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Party Polarization and Bill Cosponsorship in European Parliaments

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In recent years, the ties that Members of Parliament (MPs) create by cosponsoring legislation together have attracted interest from scholars adopting a network approach to lawmaking. This paper expands the empirical base of these studies by introducing an original dataset of 150 bill cosponsorship networks that cover 27 parliamentary chambers from 19 European countries, plus Israel. We then use the data to model the amount of partisan divisiveness found in the networks while controlling for the number of parliamentary factions, thereby providing an empirical test of Giovanni Sartori's classical distinction between the fragmentation of a party system and the degree of polarization between its components. In line with Sartori's observations, the results show that interparty ideological distance predicts some of the partisanship expressed by MPs through their propensity to cosponsor bills within and across party lines, regardless of the number of MPs and parties involved.

1. Introduction

Legislative politics often require Members of Parliament (MPs) to collaborate within and across chambers in order to amend governmental bills, to advance their own proposals, or to pass nonbinding resolutions. Part of that collaboration is reflected in the joint authorship or sponsorship of many legislative items, which previous research has found to be a useful heuristic to how MPs signal positions to other legislators (Kessler and Krehbiel 1996; Wilson and Young 1997), or to constituencies such as interest groups and voters (Koger 2003). This kind of collective position taking is further encouraged by the weakly constrained nature of cosponsorship, over which legislators generally enjoy more control than they do over votes (Schiller 1995; Desposato, Kearney, and Crisp 2011).

In recent years, the ties that MPs create by cosponsoring legislation together have attracted interest from scholars adopting a network approach to lawmaking. The general objective of that approach, which takes advantage of important developments in the statistical modeling of political and social networks (Cranmer and Desmarais 2011; Snijders 2011; Ward, Stovel, and Sacks 2011), consists in identifying the relational determinants that underlie legislative production, such as shared attributes of legislators or 'friend-of-a-friend' effects. From that perspective, the formation of cosponsorship ties is a possible entry point into the collaborative structure of parliamentary chambers (Kirkland 2014; Kirkland and Williams 2014), and a useful complement to legislative productivity and roll-call voting records in the study of parliamentary behaviour.

Drawing on existing studies of legislative cosponsorship networks in the United States and in Latin America, this paper examines the relational structure of legislative production in 20 European parliaments. In each of the 27 observed parliamentary chambers, we measure the extent of partisanship expressed by MPs through their propensity to cosponsor legislation together, aiming at a better understanding of the collaborative strategies that drive legislators in diverse parliamentary environments, under different institutional constraints.

The rest of this paper is organised as follows. Section 2 starts by reviewing the exist-

ing literature on legislative cosponsorship as a strategic position-taking device for legislators within parliamentary chambers. Section 3 then introduces original data on bills and their sponsors for a sample of legislatures located in Eastern, Northern and Western Europe. Section 4 offers a methodological framework that relies on network modularity (Zhang et al. 2008; Waugh et al. 2009) to measure the influence of partisanship on cosponsorship in each of the legislatures under examination. The results of that analysis are presented in Section 5. Section 6 concludes on the potential of network approaches for comparative studies of legislative behaviour.

2. Background

Legislative scholarship offers a wealth of studies that stress the importance of collaboration between Members of Parliament (MPs) in the lawmaking process. Cosponsorship frequently features among these collaborative cues: while in office, MPs are often granted the opportunity to support each other by apposing their joint signatures on a piece of legislation, such as an amendment, a bill or a nonbinding resolution. The possibility to nominally cosponsor legislation does not exist in every single representative democracy, but it is fairly common in both parliamentary and presidential settings, and has been for several decades in countries such as the United States (Campbell 1982), Argentina and Chile (Alemán and Calvo 2013; Micozzi 2014), and in several European countries.

There are several ways to explain, however, why MPs decide to cosponsor legislation together. Parliaments are highly strategic environments where multiple goals such as leadership, policy-specific influence or reelection can be pursued all at once, thereby making it implausible to trace down cosponsorship to a single explanatory factor. Accordingly, scholars of legislative behaviour have come up with multiple reasons for cosponsorship to occur, largely out of observations of such behaviour in the U.S. Congress (Schiller 1995; Kessler and Krehbiel 1996; Wilson and Young 1997; Koger 2003).

Taken as a whole, this segment of the literature broadly conceptualises legislative cosponsorship as a strategic position-taking device that allows a legislator to convey a signal to other legislators or to external constituents. As such, cosponsorship may seem similar to roll call votes, but as several authors have pointed out, many of the constraints that apply to parliamentary votes are less effective when it comes to initiating legislation: specifically, cosponsorship is often less subject to party discipline, insofar as party leaders and party whips exert less influence over it than they do over voting behaviour (Schiller 1995; Desposato, Kearney, and Crisp 2011; Alemán and Calvo 2013).

Consequently, while cosponsorship might share some of the properties of floor votes with regards to its ability to shape the legislative agenda, it might also be viewed as akin to the other "non-roll call position taking devices" available to legislators, such as speeches or written communications, which MPs can resort to as "mechanisms to target voters, but also interest groups, party leaders, expected presidential candidates, and even racial or ethnic clusters" (Micozzi 2014, p. 1188). This definition stresses the importance of electoral incentives and political ambition in the reasoning that might underlie the act of cosponsorship, along other possible goals such as increasing the likelihood of approval of a piece of legislation (Wilson and Young 1997; Tam Cho and Fowler 2010) or pursuing a specific policy stance (Koger 2003; Alemán and Calvo 2013).

Given the multiplicity of meanings that can be attributed to cosponsorship, it might also be useful to define it negatively, by explaining what it does *not* embody. Specifically, several scholars have raised the issue that cosponsorship might represent little more than "cheap talk" between legislators, since the act of cosponsorship is trivially time-demanding in itself and the cost of cosponsorship is low, with few penalties and possibly high rewards in case of legislative success (Kessler and Krehbiel 1996; Wilson and Young 1997; Fowler 2006a). In practice, however, cosponsorship appears to be much more selective than systematic: existing studies show that MPs cosponsor only a very small fraction of all legislation, which might be explained by the "substantial search cost involved in deciding which bills to cosponsor" (Fowler 2006a, p. 459), or by the private nature of the interactions that result in legislation to be cosponsored (Micozzi 2014, fn. 1, p. 1204). In either case, cosponsorship is much less likely to come out as a generalised,

inexpensive signal with little meaning attached to it, than as a proxy for the existence of collaborative relationships – or, from a network perspective, ties – between MPs.

Even if cosponsorship characterises as a non-trivial act, uncertainty yet remains with regards to the decision of legislators *not* to cosponsor a given piece of legislation. This issue severely affects the opportunity to use cosponsorship as an alternative measurement to roll call votes: although some studies report broad agreement between ideal points measured from both sources (Alemán, Calvo, et al. 2009), the decision not to cosponsor legislation is hardly equivalent to voting against it (Desposato, Kearney, and Crisp 2011). A safer course of research might therefore consist in asking broad, descriptive questions about the determinants of legislative cosponsorship, rather than focusing on its potential value as a benchmark of individual ideological positions.

This brief overview of existing research leaves us with a question that seems particularly fit for comparative inquiry: which factors, if any, might explain the act of cosponsorship across parliamentary environments? Since cosponsorship is inherently relational, many studies have begun to answer that question by suggesting that legislators are not simply concerned by *what* they cosponsor, but also *with whom*, thus making it a dual act of position-taking: through the joint sponsorship of selected legislative items, MPs not only express preferential attachment to specific issues, but also preferential attachment to other legislators (Gross, Kirkland, and Shalizi 2012).

This last argument features prominently in recent studies of legislative cosponsorship, which have made use of social network analysis to account for it. In its simplest form, the hypothesis translates into the phenomenon known as homophily (McPherson, Smith-Lovin, and Cook 2001): legislators are more prone to cosponsor the work of other legislators when they share some characteristics, such as ethnicity (Bratton and Rouse 2011), gender (Clark and Caro 2013), constituency (Alemán and Calvo 2013) or committee membership (Kirkland and Gross 2012). Under more complex assumptions, cosponsorship might also emerge from strategic decisions where dissimilar sponsors ally in order to maximise their legislative success, thereby forming "weak ties" motivated by outcome considerations (Kirkland 2011).

A further argument of interest about the determinants of legislative cosponsorship has been laid out by Kirkland (2014). Since cosponsorship is essentially a process of partner selection, the structure of legislative assemblies might play an additional role in that operation. As Kirkland (2014, p. 169) explains, "legislators must balance their choices about collaboration with the uncertainty surrounding those relational decisions"; as a consequence, "any institutional structures that alter the level of information, and by extension uncertainty, in a chamber regarding bill outcomes or bill sponsors will affect cosponsorship choices" (Kirkland 2014, p. 172). In that perspective, the size of the chamber and of its parliamentary committees might respectively hinder or enable learning among legislators, thereby affecting their overall propensity to cosponsor and/or their propensity to cosponsor across party lines.

To our knowledge, such network approaches to legislative cosponsorship have so far been conducted on only a limited range of country cases. The literature that we reviewed includes numerous studies of both Congressional houses of the United States, pioneered by the work of Fowler (2006a) and Fowler (2006b), as well as studies of its state legislatures (Kirkland 2011; Bratton and Rouse 2011; Clark and Caro 2013; Kirkland 2013; Kirkland and Williams 2014). We also located studies of the parliaments of Argentina (Alemán and Calvo 2013; Micozzi 2014) and Chile (Alemán 2009; Alemán and Calvo 2013), and one study of cosponsorship in a European country, focused on the legislative behaviour of a subset of MPs in the Romanian parliament (Chiru and Neamtu 2012). Our search also returned visual explorations of bill cosponsorship in the lower houses of the French (Coulmont 2011) and Czech (Gregor 2013) parliaments, and similar research on Korean legislators (Ji-yeon Lee and Yoon 2014b; Ji-yeon Lee and Yoon 2014a).

In this research, our primary aim is therefore to contribute to the literature of legislative cosponsorship by expanding its empirical base to several additional countries. Our efforts concentrate on establishing a methodological framework that turns a large number of parliamentary chambers into candidates for network studies of legislative behaviour, using bill cosponsorship as a proxy for the existence of collaborative relationships between MPs.

3. Data

This study focuses on legislative cosponsorship activity in a sample of Eastern, Northern and Western European countries, plus Israel. Table 1 summarises the data collected for this research, which cover 20 countries and 27 parliamentary chambers, over a total of 558 years and 150 legislatures, understood as periods between two nationwide legislative elections. The sample is geographically balanced between the three regions under examination and covers several parliamentary systems as well, including three federal regimes (Austria, Belgium and Switzerland) and a mix of unicameral and bicameral parliamentary systems.[1] The data are available from an online repository.[2]

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[1]Although the data for Iceland are exceptionally extensive and range back to 1907, we restricted its presence in the sample to the six most recent legislatures. This period covers all elections since the Althing was reformed to sit as a unicameral parliament, and makes the proportion of Icelandic legislatures comparable to that of other countries in the sample.

[2]See `https://github.com/briatte/parlnet`. The code for this study was written in R version 3.1.2 (R Core Team 2016), and the current release of the repository is version 2.6.1.

Region	Country	Chamber	Code	Period	Years	Legislatures
East	Bulgaria	Unicameral	BG	2005–2015	11	4
	Czech Republic	Lower	CZ-PO	1996–2015	20	6
		Upper	CZ-SE	1996–2015	20	6
	Estonia	Unicameral	EE	2007–2015	9	3
	Hungary	Unicameral	HU	1998–2015	18	5
	Lithuania	Unicameral	LT	1992–2015	24	6
	Romania	Lower	RO-CA	1996–2015	20	5
		Upper	RO-SE	1996–2015	20	5
	Slovakia	Unicameral	SK	1998–2015	18	5
West	Austria	Lower chamber only	AT	1994–2015	22	7
	Belgium	Lower	BE-CH	1991–2015	25	7
		Upper	BE-SE	1995–2014	20	5
	Switzerland	Lower	CH-CN	1995–2015	21	5
		Upper	CH-CS	1995–2015	21	5
	France	Lower	FR-AN	1986–2015	25[3]	6
		Upper	FR-SE	1986–2015	30	7
	Ireland	Lower	IE-DA	1997–2015	19	4
		Upper	IE-SE	1997–2015	19	4
	Italy	Lower	IT-CA	1983–2015	33	9
		Upper	IT-SE	1996–2015	20	5
	Portugal	Unicameral	PT	1991–2015	25	7
North	Denmark	Unicameral	DK	2001–2015	15	5
	Finland	Unicameral	FI	1999–2014	16	4
	Iceland	Unicameral	IS	1995–2015	21	6
	Norway	Unicameral	NO	1985–2015	31	8
	Sweden	Unicameral	SE	1988–2015	28	8
Asia	Israel	Unicameral	IL	2009–2015	7	3

* Missing legislature 10 (1993-1997) of the French lower chamber.

Table 1: Overview of the country sample. The country and chamber codes are used in the replication material of this research, as well as in the plots of this paper.

The initial sample of countries considered for this research included all current members of either the European Union or the European Free Trade Association, plus Israel. While several decisions were made with regards to the exact definition of a bill (see next section), the primary criterion for inclusion in the sample was the availability of historical legislative data from official parliament websites.[4]

A further technical limitation in the data collection process emerged from the format in which many parliaments choose to publish their records. On the one hand, we were able to make use of various technologies to collect bills directly from parliament websites, or from the open data portals set up by their services.[5] On the other hand, we were unable to process the data when it were provided in unparsable formats that would have required manual coding, and had to exclude countries such as Croatia or Malta for that reason.

Due to the data limitations mentioned above, one legislature of the French lower chamber is missing from the sample because too few of its bills were available in parsable format. For all other sampled chambers and legislatures, we were able to collect almost all information on bills and their sponsors, as detailed below.

3.1. Bills

For the purpose of this study, we defined 'bills' as laws initiated by one or more parliamentary legislators that become binding if they make it through the legislative process of their country of introduction. This definition is compatible with theoretical assumptions on how MPs signal their positions to their constituents or to third parties, and is comparable across countries: it corresponds, for instance, to the definition of *propositions de loi* in Belgium and France, or to *törvényjavaslat* in Hungary and *lagafrumvörp* in Iceland, and in the special case of Denmark, includes both 'preliminary bills' (*beslutningsforslag*)

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[4]The availability of legislative data has made considerable progress in the recent years, through the development of parliamentary informatics and under the pressure of third parties such as the civic organizations connected through the Opening Parliament platform: see `http://www.openingparliament.org/`.

[5]For an introduction to the technologies that we used, see the chapters on HTML, JSON, SQL and XML files in Munzert et al. (2015), as well as the chapter on XPath syntax.

and 'full-fledged' bills (*lovforslag*).

This definition excludes bills initiated by the executive branch of government, as well as nonbinding statements by MPs, such as resolutions (or early day motions in the United Kingdom). We further limited our attention to bills signed by individual MPs, i.e. bills for which *nominal* sponsorship information appear in official parliamentary records. This restriction resulted in excluding additional countries from our sample, such as Germany or Spain, where the vast majority of legislative production is produced by collective standing committees and cannot be traced to individual endorsements.[6]

The data collected according to this definition amounts to slightly above 239,000 bills, of which around 60% were sponsored by two or more MPs, for a total of around 1.5 million (co)sponsorships. These statistics are shown in more detail in Figures 1 and 2, which show their breakdown in each country, chamber and legislature. Because the data do not include governmental bills, these figures do not provide enough information on overall legislative production, which varies dramatically from one country to another in any case; there is, however, an observable trend towards increased levels of legislative cosponsorship in several countries.

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[6]Because French bills can be sponsored both by individual MPs and by entire parliamentary factions, we collected but later ignored group signatures.
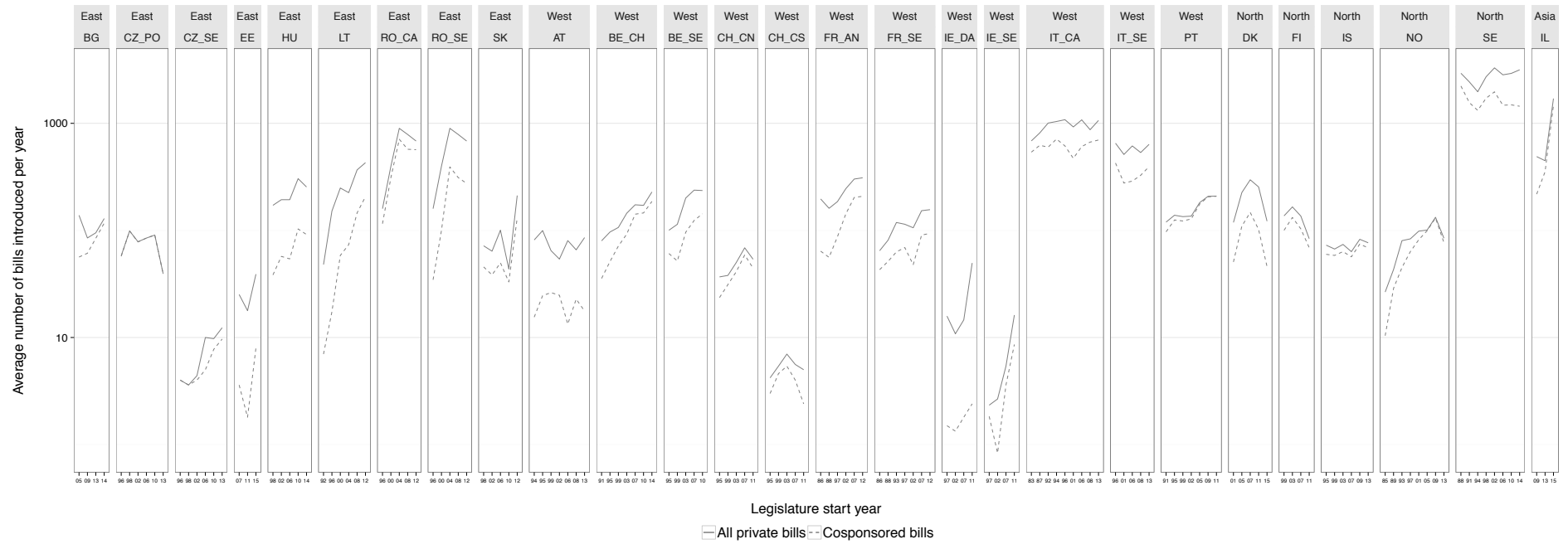
Figure 1: Average number of bills per year in each legislature. Solid lines are measured out of all bills, dashed lines out of cosponsored bills only. The vertical scale is logged.
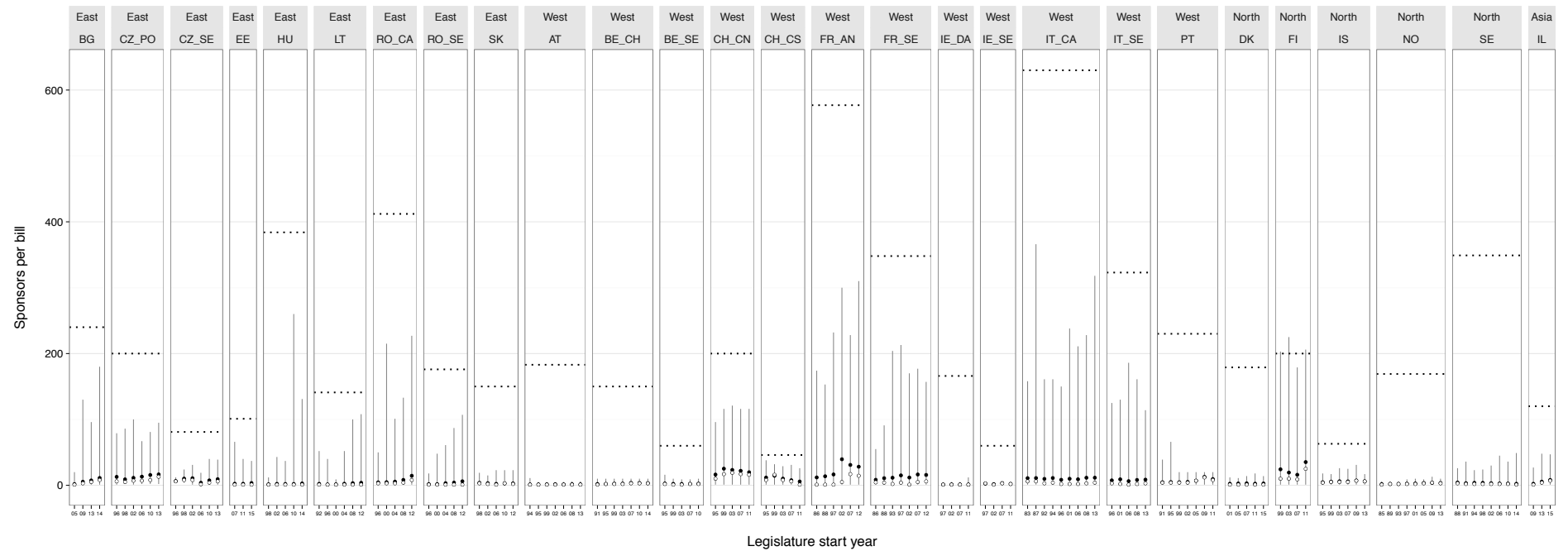
Figure 2: Number of sponsors per bill in each legislature. Vertical lines indicate the minimum and maximum number of sponsors reached in each country-chamber-legislature period. Black points mark the average number of sponsors, and white points mark the median number of sponsors. Dotted horizontal lines indicate the formal size of each parliamentary chamber, as indicated in the Inter-Parliamentary Union (IPU) PARLINE database (http://www.ipu.org/parline-e/parlinesearch.asp).

3.2. Sponsors

Using the same parliamentary sources as we used for bills, we retrieved as much information as possible on the individual legislators who sponsored the bills. The variables collected across all countries include socio-demographics (age and sex) and parliamentary career information (time in office, constituency, committee membership and party affiliation), for a total of approximately 18,000 MPs who appeared on at least one cosponsored bill. Two important simplifications regarding party affiliation and time in office had to be applied at that stage:

- *Party affiliation* was not necessarily stable across a full legislature: for example, in 2005, several Austrian MPs followed Jorg Haider in defecting from the Freedom Party of Austria (FPÖ) to create the Alliance for the Future of Austria (BZÖ). In such cases, which were particularly frequent in Iceland, we recorded the longest party affiliation of the sponsor over the legislature.

- *Time in office*, or seniority, was measured as years spent in the same parliamentary chamber, even though some countries like Italy or Romania frequently elect members of their lower chamber to the upper chamber as senators. These transitions are currently unaccounted for in our research, but might deserve separate attention from more focused studies.

To further characterize the positions of bill sponsors relative to each other, we also proceeded to match their party affiliations with an indication of where the party sits on a standardized Left/Right scale. In order to do so, we used the scores available in the latest edition of the ParlGov database (Döring 2013; Döring and Manow 2014), which are time-invariant scores computed as the weighted mean values of party positions taken from several expert surveys on political parties.[7]

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[7]For further details on ParlGov Left/Right party positions, see `http://www.parlgov.org/documentation/party-positions/`. The scores, which range from 0 to 10, are listed in full in Briatte (2016, Appendix, Section D), along with notes on the recodings that we applied to match the ParlGov data with ours.

4. Methods

4.1. Network construction

This section explains the network construction routine that we applied to each country-chamber, further divided by legislature.[8] We proceeded by matching the definition of cosponsorship ties used in network analyses of the U.S. Congress (Fowler 2006a; Fowler 2006b; Gross, Kirkland, and Shalizi 2012) and relied on a similar constructor, namely a two-mode edge list of the form

$$\{b_1, a_8\}, \quad \{b_1, a_{31}\}, \quad \{b_2, a_{27}\}, \quad \ldots$$
$$\vdots$$
$$\ldots \quad \{b_{n-1}, a_{36}\}, \quad \{b_n, a_{120}\}$$

with bills denoted b_n and MP sponsors denoted a_n. To focus the study on collaboration between legislators, we then collapsed the $b \times a$ two-mode network to a one-mode network containing strictly MPs, by connecting the first author of each bill to all other sponsors on that bill. The resulting adjacency matrix A of directed ties between MPs (i, j) is an asymmetric matrix with elements

$$A(i,j) = \left\{ \begin{array}{ll} 1 & \text{if MP } i \text{ cosponsored a bill authored by MP } j, \\ 0 & \text{otherwise.} \end{array} \right.$$

and where all diagonal elements (MPs hypothetically cosponsoring legislation with themselves) are discarded. As a result, the networks do not contain any self-loops.

Finally, since cosponsorship between two MPs i and j can occur more than once during a legislature, the ties of their network must then be valued to reflect their dif-

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[8]Our starting point was indeed to treat each parliamentary legislature as a semi-closed universe of legislators, with few entries and exits occurring between two nationwide elections. A small number of entries occurs because of by-elections or replacements, and a small number of exits occur because of deaths, resignations, cancelled elections and other relatively rare events.

ferent strength. To do so, we followed Gross, Kirkland, and Shalizi (2012) and Alemán and Calvo (2013) by weighting all cosponsorships in inverse proportion to the overall number of cosponsors on the bill, and by normalizing their sum to the maximum number of possible cosponsorships between MP cosponsor i and MP author j during the legislature.[9]

This network construction routine has two important limitations. First, because we focus on interactions between MPs, we do not account for many of the differences that might exist between bills. This is a consequence of our comparative research design: in a more restricted observational context, it would have been useful to keep that information, as suggested by Gross, Kirkland, and Shalizi (2012), in order to account for temporal or thematic variance at the bill-level. Unfortunately, most countries in our sample do not provide extensive bill details: only half of them, for instance, classify their legislation with keywords.

A second limitation comes from our decision to focus solely on the ties between the first author of each bill and his or her cosponsor(s), thereby reflecting only some of the interactions that occur when MPs decide to cosponsor legislation together. This because, like Fowler (2006a) and Fowler (2006b), we might reasonably assume that all cosponsors on a bill know who they are 'connecting to' with regards to the first author, but not that they also know every cosponsor on that same bill.

Last, while almost all countries give some importance to the first author of a bill in their parliamentary rules (for instance, by making them the default speaker for the bill), some also apply a distinction between "first authors" and "cosponsors" in their official records. By ignoring that distinction, we effectively treated a small number of "first authors" (beyond the first one) in Belgium and Italy as "cosponsors". To make sure that this simplification could be made, we compared the networks built out of all first authors in these countries with their 'simplified' counterparts, and observed only minor differences in terms of network structure.

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[9]See Gross, Kirkland, and Shalizi (2012, eqn. 1, p. 8). The resulting weights, a variant of those used by Fowler (2006a) and Fowler (2006b), are bounded between 0 and 1.

4.2. Exploratory analysis

Prior to modeling the data, we used two different strategies to explore the structure of our cosponsorship networks. We started by plotting each network, using the force-directed algorithm by Fruchterman and Reingold (1991) to place cosponsors of the same bills near each other, and further away from other sponsors. We then built interactive versions of the same graphs, in order to explore the ego networks of specific MPs and to produce alternative visualisations of each network.[10]

Exploring the networks confirmed two of the initial insights that emerged during data collection. The first one has to do with the influence of party discipline on legislative cosponsorship: many of the graphs show that party affiliations govern over most decisions to cosponsor. The second one has to do with the density of the observed networks, which varies across countries and legislatures from less than 0.01 to 0.19.[11] In fact, with a mean density of approximately 0.05 across the observed networks, the cosponsorship networks under study are much sparser than those of the U.S. state legislatures studied by Kirkland (2014).

This last observation confirms that the cosponsorship ties contained in the networks under observation are reasonably selective: on average, less than 5% of all possible ties in the networks are realised. This might be partly explained through qualitative observation: several graphs, for instance, show party leaders or their deputies frequently acting as first authors for their parliamentary group, and thereby occupying a central position within it. Cosponsorship ties, however, are too frequent to observe all their configurations without resorting to some quantification of their probability to occur, which we offer in the next section.

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[10]The visualisations are available online at `http://f.briatte.org/parlviz`.

[11]Network density is the ratio that divides the empirical number of ties in a network by the number of potential ties that it could have contained if all of its nodes had been connected to each other (Wasserman and Faust 1994, p. 314-317).

4.3. Partisan modularity

The tendency of MPs to cosponsor each others' proposed bills captures many different phenomena at once. Because introducing a bill can be used to signal a particular position to voters (such as attention to welfare issues or to constituency-specific matters), bill cosponsorship is likely to reflect shared interests or electoral incentives between two or more MPs (Brunner 2013). Bill cosponsorship, however, is unlikely to be an entirely unconstrained behaviour: party divisions, as well as intra-party divisions, are both susceptible to interfere with the decision to cosponsor a bill, if only because political parties provide informational cues to their members about the activities and positions of their other members.

According to this line of reasoning, the likelihood of cosponsorship between like-minded sponsors is susceptible to be higher within party lines than across them, even in the unlikely scenario that cross-party interactions were not to entail any sanctions for legislators. Yet partisan cues cannot be expected to be the only ones to constrain the decision to cosponsor a bill: other factors, such as shared committee membership or the overall size of the parliamentary chamber (Kirkland 2014), might also play a role in the process of collaborative partner selection among MPs.

In order to summarise and disentangle these interactions, we first need a way to measure the amount of intra-party and inter-party collaboration that occurs in each chamber. To that end, we turn to the same method as that used in several network studies of cosponsorship in the United States (Zhang et al. 2008; Waugh et al. 2009; Kirkland 2011; Kirkland and Gross 2012; Kirkland 2013; Kirkland 2014), by measuring this quantity through the network modularity statistic (Newman and Girvan 2004; Newman 2006; Leicht and Newman 2008).

Network modularity is a summary statistic that captures the extent to which the ties of the network stay confined within specific groups. Given a set of communities of actors, modularity can express the propensity of these actors to form ties within these communities, as opposed to across them. When modularity is high, the observed network contains communities that have developed many ties within them but few between

them, which, as Waugh et al. (2009) observe, is conceptually analogous to what scholars designate as polarisation in studies of roll call votes.

Network modularity is computed by comparing the proportion of network ties formed within a given vector of communities to that same proportion in a randomised network of identical dimensions. The further away the observed network is from the randomised 'null' model, the more efficient the community vector is at partitioning the network into meaningful communities (Newman and Girvan 2004; Newman 2006). In a party-based setting, *partisan modularity* therefore measures the level of within-party collaboration against random collaborative ties.

The methodology to compute the modularity of a network is retraced in Waugh et al. (2009) and Kirkland and Gross (2012). For a given community variable g, which in this case is the parliamentary group affiliation of each MP, the modularity statistic Q represents the fraction of network degree m contained inside g, minus the expected total degree of the network. Modularity can thus be expressed as

$$Q = \frac{1}{2m} \sum_{ij} \left[A_{ij} - P_{ij} \right] \delta_{g_i g_j}$$

where m is the total number of edges in the network, A_{ij} is the existence of a tie between MPs i and j, $P_{ij} = \frac{k_i k_j}{2m}$ is the total number of ties k_i formed by MP i, and $\delta_{g_i g_j} = 1$ if MPs i and j belong to the same parliamentary group, or 0 if they do not. In a directed network, this equation loses the factor of 2 in the denominator, and stays unchanged otherwise (Leicht and Newman 2008, Equation 3).

Three further characteristics of network modularity are important to underline. First, modularity can take edge weights into account to compute the degree distribution of the network. We therefore computed four party-based modularity statistics per network: one from the unweighted network edges, one from the 'raw' number of cosponsorships between two MPs, one from the *weighted quantity of bills cosponsored*, computed as in Fowler (2006a, p. 468) by weighting all cosponsorships in inverse proportion to the overall number of cosponsors on the bill, and one from the *weighted propensity to cosponsor*,

computed as in Gross, Kirkland, and Shalizi (2012, Equation 1) by weighting all cosponsorships in inverse proportion to the overall number of cosponsors on the bill, and then by normalising that sum to the maximum number of possible cosponsorships between MP cosponsor i and MP author j during the legislature.

Second, empirical estimates of network modularity are interesting to compare to the maximum level of modularity that can be reached in a given network. In order to assess that factor, we followed Waugh et al. (2009, Section 3) into maximising our modularity estimates, using up to 50 random walks with the Walktrap algorithm by Pons and Latapy (2006) to identify optimal partitions in each cosponsorship network, and then storing the highest modularity statistic attained by that method.

Figure 3 shows how our empirical, party-based modularity estimates compare with these maximised modularity scores: in effect, in most observed networks, both measures are rather close to each other, which translates into partisan divisions being highly efficient ones to describe the structure of the networks. The same figure also shows that measures of party-based modularity obtained through different edge weighting schemes are in broad agreement with each other.[12]

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[12]The correlation coefficients for our four series of party-based network modularity estimates are all superior to 0.9.

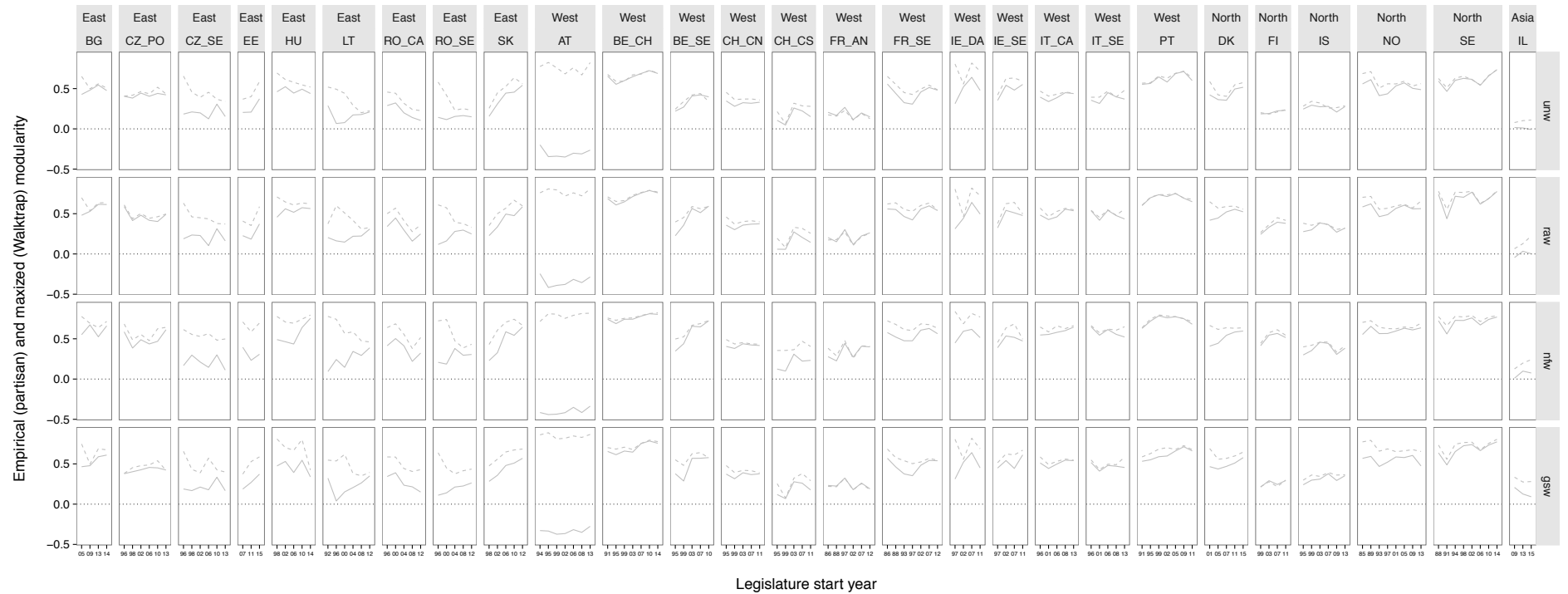Figure 3: Network modularity in all observed networks: partisan modularity in solid lines, maximised modularity in dashed lines, and null modularity as horizontal dots. Each series of horizontal panes refers to one of the weighting schemes used in the modularity computations: unweighted (unw), raw cosponsorship counts (raw), weighted quantity of bills cosponsored (nfw), and weighted propensity to cosponsor (wpc).

Third and last, modularity is bounded between -1 and $+1$: positive scores are indicative of assortative mixing, which is the situation where tie formation is more likely to occur within communities than across them, while negative scores are indicative of disassortative mixing, the opposite, and much less frequent, situation (Newman and Girvan 2004; Newman 2006). If we expect bill cosponsorship networks to be primarily structured by party affiliation, then we should have observed high, positive modularity in all networks.

In order to illustrate this last point, Figure 4 shows two highly dissimilar patterns of partisan modularity in the observed networks. Figure 4a shows one of the cosponsorship networks for Austria, the only country where the modularity statistics are always negative, which might be explained both by the small size of the networks and by the organisation of coalition government in Austria, where two parties systematically share power. In the shown example, most of the (few) cosponsorship ties represented in the network are indeed reflective of the 'black-blue' coalition formed by the ÖVP and the FPÖ during the 21st parliamentary legislature.[13]

In contrast, Figure 4b shows one of the cosponsorship networks for Belgium, all of which are highly and positively modular. This pattern derives from the Belgian party system, which is divided into linguistic communities that often come into conflict with each other (Frognier 1978). Furthermore, while some Belgian parties (like the Greens, denoted 'ECOLO', or the Flemish nationalists, denoted 'VOLKS') show little sign of cooperation with others over bill sponsorship, the far-right Vlaams Belang (denoted 'VLAAMS') shows none at all, which has a positive impact on the modularity of the entire cosponsorship network.[14]

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[13]Over that period, the Austrian party system experienced changes that also contribute to explaining the observed patterns: while government and opposition parties remained competitive, parties on each side of the divide became more cooperative with each other, leading to what Müller and Fallend (2004) call a "weak version of a two-bloc system".

[14]That impact can be estimated to a modest $0.03 - 0.04$ by removing the Vlaams Belang from the network. The absence of legislative collaboration between parties does not signify that there are no latent inter-party dynamics in highly divided institutions like the Belgian parliament (see, for instance, Vliegenthart, Walgrave, and Meppelink 2011).
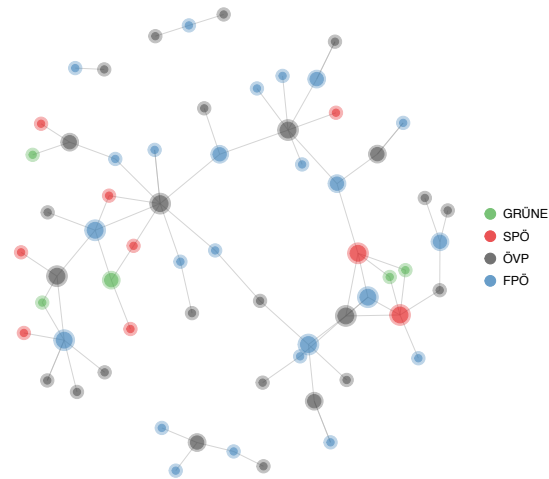
(a) Bill cosponsorship network for Austria, 21st legislature, years 1999–2002, based on 105 bills sponsored by 63 MPs; partisan modularity: -0.39 (raw cosponsorship counts) and -0.37 (weighted propensity to cosponsor).
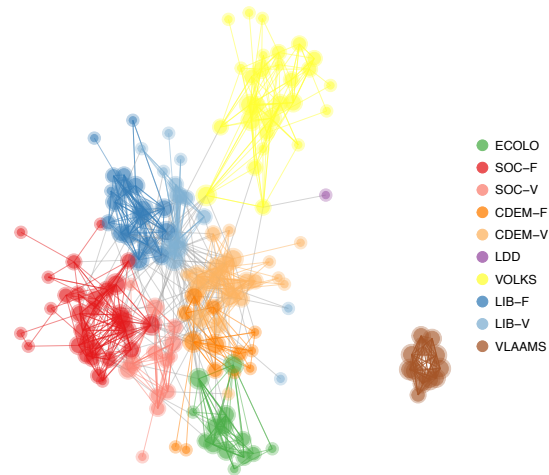
(b) Bill cosponsorship network for Belgium, 53rd legislature, years 2010–2014, based on 728 bills sponsored by 165 MPs; partisan modularity: $+0.79$ (raw cosponsorship counts) and $+0.78$ (weighted propensity to cosponsor).

Figure 4: Example cosponsorship networks expressing different patterns of partisan modularity in two West European countries. Nodes are sized proportionally to their unweighted total degree, and edges are coloured when they connect two nodes belonging to the same party. Party abbreviations are listed in full in Briatte (2016, Appendix, Section D).

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All in all, the amount of party polarisation captured by network modularity varies, for all countries but Austria, between -0.04 to $+0.81$. The median modularity score is $+0.46$ for modularity measured from raw cosponsorship counts, and $+0.44$ for modularity measured from the weighted propensity to cosponsor. Lowly modular networks, such as those observed in both Swiss chambers, often contain two or three parliamentary groups on each side of the government/opposition divide that collaborate with each other over bill cosponsorship. By contrast, some of the highly modular networks show a single party, such as the Social Democrats in Sweden, cosponsoring almost exclusively within party lines.[15]

At that stage, because some of the observed cosponsorship networks came very close to a partisan modularity score of 0, we ran two different tests to determine whether these scores might be obtained by chance, either through random edge rewiring, which preserves the degree distribution of the networks, or through randomised reassignments of the party partition vector, as suggested by Kirkland (2013). The results of both tests confirmed that our data contain a limited number of borderline cases, such as Israel, in which the measurement of party polarisation through network modularity is problematic.[16]

Last, the previously mentioned Vlaams Belang in Belgium is not the only far-right party to be isolated in the observed cosponsorship networks: this is also true, for instance, of the Jobbik party in Hungary during years 2010–2014, or of the Swedish Democrats during the same period. In these last examples, party segmentation combined to ideological dispersion translates into higher partisan modularity scores than in chambers where no party is effectively ostracised from cross-party legislative collaboration, which is indicative of the link that we later identify between partisan ideology and party polarisation.

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[15]These observations are in line both with the functioning of the Swiss political system, in which the executive is systematically composed of several parties, and with the successful electoral history of the Swedish Social Democrats, who have won large shares of parliamentary seats in almost every Swedish election.

[16]The code and results of this part of our analysis is available on demand. We have also explored an alternative measurement of network modularity through simulated annealing, with results highly comparable to those reported here.

4.4. Variable selection

To examine possible explanations of what might drive such polarisation to increase or decrease, we reviewed existing studies of legislative cosponsorship in the United States, and that of Kirkland (2014) especially. The selection of variables returned by our review fall into five broad types, from which we formulate our hypotheses.

We begin by including some information on **chamber and party structure**. If we follow Kirkland (2014) in hypothesising that "in larger legislative chambers, legislators will rely more heavily on obvious cues like party in their choices about collaborative partners," then partisan modularity should increase with chamber size. However, the number of parliamentary party groups and their size might also affect the degree of segmentation measured in each chamber, and might do so differently, especially if the cosponsorship of legislation by more than one group is perceived to increase its chances of approval. For that reason, we include three factors that we expect to cancel each other out: the total number of sponsors in the network,[17] the total number of parliamentary party groups in the network, and the median size of parliamentary party groups in the network.[18]

We then include some information on the **sponsor population** present in each network. As several previous studies of cosponsorship have shown (Bratton and Rouse 2011; Clark and Caro 2013), female MPs, newly elected MPs and unaffiliated MPs are often more active legislators; furthermore, unaffiliated MPs can adopt different collaborative strategies, such as working with only one parliamentary group, working with several of them, or even forming their own parliamentary group when parliamentary regulations allow it, as in the French Senate. We therefore include the percentage of sponsors that fall under each profile as a means to detect any change in modularity that might be associated with their increased presence in the networks.

We then include some information on **parliamentary committees and legislature**

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[17]The total number of sponsors in each network is highly correlated to the statutory size of the chamber ($\rho = 0.92$), and better captures the number of legislators who effectively engage into cosponsoring bills. Replacing the total number of sponsors with statutory chamber size does not significantly affect the results.

[18]We use the median size of the parliamentary party groups to avoid collinearity with chamber size.

duration, expecting both factors to decrease partisan modularity in the observed networks. We again follow Kirkland (2014, p. 170) in hypothesising that, because parliamentary committees "afford legislators time to learn specific information about one another and the chance to gain insights about potential partnerships," and because "larger committees help legislators develop a more optimal collaborative network by providing them chances to learn about and interact with a greater number potential partners", then an increase in the number and/or average size of these committees should have a negative effect on partisan modularity.[19] Similarly, longer legislatures might give more time to legislators to learn about each other, and might therefore produce a similar effect.

We further include measures of **cosponsorship activity**, in order to control for the different volume of legislative production in each country. The first control we introduce is the number of cosponsored bills introduced during the legislature, as a means to control for the limited potential for collaboration that might characterise less productive assemblies.[20] We then add network density as a means to control for the extent of interactions between sponsors in the network, which ensures that the fraction of modularity attributed to other predictors is measured net of that parameter. This control is especially important to estimate the net effect of chamber size: given that density is normalized by the number of sponsors in the network, "any remaining correlation between network density and network size is a result of actors in the networks actively avoiding network connections in larger networks" (Kirkland 2014, p. 178).

Finally, we include some information on the **partisan composition** of the cosponsorship networks, in the form of two parameters measured from the Left/Right scores of the parliamentary groups that participate in cosponsoring legislation. The mean of these scores intends to estimate whether parliaments dominated by either leftwing or rightwing majorities are different in terms of their degree of partisan segmentation. The standard deviation of these scores captures a different expectation: legislatures

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[19]As one might expect, the average size of parliamentary committees is correlated to chamber size, but only to a moderate extent ($\rho = 0.41$). This is likely due to our broad definition of parliamentary committees, which includes permanent as well as temporary committees, such as parliamentary inquiries, both of which are likely to enable legislators to learn about each other.

[20]Replacing the number of cosponsored bills by the overall number of bills introduced during the same period does not significantly affect the results.

in which parliamentary groups are ideologically more diverse should collaborate less, which would lead to higher network modularity.

5. Results

In order to model partisan modularity in the observed cosponsorship networks, we turned to ordinary least squares regressions of its two values, the first of which was weighted using raw cosponsorship counts, and the second of which was weighted using the weighted propensity to cosponsor.[21] Since our sample size was relatively small, we also ran Bayesian normal linear regressions (Owen et al. 2013, p. 348-353) to check the direction and magnitude of our estimates. The results of these models, which can be obtained from the replication material, were quasi-identical to those reported here, without any sign inversion or significant change in the standard errors.

For both versions of partisan modularity, we report the results of four models, each of which were ran on slightly different samples of cosponsorship networks depending on excluded country cases and missing data:

Model 1 includes all networks, at the exception of one network from the Belgian upper chamber and one other network from Portugal, for which it was not possible to measure time in office ($N = 139$);

Model 2 replicates Model 1 while excluding Austria and Ireland, due to the exceptionally negative partisan modularity of the former and the exceptionally low number of bills and sponsors of the latter ($N = 135$);

Model 3 re-adds all countries to the network sample but also adds two predictors relating to parliamentary committees, which has the effect of excluding some networks from Belgium, the French lower chamber, Ireland and Portugal, all of which did not provide reliable information on committee memberships ($N = 116$); and

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[21]We only regress empirical (partisan) modularity estimates, but the results are broadly similar if maximised modularity scores are used.

Model 4 replicates Model 3 while excluding Austria and Ireland, for the same reason as mentioned above ($N = 112$).

Tables 2 reports the results of these models for partisan modularity computed against raw cosponsorship counts, and Table 3 reports the results of these models for partisan modularity computed against the weighted propensity to cosponsor.

As indicated by our variable selection method, in both models, we control for the number of parties, the number of bills introduced, the number of bill sponsors, network density, and the duration of the legislature. The models also control for specific sponsor profiles, namely the percentage of female sponsors, the percentage of newly elected sponsors, and the percentage of sponsors with no party affiliation. Finally, the models include information on partisan composition through the average Left/Right score of the sponsors, and through the standard deviation of the same scores.

A few characteristics of the model results deserve to be highlighted:

- As shown by the residual standard errors, excluding the exceptional case of Austria (Models 2 and 4 of each table) dramatically improves the fit of the models. Including information of parliamentary committees (Models 3 and 4) further improves the fit of the models, at the expense of losing a small fraction of the sample.

- The strongest observed relationship is a negative relationship between partisan modularity and network density: as the ratio of observed to extent ties increases in the observed networks, these are less and less segmented into separate partitions, which has the expected effect to decrease their modularity statistic.

- Several predictors express very weak effects that correspond to theoretical expectations but fail to reach statistical significance. The number of bills, for instance, tends to increase partisan modularity insofar as more bills represent more uncertainty about their outcomes and their sponsors (Kirkland 2014).[22]

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[22]Conversely, as also suggested by Kirkland (2014), the number of parliamentary committees and their average size tend to reduce network modularity, although by an insignificant amount. The same is true of the percentage of unaffiliated (i.e. 'party-free') sponsors.

	M1	M2	M3	M4
Intercept	0.48**	0.47**	0.31	0.30
	(0.17)	(0.17)	(0.17)	(0.16)
Number of parties	−0.01*	−0.01*	−0.01**	−0.01*
	(0.00)	(0.00)	(0.00)	(0.00)
Number of bills / 1000	0.01	0.01	0.00	0.01
	(0.01)	(0.01)	(0.01)	(0.01)
Number of sponsors / 100	0.03**	0.02*	0.02	0.01
	(0.01)	(0.01)	(0.01)	(0.01)
Network density	−2.67***	−2.39***	−2.46***	−2.06***
	(0.36)	(0.40)	(0.33)	(0.38)
Left/Right party positions (mean)	−0.02	−0.01	0.00	0.01
	(0.02)	(0.02)	(0.02)	(0.02)
Left/Right party positions (s.d.)	0.05	0.05	0.08*	0.08*
	(0.04)	(0.04)	(0.04)	(0.03)
% female sponsors	0.00***	0.00***	0.00**	0.00*
	(0.00)	(0.00)	(0.00)	(0.00)
% newly elected sponsors	−0.00	−0.00	−0.00	−0.00
	(0.00)	(0.00)	(0.00)	(0.00)
% unaffiliated sponsors	0.00	0.00	0.00	−0.00
	(0.00)	(0.00)	(0.00)	(0.00)
Legislature duration (years)	−0.00	−0.01	−0.02	−0.02
	(0.01)	(0.01)	(0.01)	(0.01)
Parliamentary committees (number)			0.00	0.00
			(0.00)	(0.00)
Parliamentary committees (mean size)			0.00**	0.00**
			(0.00)	(0.00)
N	139	135	116	112
Adjusted R^2	0.43	0.37	0.57	0.53
Residual standard deviation	0.14	0.14	0.12	0.12

OLS coefficient estimates. Standard errors in brackets. $^{***}p < 0.001$, $^{**}p < 0.01$, $^{*}p < 0.05$

Table 2: Linear regression models of partisan modularity. The dependent variable is modularity computed against raw cosponsorship counts.

	W1	W2	W3	W4
Intercept	0.31	0.26	0.15	0.10
	(0.16)	(0.16)	(0.15)	(0.15)
Number of parties	−0.01	−0.01	−0.01	−0.01
	(0.00)	(0.00)	(0.00)	(0.00)
Number of bills / 1000	0.02	0.02	0.01	0.01
	(0.01)	(0.01)	(0.01)	(0.01)
Number of sponsors / 100	0.02*	0.02	0.01	0.01
	(0.01)	(0.01)	(0.01)	(0.01)
Network density	−2.18***	−2.23***	−2.02***	−2.09***
	(0.34)	(0.34)	(0.30)	(0.31)
Left/Right party positions (mean)	−0.01	−0.00	0.01	0.02
	(0.02)	(0.02)	(0.02)	(0.02)
Left/Right party positions (s.d.)	0.08*	0.08*	0.11***	0.11***
	(0.04)	(0.04)	(0.03)	(0.03)
% female sponsors	0.00***	0.00***	0.00*	0.00*
	(0.00)	(0.00)	(0.00)	(0.00)
% newly elected sponsors	−0.00	−0.00	−0.00	−0.00
	(0.00)	(0.00)	(0.00)	(0.00)
% unaffiliated sponsors	0.00*	0.00*	0.00	0.00
	(0.00)	(0.00)	(0.00)	(0.00)
Legislature duration (years)	−0.00	−0.00	−0.01	−0.01
	(0.01)	(0.01)	(0.01)	(0.01)
Parliamentary committees (number)			0.00	0.00
			(0.00)	(0.00)
Parliamentary committees (mean size)			0.00**	0.00**
			(0.00)	(0.00)
N	139	137	116	114
Adjusted R^2	0.41	0.40	0.58	0.57
Residual standard deviation	0.14	0.13	0.11	0.11

OLS coefficient estimates. Standard errors in brackets. $^{***}p < 0.001$, $^{**}p < 0.01$, $^{*}p < 0.05$

Table 3: Linear regression models of partisan modularity. The dependent variable is modularity computed against the weighted propensity to cosponsor.

- The relationship between ideological dispersion and partisan modularity is visible in all models. The average Left/Right party position does not appear to influence partisan modularity: according to that measure, rightwing-dominated legislative assemblies are not more modular than leftwing-dominated ones. However, when the ideological distance *between* parties increase, the propensity of MPs to cosponsor across party lines tends to decrease.

Taken as a whole, the model results confirm one of Sartori (1976/2005, p. 111)'s fundamental insights about party systems: party *segmentation*, measured here through the number of parties that participate to legislative cosponsorship during a legislature, is not equivalent to party *polarization*, measured here through the modularity of their network. Parliamentary chambers effectively vary on both dimensions, which makes the sheer number of political parties in parliament an insufficient indicator of how fragmented are the legislative politics of a country (Sartori 1976/2005, ch. 5).

This conclusion is illustrated in Figure 5, which show the predicted marginal effect of ideological dispersion among party positions on the modularity of the cosponsorship networks, while controlling for all other chamber, sponsor and party attributes listed in Section 4.4. As the standard deviation of Left/Right party positions increases, the modularity of their cosponsorship networks passes the average level of modularity in the sample, which is close to 0.45.[23] This effect lends strong support to the hypothetized influence of ideological distance over party cooperation: when that distance increases, decisions among MPs to cosponsor across party lines become less frequent.

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[23]When Austria is excluded, the mean network modularity in the sample is 0.46 using raw cosponsorship counts and 0.45 using the weighted propensity to cosponsor.
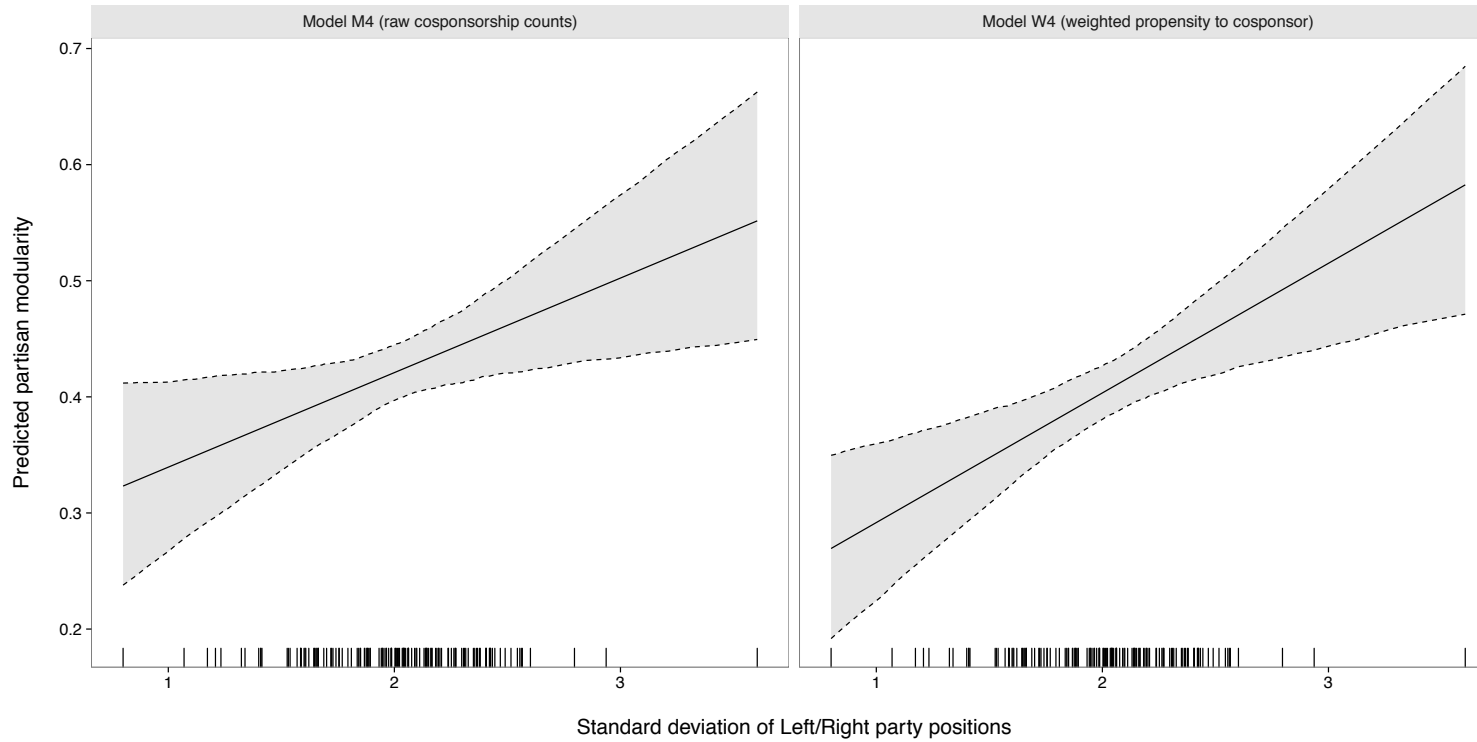
Figure 5: Partisan modularity as predicted by Models M4, which weights the dependent variable by raw cosponsorship counts, and W4, which weights the dependent variable by the weighted propensity to cosponsor. Both plots show the marginal variation of partisan modularity as a function of ideological dispersion, as measured by the standard deviation of Left/Right party scores in each parliamentary chamber.

6. Conclusion

This paper shows that some of the most fundamental assumptions about parties and party systems are measurable through quantitative means, using legislative information to determine the extent of party polarization in parliamentary environments. This paper further shows that the methods and techniques elaborated principally in the United States for the study of the U.S. Congress are empirically applicable to several European parliaments.

This paper, however, does not resolve several of the practical and methodological issues associated with the measurement of party polarization through network data. Most importantly from a data perspective, our results for Austria are highly likely to be caused by a network construction error, as the data appear to be truncated to only the first cosponsor of each bill introduced in the Austrian parliament. As a result, the exceptionally negative partisan modularity statistics estimated for Austria require to be corrected by correcting the underlying data for that country.

There are, furthermore, several methodological issues with the use of network modularity in comparative settings. Those issues are hinted at in our regression models: the very large coefficients estimated for network density clearly point to the intrinsic relationship between this network property on the one hand and network modularity on the other. Since using maximised modularity scores would only shift that problem from one measure of modularity to another, we have instead started exploring density-controlled measures of graph segmentation.

Last, our models are limited to legislature-level measurements, which should be seen only as first step towards exploring the bills data that we have collected. In future work, we plan to decompose the data by temporal periods, in order to measure possible effects associated with election years and MP incumbency in these elections. This step, however, will require using additional sponsor data that are not available from the data sources described in this paper, which leaves space for further research.

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