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2021-11

Chen , T H Y , Salloum , A , Gronow , A , Ylä-Anttila , T & Kivelä , M 2021 , ' Polarization of climate politics results from partisan sorting : Evidence from Finnish Twittersphere ' , Global Environmental Change , vol. 71 , 102348 . <https://doi.org/10.1016/j.gloenvcha.2021.102348>

<http://hdl.handle.net/10138/335438>

<https://doi.org/10.1016/j.gloenvcha.2021.102348>

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Polarization of climate politics results from partisan sorting: Evidence from Finnish Twittersphere[☆]

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ARTICLE INFO

Keywords:

Climate politics
Political polarization
Partisan sorting
Issue alignment
Social networks

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.

1. Introduction

To varying extents, public opinion on climate politics around the world is polarized (McCright et al., 2016; Capstick et al., 2015). Even in countries where overall levels of climate skepticism is low, the supporters and opponents of climate mitigation policies tend to be antagonized. Existing work on this topic shows that positions on climate politics are divided along party lines (Dunlap et al., 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).

Numerous studies have shown that current levels of polarization surrounding climate politics have undesirable effects on climate mitigation efforts. There is strong evidence of ‘backfire’ or ‘boomerang’ effects, whereby climate communication aimed at increasing support for mitigation policies instead leads to greater opposition from those who

identify with parties opposing strong mitigation (Zhou, 2016; Hart and Nisbet, 2012). These effects manifest in a wide range of behavioural and attitudinal outcomes, including general support for environmental-protection spending (Johnson and Schwadel, 2019), risk perceptions toward climate change and natural disasters (Dixon et al., 2019; Linde, 2020), and individual consumption such as energy use reduction (Ogunbode et al., 2017) and environment-friendly purchases (Gromet et al., 2013).

Further, beyond introducing immediate hurdles to climate mitigation, sustained political polarization can manifest in entrenched political cleavages (Fiorina and Abrams, 2008). This makes political competition more easily captured by extreme interests, and more likely to result in the underrepresentation of certain groups and a generally unequal democratic process (Baldassarri and Gelman, 2008). 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.

Most of the current research on climate polarization is based on the

[☆] We thank Risto Kunelius, Boyoon Lee, Kevin Reuning, Pertti Vehkalahti, and participants of the 2019 Comparing Climate Change Policy Networks Workshop held at the University of Bern for useful feedback. This research is produced under the ECANET consortium (Echo Chambers, Experts and Activists: Networks of Mediated Political Communication) funded by the Academy of Finland, Grant Nos. 320780 (TY) and 320781 (MK). Additional funding comes from the Kone Foundation (AG; Grant No. 201804137) and the Strategic Research Council, Academy of Finland (TY; Grant No. 312710).

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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 et al., 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 et al. (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 analyses (e.g. Johnson and Schwadel, 2019) begin 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 (Terävaïnen, 2010), which is more in line with global trends (Cann and Raymond, 2018). These characteristics make Finland different from the U.S. in terms of climate politics and political institutions, thereby extending the literature's range of coverage on these important dimensions. Additionally, while recent trends indicate increasing polarization among political elites, notably in the areas of climate and immigration politics (Lönnqvist et al., 2020), Finnish politics has traditionally been characterized by low levels of polarization and tendencies toward consensus politics (Kekkonen and Ylä-Anttila, 2021; Reiljan, 2020). Finland's political history therefore makes it a 'least likely' case for high levels of partisan sorting. Least likely cases are litmus tests because if the theory is supported by the data even in such an unlikely case, we can consider there to be strong evidence for the theory (Levy, 2008). In the context of our study, if partisan sorting is associated with opinions on climate policy even in a country like Finland, there is powerful evidence for the idea that political elites have begun to strategically politicize the climate issue.

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 methods have generally expanded beyond English, certain tools remain unevenly developed across languages (Djatkiko et al., 2019). In particular, sentiment analysis that is commonly used in studies of political polarization (e.g. Yarchi et al., 2020; Haselmayer and Jenny, 2017; Young and Soroka, 2012), draws heavily on language-specific resources, including sentiment lexicons, annotated corpora, and pre-trained language models (Sun et al., 2017). Because these resources are often costly to build, there can be a considerable barrier to text-based analysis for applied researchers working in smaller languages (Kaity and Balakrishnan, 2020). 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 et al., 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, research has shown 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, if political cleavages start to align, cross pressures are reduced, resulting in, at the extreme, two highly antagonized groups with no source of agreement.

Evidence from recent decades, primarily U.S.-based, indicates that partisan conflict has become the primary cleavage along which other societal issues align (Fiorina and Abrams, 2008), including positions on climate mitigation (Egan and Mullin, 2017). At the individual level, this appears to be driven by a group of microfoundations commonly referred to as motivated reasoning, whereby individuals process new information with pre-existing goals in mind (Bayes and Druckman, 2021). Under this framework, partisanship is understood to function either as a source of identity attachment or as an information shortcut about source credibility, both of which drive individuals' issue positions to sort along partisan lines (Druckman and McGrath, 2019). In the context of climate politics, this constrains climate communication and generally exacerbates partisan sources of opposition to climate mitigation (Zhou, 2016). These patterns are well established, with numerous empirical studies showing that current levels of alignment between partisanship and climate politics already manifests in 'backfire' or 'boomerang' effects across a wide range of behavioural and attitudinal outcomes, including support for climate mitigation policies (Hart and Nisbet, 2012; Johnson and Schwadel, 2019), climate risk perceptions (Dixon et al., 2019; Linde, 2020), and individual consumption (Gromet et al., 2013; Ogunbode et al., 2017).

2.1. Partisan sorting and issue alignment in climate politics

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 et al., 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. On the other hand, while we observe an associated alignment among issues under certain conditions, such as among partisans, 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 is strongest (Adams et al., 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 et al. (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 (Bornschiefer, 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 et al., 2020; Lockwood, 2018; Gemenis et al., 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 a universalist movement which encroaches on national sovereignty and sufficiency (Forchtner et al., 2018; Forchtner and Kølvrå, 2015).

In the Finnish context, the right-wing populist Finns Party is the only party to openly argue against taking ambitious climate change mitigation measures. They have questioned, for example, the wisdom of building windmills, which they argue to have infrasonic qualities that can cause adverse health effects and may also make bats explode (Parkkonen, 2016). In their political manoeuvres, the Finns Party has made a point to position the Greens and the Left Alliance, which are the most vocal supporters of climate mitigation policies in Finland, as their main opponents (Lönnqvist et al., 2020). This can be seen in part from the derogatory and climate-themed labels Finns Party representatives use to refer to the Green and the Left Alliance. For example, the former Finns Party leader coined the term 'bicycle communists' to characterize people who supposedly waste public money and are fanatical cyclists (Soini, 2019). 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 Greens have become increasingly aligned on their respective positions toward climate and immigration politics (Lönqvist et al., 2020). In the realm of immigration policy, the current leader of the Finns Party has stated that cooperating with the Green-Leftists means increasing immigration and support for the European Union, both of which the Finns Party strongly oppose (Muhonen, 2021). From the other side, the Greens and the Left Alliance supporters are often the first to criticize Finns Party initiatives on immigration, often openly calling them racist (Hirvasnoro, 2020).

Given the high salience in the links between the climate and immigration 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.

2.2. 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 (Lönqvist et al., 2020). In particular, prior research showed that there are conflicts over climate change mitigation policies in Finland. Business actors, trade unions, and some governmental organizations 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, providing us with a suitable opportunity to directly observe the formation, polarization, and alignment of public opinion on the Twitter platform.

While there are clear advantages to studying public opinion through Twitter (Barberá and Steinert-Threlkeld, 2020), this approach is limited in that Twitter users are not representative of the general population, even despite high social media use in Finland. In terms of basic socio-demographics, social media users clearly skew toward the younger age groups (over 84% for those under 45, 11% over 74, and 61% overall; Statistics Finland, 2019). On average, Twitter users also have higher levels of education compared to the rest of the population (Vainikka and Huhtamäki, 2015).

This group also tends to be politically-inclined (Vainikka and Huhtamäki, 2015). In the lead up to the 2015 Finnish parliamentary elections, for example, opinion-sharing and position-taking were prominent features of Finnish political Twittersphere (Nelmarkka et al., 2020). To obtain a better picture of the political activity on Twitter, we collected data on all followers of the six largest parliamentary parties in Finland. This data, shown in Table 1, first indicates that all political parties are highly present on Twitter. Additional qualitative readings of the Finnish political elites' Twitter accounts reveals that many of the main figures in the political parties are social media savvy and have enthusiastic followers. Second, the follower counts of all the parties are of similar scale, but when compared against their vote shares from the 2019 parliamentary elections, the Greens and Left Alliance are overrepresented. These results did not differ whether we used total follower count or subset them to only Finnish followers.

Based on the preceding discussion, we expect a Twitter sample to capture the politically-active segments of the Finnish population reasonably well. Outside of these groups, such a sample likely overrepresents those who are younger and those more supportive of Green and New Left policies, including climate mitigation measures. In terms of the voting population, a Twitter sample likely comprise mostly of voters, as the overall voting turnout is high (over 70% for the 2019 parliamentary elections). While younger people are generally less likely to vote, this difference shrinks among the high education groups that

Table 1

Follower count and vote share of the six largest parliamentary parties in Finland.

Party	Twitter Username	Followers	(Finnish)	Vote Share
Social Democrats	@Demarit	29.7	(15.5)	17.7
Finns	@persut	29.6	(15.1)	17.5
National Coalition	@kokoomus	38.9	(20.3)	17.0
Centre	@keskusta	24.9	(14.1)	13.8
Greens	@vihreat	48.3	(23.2)	11.5
Left Alliance	@vasemmisto	34.4	(17.1)	8.2

Follower counts, shown in the thousands, were collected on June 8, 2021. Across the six parties, there were 101,428 unique followers. This number is not the sum of separate follower counts, as individuals tend to follow multiple accounts. Counts of Finnish followers are inferred from the language of each user's most recent tweet, which is only available for 73,206 accounts. Vote shares are from the 2019 Finnish parliamentary elections.

Twitter users tend to come from (80–90% turnout across all age groups for those with a four-year postsecondary degree; Grönlund and Strandberg, 2019).

Given these expectations, 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 (i. e. among politically sophisticated partisans) 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 among those identifying with the Republican Party, 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 et al., 2019), which might decrease both 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 `statuses/filter` endpoint from Twitter's v1.1 API suite. This API endpoint returns in real time all tweets satisfying a set of user-specified keywords (Twitter, 2021a). 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. To ensure that we do not run into rate limiting from the API, we further checked our collected data for 'limit notices', which are server messages that contains information about how many tweets were not collected due to data volumes exceeding the allowed rate limit (Twitter, 2021b). Based on these server messages, there are no missed tweets in our data

from rate limiting.

We selected our set of hashtags in three steps. First, we followed the Finnish news in January and February of 2019 to familiarize ourselves with the various societal debates relevant to the parliamentary and European Parliament elections in Finland. Second, we manually searched through Finnish Twitter for the topics we identified. Finally, based on our manual reading of the Twitter discussions surrounding our topics, we identified the final set of hashtags, which are commonly used to represent these discussions.

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 2. 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 The Supplementary information.

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 3.

Table 2
Topics used in this study.

Issues		Parties	
Climate	Immigration	Social Democrats (SDP)	Finns
Social Security	Economic Policy	National Coalition	Greens
Education		Centre	Left Alliance

Table 3

Descriptive statistics for endorsement networks by topic and period.

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
Greens	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.

3.3. Measures

We approach the measurement question by considering, if a political system is marked by polarized individuals, what the observable manifestations would 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 partitioning algorithm (METIS; see Karypis and Kumar, 1998). Community detection for networks is a deep field (Fortunato and Hric, 2016); for 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

$$P = \frac{B_{aa} + B_{bb} - B_{ab} - B_{ba}}{B_{aa} + B_{bb} + B_{ab} + B_{ba}}, \quad (1)$$

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 $c/n_i n_j$ 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 et al., 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. Intuitively, this can be understood as the extent to which political cleavages across different topics are similar in the way they divide society.

We illustrate this concept with two examples in Fig. 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

Fig. 1. Joint endorsement networks with labeled groups. The left-hand side figure is the joint endorsement network of climate politics and economic policy. The right-hand side figure is the joint endorsement network of climate and immigration politics. On both networks, positions on climate are labeled using green and purple (in both shades), while the second topic is coded with dark and light shading of the two colours.

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 Fig. 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

Fig. 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.

networks will sit somewhere closer to the lower bound of the shape.

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). In other words, we use the normalized mutual information to measure similarity in political cleavages across different topics. This measure is bound between 0 and 1, where 0 means the two cleavages are independent and 1 means they are identical. The climate-economic policy and climate-immigration joint endorsement networks in Fig. 1 have normalized mutual information values 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 issues 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. 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 Fig. 3. We find that the scores for these endorsement networks center at approximately 0.92. 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 33 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.

4.2. Topic-pair alignment

Next, we focus on the alignment between different topic-pairs. We begin with a broad overview by reporting averaged results for climate politics' alignments with all four issue networks and all six party networks. According to our *partisan sorting hypothesis*, in this initial examination we expect to find that public opinion on climate politics exhibits tendencies of partisan sorting but not general issue alignment. Specifically, this means there should be alignment between climate politics and the party networks, but not between climate politics and the other issue networks. The results, shown in Fig. 4, support this hypothesis.

In all three periods, the climate endorsement network aligns more strongly with the party endorsement networks than with the issue endorsement networks. We measure alignment using the normalized mutual information (NMI), which is an information theoretic measure that can be used to quantify how similar two different partitioned groupings are to each other (Danon et al., 2005; Fortunato and Hric, 2016). More specifically, the mutual information between two partitioning outcomes is the expected information one learns about a node's group in one partition given its group in the other partition, and vice versa, measured in *bits* of Shannon entropy (Shannon, 1948). Mutual information is zero for two independent partitions and for two identical partitions it yields exactly the amount of information needed to describe which partition a node belongs to. Normalizing this value by the average entropy between two partitioning outcomes bounds it to the [0, 1]

Fig. 4. Averaged normalized mutual information for climate politics with party topics and issue topics.

range. In the context of our study, the resulting NMI can be roughly understood as how much better than an uninformed guess one political cleavage (i.e. partition) predicts another, presented as a proportion of the maximum possible improvement given respective group sizes. The averaged NMI values of 0.440 and 0.194 in the pre-election period, for example, show that positions on political parties perform on average more than twice as well as positions on social issues in improving predictions about positions on climate politics. Generally speaking, slight perturbations from perfect alignment cause large drops in NMI values (Tibély et al., 2013), so an NMI close to 1 is hard to achieve. From the joint network plots in Fig. 1, it is apparent that an NMI of 0.51 already indicates what appears to be a strongly aligned topic-pair.¹

Next, to study our other hypotheses, we move beyond the averaged NMI values and report the alignments between our specific topic-pairs. These results are presented in Fig. 5, which shows for each period the NMI between every topic-pair.² Alignment between the climate endorsement network and all other topic endorsement networks are the cells in the first row and column. Here, we find support for both the *universalist-communitarian hypothesis* and the *immigration alignment hypothesis*.

Following the *universalist-communitarian hypothesis*, we expect partisan sorting to be limited to the Finns Party, the Greens, and the Left Alliance. From our results, it is apparent that while public opinion on climate politics aligned with positions on parties in general, there is indeed considerable variation when parties are considered separately. Specifically, in line with our expectations, positions on the Finns Party, the Greens, and the Left Alliance (and to a lesser extent the Social Democrats) appear to be what drives partisan sorting in climate politics. Their respective NMI values with climate politics in the pre-election period are 0.59, 0.66, 0.69, and 0.48. On the other hand, the National Coalition and the Centre Party (NMI values of 0.09 and 0.13 in the pre-election period) 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 alignment levels generally decreasing following the elections.

As we expected following the *immigration alignment hypothesis*, 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

Fig. 3. Distribution of polarization by topics. The values for the eleven indicated topics are based on the collection of hashtags outlined in The Supplementary information, averaged across the three periods. The density plots are based on endorsement networks formed by the top fifty hashtags used in each period. These distributions are estimated with kernel density smoothing.

¹ In The Supplementary information, we present a series of joint network plots similar to those from Fig. 1 along with their corresponding NMI to further illustrate the relationship between NMI values and observable alignment.

² The Supplementary information contains a version of the matrices showing the NMI in numeric values.

Fig. 5. Normalized mutual information for all topic-pairs in each of the three periods. Scale runs from 0 to 0.82. A network's alignment with itself is always 1, and therefore omitted from the figure.

dimension. With NMI values of 0.51, 0.56, and 0.44 across the three periods, climate and immigration ranks among the most aligned topic-pairs overall. Indeed, with the exception of the NMI between immigration and economic policy during the inter-election period, which we discuss in more detail below, the rest of the issue topic-pairs' NMI values fall in the $[0, 0.22]$ range.

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, with NMI values falling in the $[0.19, 0.48]$ range. 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, during the inter-election period, economic policy, which is traditionally a left-right debate, aligned more closely with the universalist-communitarian cluster of topics (e.g. NMI with the Finns Party at 0.80 and with the Greens at 0.75). 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.

Finally, while we did not explicitly hypothesize about temporal trends (i.e. those that arise from the electoral cycle), our findings in this area corroborate our theoretical discussion about political polarization and alignment. First, we find that issue alignment drops to almost none in the post-electoral period, with the exception of the alignment between climate and immigration which remains at a relatively high NMI of 0.44. Compared to this non-electoral baseline (average NMI of 0.04 excluding the climate-immigration topic-pair), the slightly higher issue alignment during the two electoral periods (average NMI values of 0.07 and 0.12 excluding the climate-immigration topic-pair), provides some evidence that the context of national and European Union elections in Finland raised 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.

It also appears that public opinion toward all parties becomes relatively aligned with one another in the post-election period. The average

NMI values for all party pairs increased from 0.28 and 0.29 in the pre- and inter-election periods to 0.41 in the post-election period. There was also a drop in the variance of these values in the post-election period, with their standard deviations going from 0.28 and 0.23 to 0.16. 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. Together, these results 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.

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 Fig. 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_j for the receiver topic given membership in group_i for the sender topic, conditional on the size of group_j, 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

Fig. 6. Visualization of clustering in topic alignments. Shown are the alignment patterns among topic-groups in the pre-election period. Nodes represent the topic-group described in the main text. A directed tie indicates that membership in the sender topic-group strongly predicts (greater than 86%) membership in the receiver topic-group.

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 exhibit 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. Preferences over climate policy aligned with a subset of partisan issues that fall under the emerging universalist-communitarian political debate, but

not with issues traditionally associated with left–right distributive politics. Specifically, the populist party championed immigration skepticism, and successfully linked the climate issue to its portfolio, but the traditional distributive debate on the left–right dimension remained largely separate from climate politics in the period we examined. 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.

This finding has important implications for the study of political polarization and issue alignment in comparative contexts. Our study is but a single case, but it offers initial evidence that multiparty systems, which allow for political parties to be positioned in multidimensional policy space, can potentially buffer against system-wide polarization. Future work from the perspective of comparative political institutions should be valuable in assessing this possibility and in providing additional insights into how various types of formal institutions can shape political polarization. In the context of behavioural research on climate communication, our findings provide optimism that the right systems can facilitate the kind of policy cooperation that have been shown to be possible where political cleavages are not perfectly aligned (e.g. Dryzek and Lo, 2015).

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, it remains an open question to what extent findings about this particular system can be generalized to the broader one it is nested in. 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.

CRedit authorship contribution statement

Ted Hsuan Yun Chen: Conceptualization, Methodology, Software, Validation, Formal analysis, Data curation, Writing - original draft, Visualization. **Ali Salloum:** Conceptualization, Methodology, Software, Formal analysis. **Antti Gronow:** Conceptualization, Writing - review & editing. **Tuomas Ylä-Anttila:** Conceptualization, Writing - review & editing, Supervision, Funding acquisition. **Mikko Kivelä:** Conceptualization, Methodology, Data curation, Writing - review & editing, Supervision, Funding acquisition.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Supplementary information

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.gloenvcha.2021.102348>.

References

- Aasen, Marianne, 2017. The polarization of public concern about climate change in Norway. *Climate Policy* 17 (2), 213–230.
- Adams, James, 2012. Causes and electoral consequences of party policy shifts in multiparty elections: Theoretical results and empirical evidence. *Annual Review of Political Science* 15, 401–419.
- Adams, James, Ezrow, Lawrence, Leiter, Debra, 2012. Partisan sorting and niche parties in Europe. *West European Politics* 35 (6), 1272–1294.
- Arter, David, 2015. *Scandinavian Politics Today*, 3rd ed. Manchester University Press.
- Baldassarri, Delia, Gelman, Andrew, 2008. Partisans without constraint: Political polarization and trends in American public opinion. *American Journal of Sociology* 114 (2), 408–446.
- Barberá, Pablo, 2015. Birds of the same feather tweet together: Bayesian ideal point estimation using Twitter data. *Political Analysis* 23 (1), 76–91.
- Barberá, Pablo, Jost, John T., Nagler, Jonathan, Tucker, Joshua A., Bonneau, Richard, 2015. Tweeting from left to right: Is online political communication more than an echo chamber? *Psychological Science* 26 (10), 1531–1542.
- Barberá, Pablo, Steinert-Threlkeld, Zachary C., 2020. How to Use Social Media Data for Political Science Research. In: *The SAGE Handbook of Research Methods in Political Science and International Relations*, p. 404.
- Bayes, Robin, Druckman, James N., 2021. Motivated reasoning and climate change. *Current Opinion in Behavioral Sciences* 42, 27–35.
- Betz, Hans-George, 1993. The new politics of resentment: radical right-wing populist parties in Western Europe. *Comparative Politics*, 413–427.
- Bornschieer, Simon, 2010. The new cultural divide and the two-dimensional political space in Western Europe. *West European Politics* 33 (3), 419–444.
- Bright, Jonathan, 2018. Explaining the emergence of political fragmentation on social media: The role of ideology and extremism. *Journal of Computer-Mediated Communication* 23 (1), 17–33.
- Cann, Heather W., Raymond, Leigh, 2018. Does climate denialism still matter? The prevalence of alternative frames in opposition to climate policy. *Environmental Politics* 27 (3), 433–454.
- Capstick, Stuart, Whitmarsh, Lorraine, Poortinga, Wouter, Pidgeon, Nick, Upham, Paul, 2015. International trends in public perceptions of climate change over the past quarter century. *Wiley Interdisciplinary Reviews: Climate Change* 6 (1), 35–61.
- Conover, Michael D., Gonçalves, Bruno, Ratkiewicz, Jacob, Flammini, Alessandro, Menczer, Filippo, 2011. Predicting the political alignment of twitter users. In: *2011 IEEE Third International Conference on Privacy, Security, Risk and Trust and 2011 IEEE Third International Conference on Social Computing*. IEEE, pp. 192–199.
- Coser, Lewis A., 1956. *The Functions of Social Conflict*. Free Press.
- Danon, Leon, Diaz-Guilera, Albert, Duch, Jordi, Arenas, Alex, 2005. Comparing community structure identification. *Journal of Statistical Mechanics: Theory and Experiment* 2005 (09), P09008.
- Dixon, Graham, Bullock, Olivia, Adams, Dinah, 2019. Unintended effects of emphasizing the role of climate change in recent natural disasters. *Environmental Communication* 13 (2), 135–143.
- Djatzmiko, Fahim, Ferdiana, Ridi, Faris, Muhammad, 2019. A review of sentiment analysis for non-english language. In: *2019 International Conference of Artificial Intelligence and Information Technology (ICAIT)*. IEEE, pp. 448–451.
- Druckman, James N., McGrath, Mary C., 2019. The evidence for motivated reasoning in climate change preference formation. *Nature Climate Change* 9 (2), 111–119.
- Dryzek, John S., Lo, Alex Y., 2015. Reason and rhetoric in climate communication. *Environmental Politics* 24 (1), 1–16.
- Dunlap, Riley E., McCright, Aaron M., 2010. Climate change denial: sources, actors and strategies. In: *Routledge Handbook of Climate Change and Society*. Routledge, pp. 270–290.
- Dunlap, Riley E., McCright, Aaron M., Yarosh, Jerrold H., 2016. The political divide on climate change: Partisan polarization widens in the US. *Environment: Science and Policy for Sustainable Development* 58 (5), 4–23.
- Egan, Patrick J., Mullin, Megan, 2017. Climate change: US public opinion. *Annual Review of Political Science* 20, 209–227.
- Farrell, Justin, 2016. Corporate funding and ideological polarization about climate change. In: *Proceedings of the National Academy of Sciences*, pp. 92–97.
- Fiorina, Morris P., Abrams, Samuel J., 2008. Political polarization in the American public. *Annual Review of Political Science* 11, 563–588.
- Forchtner, Bernhard, Kroneder, Andreas, Wetzel, David, 2018. Being skeptical? Exploring far-right climate-change communication in Germany. *Environmental Communication* 12 (5), 589–604.
- Forchtner, Bernhard, Kolvraa, Christoffer, 2015. The nature of nationalism: Populist radical right parties on countryside and climate. *Nature and Culture* 10 (2), 199–224.
- Fortunato, Santo, Hric, Darko, 2016. Community detection in networks: A user guide. *Physics Reports* 659, 1–44.
- Garimella, Kiran, De Francisci, Gianmarco, Morales, Aristides Gionis, Mathioudakis, Michael, 2018. Quantifying controversy on social media. *ACM Transactions on Social Computing* 1 (1), 1–27.
- Gemenis, Kostas, Katsanidou, Alexia, Vasilopoulou, Sofia, 2012. The politics of anti-environmentalism: positional issue framing by the European radical right. Unpublished working paper.
- Gromet, Dena M., Kunreuther, Howard, Larrick, Richard P., 2013. Political ideology affects energy-efficiency attitudes and choices. In: *Proceedings of the National Academy of Sciences*, pp. 9314–9319.
- Gronow, Antti, Ylä-Anttila, Tuomas, 2019. Cooptation of NGOs or treadmill of production? Advocacy coalitions and climate change policy in Finland. *Policy Studies Journal* 47 (4), 860–881.

- Grönlund, Kimmo, Strandberg, Kim, 2019. The 2019 Parliamentary Election in Finland. In: *Voting and Public Opinion in Finland: The Parliamentary Election of 2019*. The Social Science Research Institute, Samforsk, pp. 1–7.
- Guber, Deborah Lynn, 2013. A cooling climate for change? Party polarization and the politics of global warming. *American Behavioral Scientist* 57 (1), 93–115.
- Hargittai, Eszter, Gallo, Jason, Kane, Matthew, 2008. Cross-ideological discussions among conservative and liberal bloggers. *Public Choice* 134 (1–2), 67–86.
- Hart, P. Sol, Nisbet, Erik C., 2012. Boomerang effects in science communication: How motivated reasoning and identity cues amplify opinion polarization about climate mitigation policies. *Communication Research* 39 (6), 701–723.
- Haselmayer, Martin, Jenny, Marcelo, 2017. Sentiment analysis of political communication: combining a dictionary approach with crowdcoding. *Quality & Quantity* 51 (6), 2623–2646.
- Hassinen, Heta, 2019. Tekivätkö kampanjat eduskuntavaaleista ilmastovaalit vai jotkin muut? Tutkijat arvioivat, mitä teemoja puolueet korostivat [Did the campaigns make the elections into a climate election or were other themes present? Researchers present their take on what themes parties brought up]. *Helsingin Sanomat* April 12. URL: <https://www.hs.fi/politiikka/art-200006068970.html>.
- Hetherington, Marc J., 2009. Putting polarization in perspective. *British Journal of Political Science* 413–448.
- Hirvasnoro, Kai, 2020. Honkasalo: Perussuomalaisten kohukirja ei yksittäinen näkemys, vaan osoitus systemaattisesta rasismista ja naisvihasta. *Kansan Uutiset* (Last accessed: June 23, 2021). URL: <https://www.kansanuutiset.fi/artikkeli/4273272-honkasalo-perussuomalaisten-kohukirja-ei-yksittainen-nakemys-vaan-osoitus-systemaattisesta-rasismista-ja-naisvihasta>.
- Intergovernmental Panel on Climate Change, 2018. *Global Warming of 1.5C: An IPCC Special Report on the Impacts of Global Warming of 1.5C Above Pre-industrial Levels and Related Global Greenhouse Gas Emission Pathways, in the Context of Strengthening the Global Response to the Threat of Climate Change, Sustainable Development, and Efforts to Eradicate Poverty*. World Meteorological Organization.
- Iyengar, Shanto, Lelkes, Yphtach, Levendusky, Matthew, Malhotra, Neil, Westwood, Sean J., 2019. The origins and consequences of affective polarization in the United States. *Annual Review of Political Science* 22, 129–146.
- Johnson, Erik W., Schwadel, Philip, 2019. Political polarization and long-term change in public support for environmental spending. *Social Forces* 98 (2), 915–941.
- Kaity, Mohammed, Balakrishnan, Vimala, 2020. Sentiment lexicons and non-English languages: a survey. *Knowledge and Information Systems*, 1–36.
- Karypis, George, Kumar, Vipin, 1998. A fast and high quality multilevel scheme for partitioning irregular graphs. *SIAM Journal on Scientific Computing* 20 (1), 359–392.
- Kekkonen, Arto, Ylä-Anttila, Tuomas, 2021. Affective blocs: Understanding affective polarization in multiparty systems. *Electoral Studies* 72, 102367.
- Keivins, Anthony, Soroka, Stuart N., 2018. Growing apart? Partisan sorting in Canada, 1992–2015. *Canadian Journal of Political Science/Revue canadienne de science politique* 51 (1), 103–133.
- Krackhardt, David, Stern, Robert N., 1988. Informal networks and organizational crises: An experimental simulation. *Social Psychology Quarterly*, 123–140.
- Kriesi, Hanspeter, Grande, Edgar, Lachat, Romain, Dolezal, Martin, Bornschier, Simon, Frey, Timotheos, 2006. Globalization and the transformation of the national political space: Six European countries compared. *European Journal of Political Research* 45 (6), 921–956.
- Layman, Geoffrey C., Carsey, Thomas M., 2002. Party polarization and ‘conflict extension’ in the American electorate. *American Journal of Political Science* 786–802.
- Layman, Geoffrey C., Carsey, Thomas M., Horowitz, Juliana Menasce, 2006. Party polarization in American politics: Characteristics, causes, and consequences. *Annual Review of Political Science* 9, 83–110.
- Levy, Jack S., 2008. Case studies: Types, designs, and logics of inference. *Conflict Management and Peace Science* 25 (1), 1–18.
- Linde, Stefan, 2020. The politicization of risk: Party cues, polarization, and public perceptions of climate change risk. *Risk Analysis* 40 (10), 2002–2018.
- Lockwood, Matthew, 2018. Right-wing populism and the climate change agenda: exploring the linkages. *Environmental Politics* 27 (4), 712–732.
- Lönnqvist, Jan-Erik, Ilmarinen, Ville-Juhani, Sortheix, Florencia M., 2020. Polarization in the wake of the European refugee crisis—a longitudinal study of the Finnish political elite’s attitudes towards refugees and the environment. *Journal of Social and Political Psychology* 8 (1), 173–197.
- Mason, Lilliana, 2015. I disrespectfully agree: The differential effects of partisan sorting on social and issue polarization. *American Journal of Political Science* 59 (1), 128–145.
- McCright, Aaron M., Dunlap, Riley E., 2011. The politicization of climate change and polarization in the American public’s views of global warming, 2001–2010. *The Sociological Quarterly* 52 (2), 155–194.
- McCright, Aaron M., Dunlap, Riley E., Marquart-Pyatt, Sandra T., 2016. Political ideology and views about climate change in the European Union. *Environmental Politics* 25 (2), 338–358.
- Metaxas, Panagiotis, Mustafaraj, Eni, Wong, Kily, Zeng, Laura, O’Keefe, Megan, Finn, Samantha, 2015. What do retweets indicate? Results from user survey and meta-review of research, in: *Ninth International AAAI Conference on Web and Social Media*.
- Meyer, Thomas M., Wagner, Markus, 2013. Mainstream or niche? Vote-seeking incentives and the programmatic strategies of political parties. *Comparative Political Studies* 46 (10), 1246–1272.
- Moors, Guy, 2008. Exploring the effect of a middle response category on response style in attitude measurement. *Quality & Quantity* 42 (6), 779–794.
- Mudde, Cas, 1999. The single-issue party thesis: Extreme right parties and the immigration issue. *West European Politics* 22 (3), 182–197.
- Muhonen, Teemu, 2021. Jussi Halla-aho väläytti yllättäen työntekijöille heikennyksiä, joita perussuomalaiset aiemmin vastusti - miksi? *Helsingin Sanomat* (Last accessed: June 23, 2021). URL: <https://www.hs.fi/politiikka/art-200008011746.html>.
- Myers, David G., 1978. Polarizing effects of social comparison. *Journal of Experimental Social Psychology* 14 (6), 554–563.
- Nelimarkka, Matti, Laaksonen, Salla-Maaria, Tuokko, Mari, Valkonen, Tarja, 2020. Platformed Interactions: How Social Media Platforms Relate to Candidate–Constituent Interaction During Finnish 2015 Election Campaigning. *Social Media+ Society* 6 (2), 2056305120903856.
- Ogunbode, Charles Adedayo, Liu, Yue, Tausch, Nicole, 2017. The moderating role of political affiliation in the link between flooding experience and preparedness to reduce energy use. *Climatic Change* 145 (3), 445–458.
- Otto, Adeline, Gugushvili, Dimitri, 2020. Eco-Social Divides in Europe: Public Attitudes towards Welfare and Climate Change Policies. *Sustainability* 12 (1), 404.
- Parkkonen, Tommi, 2016. Perussuomalaiset huolissaan: Lepäkot räjähtelevät. *Ilta-lehti* (Last accessed: June 23, 2021). URL: <https://www.iltalehti.fi/uutiset/a/2016100522418945>.
- Poortinga, Wouter, Spence, Alexa, Whitmarsh, Lorraine, Capstick, Stuart, Pidgeon, Nick F., 2011. Uncertain climate: An investigation into public scepticism about anthropogenic climate change. *Global Environmental Change* 21 (3), 1015–1024.
- Reiljan, Andres, 2020. Fear and loathing across party lines’ (also) in Europe: Affective polarisation in European party systems. *European Journal of Political Research* 59 (2), 376–396.
- Ross, Ashley D., Rouse, Stella M., Mobley, William, 2019. Polarization of climate change beliefs: the role of the millennial generation identity. *Social Science Quarterly* 100 (7), 2625–2640.
- Rydgren, Jens, 2008. Immigration sceptics, xenophobes or racists? Radical right-wing voting in six West European countries. *European Journal of Political Research* 47 (6), 737–765.
- Shannon, Claude E., 1948. A mathematical theory of communication. *The Bell System Technical Journal* 27 (3), 379–423.
- Sohlberg, Jacob, 2017. The effect of Elite Polarization: a comparative perspective on how party elites influence attitudes and behavior on climate change in the European Union. *Sustainability* 9 (1), 39.
- Soini, Timo, 2019. Fillarikommunisti ei pelasta maailmaa. URL: <http://timosoini.fi/2018/05/fillarikommunisti-ei-pelasta-maailmaa/>. (Last accessed: June 23, 2021).
- Statistics Finland, 2019. One-half of Finns have shopped online in the past three months. URL: https://www.stat.fi/til/sutivi/2019/sutivi_2019-11-07_tie_001_en.html. (Last accessed: June 19, 2020).
- Strehl, Alexander, Ghosh, Joydeep, 2002. Cluster ensembles—a knowledge reuse framework for combining multiple partitions. *Journal of Machine Learning Research*, 3(Dec):583–617.
- Subay, Elizabeth, 2015. Explaining group influence: The role of identity and emotion in political conformity and polarization. *Political Behavior* 37 (1), 221–251.
- Sun, Shiliang, Luo, Chen, Chen, Junyu, 2017. A review of natural language processing techniques for opinion mining systems. *Information Fusion* 36, 10–25.
- Teräsväinen, Tuula, 2010. Political opportunities and storylines in Finnish climate policy negotiations. *Environmental Politics* 19 (2), 196–216.
- Tibély, Gergely, Pollner, Péter, Vicsek, Tamás, Palla, Gergely, 2013. Extracting tag hierarchies. *PLoS One* 8 (12), e84133.
- Tranter, Bruce, 2011. Political divisions over climate change and environmental issues in Australia. *Environmental Politics* 20 (1), 78–96.
- Tranter, Bruce, Booth, Kate, 2015. Scepticism in a changing climate: A cross-national study. *Global Environmental Change* 33, 154–164.
- Twitter, 2021. Standard stream parameters — Docs — Twitter Developer Platform. URL: <https://developer.twitter.com/en/docs/tweets/filter-realtime/guides/basic-stream-parameters>. (Last accessed: June 6, 2021).
- Twitter, 2021. Streaming message types — Docs — Twitter Developer Platform. URL: <https://developer.twitter.com/en/docs/twitter-api/v1/tweets/filter-realtime/guides/streaming-message-types>. (Last accessed: June 6, 2021).
- Vainikka, Eliisa, Huhtamäki, Jukka, 2015. Tviittien politiikkaa—poliittisen viestinnän sisäpiirit Twitterissä. *Media & viestintä* 38 (3).
- West, Brady T., Blom, Annelies G., 2017. Explaining interviewer effects: A research synthesis. *Journal of Survey Statistics and Methodology* 5 (2), 175–211.
- Yarchi, Moran, Baden, Christian, Kligler-Vilenchik, Neta, 2020. Political polarization on the digital sphere: A cross-platform, over-time analysis of interactional, positional, and affective polarization on social media. *Political Communication*, 1–42.
- Young, Lori, Soroka, Stuart, 2012. Affective news: The automated coding of sentiment in political texts. *Political Communication* 29 (2), 205–231.
- Zhou, Jack, 2016. Boomerangs versus javelins: how polarization constrains communication on climate change. *Environmental Politics* 25 (5), 788–811.