covered by the news media prior to that [17], the media-politics relationship should rather be thought of as reciprocal. Correspondingly, the existence of this reciprocal influence of media and politics may serve as a foundation for using news media as an adequate proxy for modelling bilateral and international relations.

6 CONCLUSION

In our study, we employed network analysis and sentiment assessment of news articles to explore changes in international relations as represented in global media coverage from 2015 to 2023. Utilizing the Global Database of Events, Language, and Tone (GDELT), alongside the World Press Freedom Index, we constructed networks

to analyze the dynamics of international relations, identifying key players and the impact of significant events on these dynamics.

Our findings underscore the hegemonial position of the United States in the global politics, despite observing a gradual decline as reflected by its receding network centrality over the examined period. This decline is contrasted by a significant rise in China's centrality, indicating its growing influence in international affairs. Moreover, the analysis of the Russian-Ukrainian conflict revealed how major events can polarize global media coverage and alter bilateral relations, highlighting the potential for media to reflect and influence geopolitical shifts.

We argued that the study is limited by its reliance on publicly available news as a proxy for international relations, which may not always capture covert diplomatic activities or accurately reflect the complex nature of state interactions. Additionally, the simplification of actors in the subset of GDELT data used to model relations may also obscure the role non-state actors or internal factions play within countries.

Future research could, therefore, refine the methods used by incorporating more nuanced actor classifications and exploring the impact of media freedom on the portrayal of international events more thoroughly. Additionally, investigating more concretely the reciprocal relationship between media coverage and political action could provide insights into the extent of mediatization, communication strategies and reciprocal influence of politics and media and their implications for international relations and affairs.

This study contributes to our understanding of the evolving international order through the lens of media coverage, illustrating the potential of network analysis and sentiment assessment as tools for the analysis of politics, specially international relations. By highlighting the changing dynamics of key players and the impact of significant events, this research is an endeavour to provide insights into the complex interplay between media and international politics.

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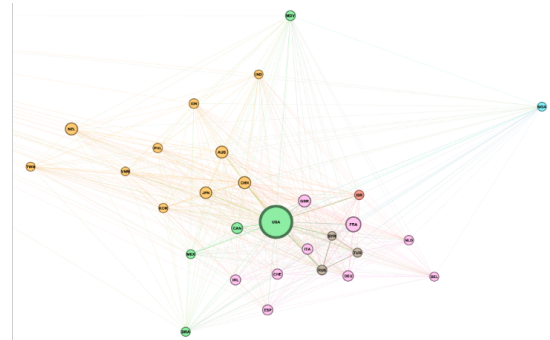
A APPENDIX

A.1 World Press Freedom Index Classification

| | Methodology | |
Class	New	Old
Good	85-100	85-100
Satisfactory	70-85	75-84
Problematic	55-69	65-74
Difficult	40-54	45-64
Very Serious	0-39	0-44

Table 4: Qualitative classification of World Press Freedom Index scores

A.2 Example Network

Figure 4: An example co-occurrence network for the year 2015 illustrating the relationship between a subset of all countries

A.3 Key Player – Additional Information

	2015-2023		2017-2023	
	Mean	%-Change	Mean	%-Change
USA	0.912	-7.71	0.905	-8.75
Russia	0.2179	12.78	0.228	22.49
China	0.1595	61.58	0.169	103.4

Table 5: The mean Betweenness Centrality and %-change for the three superpowers, USA, Russia and China, in the period from 2015-2023 and 2017-2023
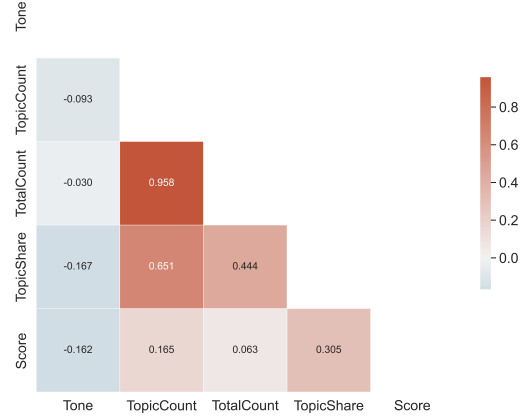
A.4 Event Polarization – Additional Information
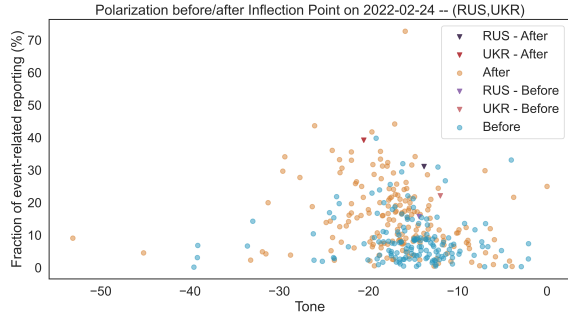
Figure 5: Polarization 30-days before/after the start of the Russian-Ukrainian war on February 24th, 2022.
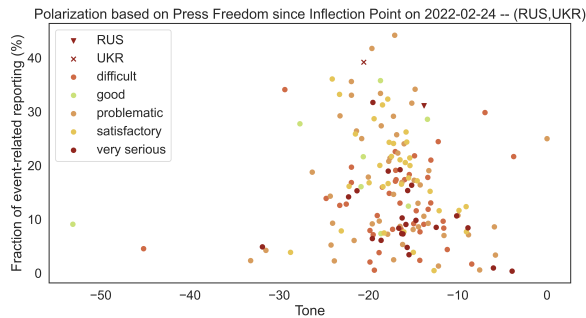
Figure 6: Polarization based on country opinions and press freedom since February 24th, 2022

Figure 7: Spearman correlation matrix for tone and topic share of countries, including their press freedom score, after the commencement of the Russian-Ukrainian war on Feb. 24th, 2022.

Table 6 highlights simple, descriptive statistics for the event-related polarization illustrated in the scatter plots in Figure **??**. It displays the mean, minimum and maximum values for the tone and total share of event-related reporting before and after the commencement of the Russian-Ukrainian war in addition to the press freedom-based polarization since its start. We note that the values across the before/after and press freedom plots differ only due to press freedom information not being available for some countries in the WPFI [14] dataset.

A.5 Tone Spread analysis for other countries

Continuing from the discussion in subsection 4.2.2, we present a bar plot illustrating the tone spread and accompanying summary statistics for nations not directly engaged in the Russian-Ukrainian conflict but rather observing it. This analysis endeavours to depict variances in sentiment among influential countries from different parts of the world and discern whether certain nations exhibit more negativity towards the conflict than others.

## A.6 Meanings of some CAMEO event codes

Here, we include decoding for some of the event codes that appeared in this report, which can also be found in the CAMEO Codebook [16].

- 42 == Make a visit: This event code signifies instances where Actor1 visits Actor2. Notably for Fig. 3 it's the most frequent event, and it's particularly interesting because it indicates diplomatic visits made by either Russia or Ukraine to their opponent following the onset of the war.
- 43 == Host a visit: This event code denotes occasions where Actor1 hosts a visit by Actor2.

	Tone			TopicShare		
	Before	After	Press Freedom	Before	After	Press Freedom
mean	-15.409	-17.131	-17.248	8.698	15.685	15.544
min	-39.560	-53.126	-53.126	0.173	0.385	0.385
max	-2.072	0.0	0.0	39.810	72.727	44.208

Table 6: Descriptive statistics for event-related polarization on all event types involving RUS & UKR from January to April 2022 (see Fig. 5) and press freedom-based polarization since Feb. 24th, 2022 (see Fig. 6)
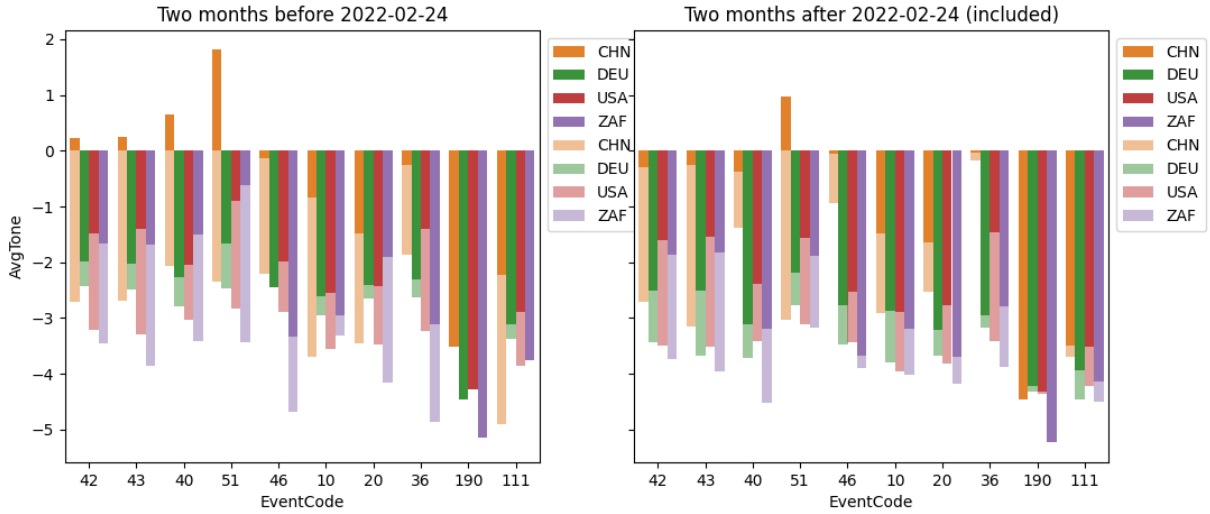
Figure 8: Tone spread of other countries' media outlets before/after the start of the Russian-Ukrainian conflict. For the event code meanings refer to A.6.

				Before					After
		CHN	DEU	USA	ZAF	CHN	DEU	USA	ZAF
All events	mean	-2.52	-3.32	-3.51	-3.53	-2.53	-3.52	-3.55	-4.06
	min	-11.6	-10.1	-8.33	-12.57	-10.81	-10.63	-11.33	-14.56
	max	4.48	1.28	2.02	2.86	6.7	2.19	0.82	2.18
Events Russia-Ukraine actors only	mean	-3.45	-2.77	-3.68	-3.9	-3.04	-3.7	-4.04	-4.56
	min	-14.71	-6.11	-15.89	-8.72	-11.37	-7.51	-11.33	-10.35
	max	1.29	2.9	2.02	-0.34	3.75	2.48	2.11	1.31

Table 7: Descriptive statistics for tone spread analysis on all events from January to April 2022; Fig. 8 features top 10 most frequent events from that period of time. CHN, DEU, USA, ZAF denote media outlets of the following countries respectively: China, Germany, USA, and South Africa.

- 51 == Praise or endorse: This event code encompasses expressions of support, commendation, or approval towards a policy, action, or actor. It often involves verbal acts, such as publicly endorsing a particular stance or action. For instance, it could entail a government welcoming a statement from another country as evidence of earnest efforts towards achieving a settlement in diplomatic negotiations.

- 190 == Use conventional military force: This event code indeed signifies the use of conventional military force by Actor1 against Actor2.