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Dynamic networks of negotiation for international climate change cooperation

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ABSTRACT

The global response to climate change is negotiated through the UNFCCC's Conferences of the Parties (COPs). Initially focused on reducing emissions from developed countries, the UNFCCC has shifted toward broader global responsibility. Despite this, its formal institutions and negotiating blocs remain stable and do not fully explain COP successes or failures. This study examines country affiliations at each COP, which are not evident in public votes or documents. Instead, we analyze high-level segment (HLS) speeches, extracting co-mentions of countries to map dynamic negotiation networks. We use Dynamic Network Logistic Regression (DNR) to model these affiliations, revealing shifting informal allegiances. Findings indicate that negotiation affiliations dissolve over time. The European Union exhibits strong internal homophily, while major countries like China, Russia, the US, and Japan decrease future co-mentions, unlike Germany, which increases them. Additionally, network clustering raises the likelihood of co-mentions, while prior co-mentions (inertia) and past exclusion from co-mentions boost future mentions. This approach captures the evolving structure of international climate negotiations beyond formal blocs.

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Introduction

The international community's efforts to craft a global response to climate change primarily occur at the United Nations Framework Convention on Climate Change (UNFCCC) and at the UNFCCC's annual Conferences of the Parties (COPs) more specifically. These latter COP negotiations occur during multi-week, in-person conferences held at rotating venues worldwide. It was during these very COP negotiations that the international community achieved what are arguably the two most notable international agreements concerning global climate change cooperation to date: COP 3's Kyoto Protocol in 1997 and COP 21's Paris Agreement in 2015. Alongside these achievements and others,[1] the UNFCCC and its annual COPs have also become increasingly *global* in scope. This is not only reflected in the UNFCCC's now near-global country membership but also in an increasing focus on climate change responsibilities that now extend to all countries of the world – as opposed to only those developed countries who primarily bear responsibility for historical carbon emissions (Bagozzi 2015; Kuyper, Schroeder, and Linnér 2018a; Lesnikowski et al. 2019).

Such trends track closely to scholarly understandings of the UNFCCC's broader evolution over time. Herein, for example, Kuyper, Schroeder, and Linnér (2018a) characterize the UNFCCC and its COPs as exhibiting three primary shifts since their establishment in 1995. First, the UNFCCC saw a reorientation – especially after 2012 (i.e., COP 18) – away from a governance model that primarily targeted developed country behaviors and towards a model focused on raising global ambition more generally. Second, and alongside this equalizing of climate responsibilities among developed and developing countries, the UNFCCC experienced a broadening of its participatory model over time. Third, and concomitantly, the UNFCCC has also seen an expansion of its core tenets. In this regard, its original focus on mitigation has now shifted to instead rest upon the tripartite goals of mitigation, adaptation, and finance – as is now enshrined under the Paris Agreement.

Yet, even with this progress and evolution, it is commonly recognized that the UNFCCC and global cooperation have significantly underperformed in addressing the climate change (Cass 2015; Clemoncon 2016; Harris 2022; Kem, 2015; Kumar 2015; Leiter 2023; Spash 2016; UNE, 2022; Widerberg and Stenson 2013).[2] This holds true for the Kyoto Protocol[3] and post-Kyoto period more generally,[4] as well as for the Paris Agreement itself (Cass 2015; Clemoncon 2016; Kem, 2015; Spash 2016) and the post-Paris period (Leiter 2023; Pearce 2017). In each of these instances, researchers characterize the UNFCCC's overall institutional framework as being deficient or

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insufficient in its abilities to successfully address global climate change (Stavins 2010; Victor 2011).[5]

To explain these shortcomings, scholars frequently point to the UNFCCC's broader institutional design and alliance-based negotiating structure. With respect to the former, some critique the UNFCCC's one-member-one-vote rule under the rationale that it provides even the smallest of countries equal voice to that of major powers and significant carbon emitters in climate negotiations (Depledge 2006; Heyward 2007, 10). Here, research at times contends, for instance, that small island states can shift the UNFCCC agenda away from purely environmental issues and more towards broader security and prosperity concerns (Jaschik 2014, 286). With respect to the UNFCCC's alliance-based negotiating structure, researchers emphasize a set of deeply entrenched UNFCCC alliances and negotiating positions that have mainly been in place since negotiations over the UNFCCC began (Depledge 2006; Eckersley 2012, 3). With such key negotiating blocs reflecting well-established alliances such as the Group of 77 (G-77), the European Union (EU), the Alliance of Small Island States (AOSIS), and the Organization of Petroleum Export Countries (OPEC), scholars, in turn, contend that these negotiating blocs – alongside the UNFCCC's one-member-one-vote feature mentioned above – have served to institutionalize the north–south divide in the UNFCCC's negotiating venue to the detriment of international cooperation (Depledge 2006).

However, there are good reasons to be skeptical of the above claims concerning the preeminence of the UNFCCC's alliances and one-member-one-vote rules in impeding climate change cooperation. For one, evidence suggests that developed countries, major powers, and/or broader economic interests often circumvent these institutional design and alliance features to the detriment of cooperation. Falzon et al. (2023), for example, highlights loss and damage mechanisms under the UNFCCC. After Vanuatu's induction of a proposal for damage mediation in 1991, such mechanisms were paradoxically only formalized in 2022 at COP 27. During the interim, as the authors note, developed countries successfully opposed such mechanisms by limiting issue scope, reducing transparency, manipulating concepts, and pushing non-transformative solutions. This pattern is consistent with broader environmental sociology research suggesting, for example, that (i) the Global South's challenges in climate negotiations arise from developing countries' relative lack of capacity and inabilities to negotiate effectively (Roberts and Parks 2006) and (ii) the role of major powers, climate skepticism, and politicians in shaping global climate change regulation, to the detriment of environmental and developing country interests (Davidson 2022).

Second, it is also important to recognize that the UNFCCC's one-member-one-vote rule and alliance blocs have also been highly stable over time. Indeed, Depledge (2006) notes about the specific UNFCCC negotiating blocs mentioned above, '[a] remarkable feature of the climate change regime is how political alliances have remained so stable over time.' In contrast, we can further note that the UNFCCC's one-member-one-vote rule has proven to be even more time-invariant. These static qualities complicate their effects on UNFCCC negotiating outcomes, especially in light of the UNFCCC's aforementioned temporal evolution and punctuated negotiation successes and failures over time. To gain insights into how these latter time-varying outcomes have been shaped by the UNFCCC's member alliances and negotiating structures, we accordingly need to look beyond the UNFCCC's static negotiating blocs and institutions. We propose doing so by measuring and evaluating countries' affiliations with one another as they organically arise within and across each specific UNFCCC COP. Because these affiliations are not self-evident within public COP votes or final COP documents, we aim to do so by instead focusing on countries' high-level segment speeches – and the country co-mentions that arise within these speeches. As these speeches are made anew at each annual COP, we contend that this approach will provide a unique window into the more fluid negotiating alliances and structures that arise within each COP.

In extracting country co-mentions from each nation-state's high-level segment UNFCCC COP speech, we can capture a dynamic picture of countries' negotiation networks and alliances at the annual COP-level. As discussed below, we specifically do so for countries' UNFCCC high-level segment COP speeches for the 2010–2023 period. In a similar fashion to motivations for the automated analysis of legislative speech (Lauderdale and Herzog 2016; Quinn et al. 2010), we contend that these COP high-level segment speeches provide nations with a unique opportunity to outline their national positions on global climate change cooperation in a manner that is far more flexible, observable, and candid than countries' official negotiating blocs or expressions of support. This flexibility is especially critical given that changing bargaining positions commonly arise from one COP to the next and generally occur against the backdrop of a negotiating space that is itself already expansive in terms of cooperation themes, negotiating members, and overlapping affiliations (Bagozzi 2015; Genovese 2014; Kuyper, Schroeder, and Linnér 2018a; Lesnikowski et al. 2019). For these reasons, we argue that countries' high-level segment COP speeches provide member and observer countries with a unique ability to distinguish their current bargaining priorities from those of past negotiations and those of other (allied) countries. With respect to understanding and measuring changes in UNFCCC negotiating patterns and outcomes over time, such reflexivity is critical.

After extracting our negotiation networks over 13 years, we first look at the networks descriptively (Wasserman and Faust 1994) and then follow-up this analysis with a series of lagged dynamic network regression (DNR) (Almquist and Butts 2013, 2014a, 2014b; Mallik and Almquist 2019). We find strong evidence for shifting negotiation dynamics over time. For example, after accounting for the temporal persistence of negotiating networks over time, countries falling outside of these networks (i.e., isolates) see a high likelihood of engagement in the future. Yet, over our period of analysis overall, negotiation affiliations dissolve, and we further identify a higher mean degree of co-mentions (and clustering) in the early years of our sample frame as opposed to later years – with some divergence in these trends during the height of the COVID-19 pandemic. Consistent with some past research (Hurrell and Sengupta 2012), these overall trends suggest that the North–South divide in global climate change cooperation may erode. In its place, our findings of dissolution and isolates' higher likelihoods of future engagement together indicate that countries may be working to establish broader dialogue in light of the increasingly severe and immediate consequences of climate change itself. Our DNR approach's lack of reliable or sizable effects for the influence of several major emitters and for homophily within the G77 + China is consistent with this interpretation and with our broader contentions over the limitations of static (institutional and alliance) features in explaining UNFCCC COP outcomes. At the same time, we also find evidence of strong EU-based homophily in comparison to non-EU country groupings. Some relatively more muted evidence suggests that Germany may uniquely (among major carbon emitters) exert a leadership role within our negotiation networks, indicating the continued importance of at least some key powers and alliances within the UNFCCC negotiating space.

Theoretical mot`ivation

Researchers have long acknowledged the long-term policy-nature of climate change (Hovi, Sprinz, and Underdal 2009). Such policies not only require effective up-front specification and commitment of resources but consistent implementation of such resources over time. Yet, the reality of climate change ensures that 'most benefits of mitigation are global and distant, while costs are local and immediate' (Gollier and Tirole 2015, 6). As a result, governments – given their own relatively limited time horizons and susceptibility to non-environmental interests – often have incentives to under-supply climate change policy. Indeed, under a meso-approach perspective to the climate change problem (Dietz, Shwom, and Whitley 2020), a variety of different groups, organizations, and institutions influence climate change and its solutions – including social, environmental, and corporate interests, among others. While this can, in principle, foster environmental justice-based solutions to climate change, inequalities in emission distributions and capacities between countries in the Global North and South (Givens, Huang, and Jorgenson 2019; Roberts and Parks 2006) often advantage major powers and developed countries' political and economic interests to the determent of developing country interests and actors (Givens, Huang, and Jorgenson 2019; Roberts and Parks 2006). Given the global commons nature of climate change, these dynamics especially complicate prospects for achieving uniform climate change agreements internationally. Nevertheless, with the increasing threat posed by anthropogenic activity to the Earth's climate and the international community's continued inability to address this problem at a global scale (Hale, Held, and Young 2013), some consensus relative to worldwide climate risks has been reached in recent years (Burleson 2016). This has correspondingly catalyzed further calls for international cooperation over climate change (Ansari, Wijen, and Gray 2013, Galán-Martín et al. 2018; Raihani and Aitken 2011).

This demand for collective action has fostered a dedicated set of international institutions to facilitate negotiations among nation-states and develop global agreements that will effectively address the climate change problem through international cooperation (Kong 2015; Lange, Vogt, and Ziegler 2007; Rietig 2019). Yet, considering the uncertain effectiveness of international cooperation, social scientists have repeatedly raised concerns over the pace and overall impact of these collective efforts in confronting climate change (Depledge 2006; Kem, 2018; Raihani and Aitken 2011; Victor 2006; Ward, Grundig, and Zorick 2001). These critiques and others often focus on the UNFCCC as the centerpiece of international climate change cooperation (Hermwille et al. 2017; Keohane and Victor 2011; Soroos 2001; Widerberg and Pattberg 2015). To this end, the UNFCCC's annual COPs are the central platform and decision-making body for advancing countries' cooperative actions. They accordingly serve as a primary focal point for assessments of international climate change negotiation dynamics.

Since 1995, the UNFCCC's COPs have been held annually on a rotating basis around the world (Blinova, Emuru, and Bagozzi 2024). Over roughly two-week periods each year, these COPs endeavor to involve UNFCCC member and observer countries in designing universal and legally binding agreements that could foster meaningful responses toward climate change and its associated environmental and social implications. Yet, to date, arguably, only two imperfect landmark achievements have been reached under the UNFCCC – the Kyoto Protocol, adopted at COP 3 in

1997, and the Paris Agreement, adopted at COP 21 in 2015. In these regards as Keohane and Oppenheimer (2016, 150) note, major international treaties adopted within UNFCCC, such as the Paris Agreement, are 'less an accomplishment than part of an ongoing process,' which only 'opens the door to progress on climate but does not assure it.'

Indeed, and despite its seemingly global scope and increasing focus on an ever-diverse array of climate change issues, the UNFCCC regime – and international cooperation within it – have seen a range of critiques (Bagozzi 2015; Elliott 2018; Kuyper, Schroeder, and Linnér 2018b). Victor (2016) contends that for much of the last few decades of global climate governance, 'diplomatic efforts achieved very little.' This, he argues, is because divergence of interests within the UN's climate forum ensures that the most highly motivated negotiating parties remain a minority, whereas those whose 'controlling behavior matters most' remain less motivated. Hale (2020) echoes similar contentions in observing that 'actors face very different benefits and costs from mitigation policies,' which also ensures that incentives to cooperate and comply with agreements have a shifting nature depending on circumstances beneficial for the national interests of the states.

At the same time, many point to international power inequalities as a central impediment to global climate action. Major powers, including the US and China, have often been highlighted in this regard as making or breaking cooperation success at the UNFCCC's COPs and otherwise (Dong 2017; Davidson 2022; Hurri 2020; Schreurs 2016). Others have highlighted the role of such international power inequalities in fostering climate change cooperation stalemate between the Global North and South (e.g., Burns, Davis, and Kick 1997; Givens, Huang, and Jorgenson 2019; Roberts and Parks 2006). According to this latter line of research, the Global South's ineffectiveness in global climate negotiations is attributable to developing countries' relative deficiencies in capacity and their power to negotiate effectively during climate change talks, alongside their broader mistrust and uncertainty during such talks (Roberts and Parks 2006). These power inequalities have also enabled politicians from major powers such as the US to directly and indirectly (by encouraging others partaking in cooperation) steer the climate change agenda away from developing country interests and towards their own domestic (economic) interests (Davidson 2022) – a phenomenon that was also identified in earlier international environmental agreements and negotiations (Gareau 2008). Alongside the factors outlined above, a variety of intersecting challenges – including uncertainty over climate change's effects, outright disregard for its consequences, and the global commons nature of the climate change problem – remain entrenched in the UNFCCC's negotiating structure and together serve to inhibit further practical cooperation within this climate forum (Hermwille et al. 2017; Raihani and Aitken 2011). As such, many have concluded that the design of the UNFCCC regime has fallen short of what it intended to achieve (Hermwille et al. 2017; Spash 2016).

One primary design feature that has been singled out as reinforcing the shortcomings outlined above is the alliance-based negotiating structure that underpins country-level COP negotiations and the broader UNFCCC itself. To this end, scholars have identified a set of deeply entrenched UNFCCC alliances and negotiating positions that have mainly been in place since negotiations over the UNFCCC began (Eckersley 2012). In this context, negotiation alliances encompass formal Party (i.e., UNFCCC member country) groupings within the UNFCCC that are united by their shared climate change negotiation priorities. Each corresponding alliance thereby enhances that group's negotiation positions and interests within the UNFCCC and its corresponding COPs. These negotiation groupings – such as, for example, Alliance of Small Island States (AOSIS), G77 + China; or Least Developed Countries (LDC), and others – have been active and largely fixed in both membership and total number over the most recent 20-year lifespan of the UNFCCC. Over this same period, these alliances have dominated this negotiating space and, to a certain extent, have complicated international cooperation under the UNFCCC by fragmenting it into disparate negotiation blocs representing incongruous sets of interests (Castro and Klöck 2020).

For example, in considering the G77 + China in the context of climate negotiations Kasa et al. (2008, 115), notes that this particular negotiation alliance has become a key advocate of developing countries in its representing the 'interests and views of the "South" in the current international system.' As such, this bargaining alliance's interests have primarily focused on addressing poverty and vulnerability, distinct from other key alliances centered on the Global North, such as the EU. At the same time, as Stephenson et al. (2019) demonstrates, understanding countries' (or negotiation alliances') priorities within climate negotiations is much more complicated than a simple Annex I – non-Annex I dichotomy due to the UNFCCC's often multiple negotiation alliance groups that often cross-cut this divide. This complexity is further exacerbated by emerging power blocs such as Brazil, South Africa, India, and China (namely BASIC group), whose developmental choices reshape relations with countries from other alliances within the climate regime as well as north–south relations itself (Hurrell and Sengupta 2012; Hochstetler and Milkoreit 2014).

The institutional and alliance features outlined above are highly relevant to understanding the UNFCCC regime and climate change cooperation. Yet, there are also reasons to doubt their explanatory

power in this context given their 'ossification' relative to the temporal evolution and punctuated negotiation successes and failures of the UNFCCC's COPs (Depledge 2006; Kinley et al. 2021; Maslin, Lang, and Harvey 2023). Indeed, as noted earlier, the UNFCCC's institutions and alliances have remained highly static over time. By comparison, the UNFCCC's two most notable achievements (The Kyoto Protocol and the Paris Agreement) fell nearly 18 years apart. Between Kyoto and Paris, various cooperation successes and failures frequently occurred – confirming the dynamic nature of the negotiating process within the UNFCCC. The success of the Kyoto Protocol at COP 3 in 1997 can be contrasted by the long wait time for its ratification and the obstacles in its implementation thereafter. At the same time, at least some punctuated breakthroughs were quickly achieved surrounding technical discussions of the Protocol, such as COP 4's Buenos Aires Plan of Action. This can, in turn, be contrasted against the disagreements between Parties in relation to emission trading mechanisms and monitoring issues at COP 6. The latter negotiation roadblocks eventually led to the suspension of COP 6 and its resumption in Bonn the following year, where the UNFCCC's Parties had relatively more success (Yamin, Burniaux, and Nentjes 2001).

After the ratification of Kyoto at COP 11, the UNFCCC continued to exhibit similar fits-and-starts in international cooperation progress vis-Ã-vis climate change. At COP 13, for example, during discussions of the Bali Road Map, Parties refused to agree on various core issues, including the prospects of future binding agreements that offered the potential of bringing the US on board. As Maslin, Lang, and Harvey (2023) notes, it was only after a leader from Papua New Guinea called on the US to 'lead, or get out of the way' that a weak consensus was reached. Some progress – albeit perhaps below expectations – was similarly achieved at COP 15 with the conclusion of a Copenhagen Accord that laid the foundation for further discussions about future legally binding agreements. Yet, subsequent challenges in negotiating parties to effectively agree on what these agreements should look like led to continued discussions in Cancun at COP 16, Durban at COP 17, and to varying degrees at subsequent conferences. While this period saw few major breakthroughs in and of itself, it nevertheless established a degree of relative momentum in the lead-up to the Paris Agreement in 2015 at COP 21.

As demonstrated by examples, the oscillating dynamics of UNFCCC negotiations have seen intermittent failures and successes in progressing toward a solution to the global climate change challenge. This pattern of uneven progress has continued following the successful conclusion of the Paris Agreement where, for example, Parties, on the one hand, have increasingly demonstrated global solidarity towards committed climate change action and, on the other, failed to agree on actual cooperative approaches – thereby diverting attention from pressing climate problems (Obergassel et al. 2020). Thus far, this post-Paris period can accordingly be characterized as one of ambiguity and ineffectiveness in climate negotiations – with a rising degree of skepticism over climate change progress in this venue among scholars (Allan 2019; Spash 2016).

In light of this temporal variation in countries' abilities to address climate change under the UNFCCC's COPs, understanding these uneven cooperative dynamics and their drivers is paramount. Critically, this temporal variation in negotiation successes and failures is unlikely to be explained by the UNFCCC's relatively static institutions and alliance structure, which we referred to earlier. Instead, negotiating countries appear to find ways to break new ground and make new connections to advance their aims at these COPs. To this end, the recent efforts of least-developed countries (LDCs) in this forum are illustrative. As Gray and Cointet (2023) argues, such countries managed to increase their capacity to speak to and shape multilateral climate negotiations through a deliberative style that persuaded developed countries from the periphery. As the authors note, in these endeavors, LDCs employed the following tactics: vocal magnification (in terms of frequency of LDC speech within UNFCCC forum); opposition avoidance (i.e., sidestepping controversial talks); moral maneuvering (as in reframing LDC identities from that of passive victims to injured parties); and pragmatic reversals (i.e., securing political capital by adjusting stated preferences). As several of these tactics suggest, expanding UNFCCC speeches – and ostensibly the scope and targets of such speeches – appears to be a key mechanism for advancing climate change cooperation at the UNFCCC.

Based on the theoretical motivation outlined above, it is pertinent to consider year-to-year shifts in underlying international climate negotiating ties within this forum and the annual factors that shape this annual variation to understand how these dynamics affect negotiation outcomes. To this end, in what follows, we measure and analyze the temporal variation in country-to-country cooperation patterns at an annual level – and its determinants – with the UNFCCC's COPs below. Our core contentions herein are as follows. First, and partly in recognition of the significant temporal variation in COP negotiation outcomes over the UNFCCC's history, we anticipate that underlying country-to-country negotiation networks will exhibit significant year-to-year variation – which is in contrast to the UNFCCC's temporally static negotiation alliances. Second, and again relative to the UNFCCC's more static institutions and structures, we further anticipate that our uncovered negotiation networks will be more beholden to the influences of major powers and key

carbon emitters – whose role(s) in the UNFCCC's formal negotiation structures is arguably suppressed by (i) the composition and number of formal negotiating alliances and (ii) UNFCCC's broader one-member-one-vote rule. We then refine these overarching expectations into more specific hypotheses after introducing our modeling approach and specific parameters of interest further below.

Methods

Text-as-data

To construct a time-varying network of nation-states' declared affiliations at the UNFCCC, we first collect a sample of countries' UNFCCC COP HLS speech transcripts. We can download PDF transcripts of all HLS speeches made by formal UNFCCC parties and observer states across COPs 16–28 (i.e., from 2010–2023) from COP-specific websites. These HLS sessions are held during the latter portion of each two-week UNFCCC COP. In these contexts, a most senior attending governmental representative for each participating party or observer state provides a national statement on their country's current climate change (cooperation) priorities, achievements, and/or concerns to COP attendees. HLS speakers are constrained to three-minute speeches (UNFCCC 2023, 49), forcing them to strategically select these points of emphasis and any associated countries they choose to mention therein. The specific (type of) government representative tasked with providing such HLS statements varies across countries and time, with common positions being heads of state, cabinet ministers, or ambassadors.

In principle, each UNFCCC party and observer state had an opportunity to provide an HLS speech at each COP mentioned above. However, in practice, the number of HLS speech PDFs that were available for COPs 16–28 was variable. For some COPs, a few countries opted against giving a HLS speech. In other rare cases, a country's HLS speech transcript PDF was not (properly) uploaded to its associated COP website. As a result, the publicly available collections of HLS speech transcripts for COPs 16–28 encompassed between 71 and 154 speaking countries, depending on the COP considered. Our resultant annual HLS speech corpora accordingly have 116 speaking countries on average. Previous analyses of UNFCCC HLS speeches found that these missingness patterns were not reliably associated with potentially relevant factors such as CO_2 emissions per capita or GDP per capita (Bagozzi 2015, 451). We hence assume the missingness of this dimension to be random in our analyses further below. After collecting all available HLS speech transcripts for COPs 16–28, we standardized them for machine-based text analysis in several steps. First, we converted all speeches to plain text, sometimes using optical character recognition (OCR) for this conversion when a speech transcript PDF was a PDF image file. Second, we translated non-English speech transcripts to English via Google Translate.[6] This is consistent with Bagozzi (2015) and is unlikely to have an adverse effect on our specific analyses given that we only use these speech texts to recover information on country mentions – as opposed to broader syntactic or semantic speech characteristics.

The steps described above created an overarching corpus of 1,513 HLS speeches. For these individual COP HLS country speeches, we next sought to count the number of non-directed co-mentions involving (a) the country delivering the speech and (b) each additional country mentioned within the body of the speech itself.[7] To minimize the potential for false negatives due to variants in the manners by which countries may refer to other countries[8] – including over time[9] – we developed and applied a country name standardization dictionary to all (English language-standardized) speech transcripts before calculating our co-mentions. To address the possibility of false positives in the typical case of speaking countries thanking a particular COP's host country (government) during the opening of their remarks, we removed all instances of a given COP's host country name from that COP's associated HLS speeches. We then counted the remaining (a)-(b) co-mentions for all 193 relevant UNFCCC participating countries within each COP-HLS-specific set of speeches for our period of interest in a manner that was robust to any (non)capitalization patterns within our speeches' remaining country mentions.

Altogether, this created an intermediate dataset at the individual COP-HLS speech-level. This intermediate dataset specifically recorded the number of times that a speaking country (a) mentioned another country (b) – separately for each country (b) across all relevant 193 UNFCCC country participants within each COP-HLS. We then summed these counts for each unique non-directed UNFCCC country pair and COP-HLS to create a COP-country pair-level dataset. In this case, for a given country pair at the individual COP level, its co-mention count reflects the sum of country (a)'s counts of mentioning country (b) in country (a)'s speech *and* country (b)'s counts of mentioning country (a) in country (b)'s COP-HLS speech for that year.[10] This is the primary dataset of COP-level non-directed country-to-country co-mentions-[11] We use it to construct our time-varying networks further below. For the descriptive analysis, we also, at times, look over the sum of these annual COP-level networks further across all COPs to provide a more aggregate representation of our cooperation network(s).

Network analysis

We need to construct networks from the co-mention speeches to perform network analysis. We do this by building yearly (longitudinal) country-to-country

networks where we have one, if any, co-mention exists between two countries and zero otherwise. This produces 13 years of co-mention networks over the observed COP period. We analyze both the aggregate networks (summed over 13 years) and disaggregate networks as a lagged dynamic network regression model, a sub-family of temporal exponential random graph models (TERGMS) (Almquist and Butts 2014b) that has been shown to be effective for understanding the network mechanisms in longitudinal network data. This follows a long line of work in the sociology and environmental literature; for example, Thombs (2022) demonstrates the importance of analyzing dynamic data for understanding the impacts of different decisions on climate change, with a clear improvement in understanding the real impact of temporal change happening in issues around fossil fuel consumption across US States.

Dynamic network analysis

Social network analysis and network science (Brandes et al. 2013; Wasserman and Faust 1994) have long been focused on issues of network change. Specifically, dynamic network analysis is concerned with how relationships between entities change over time and are used across many disciplines in the social sciences (Almquist and Butts 2014b). Here, we focus on lagged *dynamic network regression* (DNR) models that rely on past information and exogenous variables to model change in relationships. These models can handle missing data and vertex dynamics (Almquist and C. Butts 2013, 2014a, 2014b; Mallik and Almquist 2019). Generally speaking, DNR models are a subset of *Temporal Exponential-family Random Graph Models* (TERGM) and simplify the assumptions of TERGMs by assuming conditional independence given past information; this makes DNR models similar to vector autoregressive (VAR) models and can be expressed as $\Pr(Y_t|Y_{t-1:t-k}, \theta, s, X_t) = \prod_{(i,j)\in V_t \times V_t} \text{Bern}\ (Y_{ijt} \mid \text{logit}^{-1}\ (\theta^T\ \text{s}\ (Y_{t-1:t-k}, X_t)))$. DNR models can also incorporate vertex dynamics using a separability condition and are then expressed as $\Pr(V_t, Y_t|G_{t-1:t-k}, X_t) = \prod_{(i)\in V_t} \text{Bern}(V_{it}|\ \text{logit}^{-1}\ (\psi^T w(G_{t-1:t-k}, X_t))) \times \prod_{(i,j)\in V_t V_t} \text{Bern}\ (Y_{ijt} \mid \text{logit}^{-1}\ (\theta^T\ \text{s}(\text{Y}_{t-1:t-k}, \text{X}_t, \text{V}_t)))$. A significant advantage of DNR models is that they do not produce degenerate results as general TERGMS (Almquist and Butts 2014b). Further, the DNR model provides a flexible and large-scale model to analyze network dynamics with or without vertex dynamics (Almquist and Butts 2014b). DNR has been used to understand organizational dynamics (Almquist, Spiro, and Butts 2017), online political party alliances in blog-to-blog citation dynamics Almquist and Butts (2013), windsurfer friendships (Almquist and Butts 2014b), and other phenomena. These models operate on the principle that each edge in a network at a given time arises from a Bernoulli trial, with the parameter being the inverse logit of a function of previous network states, conditional on sufficient statistics of the past network formations. This framework is a type of vector autoregressive (VAR) model/process (Freeman, Williams, and Lin 1989), where the likelihood of these models is built on conditional properties of the network. The model can be broken into two conditionally independent parts: the evolution of the edges conditioned on the vertices and the evolution of the vertices themselves conditioned on the past. The likelihood for the edge evolution is based on the following conditional probability framework, using the nomenclature of Almquist and C. Butts (2014b); Mallik and Almquist (2019):

$$Pr(Y_t|V_t, Z_{t-1}, \ldots, Z_{t-k}, X_t) = \prod_{(i,j)\in V_t \times V_t} Bern(Y_{ijt}|\text{logit}^{-1}(\theta^T s(Y_{t-1:t-k}, X_t, V_t)))$$

Here, Y_t represents the adjacency matrix at time t, V_t is the vertex set at time t, $Z_{t-1:t-k}$ denotes the graph states (edge and vertex sets) at the k previous time points, X_t is the covariate set, $s(.)$ is the vector of sufficient statistics for the edge set, and θ is a vector of parameters.

The model assumes a relaxed temporal Markov assumption where the network state depends on the states of the networks over some previous k time points, and edges are conditionally independent within the same time slice, given the history and covariates. The conditional probability gives the likelihood for vertex evolution:

$$Pr(V_t|Z_{t-1}, \ldots, Z_{t-k}, X_t) = \prod_i Bern(I(v_i \in V_t)|\text{logit}^{-1}(\psi^T w(V_{t-1:t-k}, X_t)))$$

where, $I(v_i \in V_t)$ is an indicator function for whether vertex i is present at time t, $w(.)$ is the vector of sufficient statistics for the vertices, and ψ is a vector of parameters. This assumes that some finite set V_{max} includes all possible vertices; the vertex set at time t is conditionally independent of network realizations prior to a fixed point in the past, given the history and covariates. The presence of a vertex is conditionally independent of the presence of another vertex given the edges at time t, past realizations, and covariates. The joint likelihood of Z is the product of the respective vertex and edge likelihoods, which implies that vertex and edge parameters can be estimated separately.

Inference in these models can be estimated either through maximum likelihood methods (Almquist and Butts 2014b) or Bayesian methods (Almquist and Butts 2014a). In both cases, a logistic regression framework achieves the parameter estimation for both vertex and edge dynamics. The separability of the likelihood

allows for standard logistic regression methods in the frequentist or Bayesian toolkit. Mallik and Almquist (2019) introduced penalized likelihood methods for model selection beyond standard AIC and BIC methods used by Almquist and Butts (2014b). There are known modeling limitations that can induce some bias in the statistical estimates if the model is misspecified (Thombs 2022); our models are relatively robust against this issue by combining model selection methods, predictive checks, and complete data of the network time-series, see Almquist and Butts (2014a, 2014b); Mallik and Almquist (2019) for a full review of these practices.

Parametrization of the DNR model

We focus on the network position and key contextual effects within the dynamic social network through our parameterization of the DNR model. We focus on six key parameters/hypotheses. We will first formally test the inclusion of these hypotheses through an Akaike information criterion test of inclusion, where we will rank each model by its penalized likelihood and accept the best-fitting model as the most likely – this works as a global hypothesis test overall proposed mechanisms (Almquist and Butts 2014b). Drawing upon the broader expectations outlined within our Theoretical Discussion section further above, below are five key parameters/hypotheses that we consider when assessing our DNR model:

1. Hypothesis 1 (Homophily): In speaking to long-standing recognition of the North–South Divide within the UNFCCC and global climate change cooperation (Burns, Davis, and Kick 1997; Penetrante 2013; Roberts and Parks 2006), the largest formal negotiating alliances within our period of analysis – the European Union (EU) and G77 + China – will engage in preferential co-mentions. I.e., we expect there to be an increased likelihood of ties between EU countries and between G77 + China countries than between or within non-ingroup countries.

2. Hypothesis 2 (Popularity): Given our earlier contentions concerning major emitters and past discussions of the influence of major carbon emitters in global climate negotiations (Davidson 2022; Dong 2017; Hurri 2020; Schreurs 2016), we expect more co-mentions between the top five carbon emitters over the time period considered (US, China, Japan, Russia, Germany). Here, we specifically expect all our popularity terms (Sociality) to be positive for all countries.

3. Hypothesis 3 (Clustering): Given extant research concerning the social structure of international cooperation at the UNFCCC and more broadly (Castro and Klöck 2020; Greenhill and Lupu 2017), we expect there to be a positive impact for previous co-mentions in triadic or high groupings. I.e., we expect a positive measure for our clustering term.

4. Hypothesis 4 (Isolates): In light of our earlier characterizations of (i) the underlying UNFCCC negotiating space as being more flexible and dynamic than its institutions and formal alliances may suggest and (ii) negotiating parties using deliberative approaches to expand influence and engage new actors in this forum (Gray and Cointet 2023) – we expect that not being co-mentioned previously to increase the likelihood of being mentioned in subsequent years. I.e., we expect this term to be positive.

5. Hypothesis 5 (Social Inertia; Y_{t-1}): The above expectations notwithstanding, the broader political inertia of the UNFCCC and international climate change cooperation (Boston and Lem, 2011; Kinley et al. 2021) furthermore leads us to expect historically being co-mentioned will increase the likelihood of being mentioned in subsequent years. I.e., we expect this term to be large and positive.

Results

As described in the previous section, we consider homophily, clustering, sociality, historical isolation, and lagged co-mentions as key mechanisms for co-mentions. We apply the AIC decision criterion to select the best-fitting model (see Table 1).

Network descriptive statistics

Before we analyze the 13 years of co-mention networks (we can view the aggregate national plot in Figure 1),

Table 1. Network descriptive statistics year by year for the co-mention networks.

Network Year	Density	SE Density	Mean Degree Mean Degree	SE Mean Degree	Clustering Coef.	SE Clustering Coef.
2010	0.0078	0.0063	1.5052	0.1938	0.0309	0.0124
2011	0.0135	0.0083	2.5979	0.4216	0.0909	0.0206
2012	0.0111	0.0075	2.1340	0.2921	0.0884	0.0204
2013	0.0043	0.0047	0.8351	0.1213	0.0458	0.0150
2014	0.0041	0.0046	0.7938	0.1240	0.0221	0.0105
2015	0.0037	0.0044	0.7216	0.1032	0.1000	0.0215
2016	0.0033	0.0041	0.6392	0.0911	0.0226	0.0107
2017	0.0049	0.0050	0.9381	0.1629	0.0855	0.0201
2018	0.0059	0.0055	1.1340	0.1677	0.0776	0.0192
2019	0.0100	0.0071	1.9278	0.2684	0.0769	0.0191
2021	0.0148	0.0087	2.8557	0.3699	0.1219	0.0235
2022	0.0033	0.0041	0.6289	0.1081	0.0306	0.0124
2023	0.0043	0.0047	0.8247	0.1205	0.0116	0.0077

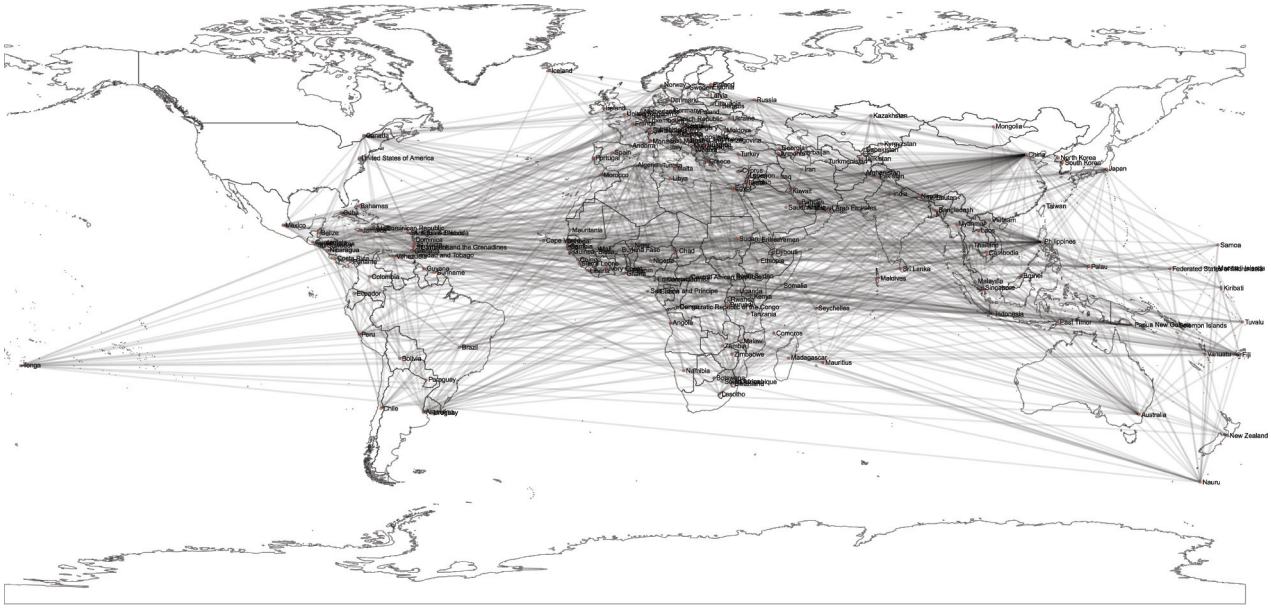

Figure 1. Aggregate relational network of all 13 year co-mention networks plotted on longitude and latitude world positions.

we first review the basic descriptions of the network (see Figure 1 and 3 for a visual of the network). Here, we can see the spatially aggregated structure and key spatial groupings (e.g., a strong EU and Asia focus), which together are consistent with several of the DNR findings and discussion points outlined further below. We can contrast this with Figure 2, which organizes the countries by their eigenposition (Wasserman and Faust 1994). This allows us to see clear clustering around core and periphery countries. This metric highlights China and its interaction with less developed countries[12] and the aggregate clustering and domination of the EU on average.

We also look at core descriptive statistics on this Density, Mean Degree, and Clustering network. We see in Table 2, that the earlier years are more active (higher density/mean degree) and clustering with a bump in the COVID-19 widow (2021), and otherwise sparse activity thereafter.

Dynamic logistic regression

We next turn more directly to our dynamic logistic regression results, where we test the five hypotheses in the earlier section (See Table 1). First, we find that each proposed mechanism seems to predict the likelihood of a co-mention; however, not all effects are significant. We treat this as soft evidence that all mechanisms (hypotheses) under consideration have been supported over this period. For effects that are statistically significant, we treat this as strong evidence of the importance of said mechanism. In partial support of Hypothesis 1, we find that EU homophily effects are substantial and statistically significant – i.e., that EU countries are more likely to co-mention other EU countries. This is less so the case for the G77 + China. In general, we find that co-mentions persist over time quite strongly, i.e., the parameter for being in co-mention in the past increases the likelihood of a co-mention in the future. However, in support of Hypothesis 4, we also find that being isolated increases the likelihood (by a small amount) of being in a co-mention in the future. However, this effect is not nearly as large as being in a co-mention historically. We generally treat this as a small boost for being overlooked in a previous year, but one that is much smaller than being actively engaged during that previous year. Last, while the popularity (i.e., sociality – Hypothesis 2) effects are not particularly strong or reliable, their direction is, we think, informative, with all major carbon emitters considered being negatively mentioned aside from Germany. In general, we take this to mean that being a major carbon emitter does not strongly increase the likelihood of a co-mention except for Germany – a leader in global climate change cooperation not only via its role within the EU but also its efforts in green and renewable energy technologies.

Discussion

The above analysis constructed a series of country-to-country co-mention networks for each individual UNFCCC COP from 2010 to 2023 using countries' HLS speeches. In analyzing these time-varying negotiating networks with DNR models, we found that the UNFCCC's negotiation networks were highly fluid, with significant changes over time. This – when viewed alongside the intermittent successes and failures of the UNFCCC over this period – together challenges common assumptions as to the importance of formal

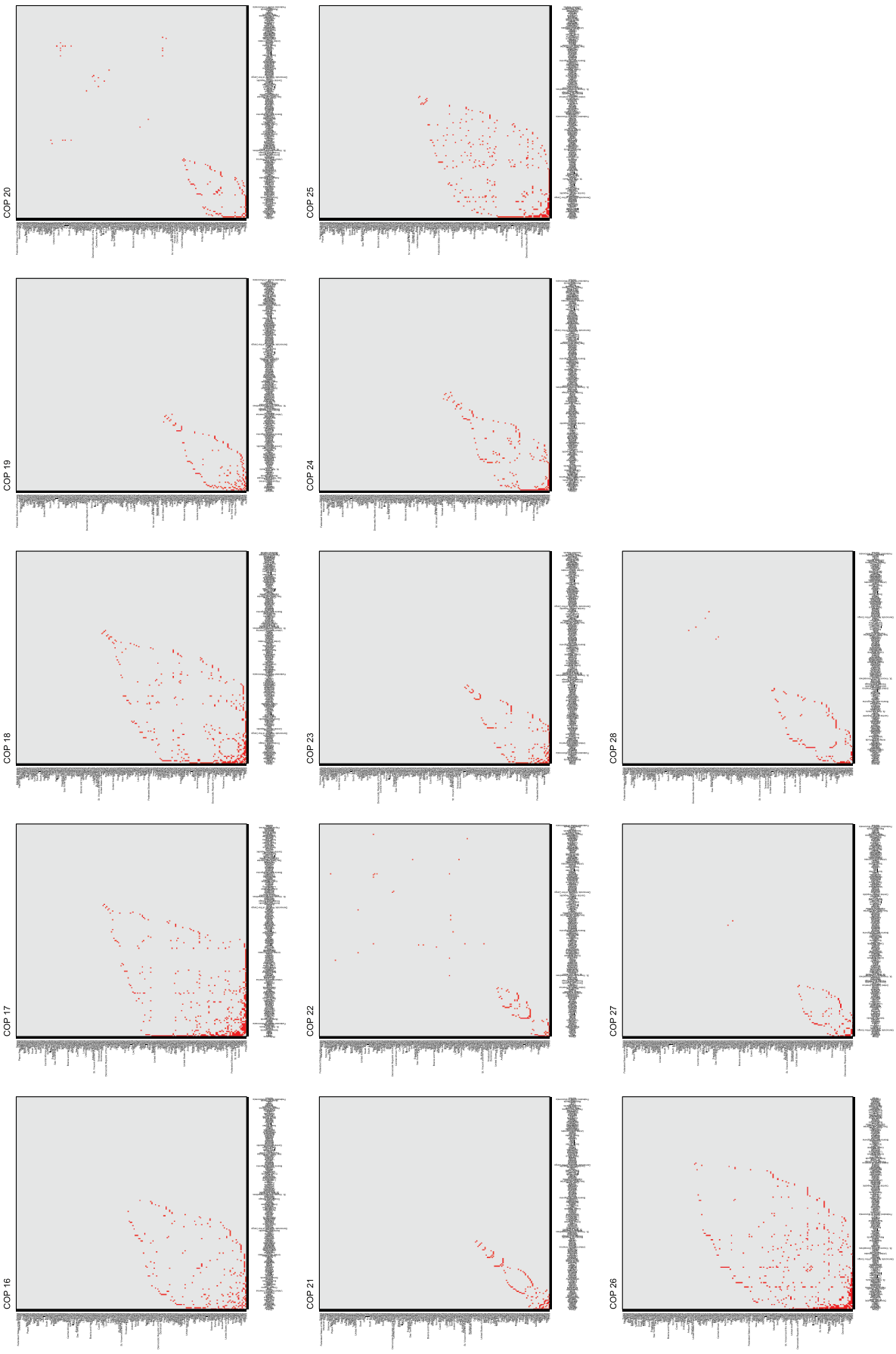

Figure 2. Disaggregated relational networks of all 13 years co-mention networks plotted by their eigen-score.

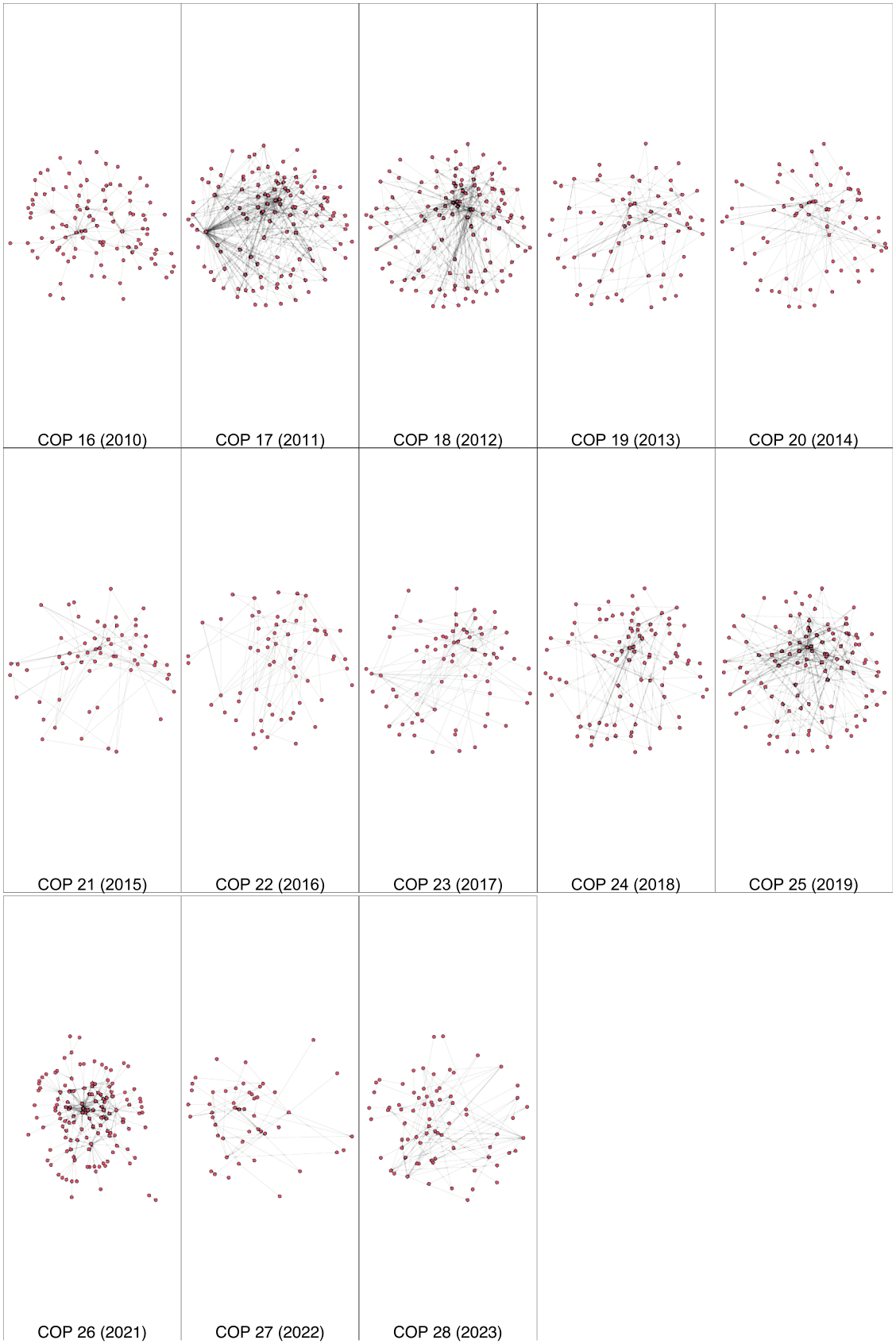

Figure 3. Thirteen years of co-mention networks plotted under the Fruchterman-Reingold force-directed method.

UNFCCC institutional structures and alliances in shaping cooperative outcomes within this venue (Genovese, McAlexander, and Urpelainen 2023; Müller and Gomez-Echeverri 2009; Stavins 2010). We then further identify several key insights into the drivers and dynamics of our uncovered negotiation networks that help to shed light on how these networks may interact with and underpin global climate change cooperation.

Firstly, we find that even after accounting for the temporal persistence of co-mentions within our COP

Table 2. DNR model comparison ordered by AIC. significance at the 0.05 level labeled with *.

	Model 8	Model 7	Model 5	Model 4	Model 3	Model 2	Model 1	Model 6
$I\{EU_{00}\}$	−4.87 (0.06)*	−4.91 (0.06)*	−4.89 (0.06)*	−4.93 (0.06)*	−4.97 (0.06)*	−4.88 (0.05)*	−4.96 (0.06)*	−5.03 (0.04)*
$I\{EU_{11}\}$	−5.23 (0.22)*	−4.97 (0.19)*	−5.17 (0.20)*	−5.10 (0.22)*	−5.13 (0.24)*	−5.21 (0.21)*	−5.53 (0.20)*	−5.29 (0.21)*
$I\{EU_{01}\}$	−4.99 (0.07)*	−4.93 (0.07)*	−4.96 (0.07)*	−4.94 (0.07)*	−5.04 (0.07)*	−4.91 (0.06)*	−5.06 (0.07)*	−5.08 (0.06)*
Triad Closure	0.10 (0.05)	0.16 (0.04)*	0.15 (0.06)*	0.08 (0.07)	0.09 (0.06)	0.02 (0.04)	0.05 (0.05)	0.18 (0.04)*
Sociality (China)	−0.16 (0.27)	−0.30 (0.29)	−0.01 (0.23)	–	0.15 (0.25)	−0.06 (0.27)	−0.17 (0.25)	0.09 (0.24)
Sociality (Germany).	0.28 (0.23)	–	–	–	–	–	–	0.26 (0.22)
Sociality (Japan)	−0.07 (0.25)	−0.60 (0.33)	–	–	–	–	–	0.26 (0.22)
Sociality (Russia)	−0.19 (0.28)	0.33 (0.21)	0.03 (0.28)	–	–	–	–	−0.41 (0.30)
Sociality (USA)	−0.12 (0.26)	−0.19 (0.27)	−0.25 (0.21)	–	–	0.28 (0.28)	–	0.10 (0.24)
I{G77and China }	0.01 (0.05)	−0.03 (0.05)	–	0.04 (0.05)	0.10 (0.05)	–	0.08 (0.05)	−0.06 (0.05)
Isolates	0.16 (0.04)*	0.13 (0.04)*	0.16 (0.04)*	0.15 (0.04)*	0.13 (0.04)*	0.17 (0.04)*	0.11 (0.04)*	–
Y_{t-1}	2.78 (0.09)*	2.78 (0.09)*	2.77 (0.09)*	2.79 (0.09)*	2.78 (0.09)*	2.79 (0.09)*	2.79 (0.09)*	2.80 (0.09)*
AIC	17,990	17,990	17,990	17,990	18,000	18,000	18,000	18,010

speeches, being isolated increases the likelihood of a co-mention in the future. This evidence suggests that negotiating parties are using expansions of high-level COP speeches to broaden their influence over the climate agenda by engaging with new countries in the UNFCCC forum. Such a result accordingly helps to underscore the flexible and dynamic nature of UNFCCC COP negotiations, in contrast to the more static institutions and alliances mentioned earlier. This finding is also consistent with the findings for LDCs in recent climate negotiations advanced by (Gray and Cointet 2023), wherein such countries used deliberative techniques to influence developed countries and the global climate agenda from the periphery.

Second, major carbon emitters do not appear to exhibit similar or even particularly strong influence within our negotiation networks. The latter quality suggests that countries do not primarily organize their negotiations around the most significant and powerful carbon emitters. At the same time, the signs associated with these major emitter estimates may be informative. Germany, in this case, may be positively associated with the likelihood of co-mentions within our annual negotiation networks. In contrast, China, Russia, Japan, and the US decrease the likelihood of such co-mentions. Accordingly, Germany – likely thanks to its leading role in the areas of green and clean energy technologies within this venue and otherwise (Hohler, Greenwood, and Hunt 2008; Jnicke 2016) – **be emerging as a leader or catalyzing force, with many other countries aligning with Germany. By comparison, Russia, Japan, the US, and, to a lesser extent, China do not appear to exert this type of influence, with other countries potentially distancing themselves from these major emitters and their corresponding domestic and international climate change stances as draggers[13] in negotiations during this period. Together, the above interpretation reaffirms contentions (e.g., Chandler 2009; Hurri 2020) as to the increasing leadership role played by Germany as opposed to the US and China, especially in more recent COPs, whereby Germany's stance on renewable and green energy and technologies appears to be serving as a model for climate change cooperation and stances moving forward, as opposed to the more static or at times backsliding behaviors towards climate change cooperation offered by China, Russia, and the US.

Our findings for the EU confirm and align with these conclusions. In particular, our results of strong EU-based homophily compared to non-EU country groupings underscore the increasingly cohesive nature and role of the EU in recent UNFCCC COPs. This is consistent with the growing evidence of the EU leading efforts in mitigation and adaptation collectively pinpointed within the climate talks (Bremberg and Michalski 2024; Del Pilar Bueno 2020; Rayner et al. 2023; Oberthür and Dupont 2021). Hence, in this

context, the EU appears to exert substantial influence within the UNFCCC's contemporary COP negotiations, including when compared to major powers such as China and the US. At the same time, this finding may also speak to the continued importance of at least some alliances within the UNFCCC negotiating space.

However, we also find strong evidence for shifting network dynamics over time. For example, over our period of analysis, negotiation affiliations dissolve, and we further identify a higher mean degree of co-mentions (and clustering) in the early years of our sample frame as opposed to later years – with some divergence in these trends during the height of the COVID-19 pandemic. One potential explanation for the latter divergence may be the relative ease of electronic COP participation during this window, which reduced barriers to COP participation for some countries – including LDCs – by decreasing costs for traveling and eliminating traditional barriers to attendance (Craft et al. 2021). This result is consistent with broader contentions over the promise of UNFCCC virtual attendance for inclusivity, even given shortcomings in virtual attendance opportunities pot-COVID-19 (Welch, Fernley, and Dolan 2023). Hence, the interplay between virtual attendance, COVID-19, and COP negotiation networks is worth further investigation. Turning to the broader findings of negotiation affiliations dissolving over our period of analysis, this, too, helps shed light on the changing nature and structure of UNFCCC negotiations. In particular – and consistent with some past research (Hurrell and Sengupta 2012) – it perhaps implies that the traditional developed-developing country divide in global climate change cooperation appears to be eroding. More broadly, these findings of dissolution may imply that countries are working to establish broader dialogue in light of the increasingly severe and immediate consequences of climate change itself – moving away from established negotiation alliances and the fragmentation they imply.

Conclusion

Taken together, the above findings underscore the evolving negotiation dynamics of the UNFCCC and its COPs. These dynamics lie in stark contrast to the more static UNFCCC institutions and alliance blocs but nevertheless align well with the highly variable negotiation successes and failures observed over the UNFCCC's lifespan. Our more specific DNR findings – especially relative to major emitters, past co-mentions, and the EU – furthermore help to validate our approach and its findings with reference to broader contentions as to the underlying nature of recent UNFCCC negotiations (Bremberg and Michalski 2024; Del Pilar Bueno 2020; Oberthür and Dupont 2021; Verlin Laatikainen 2020).

In these manners, our paper not only offers key substantive insights into the UNFCCC's negotiation networks – and their drivers and dynamics – but illustrates the promise of using high-level segment UNFCCC COP speeches to recover informal networks of affiliation via country-to-country co-mentions. This highlights several important future extensions. For example, research may extend our DNR analyses by exploring additional influences of the UNFCCC's informal negotiation networks with the aid of our data. Likewise, researchers could consider using our approach to extract and analyze similar time-varying negotiation networks from country speeches offered at international conventions outside the climate change arena, including those pertaining to broader environmental conservation issues, international security, and international political economy. Finally, the time-varying co-mentions extracted thus far provide only a single initial layer of relevant negotiation network information that can be obtained via our speeches and approach. Future work could extend these extracted networks to consider the direction of mentions or weight of each mention by the sentiment or themes of text surrounding the immediate mention itself.

More broadly, this study emphasizes the value of incorporating dynamic network analysis into the study of international (climate change) negotiations. We can offer a more nuanced understanding of global climate governance by examining the temporal changes in co-mentions and identifying key contextual factors that shape these informal alliances. Importantly, and notwithstanding the UNFCCC's traditional alliances and voting rules, negotiation dynamics and country influence are not static. As the UNFCCC continues to adapt to the growing urgency of climate change, understanding these latent negotiating features – and the informal affiliations that correspondingly emerge and dissolve at each COP – offers critical insights into the negotiation process. For policymakers, advocates, and academics, this stands to facilitate better predictions of future negotiation dynamics and to potentially inform strategies for more effective international cooperation.

Notes

1. Such as 2010's Green Climate Fund.
2. Also see (Depledge 2006, 1), who contends that 'the global climate change regime – centered on the 1992 [UNFCCC] and the 1997 Kyoto Protocol – has not only got "stuck," but is digging itself into ever deeper "holes" of rancorous relationships, stagnating issues and stifled debates, and thus rendering itself unable to serve as a tool or arena for learning.'
3. Especially in terms of (1) the Kyoto Protocol's slow ratification process and key nation-states' abilities to fulfill their commitments (Buchner and Dall'Olio 2005; Crowley 2007 and (2) inabilities to secure US ratification of the Kyoto Protocol or similar binding

commitments from developing states such as China and India (Victor 2006, 91).
4. E.g., via characterizations of the pos-Kyoto period of global climate change cooperation as being one of deadlock (Heyward 2007, 531), gridlock (Victor 2011; Keohane and D. Victor 2011, 10), or stalemate (Soroos 2001; Sharma 2010); as well as more focused critiques on the post-Kyoto Green Climate Fund (Kumar 2015).
5. Also see Long (Long 2020, 12), who notes that 'Even scholars previously dedicated to an international environmental law approach to problems such as climate change have concluded sharply that the approach embodied by the UNFCCC is not sufficient to address climate change,' in citing Carlarne (2014).
6. While many HLS speeches were originally given in English, a smaller share was delivered in other languages such as Spanish or French and, to a lesser extent, Arabic, Portuguese, or Russian.
7. The use of text-derived co-mentions for construction of (environmentally oriented) social actor networks has wide precedence in the literature (Culotta, Bekkerman, and McCallum 2004; Davidov, Rappoport, and Koppel 2007; Chang, Boyd-Graber, and Blei 2009; Almquist and B. Bagozzi 2019).
8. E.g., 'DRC' versus 'Democratic Republic of Congo' versus 'Democratic Republic of the Congo'.
9. E.g., 'Czech Republic' versus 'Czechia'.
10. Note that for country pairs where country (a) or (b)'s speech is missing for a given COP-HLS, the final count simply reflects the count for the existing speech.
11. We dichotomized the network so that we have one, if any, co-mention and zero otherwise.
12. Although this effect is attenuated when accounting for change over time – see the next section.
13. To borrow terminology from Sprinz and Vaahtoranta (1994).

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Data and code availability

Supplementary material is available at the *Harvard Dataverse* at https://doi.org/10.7910/DVN/R7LYRF.

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