Article

Homophily and Polarization in Twitter Political Networks: A Cross-Country Analysis

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Abstract
Homophily, the tendency of people to have ties with those who are similar, is a fundamental pattern to understand human relations. As such, the study of homophily can provide key insights into the flow of information and behaviors within political contexts. Indeed, some degree of polarization is necessary for the functioning of liberal democracies, but too much polarization can increase the adoption of extreme political positions and create democratic gridlock. The relationship between homophilous communication ties and political polarization is thus fundamental because it affects a pillar of democratic regimes: the need for public debate where divergent ideas and interests can be confronted. This research compares the degree of homophily and political polarization in Catalan MPs' Twitter mentions network to Dutch MPs' Twitter mentions network. Exponential random graph models were employed on a one-year sample of mentions among Dutch MPs (*N* = 7,356) and on a one-year, three-month sample of mentions among Catalan MPs (*N* = 19,507). Party polarization was measured by calculating the external–internal index of both Twitter mentions networks. Results reveal that the mentions among Catalan MPs are much more homophilous than those among the Dutch MPs. Indeed, there is a positive relationship between the degree of MPs' homophilous communication ties and the degree of political polarization observed in each network.

Keywords
homophily; parliamentarians; political networks; political polarization; political communication; Twitter

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1. Introduction

Homophily is the principle asserting that "the contact between similar people occurs at a higher rate than among dissimilar people" (McPherson et al., 2001, p. 416). It describes a fundamental characteristic of social networks and uncovers a mechanism through which "distance in terms of social characteristics translates into network distance" (McPherson et al., 2001, p. 416). Simply put, homophily argues that one is more likely to have ties with similar people than with dissimilar people (Himelboim et al., 2013).

It is claimed that homophily is an empirical regularity in social life (Kossinets & Watts, 2009), which "limits people's social worlds in a way that has powerful implications for the information they receive, the attitude they form, and the interactions they experience" (McPherson et al., 2001, p. 415). In their path-breaking research, Lazarsfeld and Merton (1954, p. 24) divided homophily into two different types: "status-homophily" and "value-homophily." Status-homophily comprises both ascribed characteristics (e.g., age, sex, race, social class, and ethnicity) and acquired characteristics (e.g., occupation, religion, and education); value-homophily refers to the association with others with similar attitudes, values, and beliefs.

The literature suggests that homophily often characterizes communications among users on social media. An early study conducted by Adamic and Glance (2005) found that political bloggers prefer to establish connections (hyperlinks) with blogs with similar political

views. Researching MySpace, Thelwall (2009) found substantial evidence of homophily for ethnicity, religion, age, country, marital status, attitude towards children, sexual orientation, and reason for joining the platform. On Facebook, Wimmer and Lewis (2010) showed that racial homogeneity results from racial homophilic ties among users, and Barnett and Benefield (2015) found cultural homophily to be one of the causes of international Facebook friendship networks. Similarly, several studies conducted on Twitter have shown that communications among individuals with shared sociodemographic characteristics and political attitudes are more likely to happen than with dissimilar individuals (Esteve-Del-Valle et al., 2021; Himelboim et al., 2013; Hong & Kim, 2016).

Contrary to popular belief, homophily can have positive effects on political behavior. Prior work shows that political homophily provokes dense clusters of within-group ties that put pressure on participating in costly or risky political activities (Centola, 2013). Indeed, political homophilous networks have a significant advantage in facilitating political actions which require social confirmation, such as attending political protests, engaging in discussion about controversial topics, or turning out to vote (Esteve-Del-Valle & Bravo, 2018a, 2018b; González-Bailón et al., 2011; Romero et al., 2011). Political homophily may also help insulate individuals "from exposure to false or offensive information" (Boutyline & Willer, 2016, p. 552).

However, political homophily can also have harmful consequences. Previous research reveals that individuals with low cross-cutting ideological exposure are less likely to see opposing viewpoints as legitimate and less able to build their own arguments (Huckfeldt et al., 2004). These individuals are more likely to hold extreme political attitudes (Huckfeldt et al., 2004) and be less tolerant than people with ties to others who hold different political views (Mutz, 2002). Increased political homophily is, therefore, a source of political discord and polarization (Boutyline & Willer, 2016; Esteve-Del-Valle & Bravo, 2018a; Himelboim et al., 2013), whereas individuals' network heterogeneity is found to nurture political tolerance (Scheufele et al., 2006).

Despite the interest in studying political homophily on social media, research into how social network sites affect communication among parliamentarians (Hong & Kim, 2016; Nuernbergk & Conrad, 2016; van Vliet et al., 2020) is slim. Furthermore, the study of political homophily in online parliamentary networks (Koiranen et al., 2019; Mousavi & Gu, 2015) is still only in its infancy, even though MPs are at the core of political life and have the mandate to represent people's interests and concerns in national assemblies. The research presented here aims to narrow this gap by studying whether Twitter mentions among Catalan parliamentarians and among Dutch MPs are homophilous. Furthermore, it investigates the relation between the degree of homophily (or heterogeneity) among the Catalan and Dutch parliamentarians' mentions, at a dyad level, with the degree of political polarization in both networks, at a network level.

The term "political polarization" is used here to characterize the extent to which interactions (mentions) in the Dutch MPs' Twitter mentions network occur only among members of the same parliamentary group or across groups. The degree of party polarization is assessed at both the parliamentarian level and the whole Twitter mention network level.

The article asks the following research questions:

RQ1: To what extent do mention ties among Catalan MPs and among Dutch parliamentarians show homophily?

RQ2: Is there a relation between the degree of homophily among Catalan MPs' mentions and among Dutch MPs' mentions and the degree of political polarization in each of the parliamentary mentions' networks?

Around one year of samples of all the mentions among Catalan (N = 19,507) and Dutch MPs (N = 7,356) were collected. Both datasets were gathered during non-electoral periods because the aim of the two independently conducted investigations was to assess MPs' communication behavior during ordinary legislative sessions. During these sessions, parliamentarians are expected to create more alliances with colleagues of different parliamentary groups to support specific views on political issues. This is especially important in multi-party systems such as the Catalan and the Dutch examples. Among the different communication layers on Twitter (relations, retweets, and mentions), this research focuses on MPs' mentions because this network is expected to better reflect cross-party and cross-ideological connections (Esteve-Del-Valle et al., 2021). Indeed, previous research has revealed that politicians actively use mentions to converse (Esteve-Del-Valle et al., 2020; van Vliet et al., 2020).

Catalonia and the Netherlands offer two excellent case studies. In terms of the use of Twitter, usage rates among Catalan (85%) and Dutch MPs (96%) were very high and relatively similar. Furthermore, both political contexts are parliamentary democracies in which the formation of the government depends on the support of the parliament. This encourages MPs to negotiate to gain the support of other parliamentary groups (at times ending up in coalitions) for a government to be formed. Certainly, polarization is a threat to these negotiations. Secondly, both countries have proportional electoral laws with low electoral thresholds (3% in Catalonia and 0.6% in the Netherlands), which facilitate the entry of smaller parties to parliament with relative ease. This has resulted in seven medium-sized and fringe parties filling the 135 seats of the Parlament de Catalunya (Catalan parliament) and 11 parties occupying the 150 seats of the

Twede Kamer (Dutch parliament). In these fragmented systems, where continuous negotiations are needed to reach agreements, polarization—making it more difficult to reach these agreements—can reduce legislatures to a gridlock. However, for the goals of this research, this political fragmentation is beneficial as it allows us to test hypotheses related to political homophily and polarization in different political systems other than the two-party system of the US, which is largely overrepresented in the research samples. In addition, this comparison sheds unprecedented light on the similarities and differences concerning the degree of homophily and polarization in two European parliamentary Twitter networks.

The main contributions of this article are as follows: First, this appears to be the first time that a cross-country comparison of the degree of homophilous ties in Twitter parliamentary networks has been conducted. Therefore, the results of this comparison provide unprecedented insights into the state of political homophily in online parliamentary networks. Second, the methods employed here (ERG models and external-internal [E-I] index) combine explanations at the dyad and network levels. Providing explanations at both levels is important to establish the relationship between dyadic homophily and network homophily, when existent. In addition, it allows us to overcome an important limitation of previous research in the field, that is, the analysis of political homophily either at one level of analysis (dyad) or at the other (network). Third, the present analysis not only assesses the degree of political homophily and polarization independently but also establishes a relation between both phenomena. Despite the explanatory power of such a combination, research trying to combine both phenomena is in its early stages (Esteve-Del-Valle & Bravo, 2018a; Esteve-Del-Valle et al., 2021).

2. Literature Review

Political theorists have long considered dialogue between people holding dissimilar views a key prerequisite for sustaining a democratic citizenry (Habermas et al., 1989; Mill, 1859). Mill held that individuals' engagement with political disagreement helps develop skills to critically evaluate one's political claims and better justify ideas. Likewise, Arendt (1961, p. 241) contended that debate "constitutes the very essence of political life," without which it is impossible to form "enlightened political opinions that reach beyond the limits of one's own subjectivity to incorporate the standpoints of others" (Boutyline & Willer, 2016, p. 1). Besides these normative arguments, exposure to people with different views is important because it can profoundly impact "individuals' beliefs—and their strengths" (Barberá, 2020, p. 10). Individuals' network heterogeneity has been found to increase political tolerance (Scheufele et al., 2006), while exposure to like-minded people is associated with the adoption of extreme positions (Mutz & Paul, 2001).

If the use of social media exposes people to like-minded viewpoints and prevents contact between different groups, it can also be expected to strengthen people's political beliefs and increase political polarization. However, empirical research on the consequences of the use of social media on political polarization is slim and offers mixed results. This study contributes to clarifying these contradictory results.

2.1. Reciprocity: A Network-Endogenous Mechanism

Reciprocity, the likelihood of vertices in directed networks to be mutually linked, is a well-documented mechanism in the formation of communication ties in Twitter political networks. Yoon and Park's (2014) early study of South Korean politicians' interactions on the following–follower network and on the mentions' network used reciprocity to ascertain the factors explaining politicians' communication ties. However, they did not find the reciprocity effect significant in either network. In contrast, Esteve-Del-Valle and Bravo (2018b) found that reciprocity explained the existence of communication ties in Catalan MP's following–follower Twitter network. Similarly, Hekim (2021) also found mutuality explained retweets among Turkish politicians. Taking into account the findings of previous literature, reciprocity among the Catalan and the Dutch MPs' mentions is expected to explain the communication ties between the parliamentarians. Thus, the following hypothesis is proposed:

> H1: The reciprocity in the Catalan MPs' mention Twitter network and the Dutch MPs' Twitter mentions network is assumed to significantly explain communication ties among the members of each network.

2.2. Network-Exogenous Mechanisms

2.2.1. Status-Homophily

On Twitter, the findings of previous studies on parliamentary networks suggest that status-homophily explains the formation of communication ties. Comparing the mentions and retweet networks of 370 US House Representatives, Mousavi and Gu (2015) found that gender homophily explained the communications among them. More specifically, they found that female representatives were more likely to mention and retweet other female representatives. In Catalonia, research on the factors explaining relationships (following–follower) among the Catalan parliamentarians conducted by Esteve-Del-Valle and Bravo (2018b) also found that gender homophily explained the existence of ties among the MPs. However, in the Catalan case, male MPs were more likely to establish communication relationships with other male MPs. Indeed, this study suggested that MPs' political position (being a leader of a political party) and age (being an older MP) increased

parliamentarians' likelihood of establishing communication ties. In a similar vein, Koiranen et al.'s (2019) study of Finish MPs' following–follower Twitter network found the same gender to have a slight positive effect on relations formed by parliamentarians, and that parliamentarians' likelihood of following each other decreased with the age difference. More recently, the study conducted by Esteve-Del-Valle et al. (2021) on the Twitter communication behavior of Dutch MPs shows that MPs' age, gender, and participation in the parliamentary commissions explain the formation of Twitter communication ties among them. Specifically, young and female MPs, highly engaged with the work in the chamber, are more likely to receive mentions than the rest of parliamentarians. Given prior research findings concerning the existence of status-homophily in parliamentary Twitter networks, the following hypotheses are proposed:

> H2 (gender homophily): Catalan and Dutch MPs are highly likely to mention Catalan and Dutch MPs of the same gender.

> H3 (age homophily): Young (26–44 years) Catalan and Dutch MPs are highly likely to mention other young Catalan and Dutch MPs.

> H4 (leadership position homophily): Catalan and Dutch MPs in leadership positions are highly likely to mention other Catalan and Dutch MPs in leadership positions.

2.2.2. Value-Homophily

Prior research has found ideological homophily to be present in Twitter communication networks. An early study conducted by Conover et al. (2011) on political hashtags some weeks before the US congressional midterm elections revealed that retweets replicated the known partisan split in the online world, while interactions in the mention network showed contacts among ideologically opposed individuals. Yoon and Park's (2014) study of Korean politicians' use of Twitter revealed high degrees of homophily in the following–follower network, while in the mention network interactions between politicians with different ideologies occurred more often. Colleoni et al.'s (2014) investigation of homophily in US Twitter politics found that, in general, Democrats exhibited higher levels of political homophily. However, Republicans who followed official Republican accounts showed higher levels of homophily than Democrats. In the overall communication network of Twitter, Gruzd and Roy's (2014) analysis of 5,918 tweets on the 2011 Canadian federal election revealed a clustering effect around shared political views among supporters of the same party, but also some "evidence of cross-ideological discourse" (Gruzd & Roy, 2014, p. 38). More recently, Koiranen et al.'s (2019) research found that Finish MPs (left–right) stance concerning socioeconomic issues sig-

nificantly explained followee connections between the parliamentarians. In sum, given that previous research shows that ideological homophily explains the formation of communication ties in Twitter political networks, the following hypothesis is proposed:

> H5 (ideological homophily): Catalan and Dutch MPs are highly likely to mention other Catalan and Dutch MPs with the same political ideology.

3. Data and Methods

Twitter mentions from Catalan and Dutch MPs were collected. The Twitter accounts of 116 Catalan parliamentarians were scraped to retrieve all the MPs' mentions (19,507) from January 1, 2013, to March 31, 2014. As for the Dutch MPs, Coosto (https://www.coosto.com/en) was used to collect a one-year sample of all tweets (131,963) posted by 144 Dutch MPs from November 3, 2015, to November 3, 2016. The adjacency matrix of MPs' mentions was then created using a Python script that filtered out tweets in which MPs mentioned other MPs. This resulted in a total network of 7,356 mentions among Dutch legislators.

UCINET, a software package for the analysis of social network data (Borgatti et al., 2002), was used to obtain the descriptive statistics of the network. Gephi, an open-source network exploration and manipulation software, was used to visualize the networks (Bastian et al., 2009). Furthermore, ERG models (see Lusher et al., 2012) were employed to find out the network characteristics (reciprocity) and the MPs' attributes (ideology, political position, age, and gender) that explain the degree of homophily in the communication ties (mentions) among the Catalan and Dutch parliamentarians, respectively.

ERG models are "tie-based models for understanding how and why social network ties arise" (Lusher et al., 2012, p. 9). The goal of the ERG models is to "generate a large set of random networks based on a chosen set of network properties and node attributes from the observed network" (Gruzd & Tsyganova, 2015, p. 131).

This procedure allowed us to see if the presence of homophilous communication ties in the Catalan and Dutch Twitter mentions networks was due to chance, or if it was due to network properties and MPs' attributes, and which of these network properties and node attributes influenced the formation of these ties.

ERG models were employed by using the "statnet" suite of packages in R (Goodreau et al., 2008), which includes the package "ergm.count" (Krivitsky, 2021), employed here to fit the ERG models to the two weighted parliamentary mention networks. First, a null model without any predictors (*net ~ edges*) was built. Following the null model, and in line with prior literature (Hekim, 2021; Yoon & Park, 2014), a model was created using the parameter of reciprocity, a basic estimator (cf. Shumate & Palazzolo, 2010) of communication tie formation in online networks (*net ~ edges + mutual*). Since the

study's main goal was to evaluate the existence of status-homophily and value-homophily, that is, the influence of MPs' attributes on their mentioning behavior, the decision of using one network parameter was considered to be the most appropriate.

Different MPs' attributes were then added to Model 1. These attributes were chosen based on prior research findings in the field, as mentioned in the literature review. First, the ideology (left–right; Catalonia: $M = 0.48$ and $SD = 0.5$; the Netherlands: $M = 0.42$ and $SD = 0.49$) of the parliamentarians was added (*net ~ edges + mutual + nodematch ['Ideology']*; Model 2). This was followed by the addition of the political position (Catalonia: $M = 0.18$ and $SD = 0.38$; the Netherlands: $M = 0.21$ and $SD = 0.41$) of the MPs (*net ~ edges + mutual + nodematch ['PolPos']*; Model 3). In the final iteration, two MPs' sociodemographic characteristics were added: age (Catalonia: $M = 45.46$ and $SD = 9.01$; the Netherlands: $M = 46.76$ and $SD = 8.32$) and gender (Catalonia: $M = 1.41$ and $SD = 0.494$; the Netherlands: $M = 0.6$ and $SD = 0.49$). To determine the quality of the resulting model, randomly generated networks were compared to the observed networks by assessing the goodness of fit of the ERG models in plots (Hunter et al., 2008; Li & Carriere, 2013). Following Hunter et al. (2008), to assess the goodness of fit of the models, the in-degree statistic, and the geodesic distance statistic were employed.

The description of the network parameter and the nodes' attributes, the adjacency matrix of the Catalan MPs' Twitter mentions network and of the Dutch MPs' mention Twitter network, and the files containing the attributes of the Catalan and the Dutch MPs are available online (see Supplementary File).

Moreover, the degree of homophily among Catalan MP's mentions and among the Dutch MPs' mentions was compared to the degree of polarization in both networks. To do so, UCINET was used to calculate the E-I index. This is a measure of group embedding created by Krackhardt and Stern (1988) based on analyzing the number of ties inside and between groups. It divides the total number of ties by the number of ties that group members have to outsiders, minus the number of ties that group members have to other group members. The resulting index ranges from –1 (all ties are internal to the group) to +1 (all ties are external to the group). A permutation test is used to determine whether a given E-I index value differs considerably from what would be predicted by random mixing (i.e., no preference by group members for links within or outside the group; the default is 5,000 trials).

4. Political Characteristics

4.1. Catalonia

Catalonia was experiencing an unprecedented political context when the data was collected, with demands for an independence referendum. These demands pushed

Catalan parties to position themselves in favor of or against Catalan independence, which fueled political polarization in the region. The Catalan party system was divided into a number of medium-sized parties following the November 25, 2012 elections: Convergence and Union (CiU), Republican Left of Catalonia (ERC), Socialist Party of Catalonia (PSC), People's Party of Catalonia (PP), ICV-EUiA, Citizens (C's), and Candidacy of Popular Unity (CUP). CiU is a Catalan nationalist center-right party. In the 2012 elections, it won 50 seats. ERC is a pro-independence, left-wing party. In the elections, it gained 21 seats. PSC won 20 seats in the 2012 elections. The PP is a right-wing Spanish nationalist party that won 19 seats in the recent election. ICV-EUiA is a left-wing eco-socialist party that won 13 seats in the election. C's is a moderate and non-Catalan-nationalist party that gained nine seats. CUP is a far-left, pro-independence coalition that gained three seats in the 2012 election. Furthermore, the Catalan party system was divided into two ideological groups: leftists and rightists, as well as Catalan nationalists and non-Catalan nationalists.

4.2. The Netherlands

Following the September 12, 2012 elections, the Dutch party system was divided into 11 medium-sized and fringe groups, occupying 150 seats in parliament. The People's Party for Independence and Democracy (VVD) is a right-wing liberal party that emphasizes self-determination and freedom (van Herk et al., 2018). It gained 41 seats in the 2012 elections. The Labour Party (PvdA) is a progressive and social democratic party. It obtained 38 MPs. The PVV (15 seats) is a nationalistic, populist party with conservative and rightist ideals. It is also an anti-immigrant, anti-Islam, and anti-European party. It gained 15 MPs. The Socialist Party (SP) is a left-wing socialist and Eurosceptic party. It gained 15 seats. The Christian Democratic Appeal (CDA) is a conservative, centrist party with 13 MPs. Democrats 66 (D66) is a reformist social, liberal party with 12 seats. The Christian Union (CU), with five seats, is a Christian democratic party with more conservative Christian principles than the CDA but more progressive social ideas. The Green Party (GL), with five seats, is a social-democratic left-wing party that focuses on environmental problems. The Reformed Political Party (SGP) is a right-wing conservative protestant Christian party with three seats. The Party for the Animals (PvdD), a social-democratic party dedicated to animal rights and welfare, and the 50Plus party (50Plus), which advocates for the concerns of retirees, each hold two seats.

5. Network Characteristics

In the case of the Catalan MPs' Twitter mentions network, 116 MPs tweeted a total of 19,507 mentions, while in the case of the Dutch MPs' Twitter mentions network, 144 parliamentarians tweeted a total of 7,356 mentions.

The descriptive network statistics of both the Catalan and the Dutch MPs' Twitter mentions networks are summarized in Table 1.

The descriptive statistics of both networks reveal some similarities but also some important differences between the networks. As is common in most online networks, a small number of parliamentarians attracts and sends most of the mentions, thus the maximum values, Max (K_{in}) = 1,409 (Catalonia) and 204 (the Netherlands), and the Max (K_{out}) = 773 (Catalonia) and 361 (the Netherlands), compared to the mean degree (d = 25.750 in Catalonia, and d = 15.354 in the Netherlands), are indicative of the underlying long tails distribution. In addition to the dissimilar activity in the networks (Catalonia = 19,507 mentions; the Netherlands = 7,356 mentions), the descriptive network statistics show a much lower density for the Catalan MPs' mentions network (0.224) than for the Dutch parliamentarians' mentions network (0.341). This means that, while in the Catalan network, only 22.4% of the total mentions among the parliamentarians occurred, in the Netherlands network, 34.1% of the possible total mentions among the parliamentarians took place. Despite the differences in the densities of the networks, the average path length of both networks (Catalonia = 1.867; the Netherlands = 2.191) is similarly low, revealing that the average distance between the MPs is 1.867 and 2.191 steps, respectively. Thus, although the density in the networks is quite low, notably in the Catalan network, the short distances between the MPs make it possible for them to connect to others easily. Lastly, the modularity scores reveal that the Catalan MPs' Twitter mentions network is much more fragmented than the Dutch parliamentarians'. Both networks can, however, be classified as being tight crowd and affiliation networks. They are tight crowd networks because they have between two and six clusters (with modularity scores of 0.548 in the case of the Catalan network and 0.286 in the case of the Dutch network) and few isolates (Hansen et al., 2011, p. 8). These characteristics belong to the so-called affiliation networks (Borgatti et al., 2016). Given its partisan and ideological nature, this is the typical network type to be expected in online legislative networks (Esteve-Del-Valle & Bravo, 2018b).

6. Results

6.1. Results of the Exponential Random Graph Models

Table 2 summarizes the results of the ERG models (Model 4) for the Catalan MPs' and the Dutch MPs' Twitter mentions networks. The information criterion was driven by significance levels, the Akaike information criterion and the Bayesian information criterion.

The first column of the table reports the estimates of the baseline model (Model 1) containing the arc and the full specification of endogenous network effects (mutuality). The edge parameter is negative for both networks, a common characteristic of sparse networks (see Mai et al., 2015). The estimates indicate that reciprocity (mutuality) is positive and significant ($p < 0.001$) for the Catalan MPs' Twitter mentions network (EST = 2.042; SE = 0.069), whereas for the Dutch parliamentarians' the network is positive (EST = 0.140; SE = 0.096) but not significant.

Model 2 adds to the MPs' network endogenous parameters their ideology (left–right). The estimates of this node attribute are positive and significant ($p < 0.001$) for the left (EST = 1.079; SE = 0.004) and for the right ideology (EST = 0.423; SE = 0.004) in the Catalan parliamentarians' Twitter mentions network, whereas for the Dutch MPs' network the estimates are negative and significant ($p < 0.01$) for the left ideology (EST = −0.184; SE = 0.004) and non-significant for the right ideology (EST = 0.073; SE = 0.050). In line with these estimates, which can be interpreted as conditional log-odds ratios, left and right ideology positively affect Catalan MPs' homophilic communication ties. For instance, holding a left ideology increases the MPs' odds of mentioning an MP holding the same ideology (all else being equal) by about 100%. In contrast, in the Dutch parliamentarians' Twitter network, holding a left ideology decreases the likelihood of mentioning MPs with the same ideology by 18.4%, revealing a much more heterogeneous communication behavior than observed in the Catalan network. These different degrees of ideological homophily (left–right) can also be visually observed in the network visualization shown in Figure 1.

The Catalan MPs mentions' Twitter network (116 nodes and 2,987 edges) is displayed on the left, and

Table 1. Descriptive network statistics of the Catalan and the Dutch MPs' Twitter mentions network.

	Catalan MPs' Twitter Mentions Network	Dutch MPs' Twitter Mentions Network
N (number of vertices)	116	144
E (number of directed edges)	2,987	2,211
d (mean degree)	25.750	15.354
Max (K_{in}; maximum indegree)	1,409	204
Max (K_{out}; maximum outdegree)	773	361
Graph density	0.224	0.341
Average path length	1.867	2.191
Modularity (Newman & Girvan, 2004)	0.548	0.286

Table 2. Factors underlying communication flows in the Catalan and Dutch MPs' Twitter mentions networks: Models 1–4.

	Catalan MPs		Dutch MPs	
	EST	*SE*	*EST*	*SE*
Structural Features (Model 1)				
Edges	−2.465***	0.061	−2.141***	0.056
Mutuality	2.042***	0.069	0.140	0.096
Ideology (Model 2)				
Left	1.079***	0.004	−0.184**	0.069
Right	0.423***	0.004	0.073	0.050
Political Position (Model 3)				
No Leader	0.083*	0.044	0.114	0.052
Leader	0.008	0.103	−0.203	0.125
Sociodemographic Characteristics (Model 4)				
Age (26–44)	0.515***	0.047	0.149*	0.060
Age (45–59)	−0.356***	0.055	−0.032	0.005
Age (≥60)	−0.753*	0.304	−0.219	0.282
Gender (Male)	0.037	0.048	−0.057	0.066
Gender (Female)	0.017	0.053	0.113*	0.050
Akaike Information Criterion	14,213		14,185	
Bayesian Information Criterion	14,228		14,272	

Notes: * $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$; *EST* = Estimates; *SE* = Standard Error.

the Dutch MPs mentions' Twitter network (114 nodes and 2,211 edges) is displayed on the right. The Force Atlas 2 algorithm, which pulls together nodes that are connected by ties, was used to generate both visualizations. The color of the nodes represents the MPs' ideology (left = green; right = red). The size of the nodes has been standardized for visualization purposes. In the Catalan parliamentarians' network, two differentiated clusters of interaction can be observed, showing that most of the mentions in the network occur between MPs holding the same ideology. Conversely, in the Dutch MPs' network, parliamentarians holding different ideologies are closely located in the graph, revealing the existence of many more cross-ideological interactions.
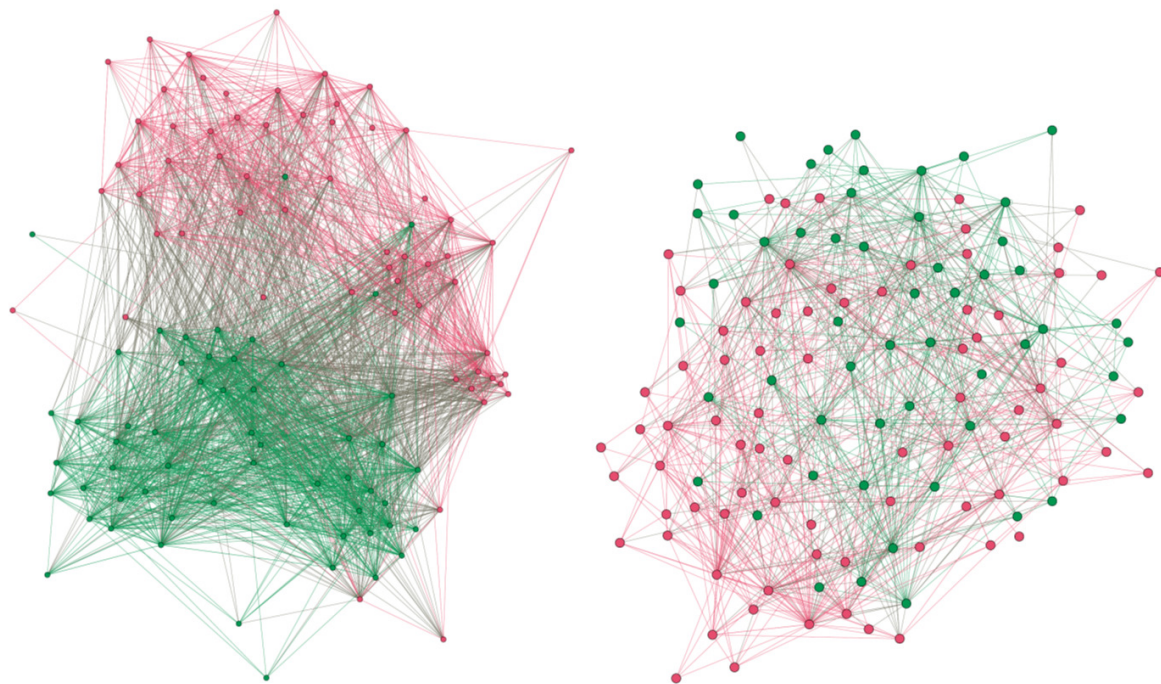

Figure 1. Mentions between left–right Catalan MPs (left network) and between left–right Dutch MPs (right network).

Model 3 adds to the previous model the MPs' political position as a possible explanation of the homophilic communication ties (mentions) among Catalan parliamentarians and among Dutch MPs. Controlling for the endogenous network effect (mutuality), the estimates for the Catalan MPs' Twitter mention network (EST = 0.083; SE = 0.044) suggest a significant ($p < 0.05$) and positive homophilic communication behavior among the parliamentarians who do not hold political leadership positions, while for those holding a political position the estimates (EST = 0.114; SE = 0.052) are not significant. Concerning the Dutch MPs' Twitter mentions network, both estimates, those of the parliamentarians not holding a political leadership position (EST = 0.008; SE = 0.103) and those of the MPs holding these positions (EST = −0.203; SE = 0.125) are not significant.

In Model 4, we added the MPs' sociodemographic characteristics (age and gender) to the previous ERG models. The estimates of the age are significant ($p < 0.001$) and positive for the youngest MPs (26–44) of the Catalan network (EST = 0.515; SE = 0.047), and significant ($p < 0.05$) and positive for the Dutch network (EST = 0.149; SE = 0.060). For the second age cohort (45–59), the estimates are negative in both networks, rejecting the idea of homophilic communication ties among the MPs of this cohort. However, while in the case of the Catalan MPs, the estimates (EST = −0.356; SE = 0.055) are significant ($p < 0.01$), in the Dutch network, the estimates (EST = −0.219; SE = 0.282) are not significant. Indeed, the estimates of the oldest cohort of MPs (≥60) reveal a similar tendency. In both networks, these estimates are negative, but in the Catalan network, the estimates (EST = −0.753; SE = 0.304) are significant ($p < 0.001$), whereas in the Dutch network, the estimates (EST = −0.219; SE = 0.282) are not significant. Lastly, concerning the gender, the estimates of the Catalan par-

liamentarians' Twitter mentions network do not show any homophilic behavior among male (EST = −0.037; SE = 0.048) or female MPs (EST = −0.057; SE = 0.066); and for the Dutch MPs' network the estimates are negative (EST = −0.057; SE = 0.066) but not significant for the male MPs and positive (EST = 0.113; SE = 0.050) and significant ($p < 0.05$) for the female MPs. These results reveal that in terms of the MPs' gender, the Dutch female parliamentarians are the only ones showing a homophilic mentioning behavior.

To sum up, H1 is partially corroborated because reciprocity only explains the formation of mentions' ties among the Catalan MPs. This is an unexpected finding since reciprocity was expected to explain the formation in both networks. As for the existence of status homophily, age explains the formation of mention ties among young (26–44) Catalan MPs and among young (26–44) Dutch MPs (H3). However, only in the Netherlands can the existence of gender homophilous ties be observed (H2). Furthermore, concerning MPs' political position (leadership position homophily), homophilous ties seem to be present only among Catalan parliamentarians not holding leadership positions (H4). Lastly, the existence of ideological homophily is corroborated in the case of Catalan parliamentarians exclusively (H5). This is also an important unexpected finding since ideological homophily was assumed to influence the formation of communication ties in both networks.

To assess how well the model captures the structure of the data, Figure 2 shows how the observed in-degree and minimum geodesic distance distributions replicate the network statistics observed in the original data.

The vertical axis in both figures represents the relative frequency. The solid lines represent the observed statistics in the actual network (thick black lines).
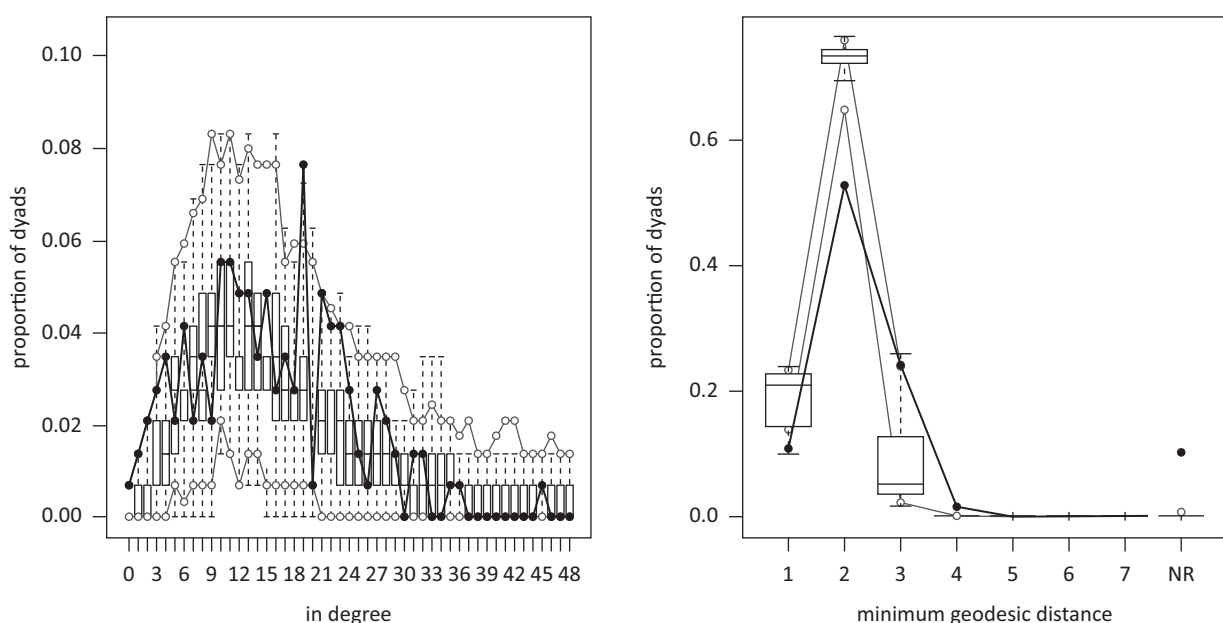

Figure 2. Goodness-of-fit diagnostics (Model 4: Dutch MPs Twitter mentions network).

The grey lines show the 95 percentile range of the simulated data. The model performs reasonably well for the in-degree and the geodesic distance distributions. The observed distributions generally fall within the quantile curves for most of the range. The model overestimates the average in-degree distribution and geodesic distance, but overall, the model represents the shape of the distributions.

6.2. Results of the E-I Index

The E-I index was calculated to assess the degree of polarization in the Catalan parliamentarians' mentions network and the Dutch MPs' mentions network. Table 3 below shows the results of the analyses.

The values of the rescaled E-I index (number of iterations: 5,000), which takes into account the group sizes of the parties, show that the Catalan MPs' mention Twitter network (−0.082) is much more polarized than the Dutch network (0.238). These results corroborate the findings of the ERG models, which show a higher degree of homophilic communication ties among the Catalan parliamentarians' mentions (see Table 2) than among the mentions of the Dutch MPs.

7. Discussion and Conclusion

This research reveals that the communication ties among Catalan MPs are much more homophilous than the communication ties among the Dutch parliamentarians. Concerning the existence of value-homophily, holding similar ideological views (left–right) explains the existence of mentions among the Catalan MPs to a large extent (see Figure 1), whereas ideological similarity does not explain the existence of mentions among Dutch parliamentarians. A possible explanation for such a divergent effect of ideological similarity can be drawn from the different political cultures of both parliamentary networks. While in Catalonia, a relatively young democratic party system, communications in Twitter with MPs holding opposite views are often disregarded by fellow politicians and political parties, in the Netherlands, a long-running democratic party system, with a strong tradition of mutual consultation (Lijphart, 1999), negotiation, and coordination among parties (Hendriks & Toonen, 2001), interactions among MPs who think differently seem to occur much more often.

As for the existence of status-homophily, in line with previous research in the field (Straus et al., 2013), our data reveal high levels of homophily among the mentions of young (26–44) Catalan MPs and young (26–44) Dutch MPs. However, in contrast to previous studies which found that gender similarity explained interactions in Twitter political networks (Esteve-Del-Valle et al., 2021; Karlsen & Ejolras, 2016), homophilous gender ties were only found to explain interactions among female MPs in the Netherlands. The same applies to the *leadership position homophily* among the MPs (holding a political position), which despite being found to explain the existence of followee relations among politicians (Esteve-Del-Valle & Bravo, 2018b), does not explain the existence of homophilous ties among the Catalan MPs or among the Dutch MPs.

The results also show that homophilous ties at the dyad level (MP–MP) explain the degree of polarization in the Twitter mentions network at a network level. Thus, in Twitter mention networks with a high degree of homophilous communication ties among the nodes, the degree of political polarization in the networks is expected, ceteris paribus, to be higher than in networks with more heterogeneous communication ties.

Lastly, the study shows the relevance the political context has in affecting communications on Twitter. In a context where parliamentarians are pushed to choose between being in favor or against the independence of Catalonia, MPs' use of Twitter could be entrenching their ideological views. On the other hand, in the Netherlands, a much less polarized political context, with a strong tradition of consensus-seeking, by facilitating interactions between parliamentarians who think differently, Twitter could help enhance the infrastructure of "consensus democracies," in which effective government is possible despite the fragmentation of the party system.

The findings of this study are also significant to determine whether social media contribute to the expansion of the public sphere in online legislative networks. They suggest that communications on Twitter can enclose politicians in so-called "echo chambers" (Catalan network) or open up cross-ideological and cross-party interactions (Dutch network). These results align with those found by Karlsen et al. (2017) in their experimental study of online debates, which argues that "the Internet provides the opportunity to interact with like-minded people and those with opposing views at the same time" (Karlsen et al., 2017, p. 270), and they appear to back up Barberá et al.'s (2015) suspicion that previous studies in the field may have overestimated the degree of political polarization in social media.

This study has some limitations. On the one hand, MPs' communications were only investigated in the Twitter mention network; thus, future research should expand this inquiry to the study of the other two

Table 3. Rescaled E-I index of the Catalan MPs' Twitter mentions network and the Dutch MPs' Twitter mentions network.

	Catalan MPs' Network	Dutch MPs' Network
Rescaled E-I index	−0.082	0.238

Note: The E-I index ranges from −1 (all ties are internal to the group) to +1 (all ties are external to the group).

Twitter communication layers (following–follower and retweet). On the other hand, the ERGMs could be complemented with more attributes, such as MPs' educational level, another potential status-homophily factor, or their position in the parliamentary chamber (e.g., parliamentary group leader) as a potential value-homophily factor. However, this research contributes to expanding the study of homophily and political polarization among political elites—key agents of online political polarization—and opens new avenues for future research in the field.

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Conflict of Interests

The author declares no conflict of interests.

Supplementary Material

Supplementary material for this article is available online: https://osf.io/924mu/?view_only=fbbc11b5e9da4075b2 ad5925ff344c21

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