Polarization of Climate Politics Results from Partisan Sorting: Evidence from Finnish Twittersphere*

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Abstract

Prior research shows that public opinion on climate politics sorts along partisan lines. However, they leave open the question of whether climate politics and other politically salient issues exhibit tendencies for issue alignment, which the political polarization literature identifies as among the most deleterious aspects of polarization. Using a network approach and social media data from the Twitter platform, we study polarization of public opinion toward climate politics and ten other politically salient topics during the 2019 Finnish elections as the emergence of opposing groups in a public forum. We find that while climate politics is not particularly polarized compared to the other topics, it is subject to partisan sorting and issue alignment within the universalist-communitarian dimension of European politics that arose following the growth of right-wing populism. Notably, climate politics is consistently aligned with the immigration issue, and temporal trends indicate that this phenomenon will likely persist.

Keywords: climate politics; political polarization; partisan sorting; issue alignment; social networks

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1 Introduction

To varying extents, public opinion on climate politics around the world is polarized (McCright, Dunlap and Marquart-Pyatt 2016; Capstick et al. 2015). Even in countries where overall levels of climate skepticism is low, the supporters and opponents of climate change mitigation policies tend to be antagonized. Numerous studies show that current levels of polarization has undesirable effects on efforts to address the climate change issue, such as constraining climate communication (Zhou 2016) and decreasing support for both public and private environmental spending (Johnson and Schwadel 2019; Gromet, Kunreuther and Larrick 2013). Better understanding of the characteristics of climate polarization is the first step to addressing it. However, despite the urgency of the situation, research into what drives polarization of public opinion in this area remains limited.

Existing work on this topic shows that positions on climate politics is divided along party lines (Dunlap, McCright and Yarosh 2016; Farrell 2016; Guber 2013; McCright and Dunlap 2011). This suggests that the polarized public opinion on climate change is driven by partisan sorting, the phenomenon where the public aligns itself more closely with their preferred parties because the increasing polarization of political elites makes it easier to do so (Hetherington 2009; Fiorina and Abrams 2008). Beyond the deleterious consequences introduced by the polarization of climate politics in itself, partisan sorting has the additional implication that the issue becomes more easily captured by extreme interests, leading to uneven political representation (Baldassarri and Gelman 2008).

Most of this research is based on the United States context (Capstick et al. 2015), which in many ways differs from the rest of the world. First, the most salient climate debate in the U.S. is about beliefs toward the existence of anthropogenic climate change (Dunlap and McCright 2010) instead of policy-based debates that are more common elsewhere (Cann and Raymond 2018). Second, the U.S. has a strong two-party system characterized by both ideological and affective polarization along party lines (Fiorina and Abrams 2008; Iyengar et al. 2019). This deep political divide combined with the emotive nature of the climate issue makes it unsurprising that positions on climate issues and broader party politics are aligned in the U.S. These studies therefore have relatively low generalizability despite the U.S.’s broader importance in global climate politics. Outside of the U.S. context, studies from Australia (Tranter 2011), Norway (Aasen 2017), and the United Kingdom (Poortinga et al. 2011), as well as those conducted cross-nationally (Sohlberg 2017; McCright, Dunlap and Marquart-Pyatt 2016; Tranter and Booth 2015) similarly find that individuals’ outlooks on climate politics align with their partisanship and ideological positions. Still, the research is sparse, covering only a small subset of countries in the world; in a recent review, McCright, Dunlap
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and Marquart-Pyatt (2016) found only 11 non-U.S. based studies on climate polarization.

Beyond the issue of limited country cases, two important gaps remain in the literature. First, most previous studies rely primarily on self-reported items from surveys, which largely constrains the examination to the individual level. This in turn limits our ability to observe contextual or emergent dynamics governing public opinion polarization (Capstick et al. 2015). Survey-based cohort analysis (e.g. Johnson and Schwadel 2019) begins to move beyond individuals, but are rare in the literature. Related to this, common measurement errors in surveys (i.e. tendency to choose middle options, see Moors 2008) will strongly influence inferences about polarization (Hetherington 2009). Second, to the extent that existing work shows evidence of partisan sorting in public attitudes toward climate politics, they leave open the question of further alignment between climate and other socially salient issues. In the polarization literature, an important question is whether partisan sorting will yield alignment in individuals’ positions across issues (Baldassarri and Gelman 2008), leading to entrenched in-group identities that make it difficult to reach agreements despite the supposed flexibility from working in multidimensional policy space (Mason 2015).

Given the current state of the field, further work into a broader set of cases, especially using more diverse methodological approaches and with an additional focus on how climate politics relate to other socially salient issues, will provide a better understanding of how climate politics becomes polarized. We address these gaps by studying polarization of climate politics in Finland using social network data from the Twitter platform. Our study makes a number of contributions.

First, Finland as a case is advantageous on several fronts. Finland has a multiparty political system, and the climate debate in Finland centers on the tradeoff between environmental and socioeconomic concerns (Teräväinen 2010), which is more in line with global trends (Cann and Raymond 2018). These characteristics make Finland different from the U.S. on the important dimensions of climate politics and political institutions, thereby providing a wide range of coverage. Additionally, Finnish politics has traditionally been characterized by low levels of polarization and tendencies toward consensus politics (Reiljan 2020). Recent trends, however, indicate increasing polarization among political elites, notably in the areas of climate and immigration politics (Lönnqvist, Ilmarinen and Sortheix 2020). Finland’s political history therefore makes it a ‘hard’ case where partisan sorting should be low, and because political elites have begun to strategically politicize the climate issue, it is particularly suitable for studying the effect of partisan sorting on climate polarization.

Second, we take a system-level examination of polarization using social media data, which allows us to unobtrusively observe emergent behaviour (Barberá and Steinert-Threlkeld 2020). This is particularly important for our study, as prior research on the mechanisms
of polarization shows that it is a relational, group-level phenomenon (Suhay 2015; Myers 1978). Our use of social media data allows us to directly observe individuals placing themselves with or against one another in a public forum, affording us the construct validity not available from a survey-based study, which usually rely on aggregated differences in individual responses to infer polarization.

Finally, an additional benefit of our network-based approach is that it is agnostic to language outside of possessing case-specific knowledge, making it readily applicable to different contexts. While natural language processing tools have generally expanded beyond English, there is still a large gap in how they perform across different languages (Djatmiko, Ferdiana and Faris 2019). Twitter, additionally, is a constrained medium less suitable for textual analysis. Our paper is therefore useful as a guide for a large-scale approach to studying polarization without relying on text.

The remainder of this paper proceeds as follows. In the second section, we describe our theoretical framework and outline a number of expectations. Here, we also discuss the importance of focusing on alignment instead of single-issue polarization. In the third section, we present our empirical approach, which applies network methods to studying public opinion polarization and alignment. We also describe our data and data collection procedure. In the fourth section, we present our findings. We show that, among a set of politically relevant topics, climate politics is not particularly divisive. However, there is strong evidence of partisan sorting, where positions on climate issues are strongly aligned with positions on political parties. With regard to specific issues, climate attitudes have become strongly aligned with attitudes toward immigration. Together, our results indicate that the new universalist-communitarian dimension of political competition emphasized by right-wing populists parties has become an important driver of climate politics polarization, and that electoral cleavages over issues in this political space have become more coherently aligned.

2 Theoretical Framework and Expectations

The goal of this study is to look for evidence of polarization in public opinion toward climate politics in the Finnish multiparty system, and to characterize the nature of this polarization. Specifically, informed by the broader literature on political polarization (Fiorina and Abrams 2008; Baldassarri and Gelman 2008; Layman, Carsey and Horowitz 2006), we ask whether the observed climate polarization can be attributed to partisan sorting, and whether this has led to its alignment with other socially salient issues. Our primary focus, therefore, is on how polarization of climate politics aligns with other sources of societal cleavage.

Our emphasis on alignment of cleavages instead of single-issue polarization is motivated
by the logic outlined in Baldassarri and Gelman (2008). To the extent that political issues afford different positions, a populace that is divided over multiple issues is not necessarily harmful to social stability. In open societies, multiple non-overlapping societal cleavages create cross pressures that balance each other out, preventing a single source of conflict from becoming entrenched (Coser 1956). Highly polarized positions on climate change is not necessarily a problem as long as they do not correlate with opinions on other divisive issues such as immigration. If multiple divisive issues are independent, any two individuals will in expectation agree on half the issues and disagree on the other half, thereby reducing the kind of polarized animosity that makes it difficult to reach agreements. Indeed, while polarization constrains climate communication (Zhou 2016), studies show that even climate change deniers can be convinced of accepting greenhouse gas mitigation policies when proponents use arguments based on common ground outside of climate politics itself (Dryzek and Lo 2015). However, when these cleavages start to align, cross pressures are reduced, resulting in, at the extreme, two highly antagonized groups with no source of agreement.

Studying what drives public opinion to align across topics (i.e. political parties and issues) is therefore important to understanding polarization. Prior research on this question identified two primary types of alignment (Fiorina and Abrams 2008; Layman, Carsey and Horowitz 2006). First, partisan sorting refers to the process by which the public sorts itself into entrenched partisan identities, resulting in a populace that is divided along party lines despite holding relatively nonaligned positions across different issues. Second, issue alignment refers to the phenomenon that the electorate’s actual preference over policy shifts until ideological divisions become aligned (Baldassarri and Gelman 2008). These two types of alignment can arise independently, but it is within expectations that they reinforce each other under certain conditions (Layman and Carsey 2002).

It is well established that partisan sorting exists in the U.S. context (Fiorina and Abrams 2008), as evidenced by the overwhelming alignment of issue positions with partisanship. In certain scenarios, such as among partisans, we observe an associated alignment among issues, but there is no clear evidence of general issue alignment (Baldassarri and Gelman 2008). More specifically, the research shows that for partisan sorting to yield issue alignment, individuals need to possess enough political interest and sophistication, so it usually manifests only among partisans (Baldassarri and Gelman 2008; Layman and Carsey 2002). There are considerably fewer studies of partisan sorting in multiparty systems (e.g. Adams 2012; Kevins and Soroka 2018), and here the evidence is highly mixed, depending largely on the case selection and research design specifications.

In the context of climate politics, we expect partisan sorting because climate politics started its life in the public mind as a ‘niche’ issue where expectations for partisan sorting
strongest (Adams, Ezrow and Leiter 2012). As a niche issue, generally understood as specific or narrow topics not directly related to economic policies, climate change was championed, and on the other side antagonized, by nontraditional parties. The Green and to some extent New Left parties have been the primary champions of stronger climate policies. This demand has more recently become mainstream so that established parties have taken stronger positions. This mainstreaming, driven by the mounting scientific evidence on the need to address climate change, as well as the global political process around the United Nations Framework Convention on Climate Change (UNFCCC) has recently been met with rising opposition from populist right parties in many European multiparty democracies. The 2019 parliamentary elections in Finland were in fact coined by some as the ‘climate elections’ (Hassinen 2019). This trend of political elites polarizing around the climate issue, coupled with the issue’s increasing salience in the public debate, leads us to expect public opinion on climate politics to exhibit partisan polarization tendencies. On the other hand, it is less likely for public opinion on climate politics to align more broadly with public opinion across multiple other issues, simply due to the fact that this phenomenon is generally rare even in highly polarized political environments like the U.S. Indeed, a recent examination of the European Social Survey found that individuals were relatively evenly distributed in terms of support across the two dimensions of climate and social welfare policy (Otto and Gugushvili 2020). From this, we have the partisan sorting hypothesis:

**Hypothesis 1:** Public opinion on climate politics will align more strongly with public opinion on political parties than with other political issues.

Compared to two-party systems, multiparty systems afford political parties the flexibility to be more eclectic in their chosen issues (Meyer and Wagner 2013). This is especially so for niche parties, which tend to emphasize issue ownership instead of general competence in governing. Here, Adams, Ezrow and Leiter (2012) find that niche parties across 14 European countries and their supporters tend to exhibit more partisan sorting than mainstream parties. Further, and especially relevant to our focus on climate politics, research on European politics demonstrates the rise of a cultural dimension to political conflict in addition to the traditional left-right distributive divide (Kriesi et al. 2006). This new dimension has been characterized as a universalist-communitarian divide focused on the role of the community as an organizing principle of society, with the communitarian populist right arguing against the global inclinations of the universalist New Left (Bornschier 2010).

On the climate issue, right-wing populist parties in Finland and elsewhere in Europe have positioned themselves as main opponents in the debate (Lönnqvist, Ilmarinen and Sortheix 2020; Lockwood 2018; Gemenis, Katsanidou and Vasilopoulou 2012). They largely take the
communitarian stance that their countries should not be responsible for bearing the costs of climate change mitigation, in many cases labeling the climate movement, with associated international processes around the UNFCCC, as an universalist movement that encroaches upon national sovereignty and sufficiency (Forchtner, Kroneder and Wetzel 2018; Forchtner and Kølvraa 2015). Given the increasingly salient role the populist-right has taken as climate policy opponents, we have the universalist-communitarian hypothesis:

**Hypothesis 2:** Partisan sorting of climate politics will be driven primarily by populist parties and their opponents.

Finally, we return to consider the relationship between partisan sorting and issue alignment in light of the preceding discussion on right-wing populist parties. As noted above, prior research indicates that issue alignment can be a product of partisan sorting given suitable conditions (Baldassarri and Gelman 2008; Layman and Carsey 2002). Specifically, individuals with sufficient political interest or sophistication to overcome the difficulties of identifying their parties’ positions across multiple different issues will adjust their own ideological positions on these issues accordingly, thereby leading to issue alignment.

Here, we point to immigration as a potential topic for climate politics to become aligned with. Even more than climate politics, immigration skepticism is an issue heavily championed by right-wing populist parties in Europe (Rydgren 2008; Betz 1993). This issue fits directly into the universalist-communitarian debate, and is a central mandate for many of these parties (Rydgren 2008). From the perspective of political parties, especially niche parties, linkage across issues can be advantageous as it prevents them from being seen as single-issue parties (Mudde 1999), and can consolidate their support base against any particular issue from becoming irrelevant. There is evidence of this behaviour in Finland, where a recent study found that political elites from both the right-wing populist Finns Party and the Green League have become increasingly aligned on their respective positions toward climate and immigration politics (Lönnqvist, Ilmarinen and Sortheix 2020). Given this move, and the high salience in the links between these two issues via the new universalist-communitarian debate, we expect that public opinion on climate and immigration politics will be aligned with each other in addition to exhibiting partisan sorting. This leads to the immigration alignment hypothesis:

**Hypothesis 3:** Public opinion on climate politics will align with public opinion on immigration, but not with traditional left-right distributive politics.

To recapitulate, our expectations are that polarization in climate politics exhibits strong tendencies of partisan sorting, which leads to public opinion on climate politics aligning
strongly with attitudes toward right-wing populist parties and their opponents, and toward the immigration issue contended by these parties. To examine public opinion on these topics (i.e. parties and issues), we focus on public displays of agreement from the Twitter platform in the months surrounding the 2019 Finnish parliamentary and European Parliament elections. Before moving to presenting our empirical approach, we provide a brief background on our case and contextualize our expectations in terms of climate politics and political polarization in Finland and Finnish Twittersphere in particular.

2.1 Climate Politics in Finland and Finnish Twittersphere

The Finnish political system has traditionally been based on a tripartite corporatist collaboration between employers, employees, and the government. This has made politics more consensual compared to the two-party system of the U.S. (Arter 2015). Finnish governments often consist of multiple parties from both the left and the right. This tends to lessen inter-party conflicts because parties expect to enter government with one another at some point in the future. However, the recent rise of a right-wing populist party, the Finns Party, along with the falling popularity rates of traditional parties, has introduced new cleavages. The Finns Party has become almost as popular as the traditional mainstream parties, the center-left Social Democrats and the center-right National Coalition, making them less of a niche party at least in recent years.

Despite the history of consensus politics in Finland, there is evidence of polarization and observable levels of alignment between issues in specific contexts (Lönnqvist, Ilmarinen and Sortheix 2020). In particular, prior research showed that there are conflicts over climate change mitigation policies in Finland. Business actors, trade unions, and some governmental organisations think that economic growth is more important than climate change mitigation and this stance has met resistance from environmental, civil society actors and political parties from the left of the spectrum (Teräväinen 2010; Gronow and Ylä-Anttila 2019). These findings, however, remain generally limited to political and economic elites.

On April 14 and May 26, 2019 respectively, Finland held its parliamentary election and European Parliament election. During the lead up to these elections, climate politics was among the salient debates, thereby providing us with a suitable opportunity to directly observe the formation, polarization, and alignment of public opinion on the Twitter platform.

Twitter, of course, is not representative of the general population. While there are clear advantages of studying public opinion through Twitter (Barberá and Steinert-Threlkeld 2020), it remains imperative to explicitly contextualize our expected findings in terms of what we understand about Finnish Twittersphere. First, note that use of social media in
Finland is high (Statistics Finland 2019). However, there is a clear skew toward the younger population (over 84% for those under 45, 11% over 74, and 61% overall), with the Twitter user group being particularly overrepresented by more politically inclined and urban individuals (Vainikka and Huhtamäki 2015). Finally, Nelimarkka et al. (2020) found that opinion-sharing and position-taking were prominent features of Finnish political Twitter-sphere in the lead up to the 2015 Finnish parliamentary elections, which bodes well for our approach of measuring public opinion using the platform.

Given the preceding discussion, our findings about how climate politics exhibit tendencies of partisan sorting and issue alignment should be understood as applying to a more politically sophisticated and active segment of the population. As discussed above, under such conditions we should be more likely to observe issue alignment (Baldassarri and Gelman 2008). At the same time, it merits noting that a U.S.-based study found that younger individuals with more education (who are overrepresented on Twitter) tend to be less likely to align with their party on the climate issue (Ross, Rouse and Mobley 2019), which might decrease observable partisan sorting and issue alignment.

3 Empirical Approach

In this study, we take a network approach to studying public opinion. Specifically, we measure individuals' political attitudes by looking at the networks of agreement among individuals communicating with one another about given topics. Using publicly available data from the Twitter platform, we construct networks where individuals agreeing with each other are connected, leading to the emergence of groups with the same stance on topics. The resulting networks allow us to apply global network measures to study polarization and cross-topic alignment, which we describe in more detail in section 3.3. This logic of aggregating relational behaviour on social media to infer positions has been applied elsewhere to measure political ideology (Barberá 2015; Conover et al. 2011), and has a number of advantages.

First, data from Twitter is publicly accessible directly through its application programming interface (API). We can therefore collect behavioural data without interacting with our subject pool. Beyond the ethical advantages of this approach, we are also able to minimize all sources of interviewer effects associated with surveys, including measurement errors as well as unit and item nonresponse (West and Blom 2017). As noted above, inferences about polarization is particularly susceptible to measurement error introduced by respondents' tendency to choose the middle category (Hetherington 2009; Moors 2008). At the same time, minimizing nonresponse means that we are able to obtain a near census of the system (with the exception of private accounts).
Related to this, the second advantage is that we are able to observe the system in its entirety over a continuous temporal period, thereby capturing outcomes of emergent processes and other behaviours that are constrained in individual-level surveys. This is particularly important for our study, as polarization and alignment across topics are system-level phenomena driven by relational, group behaviour (Suhay 2015; Myers 1978). Whereas survey-based studies infer the level of polarization using aggregated differences in individual responses, we are able to directly observe individuals placing themselves with or against one another in a public forum across multiple topics.

3.1 Data Collection

We collected tweet and retweet data over the entire election and post-election period, from March 1 to July 31, 2019. Data collection was done via the Twitter API which returns all tweets satisfying user-specified conditions (Twitter 2020). Specifically, we filtered the Twitter stream by a set of 317 hashtags, meaning that all tweets and retweets which include at least one of these hashtags entered our data set, subject to a small number lost to random connection drops. These hashtags were selected based on relevance to the parliamentary and European Parliament elections in Finland.

Notably, we identified eleven topics to focus our examination on. Six of these are political parties and five of them are socially salient issues, including climate politics. These topics are outlined in Table 1. Each of these topics has its own set of associated hashtags that is a subset of the overall 317. These topic-specific subsets, which we use to measure public opinion on the topics, are mutually exclusive from each other. The hashtags used for these eleven topics are translated into English and presented in Appendix A.

| Issues          | Parties                  |
|-----------------|--------------------------|
| Climate         | Social Democrats (SDP)   |
| Immigration     | Finns                    |
| Social Security | National Coalition       |
| Economic Policy | Green League             |
| Education       | Centre                   |
|                 | Left Alliance            |

Table 1: Topics Used in this Study

We selected the four socially salient issues in addition to climate politics based on their importance to these elections, but also with an eye toward capturing the traditional left-right divide, the new universalist-communitarian divide, and a major campaign issue. Immigration was particularly salient because the anti-immigrant Finns Party had advanced significantly in the polls. Recent events prior to the election period, particularly police investigation into a series of sex crimes by immigrant men, had created public controversy...
around the issue. Together with climate politics, they constitute the majority of the current universalist-communitarian debate in Finland. Economic policy and social security are issues that traditionally divide the left and the right, and tends to be strongly present in campaign debates. Social security was particularly salient in this electoral period due to the sitting-government’s failed reform efforts. Education became a major campaign issue during these elections due to the cuts in funding by the previous government and strong demands from the part of student organizations and other actors that the cuts be reversed under the next government.

3.2 Network Construction

We divided the data collected into three periods, pre-election (March 1 to April 14), inter-election (April 15 to May 26), and post-election (May 27 to July 31). Using data from each period, we constructed a set of endorsement networks for our eleven topics. Following prior work (e.g. Garimella et al. 2018; Barberá et al. 2015), we constructed these endorsement network using retweets, which are unmodified sharing of original tweets to the retweeting user’s timeline (i.e. without accompanying text). While some account have bios indicating that their retweets are not endorsements, prior research showed that the majority of users retweet messages they agree with, find trustworthy, or endorse (Metaxas et al. 2015), and that they tend to retweet others with the same political leaning (Barberá et al. 2015).

Each resulting network has a node set containing all users who posted an original tweet containing at least one hashtag related to the given topic and all users who retweeted at least one of these tweets. Undirected ties on the network indicate the linked nodes have at least one instance of retweet between them on the given topic. Descriptive statistics for these networks are presented in Table 2.

3.3 Measures

We approach the measurement question by considering, if a political system is marked by polarized individuals, what would the observable manifestations be? Drawing on studies from computational social science (e.g. Garimella et al. 2018; Bright 2018; Barberá et al. 2015), we look for evidence of polarization in political communication patterns at the systemic level, using global network measures (i.e. network statistics computed over the entire network) of group fragmentation and cross-network group alignment. We are not the first to measure polarization using differential densities of inter- and within-group agreement, but our extension to studying alignment using similarity measures of group partitioning presents a theoretically motivated bridge between the numerous studies of within-issue polarization.
and the broader political polarization literature.

### 3.3.1 Within-topic Polarization

We measure system-level trends in public opinion polarization by considering patterns of agreement between opposing groups. Specifically, we measure polarization as the relative density of in-group agreement to out-group agreement. We assess these patterns on our endorsement networks, which are a subtype of general communication networks where all ties are publicly conveyed indications of agreement. Practically, this means subsetting all interactions on Twitter to only retweets, leaving out other commonly-identifiable ties such as follows, replies, mentions, and quotes.

We begin by partitioning the network with the objective of obtaining two similarly-sized groups that have the least amount of ties between them. In the context of endorsement networks, this captures, as we intend, two groups of individuals with the lowest level of agreement between them. Restrictions on the balance between group size is required because the unrestricted algorithm will lead to a trivial partition with a single degree-one node in one group and the rest of the nodes in the other group. While this satisfies the objective of minimizing inter-group ties to exactly one tie, it clearly does not capture our intentions. On the other hand, forcing the partitions to be perfectly balanced when real groups are not the same size will result in the partition to divide the larger group, which incorrectly inflates inter-group agreement relative to within-group agreement. We therefore set a 3:7 maximum imbalance constraint on the the partitioning algorithm (METIS, see Karypis and Kumar 1998). Community detection for networks is a deep field (Fortunato and Hric 2016); for

| Topic          | Pre | Inter | Post |
|----------------|-----|-------|------|
|                | $N_v$ | $N_e$ | $N_v$ | $N_e$ | $N_v$ | $N_e$ |
| Climate        | 14510 | 42329 | 6445 | 13624 | 6058 | 11775 |
| Immigration    | 2839 | 6878 | 1701 | 3463 | 2367 | 4968 |
| Social Security| 7276 | 16748 | 3486 | 5815 | 3291 | 5446 |
| Economic Policy| 2936 | 4420 | 2348 | 3316 | 2461 | 3638 |
| Education      | 6992 | 12199 | 3690 | 6125 | 3737 | 5864 |
| Social Democrats| 2004 | 4457 | 1256 | 2719 | 601 | 961 |
| Finns          | 1515 | 4187 | 1497 | 2971 | 1645 | 2850 |
| National Coalition | 2557 | 6458 | 1357 | 2624 | 806 | 1297 |
| Green League   | 2118 | 4402 | 1439 | 2565 | 1657 | 3660 |
| Centre         | 1489 | 2740 | 1324 | 2068 | 933 | 1609 |
| Left Alliance  | 1120 | 2341 | 704 | 1192 | 453 | 609 |

$N_v$ refers to number of nodes; $N_e$ refers to number of ties.

Table 2: Descriptive statistics for endorsement networks by topic and period.
our present problem of finding two groups with the least amount of agreement, the METIS algorithm has a straightforward and intuitive interpretation, and has been shown to work well with retweet networks (Garimella et al. 2018).

The resulting partition is used to organize the adjacency matrix of the network into a block matrix, where the within-group ties are on the main diagonal blocks and the inter-group ties are on the off-diagonal blocks. Then, given the block matrix $B$, we calculate our polarization score $P$ as

$$P = \frac{B_{aa} + B_{bb} - B_{ab} - B_{ba}}{B_{aa} + B_{bb} + B_{ab} + B_{ba}},$$

where $B_{ij}$ is the density of ties in block $ij$. Within each block, the density of ties is defined as the number of observed ties $c$ divided by the total number of possible ties $n$ (i.e. $c/(n_i(n_i - 1)/2)$ for within-group blocks and $c/n_in_j$ for inter-group blocks).

Our score extends the EI-index (Krackhardt and Stern 1988), which is based on the distribution of ties linking nodes within and between groups. The denser the within-group links relative to inter-group links, the more polarized the system. The EI-index has been used elsewhere in studies of group-moderated communication patterns (e.g. Bright 2018; Hargittai, Gallo and Kane 2008), but does not handle unequal group sizes well. Specifically, because the EI-index is based on the raw count of ties in the blocks, it increases monotonically with inequality in the groups’ sizes; off-diagonal blocks of a block matrix necessarily decrease in size relative to the main diagonal blocks as the latter becomes uneven. This undesirable property holds even for networks that have denser inter-group ties than within-group ties (i.e. those with negative EI-index when the groups are equal). Our formulation accounts for different group sizes by using the density of ties within each block, thereby maintaining a constant score as long as the density remains the same regardless of block size. When the two groups are the same size, $P$ reduces to the EI-index.

### 3.3.2 Alignment across Topic Pairs

We measure alignment across a pair of topics as how similar the two topics are in the way accounts position themselves around each topic, based on the partitioning step described in section 3.3.1. Specifically, for a given pair of topic endorsement networks, we take the subset of accounts partaking in discussions on both topics, then compare the extent to which the two pairs of groups overlap. The more each group from the first topic overlaps with one of the groups in the second topic but not with the other, the more similar the group memberships are, and the more we consider these topics to be aligned.

We illustrate this concept with two examples in Figure 1. On the left is the joint endorsement network of climate and economic policy, issues that are relatively unaligned. On this
network, accounts taking the two different positions toward climate politics are respectively coloured with green (dark and light) and purple (dark and light); on the other hand, the two positions toward economic policy are differentiated using dark (green and purple) and light (green and purple) shades. The two topics, climate politics and economic policy, has relatively low alignment, so the groups are mixed. Accounts in the green climate group are relatively evenly distributed into the light and dark economic policy groups, and those in the purple climate group are also relatively evenly distributed into the two economic policy groups. Similarly, we can see that the dark economic policy group is relatively evenly distributed into the green and purple climate groups, and so on. As discussed previously, where two topics have low alignment, there are more common sources of agreement. For example, a dark green account and a dark purple account disagree on climate politics but agree on economic policy, reducing entrenched identities that prevent cooperation in policy-making. Conversely, on the similarly-labeled joint endorsement network of climate and immigration on the right, alignment is high, and accounts are sorted into clearly defined groups. Most members of the green climate group are members of the light immigration group, and most members of the purple climate group are members of the dark immigration group.

Following the discussion outlined in our theoretical framework, a valid measure of topic alignment must have the property that as alignment increases, polarization in the given
system (i.e. joint endorsement network) will also increase even when holding within-issue polarization constant (Baldassarri and Gelman 2008). To see why a measure based on overlapping group memberships satisfies this condition, consider the following. Begin with two topic-specific endorsement networks with identical node sets, both with \( P > 0 \) (i.e. on these networks, the density of ties within communities is higher than across). Next, create a joint-endorsement network by collapsing the original endorsement ties over the common node set. Consider the limiting case where the nodes’ group memberships on the two original networks are identical. Because the partitioning step applied to the two original networks already minimized inter-group ties, the number of inter-group ties on the new joint network will remain at the lowest possible value for the given tie set. From here, decreasing the overlap between the two original group memberships will mean that the ties on the joint network will be increasingly evenly distributed across any two groups on the network. The relationship between alignment and polarization in the joint network is therefore as schematically shown in Figure 2. While it is possible to construct convoluted examples of networks that remain maximally polarized (for the tie set) across all levels of alignment, real-world networks will sit somewhere closer to the lower bound of the shape.

![Figure 2: Schematic illustration of the relationship between two networks’ alignment and the polarization of their joint network. The horizontal dotted line indicates the maximum polarization possible for the given joint endorsement network.](image)

We formally measure similarity in group memberships using the mutual information between partitioning outcomes on different endorsement networks. Mutual information is an information theoretic measure of the similarity between two distributions (Strehl and Ghosh 2002). Intuitively, it quantifies how much information knowing the group of an account in one topic gives about the account’s group in the other topic. In the context of our study, mutual information captures how certain we can be about, for example, an account’s position on climate politics given its stance toward economic policy or immigration. We use a normalized version of mutual information commonly used for comparing network partitions (Danon et al.
2005; Fortunato and Hric 2016), which corrects for unequal group sizes across topics by dividing the raw mutual information by the average of the two partitions’ informativeness (i.e. Shannon entropy). This measure is bound between zero and one, where zero means the two partitions are independent and one means they are identical. The climate-economic policy and climate-immigration joint endorsement networks in Figure 1 have normalized mutual informations of respectively 0.16 and 0.51.

4 Results and Discussion

Based on our results, we find evidence to support all three hypotheses outlined in our theoretical framework. Our set of topics are polarized to varying degrees, but there is generally low alignment between them, compared to the extent each of them are aligned with political parties (H1: partisan sorting). The main exception is the strong alignment between climate and immigration politics (H3: immigration alignment). Both of these issues are also strongly aligned with parties that primarily compete in the universalist-communitarian political dimension (H2: universalist-communitarian). Before discussing our alignment results in detail, we first briefly describe the level of within-issue polarization in the system.

4.1 Within-topic Polarization

We report here the polarization of the eleven within-topic endorsement networks. In order to contextualize the polarization scores of these topics, we also estimated the polarization scores for the fifty most common hashtags from our data set in each period, all of which are politically salient topics from the 2019 electoral period. These results are presented in Figure 3. We find that the scores for these endorsement networks center at approximately 0.83. The distributions of $P$ for the hashtag endorsement networks in the three periods appear to be similar, with the largest exception being that the inter-election period is slightly more polarized on the whole. These differences, however, should not be over-interpreted as the most common hashtags are not the same across periods.

Shown with vertical lines are the polarization scores averaged across periods for each of the eleven topics. Our results indicate that in comparison with the rest of the topics, political parties are among the more polarized. Climate politics is not particularly polarized, ranking above 42 of the hashtag endorsement networks. The other issues are also relatively unpolarized, with the exception of immigration politics, which ranks among the most polarized of the topics.
According to our partisan sorting hypothesis, in our initial examination we expect to find that public opinion on climate politics exhibits tendencies of partisan sorting (i.e. alignment between climate politics and party networks) but not general issue alignment. The results, shown in Figure 4, support this hypothesis.
First, in all three periods, the climate endorsement network aligns more strongly with the party endorsement networks than with the issue endorsement networks. Second, while we did not explicitly hypothesize about temporal trends (i.e. arising from the electoral cycle), the results are telling. In the post-election period, we find alignment between climate politics and issues in general to be very low. Compared to this baseline, the slightly higher issue alignment during the elections (i.e. pre- and inter-election periods) suggests that the context of national and European Union elections in Finland is enough to raise awareness and interest in political issues such that segments of the public are able to identify and adjust their issue positions to that of their parties’, at least in the short term. Together, these results also indicate that despite the overrepresentation of politically active and sophisticated segments of the population in the Finnish Twittersphere, general issue alignment is unlikely outside of specific politically-charged contexts.

Next, we move beyond the averaged alignments and report the relationships between our specific topics. These results are presented in Figure 5, which shows for each period the alignment between every topic-pair. Alignment between the climate endorsement network and all other topic endorsement networks are the cells in the first row. Here, we find support for both the universalist-communitarian hypothesis and the immigration alignment hypothesis.

**Figure 5:** Normalized mutual information for all topic-pairs in each of the three periods. Scale runs from 0 to 0.86. A network’s alignment with itself is always 1, and therefore omitted from the figure.

In terms of partisan sorting, while public opinion on climate politics aligned with positions on parties in general, there is considerable variation when parties are considered separately. Specifically, positions on the Finns, the Green League, and the Left Alliance (and to a lesser extent the Social Democrats) appear to be what drives partisan sorting in
climate politics. On the other hand, the National Coalition and the Centre Party appear to have little to do with climate politics. These patterns are most apparent in the pre-election period, but they hold across all periods, despite, again, alignment levels generally decreasing following the elections. As we expected, public opinion on immigration also aligned strongly with climate politics and these political parties, indicating a clustering of alignments between topics that operate primarily within the universalist-communitarian dimension.

There are two exceptions to note here. First, positions on the Social Democrats also aligned with climate politics during the elections. In fact, in the pre-election period, we observe partisan sorting specific to the Social Democrats across most topics, if only moderately. During the campaign, the Social Democrats took, for the first time, a strong pro-climate position in response to pressure from the media, the climate movement, and other parties in the wake of the release of the IPCC’s influential 1.5 degree report (Intergovernmental Panel on Climate Change 2018). This is the likely explanation for the alignment of positions on the Social Democrats and climate. The overall centrality of the Social Democrats, in turn, can be explained by the fact that they led the polls throughout the campaign and were, consequently, challenged by other parties on a wide range of issues. Second, economic policy, which is traditionally a left-right debate, aligned more closely with this cluster of topics. We propose this is due to the Finns Party’s attempt, similar to other populist-right parties in Europe, to make the discussion surrounding government debt a part of its issue portfolio. Even accounting for these exceptions, clustering along the universalist-communitarian dimension appears to be strong.

The temporal trends from the earlier examination also manifest here. In the post-electoral period, we find that issue alignment drops to almost none, with the exception of alignment between climate and immigration which remains consistently strong. Notably, public opinion toward all parties becomes relatively aligned with one another. This suggests that the post-election government formation led to parties shifting into a center-left bloc that formed the government (comprising the Social Democrats, Centre, Greens, Left and the Swedish People’s Party), leaving the center-right National Coalition and populist-right Finns Party in opposition. Partisan competition appears to become unidimensional, and climate and immigration politics are the only issues that remain sorted along partisan lines.

### 4.3 Topic-clustering along Political Dimensions

Beyond our hypotheses, our results allow us to explore the relationship between partisan sorting and issue alignment in multiparty systems more generally. Here, we note that political topics in Finland appear to be subject to a kind of sorting along specific political dimensions
(i.e. universalist-communitarian versus left-right), making the overall level of alignment in the system higher than simple partisan sorting but lower than broad general issue alignment.

To illustrate this more clearly, we use the overlap-as-information concept that mutual information is based on, and construct the network plot in Figure 6. In this figure, we show explicitly the relationship among different groups across all topics in the pre-election period. Nodes in this network are groups from the eleven different topic endorsement networks. For example, the two groups in the climate endorsement network (in green) are labeled as ‘Climate A’ and ‘Climate B’. A directed tie in this network indicates that an account belonging to the sender group means it is likely to be in the receiver group. Specifically the probability of being in group_\text{r} for the receiver topic given membership in group_\text{s} for the sender topic, conditional on the size of group_\text{r}, is above 86%, a threshold manually selected to most clearly show meaningful clusters among the topics. More generally, we can understand two connected groups having high overlap in membership, and therefore are closely related.

The immediately observable feature of this network is that, with the exception of three isolated nodes, the groups are clustered into two components, with one group from each topic on each side. This is indicative of a higher level of topic alignment beyond just pairwise alignment. Closer inspection reveals that these components are internally organized by the
two dimensions governing European politics. First, as noted above, the Social Democrats, due to their front-runner status throughout the elections, are tied to topics operating in both political dimensions. In both components, the Social Democrats are connected to a dense cluster of topics, including climate politics, that are part of the new universalist-communitarian dimension. On the other hand, the Social Democrats are also linked to topics from the traditional left-right dimension. This is more clearly observable from the component on the right, where the Social Democrats, along with the Centre Party and the National Coalition, are aligned with the traditional left-right issue of social security.

The results here then provides initial evidence that polarization and alignment in multiparty systems operate in a different manner than in two-party systems. Different from a two-party system where issue alignment driven by partisan sorting can occur only in a single dimension, a multiparty system affords a certain flexibility whereby even if persistent partisan sorting leads to alignment between issues, these outcomes can be localized to specific political dimensions. Specific to our examination, we show that while climate politics exhibited the troubling tendencies of partisan sorting and subsequent alignment with immigration politics, it did not align with positions on social security despite the latter also being an important political issue throughout the electoral period.

5 Conclusion

Prior research found evidence that public opinion on climate politics sorts along partisan lines. However, they leave open the question of whether climate politics and other politically salient issues exhibits tendencies for issue alignment, which the general political polarization literature identifies as among the most deleterious aspects of polarization. Using a network approach and social media data from Twitter, we measured public opinion on climate politics and ten other topics during the 2019 Finnish elections as the emergence of opposing groups, overcoming previously identified shortcomings associated with survey-based research on political polarization.

We found that climate politics is not particularly divisive compared to a set of politically relevant topics. However, there is evidence that it is subject to partisan sorting, where public opinion toward climate politics is strongly aligned with positions on parties, specifically the populist-right Finns Party, the Green Party, the Left Alliance, and (more moderately) the center-left Social Democrats. We also found evidence of issue alignment between climate and immigration politics, which persists throughout the electoral period and after. Together, these findings indicate that the relatively new universalist-communitarian dimension of political competition in Europe has become an important component of the climate debate in
Finland.

Our study affords a number of outlooks on the polarization of climate politics. First, while alignment can be highly dynamic and subject to the political cycle, with most issues becoming unaligned with each other after the elections, climate politics remain consistently aligned with immigration politics despite shifting political contexts throughout the electoral period and after, suggesting that this troubling phenomenon is likely to persist. At the same time, there is evidence that the Finnish multiparty system is plural enough such that even where partisan sorting led to issue alignment, it largely occurs in localized contexts; populist parties champion immigration skepticism, and successfully linked the climate issue to their portfolio, but the traditional distributive debate on the left-right dimension remains separate from climate politics. Importantly, this means that politically salient issues in this other dimension such as social security spending are therefore unlikely to be aligned with climate politics, keeping the overall polarization in the system to a manageable level.

Finally, our study should be read as an intended contribution to the broader literature on climate politics polarization. In this regard, while our focus on the Twitter platform affords us with internally valid measures of polarization and alignment in the system, the extent to which findings about this particular system can be generalized to the broader system it is nested in remains an open question. In addition to previously discussed differences between the Twitter and general populations, group behaviour across different public forums including social media platforms can vary by features of the contexts, so we might not observe the same phenomenon manifesting in, for example, Facebook discussions. In this sense, we are not able to directly compare our results to existing studies which are more uniform in their methodology. Still, we believe our study demonstrates first the importance for future work to consider issue alignment more deeply when studying climate polarization, and second the advantages of doing so using our proposed approach. We look forward to more general conclusions and greater understanding of climate politics polarization as the body of work in this area continues to grow.
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A  Data Collection Keywords

In this appendix we present the hashtags used to construct our endorsement networks. In the tables below, we omit the #, but note that all keywords were supplied to Twitter’s API with the preceding #. These hashtags have been translated into English with an eye toward ease of understanding. Please contact us for the original Finnish version. Slogans or catchphrases are marked with *.

### A.1 Climate

| carbon sink       | climate politics               | show you have a spine* |
|-------------------|--------------------------------|------------------------|
| carbon storage    | climate elections              | swamp protection       |
| climate           | nature conservation            | mass extinction wave   |
| climate strike    | biodiversity                   | peat                   |
| climate change    | now we must*                   | the environment        |

### A.2 Issues

#### Immigration

| some border       | multiculturalism               | immigrants            |
|-------------------|--------------------------------|-----------------------|
| integration of immigrants | multiculturalism | stop grooming         |
| child rape        | muslim                        | Finland is racist     |
| immigrant         | forced returns                | tolerance             |
| immigration       | paperless immigrants          | asylum seeker          |
| immigration policy | close the borders             | asylum seekers         |
| immigration election | racism                     | asylum seeker flood   |
| intruder          | racists                       | asylum                |
| immigrant         | refugees                      |                       |
| intruder          | sex crimes                    |                       |

#### Social Security

| homelessness      | basic income                  |                       |
|-------------------|-------------------------------|-----------------------|
| pension           | social security               |                       |
| inequality        | social and healthcare system  |                       |
| dependency ratio  | social and healthcare system reform |                 |
| welfare state     | health care business          |                       |
| sustainability deficit | employment               |                       |
| poverty           | unemployment security         |                       |
| local government reform | active model*             |                       |
Economic Policy

economy
taxation
economic policy
export industry

Education

students in applied science
research by students in applied science
vocational training
more than high school
no cuts in education
education
education promise
education is key
education elections
international students
student benefits
this is why Science is important

A.3 Parties

Social Democratic Party

social democrats
sdp
same direction*
future line*

Finns Party

finns party
finns party helsinki
finns party members and supporters
this is why true fins*
another big bang coming*

National Coalition

national coalition party
national coalition party cruise
national coalition party cruise 2019
we trust in finland*
at right*

Centre Party

centre party

Green League

sensible green
the greens party
show your true nature*

Left Alliance

the left
the left alliance party
the party council of the left alliance