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Patterns of democracy? Social network analysis of parliamentary Twitter networks in 12 countries

Patterns of democracy? Social network analysis of parliamentary Twitter networks in 12 countries

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Abstract

Social media networks have revolutionized social science research. Yet, a lack of comparative empirical analysis of these networks leave social scientists with little knowledge on the role that contextual factors play in the formation of social relations. In this paper we perform a large-scale comparison of parliamentary Twitter networks in 12 countries to improve our understanding of the influence of the country's democratic system on network behavior and elite polarization. One year of Twitter data was collected from all members of the parliament and government in these countries, which resulted in around two million tweets by almost 6000 politicians. Social network analysis of the Twitter interactions indicates that consensual democracies are characterized by more dense parliamentary relations but also higher hierarchy and fragmentation compared to majoritarian systems. Secondly, parliaments with a high effective number of parties are more cooperative, which results in higher inter-party relations. Next to that, we show differences in the followers, mentions, and retweets networks that hold across all countries and political systems. Our empirical results correspond to established theoretical insights and highlight the relevance of institutional context as well as the platform characteristics when conducting social media research. With this research we demonstrate the importance and the opportunities of social network analysis for comparative research.

Keywords: Parliamentary Twitter networks, Elite polarization, Social network analysis, Comparative research

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1. Introduction

Social media has drastically changed the way people all over the world interact and communicate. Politicians are no exception. Today, social media is used as a new way to communicate and engage with voters, media and other politicians [1, 2]. Especially Twitter is increasingly used by political parties and politicians to engage in political debate, publicly show support or disapproval, and communicate with other representatives [3]. This new way of communication challenges some of the established theoretical insights in political science and introduces a number of technical obstacles. Simultaneously, it offers ample new opportunities to reassess how politicians interact with others. Network theory has been applied successfully to Twitter networks to offer insights in political polarization [4, 5], opinion leadership [6], the underlying structure of political groups and countries [7], engagement with the public [8], etc. However, up to now, these studies have mostly focused on one country and do not allow for structured comparison across multiple countries to gain insights in contextual variables and country characteristics [9].

Therefore, the aim of this study is to perform a large-scale comparison of Twitter networks to investigate the influence of institutional context on parliamentary relations. From September 2018 to September 2019, one year of Twitter data was collected from all members of the parliament and government in 12 countries with different political systems. This resulted in around two million tweets by almost 6,000 politicians.

With social network analysis and visualization we aim to explore three broad research subjects. First, we investigate whether the network properties of parliamentary Twitter networks are associated with the democratic system and functioning of the countries. We characterize the topology of the networks based on four widely-used network metrics: density, centralization, modularity, and the fraction of isolated users. We apply hierarchical clustering analysis to learn which countries are more similar based on their Twitter network properties, and link this to the electoral and party system of the countries. Secondly, we analyze inter-party communication as a measure of elite polarization along party lines. Next to linking this to the electoral and party system of the country, we also explore the correlation with ideological distance between parties. Lastly, we compare results across the followers, mentions and retweets network to learn how political interactions differ depending on the platform layer. To motivate why such comparative social network analysis can be valuable to improve our understanding of online social phenomena, we focus on the concept of elite polarization.

2. Parliamentary Twitter networks and elite polarization

A certain degree of political competition is necessary for a democratic system. Competing alternatives of public policy need to be presented to the public so that they can participate in the decision-making process. However, too much competition can lead to polarization which has detrimental effects on public decision making, as it stimulates partisan motivated reasoning, instead of decision making that relies on substantive arguments [10]. Therefore, political polarization, and the factors influencing it, have long been a central topic for political science.

The increasing popularity and use of social media have triggered debates about the effect of social platforms on polarization. Some claim that social media usage leads to increased polarization because individuals are more likely to engage with views similar to their own [11]. [12] study 10 million Facebook users in the United States and observe that individuals are more likely to be exposed to information from like-minded individuals. Several studies suggest that political Twitter networks in the U.S. exhibit a highly segregated partisan structure [4, 13, 14]. Also in other countries strongly polarized structures have been observed on social platforms, including Switzerland [15], Canada [16], and Italy [17]. In contrast, others argue that social media decreases polarization by exposing individuals to ideologically diverse information [18]. [19] conclude that previous work may have overestimated the degree of ideological segregation in social-media usage in the United States. They find (especially liberal) individuals to engage in cross-ideological dissemination. Similarly, [20] demonstrate that greater internet use is not associated with faster growth in political polarization. In Europe, [21] do not find empirical evidence of increased polarization in the Netherlands, and [22] indicate that cross-cutting interactions in Italy and Germany are less exceptional than expected.

In this research we focus on elite polarization from a network perspective, by analyzing the relational networks between parliamentarians on Twitter. We view polarization as the absence of interactions between opposing political groups [4]. Elite polarization can have important consequences for democracy. Polarization among the elite may influence mass polarization [10], while elite bargaining and interaction are conducive to a stable democracy [23]. [24] state that a liberal democracy is impossible without a "consensually united" national elite, which is characterized by dense and interlocked networks of communication and influence among the elite.

The Twitter platform is well-suited to investigate interactions between parliamentarians. Twitter use among politicians is higher then among the general public, and also different:

politicians mainly use it for political purposes, while citizens use it for political and non-political goals [5]. Twitter's open character could foster more dialogue along ideological lines without party restrictions, or confine parliamentarians to partisan divisions similar to the offline world. For example, [25] find that the legislators' social connections on Twitter are less partisan than offline relations such as voting and co-sponsorship. On the other hand, Swiss politicians show a very strongly polarized structure in online support networks [15]. Similarly, communication flows of Catalan parliamentarians are found to be polarized along party and ideological lines [5, 26]. All these studies are single-country studies and do not provide insights in contextual variables influencing elite polarization and interaction, which might explain the differences in these findings.

Parliamentary relationships are influenced by the democratic model of the country. [27] describes two models of democracy. The majoritarian model is characterised by a legislature elected by a simple majority of the voters. The United Kingdom can be regarded as the majoritarian prototype, hence the alternative name "Westminster model". The second type of democracy, consensus democracy, usually employs proportional representation systems and leads to compromise and minority rights. [27] argues that the structures of power distribution represented by the consensus model fosters cooperation between politically dissimilar parties. Hence, consensus democracies are expected to exhibit a more densely connected parliamentary network. Conversely, other scholars postulate that political fragmentation is increased in proportional systems due to coalition forming and lower barriers of entry for smaller parties [28].

Comparative network analysis can provide insights in the influence of the democratic model on parliamentary interactions. Several authors argue that comparative network analysis presents a useful tool to address core questions in the social and political sciences [29, 9, 30]. Yet, while one-country Twitter studies are plentiful (see examples above), cross-country studies on parliamentary Twitter networks are sparse, with some notable exceptions. [31] emphasizes the importance of comparative research but focuses on mass polarization by means of audience duplication graphs. [32] introduce the Twitter Parliamentarian Database, including parliamentarians on Twitter in 26 countries, designed to foster comparative and transnational analysis. They developed a topology for retweets networks [3] and link this to the democratic system of a country [32]. Our study contributes to this existing work by applying a more systematic approach to compare network topologies and by integrating all layers of interaction on Twitter.

Twitter networks consist of three layers of interaction: the followers network, the retweets network and the mentions network. Each layer represents a different type of communication.

The followers network is a relational network, where an account is followed because of an interest in –and mostly, but not necessarily, agreement with– the account's content. The followers network has shown to be very informative about ideological positions [14]. The retweets network is mostly a support network, resharing the tweets of users who think alike. [33] identify topical relevance, or congruence, as the most important factor in individual retweeting decisions. Several studies have found that party members are more likely to support or retweet candidates from their own party [15, 7, 5, 32]. In contrast, the mentions network is a more dialogical network that allows to interact with users who think differently. Parliamentarians have consistently be found to have cross-cutting interactions in the mentions network [34, 5]. This suggests that politicians are more likely to follow and retweet politicians with a similar ideology whereas they are more open to connect with opposing views in the mentions network.

3. Data collection

Our study includes 11 European countries with different political systems (Netherlands, Germany, United Kingdom (U.K.), Spain, France, Belgium, Italy, Romania, Poland, Ukraine, Russia), and the United States (U.S.). Our choice to compare European countries to the U.S. is motivated by their dominant position in international politics and political research. For the aforementioned countries, all members of parliament (Chamber of Representatives and Senate), the president and members of cabinet (Prime minister, Ministers, Secretaries) and political parties (with seats in parliament as of May 2018) were collected from governmental websites and other internet sources, which are provided in Appendix A.1. For each country, two independent coders with knowledge of the language and political context in the country were asked to manually check the Twitter handles of each politician, to select authentic accounts. The instructions that the coders received can be found in Appendix A.2. This manual check was performed to avoid inclusion of fake accounts (e.g. bots or identity impersonations [35]) in our dataset. Where the two coders did not agree on the correct Twitter handle, the Twitter handle of the politician was inspected by the authors. Using this list of Twitter handles, all tweets of the politicians' accounts were streamed using the Twitter Stream API for the period of September 2018 till October 2019, resulting in one year of Twitter data.

An overview of the countries in our study can be found in Table 1. The Democracy Index (DI) for each country was derived from The Economist Intelligence Unit's (EIU) Democracy Index 2019. The Democracy Index is based on five categories: electoral process and pluralism, civil liberties, the functioning of government, political participation, and political

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culture. The index lies between 0 and 10 and is based on the ratings for 60 indicators within these categories [36]. redThe democratic model and party system of most countries are found in [27]. Lijphart [27] argues that democracies can be categorized among two dimensions. The *executives-parties* dimension groups five characteristics related to executive power, the party and electoral system, and interest groups. The *federal-unitary* dimension groups five characteristics related to federalism or unitary government. Based on these dimensions, consensus democracy is characterised by executive power sharing and decentralization, while majoritarian democracy is described by strong government and centralization. The electoral system is categorized by the International IDEA [37] into three broad families: plurality/majority systems, proportional representation (PR) systems, and mixed systems. In a plurality/majority system, a candidate or party with a plurality of votes (i.e. more than any other) or a majority of votes (i.e. more than 50 percent) is elected. In a proportional representation system, the number of votes for a party correspond to the proportion of seats in an elected body. Finally, a mixed system combines a plurality/majoritarian voting system with an element of proportional representation [37].

Table 1: Overview of the countries in our study.

Country	DI 2019 [36]	Democratic model [27]	Electoral system [37]	Party system [27]
Netherlands	9.01	Consensual	Proportional	Multi
Germany	8.86	Consensual	Mixed	Multi
U.K.	8.85	Majoritarian	Plurality	Two
Spain	8.29	Majoritarian	Proportional	Multi
France	8.12	Majoritarian	Plurality (two rounds)	Multi
U.S.	7.96	Majoritarian	Plurality	Two
Belgium	7.64	Consensual	Proportional	Multi
Italy	7.52	Consensual	Mixed	Multi
Romania	6.49	Majoritarian	Proportional	Multi
Poland	6.26	Consensual	Proportional	Multi
Ukraine	5.90	Majoritarian	Mixed	Multi
Russia	3.11	Majoritarian	Mixed	Multi

4. Methods

After some general insights on Twitter usage, activity and popularity for each of the countries, we will describe politicians' communication and relational networks on Twitter using social network analysis. We will analyze followers, mentions and retweets networks separately, since they exhibit different properties with regard to the communication flow [5]. We define a directed graph $(G = (N, M))$ where the nodes (N) represent politicians and

the edges (M) represent follower, mention or retweet relations on Twitter. A visualization of the mentions and retweets network in all our countries at the party level can be found in Appendix B.

4.1. Network topology

We first analyze the overall network structure of the parliamentary Twitter networks to measure "consensual unity" [24] in the networks. To analyze the structure of social networks Himelboim [38] proposes a network-topology based on four network characteristics: density, modularity, centralization, and the fraction of isolated users. Unified networks are characterized by high density, low centralization, low modularity, and low fraction of isolates [38]. For each country, we calculate these properties for the followers, mentions, and retweets network.

1. **Density**. This is the proportion of potential connections in a network that are actual connections and lies between zero and one [39]. This metric shows how connected politicians are in the network.

$$D = \frac{m}{n(n-1)} \tag{1}$$

   With m the number of edges and n the number of nodes.

2. **Hierarchical structure/centralization**. Centrality can be measured using different approaches [see 40, for a comprehensive overview]. We will use degree centrality, as it is widely used [41] and intuitive to understand. The degree centrality for a node v is the fraction of nodes it is connected to. The degree centrality of a network is defined as the sum of differences between the highest degree centrality and the degree centrality of all the other nodes in the network, divided by the maximum sum of differences (the latter can be proven to be equal to $n^2 - 3n + 2$) [42].

$$C_D = \frac{\sum_i^n (C_D(v*) - C_D(v_i))}{n^2 - 3n + 2} \tag{2}$$

   With $C_D(v*)$ the maximum degree centrality and $C_D(v_i)$ the degree centrality of node i. This measure lies between 0 (very decentralized) and 1 (very centralized). In the case of a directed network, we can define two separate measures of degree centrality: inward hierarchy or outward hierarchy. Inward hierarchy is based on the in-degree (being followed, mentioned, or retweeted), while outward hierarchy is based on out-degree (following, mentioning, or retweeting other politicians).

3. **Modularity**. Modularity measures the strength of division of a network into different clusters or communities [43]. Networks with high modularity have dense connections

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between the nodes within clusters but sparse connections between nodes in different clusters.

$$Q = \frac{1}{2m} \sum_{ij} (A_{ij} - \frac{k_i k_j}{2m}) \delta(c_i, c_j) \qquad (3)$$

Where m is the number of edges, A is the adjacency matrix of G, k_i is the degree of node i and $\delta(ci, cj)$ is 1 if i and j are in the same community and 0 otherwise. To partition the graph in communities we make use of the Louvain algorithm [44] which optimizes for modularity. The resulting modularity measures will lie between zero (the fraction of within-community edges is no different from what we would expect for a randomized network) and one (fully modular network).

4. **Isolates fraction**. Isolates are users who are not connected to other users in the network. In our case, these are users who have tweeted in the period under study, but did not mention/retweet others nor were mentioned/retweeted by others. The isolates fraction is the portion of isolates in the network and varies between 0 and 1.

$$I = \frac{n'}{n} \qquad (4)$$

With n' the number of isolate nodes. The fraction of isolates allows to distinguish between two types of low-density networks: networks with small disconnected groups or networks with a high number of isolates.

After we calculate these metrics for all countries, we apply hierarchical clustering analysis to learn which countries are more similar based on their Twitter network properties, and link this to the electoral and party system of the countries. First, we calculate the pairwise Euclidean distance between all countries, based on their network properties (i.e., the country's network values for density, inwards and outwards hierarchy, modularity, and isolates). We do this for the followers, mentions, and retweets networks separately. Next, we start an agglomerative clustering approach: each observation starts in its own cluster, and pairs of clusters are merged (based on minimum distance) in every step.[1]

4.2. Inter-party communication

Secondly, we analyze inter-party communication as a measure of elite polarization along party lines. The External-Internal (E-I) index was developed as a measure of group embed-

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[1] We use SciPy's hierarchical clustering `https://docs.scipy.org/doc/scipy/reference/generated/scipy.cluster.hierarchy.linkage.html`

ding based on comparing the number of relations within groups and between groups [45]. It takes the number of connections (edges) of group members to outsiders, subtracts the number of connections to other group members, and divides by the total number of connections. In our case, politicians of the same party are considered as a group, and the E-I index can be calculated as:

$$E - I = \frac{m_e - m_i}{m_e + m_i} \tag{5}$$

Where m_i denotes the number of internal connections (between two politicians from the same party) and m_e the number of external connections (between two politicians from a different party). The E-I index ranges from -1 (all connections are internal) to 1 (all connections are external). The proportion of external party relations is expected to be lower in the follower and retweets network than in the mentions network, because in the mentions network politicians more often interact with users with opposing views [5]. Furthermore, it is to be expected that inter-party engagements are higher in consensual compared to majoritarian democracies.

Secondly, we investigate to what extent the relationships in parliamentary Twitter networks are in line with party ideology. We use the Left-Right Scale (RILE) by the Manifesto Project Dataset [46] as an estimate of parties' left-right positions. The RILE index is a widely used method to measure left-right positions of parties. It measures how often a party references left (L) or right (R) issues in their electoral program (manifesto):[2]

$$RILE = R - L \tag{6}$$

The rile index lies between -100 (only left-wing issues) and +100 (only right-wing issues). The RILE scores for the parties in our study can be found in Appendix Table D.10. Note that we do not have the RILE scores for all parties available. Based on the RILE score, we calculate the Euclidean distance between parties in the two-dimensional ideological space. Next, we measure the number of inter-party relations for all pairs of political parties, divided by the total number of relations for each party. Finally, for each country, we calculate the Kendall rank correlation coefficient between the ideological distance and the proportion of inter-party relations between all pairs of parties. As an example, the ideological distance between German parties and the proportion of inter-party relations are shown in Table 2.

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[2] see https://manifesto-project.wzb.eu/down/tutorials/main-dataset

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We calculate the Kendall rank correlation using the vectorized matrices of ideological distance and inter-party relations, where we omit the diagonal elements (the distance to and relations within the own party). A scatterplot of both variables can be found in Figure 1. We expect party representatives to be more often connected to representatives of parties that are close in the ideological space than representatives of parties that are further away, especially in the retweets network.

Table 2: Ideological distance (a) and proportion of inter-party follower relations (b) between parties in Germany.

(a) Ideological distance

	LINKE	SPD	90/Greens	FDP	CDU/CSU	AfD
LINKE	0.00	20.48	20.86	42.49	44.67	59.34
SPD	20.48	0.00	0.38	22.02	24.19	38.87
90/Greens	20.86	0.38	0.00	21.64	23.82	38.49
FDP	42.49	22.02	21.64	0.00	2.18	16.85
CDU/CSU	44.67	24.19	23.82	2.18	0.00	14.67
AfD	59.34	38.87	38.49	16.85	14.67	0.00

(b) Proportion of inter-party follower relations

|	LINKE	SPD	90/Greens	FDP	CDU/CSU	AfD
LINKE	0.51	0.06	0.10	0.05	0.03	0.03
SPD	0.17	0.64	0.18	0.13	0.12	0.05
90/Greens	0.14	0.10	0.47	0.10	0.08	0.04
FDP	0.06	0.06	0.08	0.52	0.08	0.04
CDU/CSU	0.09	0.12	0.14	0.17	0.65	0.07
AfD	0.03	0.02	0.02	0.03	0.03	0.76
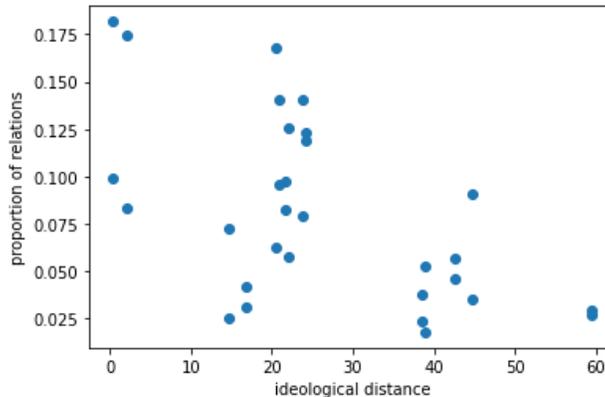
Figure 1: Scatterplot of the ideological distance and the proportion of inter-party relations between parties in Germany.

5. Results

5.1. Twitter usage

This Section provides some general insights on Twitter usage, activity and popularity for each of the countries. Table 3 and Figure 2 show the large country variation in degree of politicians with a (verified) Twitter account. In the US, almost all politicians have a verified Twitter account and to a lesser extent also in the Netherlands, Belgium, and France Twitter is popular amongst politicians. On the other side of the spectrum, in Ukraine, Romania, and

Russia, Twitter is used by less than 30% of the politicians and almost none of the accounts are verified. Interestingly, this is not directly related to the popularity of the platform among the general public as Twitter is relatively well-used by the general population in Russia. Similarly, when looking at the average number of tweets per month per politician, again, Ukraine, Romania and Russia are the least active (Figure 3).

Table 3: Overview of the number of politicians with a (verified) Twitter account per country

| Country	Total number of politicians	Percentage on Twitter	Percentage verified	Average number of followers
U.S.	950	94%	91%	354,546
Netherlands	272	87%	38%	29,113
Belgium	447	87%	20%	9,844
France	991	83%	62%	24,765
Italy	1023	78%	20%	24,994
Germany	873	71%	45%	16,039
Poland	591	70%	2%	16,782
Spain	643	54%	43%	49,017
U.K.	1486	53%	41%	46,143
Ukraine	456	30%	4%	41,505
Romania	515	29%	1%	2,064
Russia	536	24%	3%	54,755
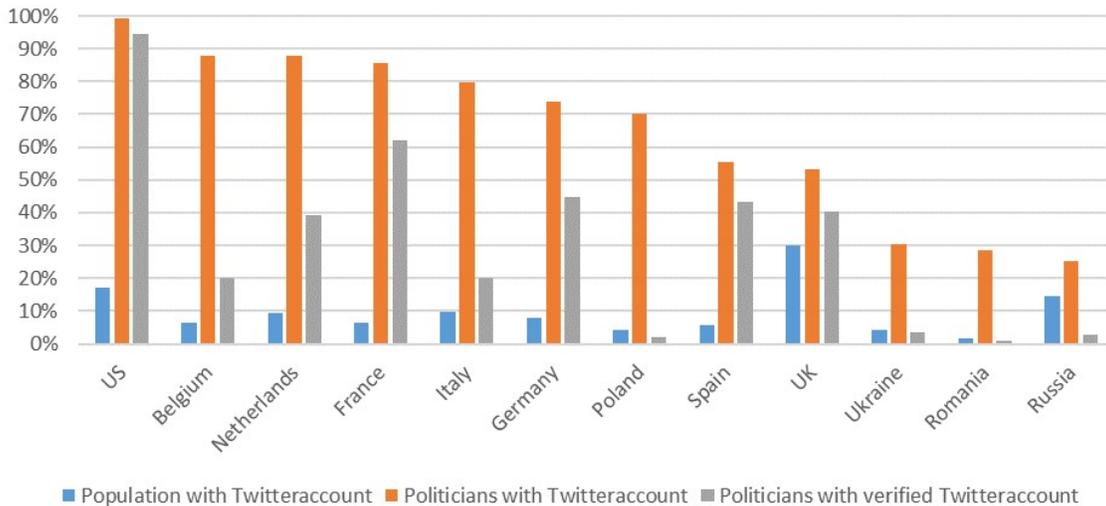
Figure 2: The proportion of politicians with a (verified) Twitter account compared to general Twitter use per country in 2019 [47].

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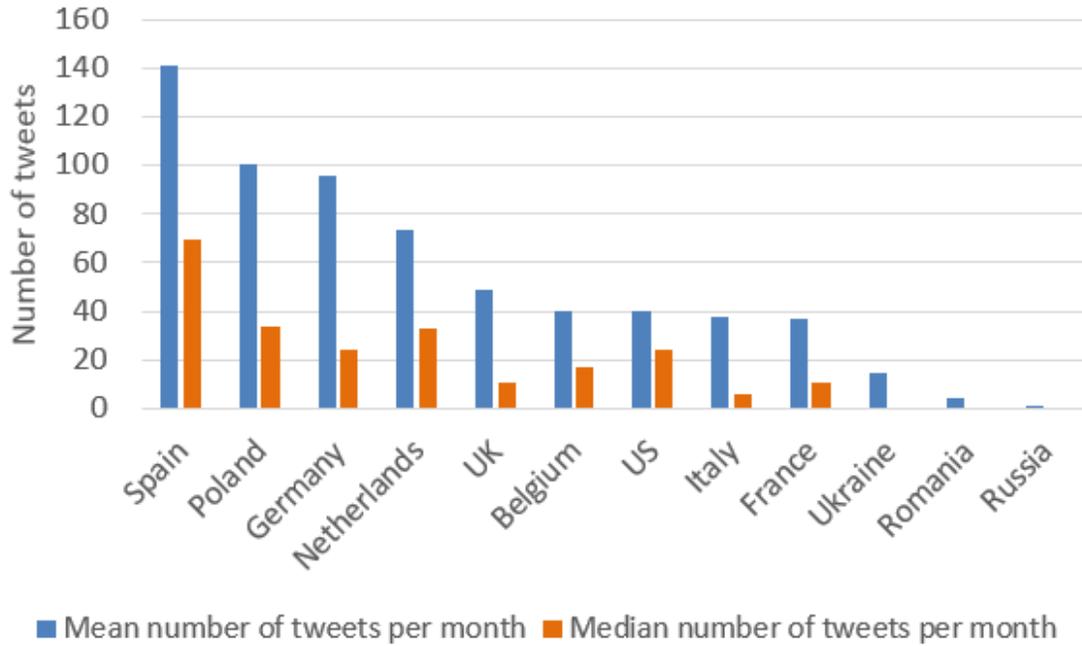
Figure 3: Average and median number of tweets in our dataset per politician per month
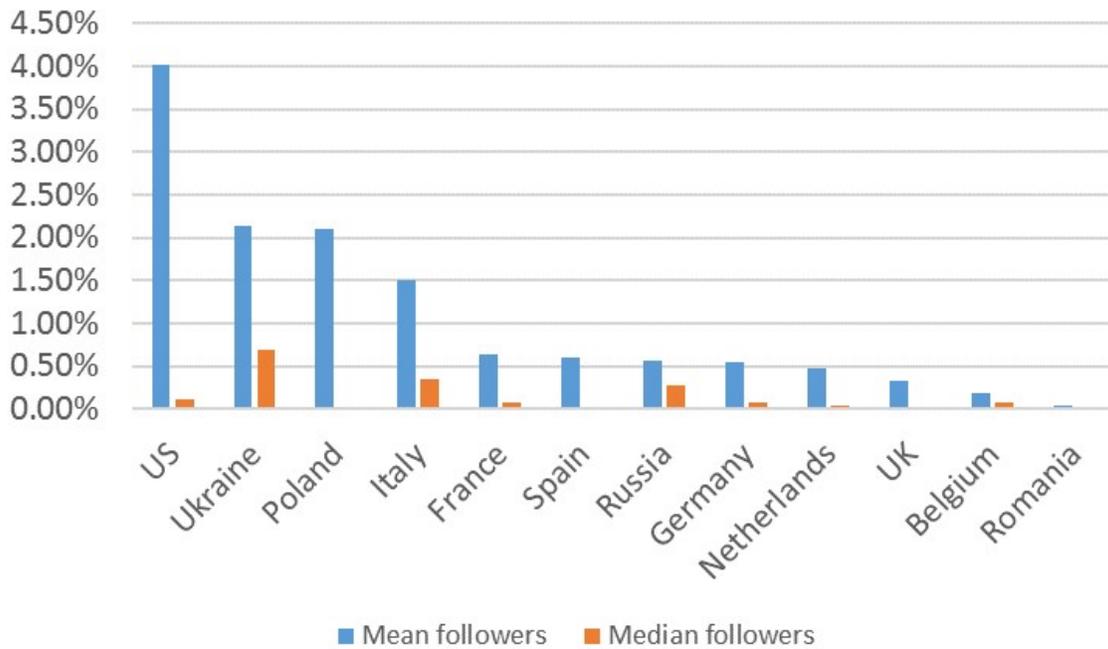
Figure 4: Average and median number of followers of politicians' Twitter accounts, as a percentage of the Twitter users per country. Twitter users per country are derived by Twitter market share per country [47] and total population of the country [48].

Lastly, Figure 4 shows the average and median followers of the politicians' accounts as a percentage of the Twitter users per country. On average, politicians have the highest (percentage) number of followers in the U.S. but this is mainly do to a few very popular accounts (e.g. in October 2019, @realDonaldTrump has 65,2 million followers and @POTUS has 26,8 million followers). Similarly, in Poland, some politicians are disproportionately popular on Twitter. On the other hand, the few politicians with a Twitter account in Russia and Ukraine are almost all followed by a relatively large number of users.

5.2. Network topology

Table 4, Table 5, and Table 6 show the network properties for the followers, mentions and the retweets networks respectively (see a visualization of the networks for Germany in Figure 5). As expected, the retweets network has higher modularity than the mentions network, but, more surprisingly, also higher modularity than the followers network, while follower and mentions network do not differ significantly.[3] Moreover, the detected clusters correspond better with the actual parties in the retweets network,[4] especially when modularity is high (Table C.9). This indicates that politicians retweet mostly within their own parties, while party structure is less observable in the followers and mentions network. Mentions on the other hand foster interaction across the whole network and have therefore lower modularity.

Furthermore, the retweets network is the least hierarchical,[5] both in terms of retweeting and being retweeted, indicating the absence of dominant players. The higher inwards hierarchy in the mentions and followers network implies that certain 'popular' politicians are more frequently mentioned than others, mostly a direct consequence of their official leadership position. [6] found that having a central political position (e.g. party leader or government function) increases the centrality in the followers and mentions networks, but not so much of the retweets network. Centrality in the retweets network is more dependent on Twitter activity then official leadership.

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[3]At the 5%-significance level after paired t-test with Bonferroni correction [49] for multiple comparisons ($\alpha/3$)

[4]We use the Adjusted Mutual Information (AMI) score to measure how well the detected clusters correspond to the actual parties. The AMI returns a value of 1 when the two partitions are identical and 0 when their labels are independent. Using the paired t-test with Bonferroni correction again, we find a significant difference in AMI scores between mentions and retweets network, but not between follower and retweets network, nor follower and mentions network

[5]Using the paired t-test with Bonferroni correction correction, we find a significant difference between mentions and retweets network, and between follower and retweets network, but not between follower and mentions network

(a) Followers network   (b) Mentions network   (c) Retweets network
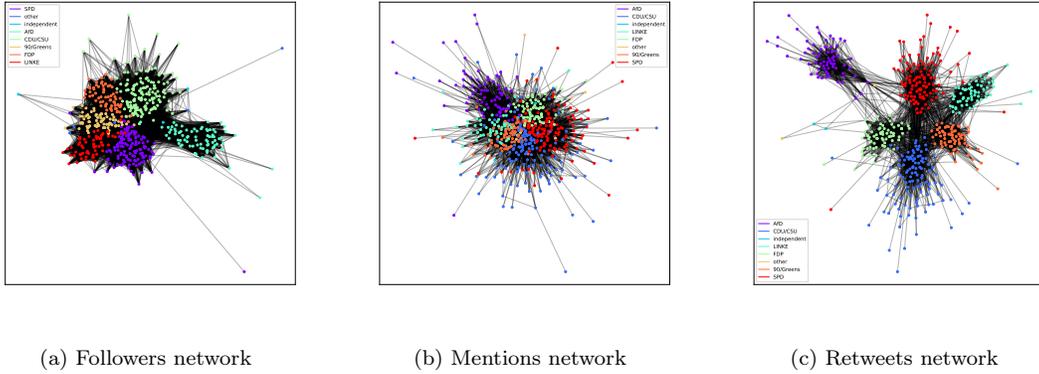
Figure 5: The parliamentary followers (a), mentions (b), and retweets (c) network in Germany.

Table 4: Description of the followers networks of the 12 countries.

Country	Density	Hierarchy in	Hierarchy out	Modularity	Isolates
Netherlands	0.24	0.42	0.58	0.13	0.03
Germany	0.14	0.46	0.66	0.40	0.05
U.K.	0.11	0.22	0.58	0.36	0.07
Spain	0.14	0.41	0.29	0.47	0.03
France	0.19	0.56	0.74	0.26	0.02
U.S.	0.15	0.30	0.60	0.32	0.08
Belgium	0.18	0.47	0.33	0.31	0.02
Italy	0.05	0.25	0.38	0.37	0.03
Romania	0.02	0.16	0.11	0.46	0.32
Poland	0.19	0.54	0.57	0.32	0.02
Ukraine	0.06	0.45	0.19	0.19	0.13
Russia	0.06	0.62	0.45	0.14	0.17

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Table 5: Description of the mentions networks of the 12 countries.

Country	Density	Hierarchy in	Hierarchy out	Modularity	Isolates
Netherlands	0.10	0.40	0.32	0.20	0.09
Germany	0.04	0.43	0.22	0.35	0.08
U.K.	0.04	0.49	0.23	0.23	0.11
Spain	0.05	0.62	0.26	0.40	0.06
France	0.05	0.63	0.18	0.22	0.03
U.S.	0.02	0.50	0.14	0.31	0.14
Belgium	0.08	0.57	0.34	0.28	0.05
Italy	0.01	0.26	0.08	0.35	0.39
Romania	0.00	0.04	0.06	0.67	0.84
Poland	0.07	0.63	0.30	0.21	0.13
Ukraine	0.01	0.12	0.05	0.47	0.74
Russia	0.00	0.06	0.04	0.75	0.75

Table 6: Description of the retweets networks of the 12 countries in our study.

Country	Density	Hierarchy in	Hierarchy out	Modularity	Isolates
Netherlands	0.04	0.12	0.10	0.61	0.19
Germany	0.02	0.11	0.12	0.71	0.18
U.K.	0.03	0.19	0.20	0.44	0.17
Spain	0.04	0.23	0.17	0.69	0.12
France	0.03	0.39	0.23	0.28	0.10
U.S.	0.01	0.13	0.15	0.44	0.25
Belgium	0.03	0.16	0.23	0.66	0.11
Italy	0.00	0.12	0.10	0.56	0.46
Romania	0.00	0.02	0.03	0.58	0.91
Poland	0.04	0.32	0.19	0.49	0.21
Ukraine	0.00	0.07	0.05	0.52	0.80
Russia	0.00	0.18	0.04	0.46	0.72

The dendrogram in Figure 6 displays the results of the hierarchical clustering based on the followers, mentions, and retweets network topologies of the 12 countries, as well as for the three network layers combined. The y-axis shows the Euclidean distance between clusters of countries. With respect to follower relations (Figure 6a), Romania is a clear outlier. As we learned from Figure 4, Romanian politicians do not have many followers. The isolates fraction for the followers network is very high and density is low. For the mentions and retweets network, Russia, Romania and Ukraine —also the least democratic countries— are clustered separate from the other countries. Twitter activity is low in these countries (see Figure 3) and thus density of the mentions and retweets networks is extremely low and there are many isolates. The network topologies of the U.K. and the U.S. —both two-party systems— are very similar to each other for all three network settings. In the followers network, they have a relatively low inwards hierarchy compared to the multi-party countries. Possibly because in a multi-party system the representatives of larger parties are more frequently followed than representatives from smaller parties. Only Italy appears to be closer to the two-party system in that respect. The Netherlands, France, Germany and Poland all have high density and high in- and outwards hierarchy in the followers network, while Belgium and Spain have a lower outwards hierarchy.

In the mentions network (Figure 6b), Germany and the Netherlands have, similar to the two-party systems, low inwards hierarchy. Mentions are more equally distributed among all parliamentarians than in the other countries. The other multi-party systems have higher inward hierarchy, which means there are some central accounts that are more often mentioned compared to the large amount of parliamentarians with little political influence. These central accounts are likely leading cabinet positions or party leaders (of larger parties).[6] Furthermore, consensual democracies have higher density in the mentions network than majoritarian systems.[7] This is in line with [27] who suggests that consensus democracies lead to increased cooperation and dialogue. Spain leans slightly over to a majoritarian system but does have proportional representation. The exceptions to this rule would be France —majoritarian system with high density—, and Germany —consensus democracy with low density. Also, Italian politicians do not mention others frequently and thus the network has a low density. Alternatively, another possible explanation for high density in the network is a relatively low number of politicians in parliament, making it 'easier' to have a densely connected network

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[6] For example, in Spain the most often mentioned accounts are —next to party accounts— Pablo Casado Blanco (party leader PP, largest opposition party), Jaime de Olano (Deputy Secretary General PP), Albert Rivera (Party leader Ciudadanos), and Teodoro GarcÃa Egea (Secretary-General PP)

[7] Tested with two-sample t-test

(a) Followers network

(b) Mentions network

(c) Retweets network

(d) Combined
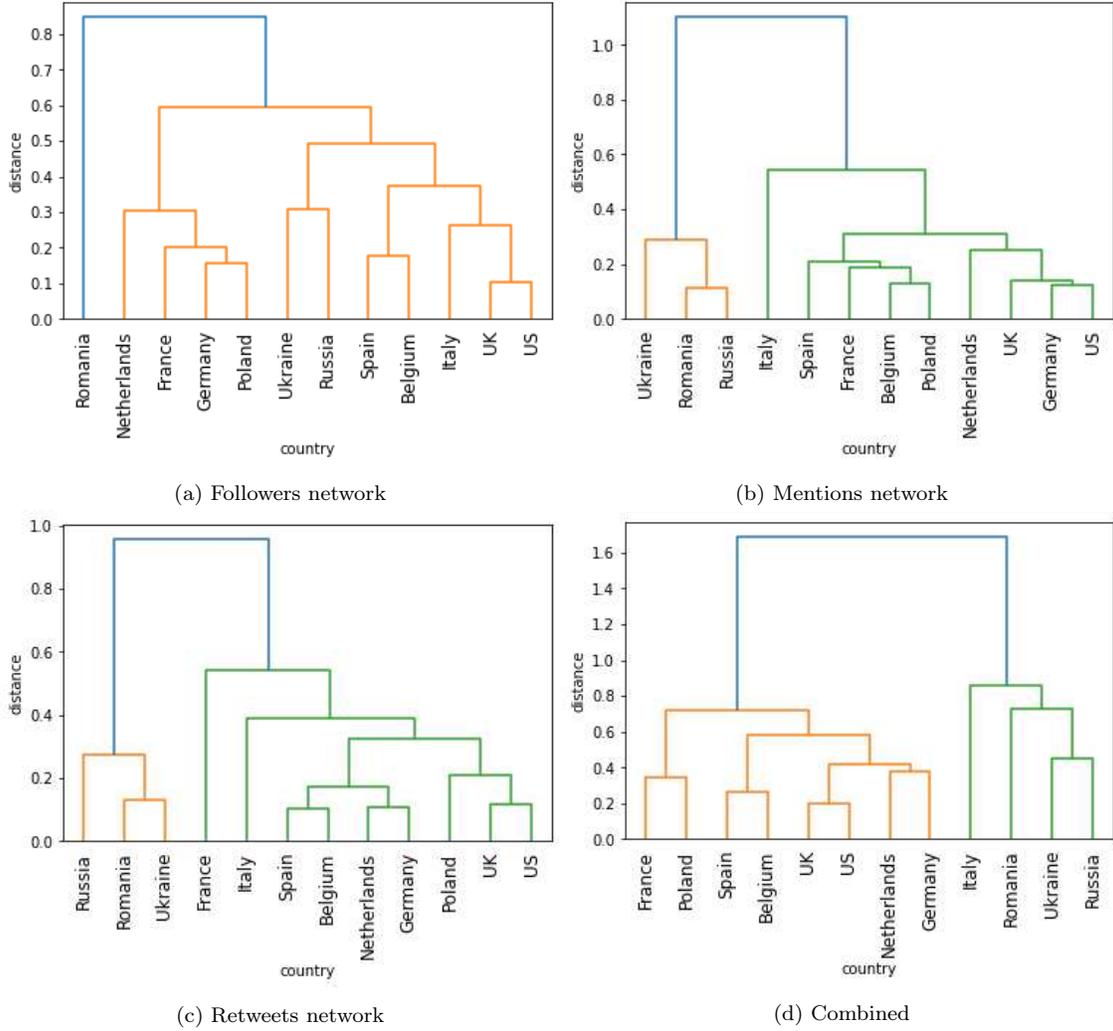
Figure 6: Hierarchical clustering dendrogram of the topology of the parliamentary followers (a), mentions (b), and retweets (c) networks, as well as a combination of all three (d) for the 12 countries in our study.

(again, France being the exception to the rule).

Regarding retweets, networking behavior and the resulting clusters are slightly different (Figure 6c). As mentioned before, retweets reflect endorsement and thus the patterns of retweeting can be revealing of the political alliances within a country. Systems with proportional representation have higher modularity (with an exception for Poland). This finding is in accordance with scholars arguing that political fragmentation is increased in proportional systems due to coalition forming and lower barriers of entry for smaller parties [28]. Also Italy is highly modular, but more distant from the other proportional systems because of low density. France has by far the lowest modularity which results a dense and interconnected retweets network. The U.S. and U.K. show a strong two-party structure in the retweets

network, characterised by low modularity and high in- and outwards hierarchy. Likewise, in Poland the network is dominated by the two major parties (see Figure 7), reflecting the recent polarization of the party landscape into two competing "blocks" of parties [50]. The groups we can distinguish using this quantitative hierarchical clustering approach on the retweets network are also visually[8] distinct and largely correspond to the network archetypes of [32], that were derived qualitatively. We find a cluster of countries with bipolar networks (U.S., U.K., and Poland), fragmented networks (Germany, Netherlands, Spain, Belgium, and Italy), and a cohesive network (France) (see Figure 7). However, based on our clustering results, we do not differentiate between what [32] call "networks with rogue clusters" and "fragmented networks". A contribution of this study is that three less-democratic countries were also included which resulted in an additional archetype: "unconnected networks", characterized by low density and many isolates.[9]

Combining the information of all three networks results in an almost perfect representation of the democratic systems and functioning of the countries. Russia, Romania, and Ukraine are clustered together. Politicians of these countries interact the least with other politicians on Twitter, and these countries have the lowest democracy scores. Yet, Figure 2 and Figure 4 show that Twitter is actually used in these countries and that politicians are followed by the population. Poland is an exception, with a low democracy score but a lot of political interaction on Twitter, and Italy is a more democratic country with little activity in the mentions and retweets network. The U.K. and the U.S. are plurality two-party systems and have a more equal distribution of mentions and less modular retweets network. Germany and the Netherlands, the most democratic countries, are proportional systems but also have low inwards hierarchy in the mentions network. Moving from high to low democracy score, Spain and Belgium are the next proportional systems. They have high modularity in the retweets network but also fairly high density and low isolates in the mention and retweets network. Finally, Poland is a proportional multi-party system but rather shows a two-party structure with relatively low modularity, while France is a plurality system with relatively high density.

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[8]After excluding isolates, we used NetworkX Spring Layout (https://networkx.org/documentation/stable/reference/generated/networkx.drawing.layout.spring_layout.html) to visualize the network. The positions of the nodes are optimized using Fruchterman-Reingold force-directed algorithm [51]. The algorithm finds an equilibrium between two opposing forces: edges hold nodes close, while nodes repel other nodes. This way, connected nodes are positioned closer together in the visualization than unconnected nodes.

[9]Since we exclude isolates from the network visualization, the resulting visualizations consists of very few nodes.

Bipolar networks
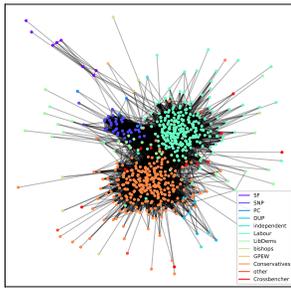
(a) UK
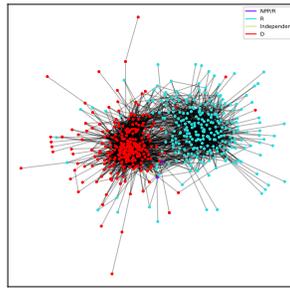
(b) US
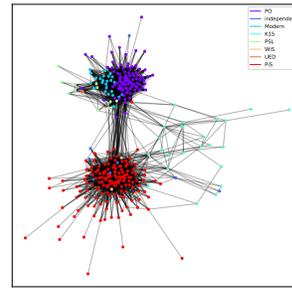
(c) Poland

Fragmented networks
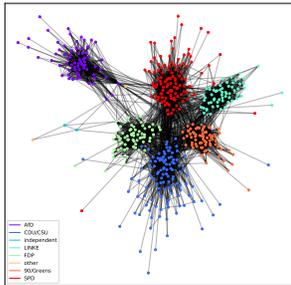
(d) Germany
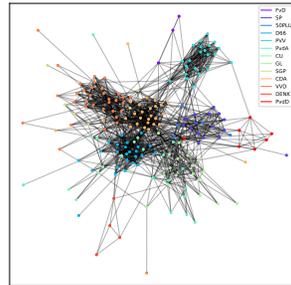
(e) Netherlands
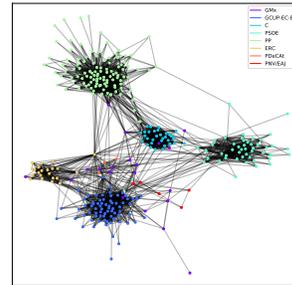
(f) Spain
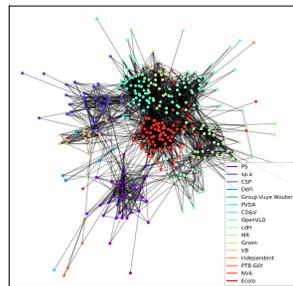
(g) Belgium
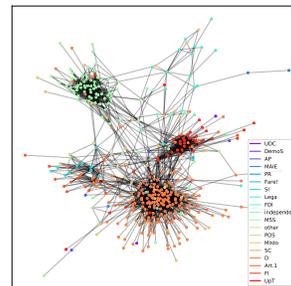
(h) Italy

Figure 7: Network visualization for the retweets networks of the 12 countries in our study.

Cohesive network
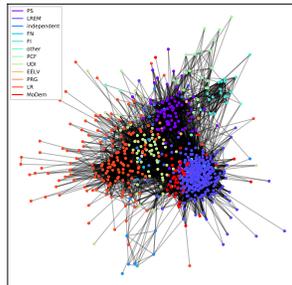
(i) France

Unconnected networks
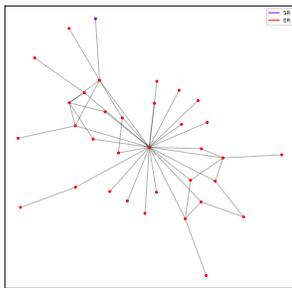
(j) Russia
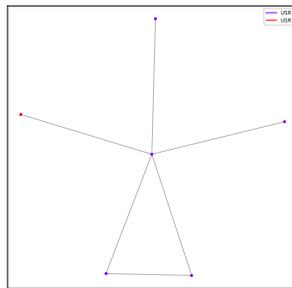
(k) Romania
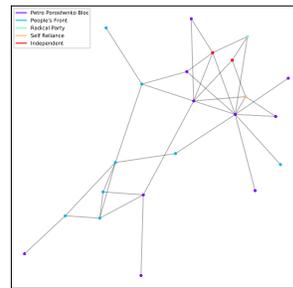
(l) Ukraine

Figure 7: (Continued) Network visualization for the retweets networks of the 12 countries in our study.

5.3. Inter-party communication

The E-I index measures the relative amount of external party communication and ranges from -1 (all ties are internal to the party) to 1 (all ties are external to the party). Table 7 shows the average E-I index per country. For most countries, the E-I index is lowest for the retweets network.[10] For the follower and mentions network, external party relations are correlated with the effective number of parties. A higher number of effective parties requires more cooperation between different parties (e.g. coalitions), which results in parliamentarians following and mentioning —but not retweeting— candidates from other parties more frequently. Interestingly, Belgium and the Netherlands even have a positive E-I index, which means they follow or mention politicians from other parties more often then from their own party. Next, we investigate whether parliamentarians prefer to interact with parties that are ideologically close to their own party.

Table 7: E-I index per country, ranked from low to high effective number of parties [52].

Country	Effective number of parties	E-I Followers	E-I Mentions	E-I Retweets
Russia	1.7	-0.85	-1.00	-0.67
U.S.	2.0	-0.66	-0.45	-0.54
U.K.	2.5	-0.60	-0.27	-0.80
Poland	2.8	-0.27	-0.06	-0.50
France	3.0	-0.28	-0.13	-0.55
Romania	3.5	0.29	-0.24	-0.64
Spain	4.2	-0.50	-0.23	-0.17
Italy	4.3	-0.00	-0.01	-0.96
Ukraine	5.5	0.36	-0.15	-0.82
Germany	5.6	-0.33	-0.09	-0.73
Belgium	7.8	0.11	0.22	-0.18
Netherlands	8.1	0.44	0.37	-0.87
Pearson's r		0.76	0.81	-0.24
P-value		0.00	0.00	0.44

Our results for the Kendall rank correlation between ideological distance and proportion of inter-party relations are inconclusive (Table D.11). Only the correlations for the Netherlands are significant at the 0.05 level for all networks.[11] For all three Dutch networks, the further apart the parties are ideologically, the less they will interact on Twitter. Additionally, for

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[10]Paired t-test with Bonferroni correction
[11]After Bonferroni's correction for multiple (three) comparisons

the followers network in Germany and Romania, and for the retweets network in Belgium we find similar results. For the other countries, the number of parties[12] is too low to find significant results. Additional research is necessary to reveal which cross-party interactions most frequently take place and for which purpose. Do politicians use Twitter as an instrument to challenge and criticize the opponent or do they rather interact with ideologically similar parties? A more in-depth sentiment analysis of the tweets could provide more clarity on this.

6. Conclusion

Elite polarization and the amount of cooperation among the elite have important implications for our democracy [10, 24]. The rise of social media has altered existing political relations and simultaneously offered new opportunities to empirically analyze these structures. A plethora of studies explore political polarization on social media, with sometimes contradictory results. A possible explanation for these contradictions is the (institutional) context in which the study takes place. Yet, little research has focused on structured comparison across multiple countries to gain insights in contextual variables and country characteristics.

We analyze the interactions in 12 parliamentary Twitter networks and find that the network topology is related to the democratic functioning and political system of the countries in our study. Consensual democracies are characterised by more dense relations but also higher hierarchy and higher fragmentation in the retweets network, while systems with plurality voting generally have lower modularity. Parliaments with a high effective number of parties are more cooperative, which results in higher inter-party relations. By design, two-party systems exhibit higher elite polarization on Twitter. In fact, these findings are far from novel or unexpected, and correspond to established theoretical insights in the field [such as 27]. However, the prominent empirical confirmation of these theoretical concepts highlights the importance of including institutional context in social media research. We need more comparative research to truly understand the influences on and the effects of polarization in our society.

Secondly, we show differences in the followers, retweets and mentions networks that hold across all countries and political systems. The retweets network is most polarized or fragmented, while politicians engage more often in inter-party interactions in the followers and mentions network, especially in countries with high effective number of parties. Twitter can

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[12]The number of parties for which we have the RILE score, i.e. the number of parties that overlap in our study and that of [46]

be conducive to both cross-cutting interactions and echo chambers depending on the layer of interaction. Furthermore, not all interactions are necessarily positive for democracy as Twitter can be used to permanently follow and attack the communication of a political opponent. Again, this could be an important part of the explanation why we find contradictory results on the effect of social media on polarization. The type of interactions we undertake on social media determines its polarizing effect.

In this work, we have specifically focused on a network approach. Nonetheless, we do want to emphasize that social network analysis in combination with textual analysis can provide more detailed insights in the motivations or goals behind interactions. For example, sentiment analysis can uncover whether a mention is meant to criticize or support an opponent [53], and with topical analysis we can learn how politicians communicate about certain issues, and which topics induce controversy [54].

Our results indicate that both the institutional context as well as the platform layer should be taken into account when trying to understand parliamentary interactions and elite polarization. Given the effects of elite polarization on mass polarization and the importance of elite cooperation for the democratic functioning of a country, these findings can have far-reaching consequences to improve our understanding of these phenomena. We show how social network analysis could be a fruitful opportunity for future comparative research on politics and social media.

Acknowledgements

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Appendix A. Data collection

Appendix A.1. Sources

The sources that were consulted to collect the names of all members of parliament (Chamber of Representatives and Senate), the president and members of cabinet (Prime minister, Ministers, Secretaries) and political parties (with seats in parliament as of May 2018) are provided in Table A.8. The websites were consulted in May 2018.

Table A.8: Sources that were consulted to find relevant politicians per country.

Country	Category	URL
Belgium	Upper house	https://www.senate.be/
	Lower house	https://www.dekamer.be/
	Cabinet	https://www.belgium.be/nl/over_belgie/overheid/federale_overheid/federale_regering/samenstelling_regering
France	Upper house	https://www.senat.fr/senateurs/ump
	Lower house	https://en.wikipedia.org/wiki/List_of_deputies_of_the_15th_National_Assembly_of_France
	Cabinet	https://en.wikipedia.org/wiki/Second_Philippe_government
Germany	Upper house	https://www.bundesrat.de/DE/bundesrat/mitglieder/mitglieder-node.html
	Lower house	https://www.bundestag.de/abgeordnete
	Cabinet	https://www.bundesregierung.de/breg-en/federal-government/cabinet
Italy	Upper house	https://parlamento17.openpolis.it/lista-dei-parlamentari-in-carica/senato/nome/asc
	Lower house	https://parlamento17.openpolis.it/lista-dei-parlamentari-in-carica/camera/nome/asc
	ministers	https://en.wikipedia.org/wiki/Council_of_Ministers_(Italy)
Netherlands	Upper house	https://www.eerstekamer.nl/alle_leden
	Lower house	https://www.tweedekamer.nl/kamerleden_en_commissies/alle_kamerleden
	cabinet	https://www.parlement.com/id/vkidc8m3p1sz/kabinet_rutte_iii_2017
Poland	Upper house	https://www.senat.gov.pl/en/senators/lista-senatorow/
	Lower house	https://en.wikipedia.org/wiki/List_of_Sejm_members_(2015%E2%80%9319)
	Cabinet	https://en.wikipedia.org/wiki/Council_of_Ministers_(Poland)
Romania	Upper house	https://www.senat.ro/
	Lower house	http://www.cdep.ro/pls/parlam/structura.gp?leg=2016&cam=2&idg=&poz=0&idl=2
	Cabinet	http://gov.ro/en/government/the-cabinet-of-ministers/
Russia	Upper house	http://www.council.gov.ru/en/structure/members/
	Lower house	https://en.wikipedia.org/wiki/List_of_members_of_the_7th_Russian_State_Duma
	Cabinet	https://en.wikipedia.org/wiki/Government_of_Russia
Spain	Upper house	http://www.senado.es/
	Lower house	http://www.congreso.es/
	Cabinet	https://en.wikipedia.org/wiki/Government_of_Spain
UK	Upper house	https://www.parliament.uk/mps-lords-and-offices/lords/
	Lower house	https://en.wikipedia.org/wiki/List_of_United_Kingdom_MPs_by_seniority,_2017%E2%80%9322
	Cabinet	https://en.wikipedia.org/wiki/Cabinet_of_the_United_Kingdom
Ukraine	Parliament	https://en.wikipedia.org/wiki/List_of_members_of_the_parliament_of_Ukraine,_2014%E2%80%9319
	Cabinet	https://en.wikipedia.org/wiki/Government_of_Ukraine
US	Upper house	https://www.senate.gov/senators/index.htm
	Lower house	https://history.house.gov/Congressional-Overview/Profiles/115th/
	Cabinet	https://en.wikipedia.org/wiki/Cabinet_of_the_United_States

Appendix A.2. Coding instructions

For each country, two independent coders with knowledge of the language and political context in the country were asked to manually check the Twitter handles of each politician. Where the two coders did not agree on the correct Twitter handle, the Twitter handle of

the politician was inspected by the authors. The coders were provided with the following instructions:

You will look for the Twitter accounts of

- Members of parliament (Chamber of Representatives and Senate)

- President and members of cabinet (Prime minister, Ministers, Secretaries)

- Political parties (with seats in parliament)

What you need to do

1. Check in the Excel sheet "Overview" whether you believe the links are trustworthy and up-to-date. If not, let me know and look for an up-to-date list of politicians if you can.
2. Check or complete the time period (i.e. the period before the next election)
3. Check in your country sheet whether you find all of the following categories (you can use the filter function on the excel column Category):
   (a) Lower house (if bicameral, otherwise only "parliament")
   (b) Upper house (if bicameral, otherwise only "parliament")
   (c) President (if applicable)
   (d) Minister
   (e) Party
4. Check whether all political parties with seats in the parliament are represented. (You can filter the column Category on "Party")
5. Go through the Excel file name by name and search the name on Twitter to find the correct Twitter account, belonging to this politician. Several users might have the same name, we need the politician's Twitter account, so read the bibliography carefully. Also, "fake" accounts exists so look for verified accounts as much as possible. If you do not find the politician's name on Twitter try to check different spellings of the name.
6. If you found the correct Twitter account, write down the following information in the excel sheet of your country:
   (a) Twittername: everything that comes after the @
   (b) Verified: is this a verified account yes/no
   (c) Followers: the amount of followers
   (d) Remarks: if you have remarks (eg. you are not sure about the account, you have found several accounts, the name is not correct etc.) you can write them down here.

7. If you did not find the Twitter account write down "Not found" in the column Twitter-name

8. If you encounter any names in the list that are not correct or if you noticed that a certain politician is not in the list, please let me know.

Appendix B. Visualization of parliamentary Twitter networks

Figure B.8: The parliamentary mentions network at party level.

Figure B.9: The parliamentary retweets network at party level.
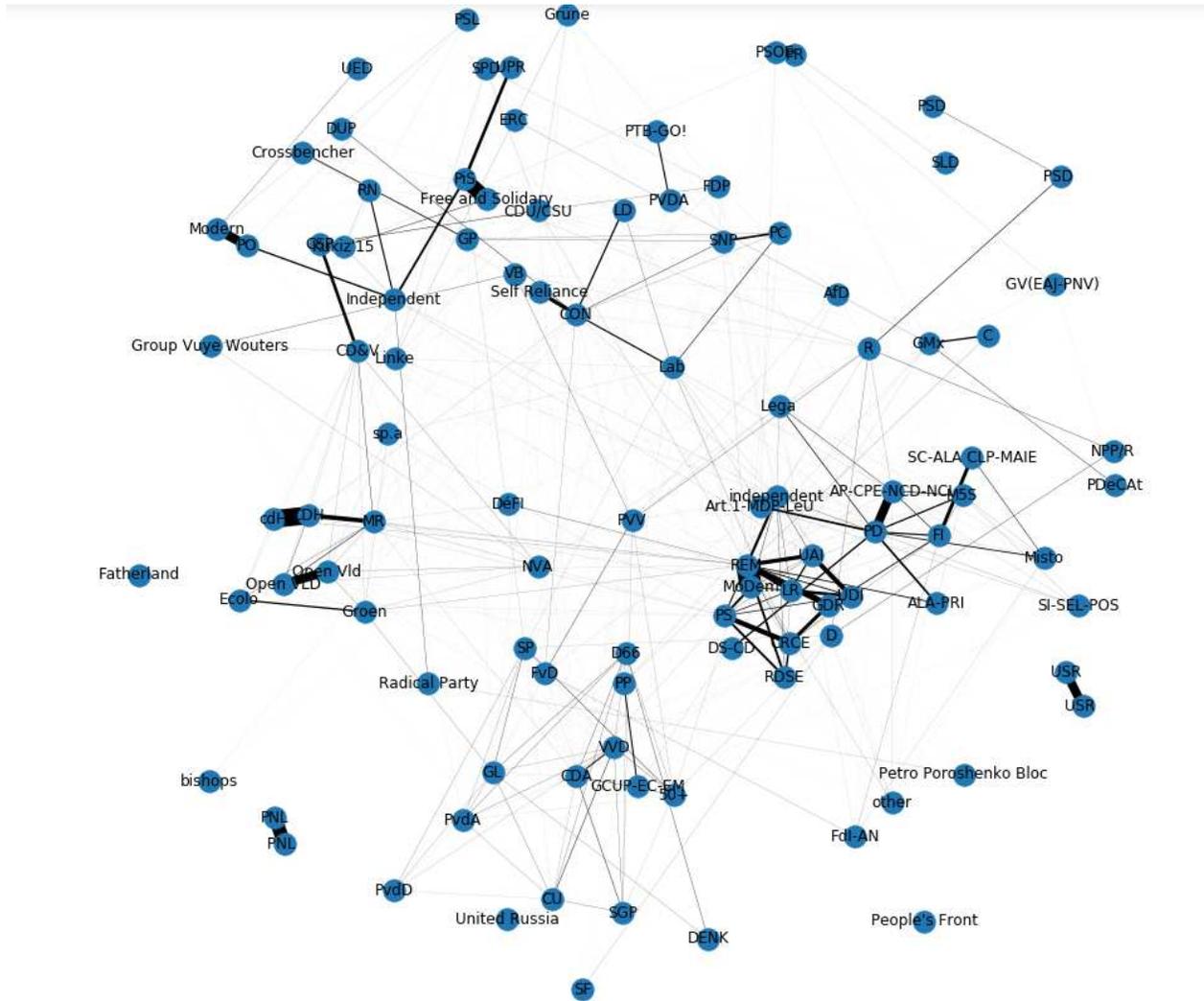
Appendix C. Community detection

Table C.9: Number of detected communities and adjusted mutual information between detected communities and parties.

Country	Parties	Followers			Mentions			Retweets		
		Modularity	Clusters	AMI	Modularity	Clusters	AMI	Modularity	Clusters	AMI
Italy	28	0.37	7	0.26	0.35	20	0.17	0.56	21	0.24
Belgium	18	0.31	5	0.59	0.28	5	0.65	0.66	8	0.78
Netherlands	14	0.13	6	0.33	0.20	7	0.44	0.61	15	0.71
Ukraine	13	0.19	8	0.07	0.47	8	0.10	0.52	7	0.07
UK	12	0.36	5	0.33	0.23	6	0.46	0.44	5	0.52
France	12	0.26	4	0.35	0.22	7	0.42	0.28	9	0.50
Romania	12	0.46	8	0.09	0.67	14	0.09	0.58	14	0.08
Spain	9	0.47	6	0.49	0.40	6	0.68	0.69	5	0.70
Germany	8	0.40	10	0.70	0.35	10	0.72	0.71	15	0.71
Poland	8	0.32	4	0.45	0.21	5	0.39	0.49	4	0.47
Russia	7	0.14	7	0.04	0.75	10	0.01	0.46	10	0.02
US	4	0.32	16	0.51	0.31	51	0.15	0.44	86	0.23

Appendix D. Inter-party communication and ideology

Table D.10: RILE scores for the intersection of parties in our study and in the Manifesto Project Dataset [46].

Country	Party	Rile
Belgium	PVDA	-33.681
	Groen	-21.849
	sp.a	-19.199
	CD&V	-11.903
	OpenVLD	-8
	NVA	4.78
	VB	8.387
France	FI	-30.019
	PS	-28.947
	MoDem	-17.92
	PCF	-16.667
	PRG	-10.056
	EÃLV	-8.636
	FN	1.674
	UDI	13.619
	LR	13.619
Germany	LINKE	-41.914
	SPD	-21.437
	90/Greens	-21.058
	FDP	0.578
	CDU/CSU	2.757
	AfD	17.43
Italy	D	-8.268
	M5S	-7.429
	Lega	4.656
	FDI	7.692
	FI	15.625
Netherlands	50PLUS	-31.11
	DENK	-24.83
	SP	-23.04
	PvdD	-18.85
	PvdA	-13.84
	GL	-9.35
	D66	-6.54
	CDA	3.60
	CU	5.48
	VVD	10.95
	FvD	16.47
	PVV	20.00
	SGP	24.71

Country	Party	Rile
Poland	PO	-13.31
	PSL	-7.26
	K15	-1.77
	Modern	4.35
	PiS	10.81
Romania	USR	-25.05
	PSD	-17.81
	UDMR	-15.28
	PMP	-1.01
	PNL	1.47
	ALDE	26.67
Russia	SR	-25.19
	KPRF	-18.30
	ER	2.79
	LDPR	13.69
Spain	ERC	-30.34
	PSOE	-29.27
	PNV/EAJ	-11.63
	C	-10.54
	PP	6.06
UK	Labour	-31.85
	SNP	-24.46
	SF	-24.41
	GPEW	-20.37
	LibDems	-19.61
	PC	-18.72
	Conservatives	6.21
	DUP	12.26
Ukraine	Fatherland	-8.33
	Svoboda	0.00
US	D	-20.58
	R	32.97

Table D.11: The Kendall rank correlation coefficient between inter-party relations and ideological distance (RILE) for the intersection of parties in our study and in the Manifesto Project Dataset [46]. For Ukraine and US only the RILE scores of two parties are available, hence the correlation cannot be calculated. Romania and Russia have nearly no interactions in the mentions and retweets network.

Country	Followers	Mentions	Retweets
Belgium	-0.20	-0.10	-0.39***
France	0.04	0.10	0.00
Germany	-0.34**	-0.12	-0.27
Italy	0.02	0.13	0.08
Netherlands	-0.19***	-0.18***	-0.26***
Poland	0.15	0.19	-0.02
Romania	-0.37**		
Russia	-0.18		
Spain	-0.06	0.06	0.14
UK	-0.06	0.12	-0.08
Ukraine			
US			

*p < .1/3; **p < .05/3; ***p < .01/3
Kendall's tau.