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ARTICLE

Does the Electoral Rule Matter for Political Polarization? The Case of Brazilian Legislative Chambers*

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This study explores the effects of electoral rules on political polarization in the legislative branch of government. Since in Brazil the districts are also the states, and senators are chosen according to the plurality-majority rule while representatives are determined by a proportional rule, the comparison between legislative chambers enables one to test whether the plurality-majority rule induces politicians to behave less moderately, and whether the proportional rule has the opposite effect. To estimate these effects, roll call data from 1988 to 2010 was analyzed and legislators' ideal points were estimated using *WNOMINATE*. Evidence in favor of the hypothesis was found, although not in every circumstance.

Keywords: Polarization; electoral rules; roll call vote; Wnominate.

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For replication, see bpsr.org.br/files/arquivos/Dataset_Bernabel.html
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This article explores the influence that particular electoral rules may have on political polarization. More specifically, the polarization in the legislative chambers, measured by the way legislators vote in roll calls. In this paper, I will explore how two different vote-counting rules affect the relationship between legislators and their parties. This relationship is understood by the concept of polarization. When the members of one party vote in one way and those of the other party vote in another way, and if this behavior is observed most of the time, then these two parties can be described as polarized. In a roll call vote, a legislator can either cast a "yea" or a "nay" vote. As this procedure is done repeatedly in one legislature, we can measure how similar, aggregated, or even polarized, are the members of two or more distinct parties. There can be many causes of polarization. In McCarty, Poole and Rosenthal (2006), the authors argue that income, immigration, and campaign finance affect polarization. Here I am going to argue that the method of counting the votes by which a legislator is elected can also have an effect on polarization. The relevance of such a study becomes noticeable when there is a redesign or reformation of an electoral system, to identify the practical consequences of different electoral rules. The seminal work on the topic is Duverger (1957), in which the author shows that a plurality-majority rule leads to political systems with two parties, whereas a proportional rule enables multi-party systems to continue their existence. However, the relationship between electoral rule and legislative behavior has not yet been fully scrutinized. If a plurality-majority rule leads to a less fragmented party system, it is reasonable to expect that the legislators of a party would behave in a more loyal way. This hypothesis is investigated in this paper.

Electoral rules are frequently analyzed with regard to their normative features, such as representativity and rationality. However, it is important to understand the practical consequences that a rule may have such as political polarization. The Brazilian case studied here is helpful to test the effect of two electoral rules on political polarization; plurality-majority and proportional rules. This paper will show that the members of Congress elected through the plurality-majority rule behave more extremely than those elected via the proportional rule, *i.e.*, they vote more often with their party. As will be explained presently, the

different electoral rules in Brazil take the same district and transform it into either a single or multi-member district.

The study of polarization in the U.S. Congress has gained scientific rigor with both the application of spatial models and the empirical estimation of ideology using large data sets. This confluence resulted in the ubiquitous mode of analysis enabled by algorithms like *NOMINATE* and *Optimal Classification*. In this study, an extension of *NOMINATE* called *WNOMINATE* is used. *WNOMINATE* takes the roll call records of legislators and two policy dimensions as input, calculates their proximity to each other, and returns the position of legislators in the policy space spanned by those dimensions. The two dimensions are fiscal and social ones, and they are constrained by the unit Euclidean circle. The algorithm normalizes the positions such that politicians that are conservative in both fiscal and social issues receive coordinates on the positive orthant. History, detailed theoretical explanation, as well as the application of this methodology to American Politics can be found in Rosenthal and Poole (2007) and McCarty, Poole and Rosenthal (2006)[1].

The U.S. Congress presents an added difficulty when comparing chambers though; the pool from which the subjects are drawn differs between the House and the Senate. The members of the House are selected from smaller districts, while members of the Senate come from the states. This is not the case with Brazil's Congress, and this feature is explored in this paper. Brazilian legislative elections on the federal level provide me with an institutional design well-suited to test the effects of two electoral rules on political polarization, namely the plurality-majority and proportional rules. The electoral features that enable this test to occur are: first, and most important, each state covers a single district only and there is no further division within it; and second, the electoral rules differ from one chamber to the other. Hence, the same district can be a single-member district in the Senate's case, and a multi-member district in the House's case.

[1] Further theoretical and empirical developments about the U.S. Congress and American Politics using the same approach are exemplified by Brady and Han (2004) and Shor, Berry and McCarty (2010).

Literature Review

The first two pieces of work on polarization were Rosenthal and Poole (1984), which looks into interest groups' classifications of legislator behavior, and Rosenthal and Poole (1985), which stated the use of roll call data directly via *NOMINATE*. The seminal work in polarization literature is Rosenthal and Poole (1997), revised as Rosenthal and Poole (2007). In this book the authors seek to understand the structure of congressional voting in the U.S., and to explain the political realignment in American history. The impact of committees and interest groups are also investigated. The main finding of this research is that American politics have had alternate times of polarization in the past, but that a strong and increasing polarization pattern has arisen in the last few decades. Among the exogenous causes of this phenomenon are income inequality and immigration. A study that claims different findings on polarization of American politics is Evans (2003). The author uses alternative statistical methods, along with survey data, to argue that American voters are not as polarized as legislators when it comes to economic issues, but the polarization of voters on moral issues is increasing[2].

In the present study I do not necessarily have the American case in mind, as I seek to unravel the existence of an institutional cause of polarization. My research approach is reversed; I posit an institutional cause of polarization and look for an empirical validation of the hypothesis. Also, I am interested in the behavior of the legislators only, and not of the voters. One previous study that links electoral rules and legislative behavior is Carrol and Eichorst (2013), where the authors show that the greater the competition, the higher the predictability of legislators' behavior. The findings in my study however could have arisen independent of the relationship in Carrol and Eichorst (2013). This is because it is possible to have electoral competition independent of the electoral rule. Admittedly and intuitively, one should expect greater competition correlating with greater number of parties, but this relation can be upside down. If there are two strong parties and no others, there must be more competition than a situation with one strong party and many electorally insignificant ones.

[2] Another different way of investigating polarization of legislators is via discourse and textual analysis; a good example is Cormack (2011).

The methodological foundations of the polarization research borrowed the Item Response Theory (IRT) from Psychology. In comparing attitudes among individuals towards similar questions, IRT provided a way of not only ordering subjects by their abilities or preferences, but also measuring the distance among those subjects. What political science researchers began to do then was to apply the IRT methodology to analyze and quantify ideological mappings, in Congress and Executive branches[3], first through the use of interest groups' ratings of politicians, and later through the use of roll call data via *NOMINATE*. (POOLE, 2005) provides technical work on this issue[4]. Here I use roll call data, which has become the standard way of investigating ideological mappings, for it is much more objective than interest groups' evaluations. An introductory tutorial of the methodology utilized in the classification of legislators using roll call data is Wiseman, Everson and Valelly (2008/2009), while Poole (1998) provides an intellectual—and as non-technical as it can ever be—recount of the origin and development of the *NOMINATE* family of methods. There remains only a few studies dealing with the topic of polarization in Brazilian politics. Leoni (2002) was the first study to bring the *NOMINATE* technology to Brazilian politics. The article describes the ideological map of parties in the House and the first three presidents after redemocratization, covering the 1991–1998 period. His results are in favor of a low dimensionality with the left-right spectrum explaining most of the legislative behavior. Morgenstern (2004) looks at the period from 1995 to 1998 and argues that the Congress has more power than the President when it comes to law-making. Desposato (2006b) studies the same legislatures as Morgenstern, but to test a party-switching model.

Zucco Jr. and Lauderdale (2011) use survey data to correct ideological mappings using roll call data, and find that there also exists a government-opposition cleavage in Brazilian congress, apart from the left-right dispute. Our research will encompass this issue when dealing with coalitions instead of parties. Desposato and Cunow (2011) use campaign contributions for the 2010

[3] For the classification of the Judiciary branch see Bailey (2007).

[4] It is noteworthy that all this literature has relied on the assumption that the appropriate distance to study decision theory is the Euclidean one. In Eguia (2012), the author claims that the Minkowski distance with $\delta = 1$ is better suited to describe utility functions. Let the vectors $x^1, x^2 \in \mathbb{R}^n$ represent the ideal points of legislators 1 and 2; the Minkowski distance between them is defined by $\|x^1 - x^2\|_\delta = (\sum_{i=1}^{n}(x_i^1 - x_i^2)^\delta)^{1/\delta}$.

presidential, gubernatorial, and congressional elections to estimate ideal points in Brazil. Their approach enables them to also grasp the ideology of the candidates who lost in the elections. They find mixed evidence of the impact of electoral rules on polarization. The first attempt to investigate the effect of electoral rules on polarization in Brazil was Desposato (2006a). In this study, the author uses a dispersion model to assess the legislators' behaviors on the Senate and the House. He finds no evidence of any impact of electoral rules on dispersion of legislatives of the same party, but only three legislatures were analyzed. This paper attempts to improve on that study by analyzing all the first six legislatures in the democratic period, and also by taking the coalitions into consideration. Mixed evidence of any impact of electoral rules on polarization is found. In Poole (2003) the author argues that Congress members in the U.S. die with their ideological boot on, i.e., once in office, they tend to remain close to their original ideological position throughout time. A similar study in the Brazilian case is yet to be done. Another possible research topic is to compare the polarization of legislators in state chambers with the ones in the federal chamber. A study of the polarization of state legislators in American states is Shor and McCarty (2011), one that could also be replicated for the Brazilian case.

Electoral Rules and Polarization

The Brazilian political system is more similar to the American one than to most of those in Europe, in that the presidential elections are separated from the congressional ones[5]. With regards to congressional elections though, Brazilian electoral rules vary according to the chamber. In Brazil, the district from which the representatives are elected is the same political territory as the state from which the senators are elected. In other words, the states are the districts. But in the elections to the Senate the plurality-majority rule is used, which means that the candidate with more votes is elected, as in a single-member district[6]. In the elections for the House, however, a proportional rule is used, *i.e.*, the state becomes

[5] For a different opinion about the similitudes and differences among the Brazilian,the American and the European systems see Limongi (2006).

[6] When there are two Senate seats in dispute we must call it a two-member district. Nonetheless, the theory and results that will be presented here rely more on the quantitative distinction between the electoral rules rather than on the qualitative ones, if any.

a multi-member district, and thence the representatives of that district, or state, are elected in accordance with the proportion of votes their parties receive[7].

The assignment to either one of the candidacies is a joint decision made by the candidate and the party; nonetheless, the party has the final authority in determining who runs for the office. From the candidate's point of view, there could exist a self-selection problem if either one of the offices was a better position than the other, as all candidates would want to run for that best position. From the party's perspective, however, a candidate should be assigned to an office according to his or her chances of winning the election, and their prospective behavior during incumbency. These issues are explored below in greater detail.

The Senate office is usually considered as a better position than the one in the House. Arguments in the favor of that are, first, the fact that the mandate is for eight years, compared with the four-year term in the House; and second, the total number of senators is less than 16% of the number of representatives, thus the senators' vote on a bill will likely be much more valuable. While there is no discrepancy between salaries, the senators do enjoy a larger sum of money to spend[8].

However, it is more difficult to obtain the party's nomination to run for the Senate, for there are only one or two seats per state per election, depending on the election year—every four years, either one-third or two-thirds of the Senate seats are open. In the House, all seats open every four years, and the seats per district vary from 08 to 70. These numbers follow a distorted proportionality with regard to the states' populations[9]. Furthermore, each party can launch only one candidate

[7] In Brazil the system is that of an open list, in which the voter votes for the party, but can also vote for a particular candidate on the list, determining then the final ordering. The other proportional rule system is that of a closed list, in which the party orders the candidates and the voter cannot cast a vote for a particular member of that list; more precisely, the voter does not influence the final ordering.

[8] This, and other information about the costs of Brazilian government, in all three branches in the federal level, can be found in www.transparencia.org.

[9] Although somewhat proportional, seats per state are limited from below by eight, and limited from above by 70. By way of example, Roraima, a low-populated state, counted in 2002 with roughly 208,000 voters and eight seats, while São Paulo, the most populous one, counted with roughly 26 million voters and only 70 seats. If São Paulo were to have the same proportion of seats as Roraima did, it would have had 984 seats. This distortion is not immediately relevant for policy-making though. The legislative behavior is, for the most part, partisan, and not divided statewise. Representatives vote partywise more often than statewise, even if the policy is not beneficial to its state. These results can be found in

per seat for the Senate, but 50% more candidates than the number of seats for the House. Re-election works exactly as in the Senate, *i.e.*, the incumbents can remain in office for an undetermined number of terms.

Moreover, there is one feature that has not been taken into consideration in this discussion; the ability to vote with the party. Note that for a politician who is not a head of a party, his or her power in determining the party's agenda is small. Therefore, if the politician's policy preferences are not exactly the same as the party ones, there will be a cost, in terms of effort, for the politician to support the party's exact agenda. The partisan behavior then will be a function of the distance between the politician and the party, and the value he places in policy and office-holding. If someone places more value in the office than in the policy, then it will be easier for him or her to follow the party, holding fixed the ideological distance between the party and the politician. Conversely, if the value placed in the office is held fixed, then the closer the party and politician are ideologically, the easier for him to vote with the party. This will be an important issue, as we will see presently, for the party will expect a "better" behavior from the senators than from the members of the House.

Hence, when a politician is deciding on the type of nomination to procure, it is not clear whether the present expected value of a seat in the Senate is always greater than a seat in the House, *i.e.*, whether it is the case that for every politician it is better to try to run for the Senate than the House[10]. As I will show presently,

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Mignozzetti, Bernabel and Gaudino (2011). In this work a Monte Carlo simulation was run using *WNOMINATE* estimates, where the representational proportions were corrected and the new seats were filled with the proportions each party had previously. The malaportionment might affect policy-making but the effect is mediated by a correlation between state and popular vote for the parties.

[10] This cost/benefit relation is then blurred because the problem is pushed to an individual level and not the aggregated one. Such a micro-causation reasoning will remain black-boxed in this study because we are more interested in the aggregated effect of electoral rules *per se*, and not in individual evaluations of office and policy. What matters for the present study is that different rules select different behavior. One can also estimate an expected utility function to test the hypothesis that the seats in the Senate are more attractive. A possible model to start with could take the senator's eight-year salary and multiply it by the probability of being nominated to run for the office and the probability of winning the election, all this multiplied by the party's expectation of loyalty and, finally, multiplied by the inverse of the ideological distance between the prospective candidate and the party. For the expected utility of a House seat, one could take the four-year salary of a representative and multiply it by the probability of securing nomination by the party and the probability of being elected, all this multiplied by the party's expectation of loyalty

the different offices appeal differently to distinct candidate types, according to their ability to fulfill the party's expectations.

From the point of view of the party though, a seat in the Senate is much more valuable than one in the House. One vote in the Senate counts $\frac{1}{81}$ of the total votes, while one vote in the House counts only $\frac{1}{513}$. It is true that when the party's heads are deciding among persons to nominate as candidates, they must seek to maximize their vote-counting. Taking only this rationale into consideration, a more notorious, powerful, and experienced politician should have precedence in running for the Senate. However, winning features are of no help if the candidate, once elected, turns his back on his party and votes with the opponents. In this way, it is fundamental that the party trusts someone before giving him the opportunity to run for the Senate seat. Note that a defection by a House member would be less problematic for the party, since there are other representatives from the same party to pursue the party's agenda in the House. Moreover, the popularity of a candidate affects the composition of the House more than that of the Senate. This is because a popular candidate in a party list helps in securing the election of more candidates of the same party or coalition.

Therefore, the electoral rule may be the very mechanism through which confidence and loyalty bounds are tied together; in other words, the channeling of polarization may be influenced by the electoral rule. Suppose that for any reason, a politician secured his indication as candidate. Once in office, the candidate should reciprocate by voting with his party, in order to ensure that in the next election, the party will enable him to defend his seat. Hence, it can very well be the fact that as a more restrictive procedure, the plurality-majority rule used in the election to the Senate induces more partisan behavior. Of course, a person can be loyal to a party before even becoming a candidate, and this loyalty must be a crucial factor, among others, that induces the party to provide him with the opportunity to run for office.

This framework resembles the screening problems in which a principal offers a menu of tasks with different levels of difficulty, and the agent self-selects for a task according to his ability. Here the two tasks would be the run for a seat

and, finally, multiplied by the inverse of the ideological distance between the prospective candidate and the party. It is not within the scope of this work to run this estimation.

and the appropriate behavior as an incumbent in the Senate and the correlation for the House. The candidate would then evaluate not only his characteristics like previous popularity and partisanship history, but also how he would behave once in the Senate or House. As a defection in the House is less harmful than one in the Senate, the assignment of a candidate to run for the House can be termed as a lower task; and one for the Senate a higher task.

Once elected, any politician should abide by the re-election rationale mentioned above. The final test between the pre- and post-election effects could be conducted by estimating how the same person behaves in the House and in the Senate. This task is left for a future study.

The same re-election logic does not work as well for the House though, because a good candidate can bring benefits to the party even without being loyal. As the electoral rule for the House is proportional with an open list, a strong candidate may pull some other winners with him, and his vote will also count for a smaller fraction of the total. It therefore follows that even if this same candidate should misbehave in his seat, the party could internalize this cost, for the representative could again bring more elected candidates with himself the next time round.

Finally, it is noteworthy that this paper is attempting to solely measure the effect of a cause. Many other processes and variables concur to explain legislator behavior. However, it is not my intention to make thorough predictions about legislative decision-making. The idea is simply to elucidate first a qualitative finding—the existence of an influence of the electoral rules on the polarization of the legislative bodies—and then make an attempt to quantify that effect. One study that would walk alongside this one is Neiva and Izumi (2012). One finding in that paper is that senators substitute votes more in line with the Executive branch. These phenomena dwell under the party-discipline type of events. Another study of this kind is Melo and Batista (2012). Focusing on the higher chamber—and this is the novelty on the paper—the authors claim that party discipline in the Brazilian Senate compares with that of the House. These processes could, for instance, lead to increased polarization in the legislature.

Data

The case study explored in this paper was produced using roll call data from 1989 to 2010 collected and generously shared by the Brazilian Center for Analysis and Planning (CEBRAP in its Portuguese acronym). This dataset covers a large part of the new democratic period, which began with the new Constitution and presidential elections in 1989. Another novelty in this paper is the fact that roll call data from the Senate was analyzed for the purpose of investigating polarization, which had not been done in previous studies. Elections to Congress occur every four years. A total of 513 representatives are elected for a four-year term, and either 54 or 27 senators are elected for an eight-year term. Some members of Congress leave before completing their terms because of reasons such as taking an office at the Executive branch, running for governor, or being expelled from Congress by its colleagues in a political judgment. Hence, during each legislature, there may be more than 513 representatives and 81 senators. In the period studied, the House had 1,958 representatives and the Senate had 273 senators. The House members voted on 1,611 roll calls, while the senators voted on 752 roll calls. On a roll call vote, the legislator is required to cast a vote, which is recorded, but this is not necessarily the case with other types of procedures. As an example, votes in a voice vote are counted but not recorded, while in a proxy vote, a legislator tells another to vote for him. In extreme cases, only the leaders of the parties would vote, and the votes of the regular legislators are assumed to be in accordance with one cast by the parties' leaders.

Most bills start in the House and if approved, go on to the Senate. If the Senate approves the bill, then it becomes a law. If the Senate makes modifications, it goes back to the House and has to be voted on again[11], which explains why the House has more roll calls than the Senate.

The empirical test

The empirical test proposed here does not have a control group *per se*, for any electoral rule could be seen as the treatment. Hence, this is a study where there are actually two different treatments; the plurality-majority rule and the proportional one. For the sake of clarity though, the plurality rule is denominated

[11] See the Brazilian Constitution, article 65.

as the treatment and the proportional rule as the control. Hence, the legislators in the Senate are considered as the treatment group and the legislators in the House are considered as the control group.

The legislatives' behavior is explored in terms of ideal points, a measure of distance among them as estimated by *WNOMINATE* package in *R*[12]. The *WNOMINATE*'s ideal points calculated here are two-dimensional, and lie in the unitary circle as seen in Figures 01 and 02. The estimates displayed in Tables 01 and 02 are the only ones in the first coordinate; this coordinate represents the economic dimension[13]. A left-wing legislator, or in the case of this study, party, will probably lie in the [-1,0] interval. Conversely, a right-wing legislator or party should lie in the [0,1] interval. Once each legislator's points in the coordinates are estimated, the comparison is straightforward. One can look to the aggregated ideal points and see whether the treatment has a significant effect on polarization, *i.e.*, whether the estimates for a left-wing party are further to the left in the Senate than in the House, and whether the estimates for a right-wing party are further to the right in the Senate than in the House. It's important to mention that the algorithm's output is simply a map, stripped of any inherent ideological content. What gives one power to interpret the estimated coordinates with confidence is the fact that I input ideology on it prior to the estimation. The *WNOMINATE* function in the *R* package requires the researcher to pin down the dimensions by selecting a legislator who is notoriously a social and fiscal conservative. With this information, the algorithm returns dimensions that are aligned with ideology. The process would work fine if I used a social and fiscal liberal legislator, but the estimates would come out inverted. One could alternatively "create" a coalition/opposition dimension, and this could explain some legislative behavior. However, the fact that the analysis in this paper found very good estimates using the algorithm in its original mode provides us with greater confidence in the validity of the method.

Four estimations were run for each chamber separately. First, the means of the clustered parties' ideal points over the whole period were estimated. Then, those means were disaggregated by legislature. Third, the legislators were

[12] A good reference on the measurement methods and software is found in Poole (2005). The reference for the *WNOMINATE* package is Lo (2007).
[13] The second dimension represents where the legislator or party dwells in the social liberal-conservative spectrum.

aggregated according to the coalitions to whom they belonged, *i.e.*, they were either members of the government coalition or not, and the effect was estimated for the whole period. Finally, the coalitions' behavior was estimated for each legislature separately. The estimations were run for every member of the Congress, and thence everyone participates in the results for the coalitions. However, the results for the parties cover only the main parties; Worker's Party (PT), Social Democracy (PSDB), Liberal Front (PFL-DEM), and Democratic Movement (PMDB)[14]. After its redemocratization, Brazil had more than two dozen parties with representation in the Congress, but the four mentioned above count for roughly 60% of the Congress members. Among these main four, PT has always been the furthest to the left while PFL-DEM the furthest to the right. PSDB shifted in 1995 from the center-left to the center-right, and has maintained this position until now. PMDB shifted from the center-right to the center-left in 2003, and has since remained so.

Hypothesis

The set of hypothesis derived from the theory and to be tested are as follows:

01. The party's mean ideal point for the senators lies to the right of the party's mean ideal point of the representatives, for a right-wing party;

02. The party's mean ideal point for the senators lies to the left of the party's mean ideal point of the representatives, for a left-wing party;

03. The coalition's mean ideal point for the senators lies to the right of the party's mean ideal point of the representatives, for a right-wing coalition;

04. The coalition's mean ideal point for the senators lies to the left of the party's mean ideal point of the representatives, for a left-wing coalition.

The ideal experiment to test whether the electoral rule affects legislator behavior would require the same legislator to be elected for both chambers at the same time, through different electoral rules, and voting on the same bills. This is probably not how most parliamentary bodies throughout the world work, and certainly it is not so for the Brazilian case. Moreover, even if such fiction were fact,

[14] The acronyms PT, PSDB, PFL-DEM, and PMDB stand respectively for Partido dos Trabalhadores, Partido da Social Democracia Brasileira, Partido da Frente Liberal-Democratas e Partido do Movimento Democrático Brasileiro.

there would still exist a remaining problem; the stable unit treatment value assumption would be violated. Note that the behavior a legislator would present in a chamber could, and probably would, be correlated with his behavior in the other chamber. It is unlikely that a person would vote differently on the same issue, at the same time, just because the bill was voted on in different chambers. Therefore, we would face an influence of treatment on control group, or vice-versa.

An alternative would be to compare the behavior of the legislators who transit between the chambers across time. It is not unusual to have House representatives elected for the Senate. One problem with this design is that the legislator would face different bills once in different chambers, for he would be a member of the chambers at different times, and the bills are usually voted on during the same legislative period. Also, the problem of correlated behavior mentioned above would persist. Aside from these problems, such a dynamic estimation can be performed, with the use of *DW-NOMINATE*, for example. *DW-NOMINATE* can estimate the individual legislator's behavior across time; the algorithm is not openly available though.

With the impossibility of a natural experiment, the identification strategy relies on the Brazilian electoral and legislative design. Remember that for electoral purposes, only the electoral rules distinguish how legislators are elected for the different chambers. This means that the district and the state are the same thing, and there are no demographic confounders in the analysis, for senators and representatives from the same state face the same constituency.

Moreover, every bill has to be voted on in both chambers in order to become law, and if one chamber makes amendments to a bill, these changes also have to be voted on in the other chamber. Hence, it is not the case that polarization occurs because of the kind of issues raised in the different chambers. These characteristics provide us with a suitable environment to test the effect of the electoral rules on polarization. Evidently, a better test would have legislators being randomly assigned to run for an office across different chambers. However, if there is a selection problem in the sense that one type of legislators select itself, or is selected by the party, to one of the chambers while another type is assigned to another chamber, this does not necessarily invalidate the hypothesis that the electoral rule is the polarization mechanism. If these types of legislators are in

some manner correlated with the electoral rule, then the hypothesis remains sound. This possible mechanism will last black-boxed until data is gathered on possible causes of selection bias; for example, seniority in the party, previous loyalty, popularity, and economic power. Such a dataset is however not yet available.

Results

The main hypothesis tested in this study is that the Senate treatment, *i.e.*, the plurality-majority rule, has a positive effect in causing polarization. Two sets of strategies were used to estimate the effect of electoral rule on polarization: the aggregated effect in the whole period and the effect separated by legislature. Within these two sets, a further division is made in taking either the four main parties individually, or the coalitions they formed. The party's or coalition's ideological mean was estimated using *WNOMINATE*. This algorithm takes roll call data to order legislators relatively to their peers. Even though the different sorts of bills that are voted constitute a multidimensional space, it is usually the case that the behavior of legislators on any bill is predictable by one or two dimensions; the economic and social ones. The accuracy of these predictions will appear presently. More than ordering the legislators, *WNOMINATE* estimates the Euclidean distance among them in two dimensions, and in this way every individual is located on a unit disc. For the numerical analysis that follows, only the legislators' coordinate in the first dimension was taken into consideration. The first dimension, the economic one, describes how legislators locate on the usual left-right spectrum, and is the most explicative, or predictive, dimension. This means that the behavior of a legislator in this dimension can be used to predict how the same legislator is going to vote in other dimensions. For the sake of rigor, one may say that in this study, polarization is being investigated in terms of the economic spectrum. There is evidence that the main hypothesis is true, *i.e.*, the plurality-majority rule has a positive effect on polarization, although not all of the findings are unequivocal in confirming this.

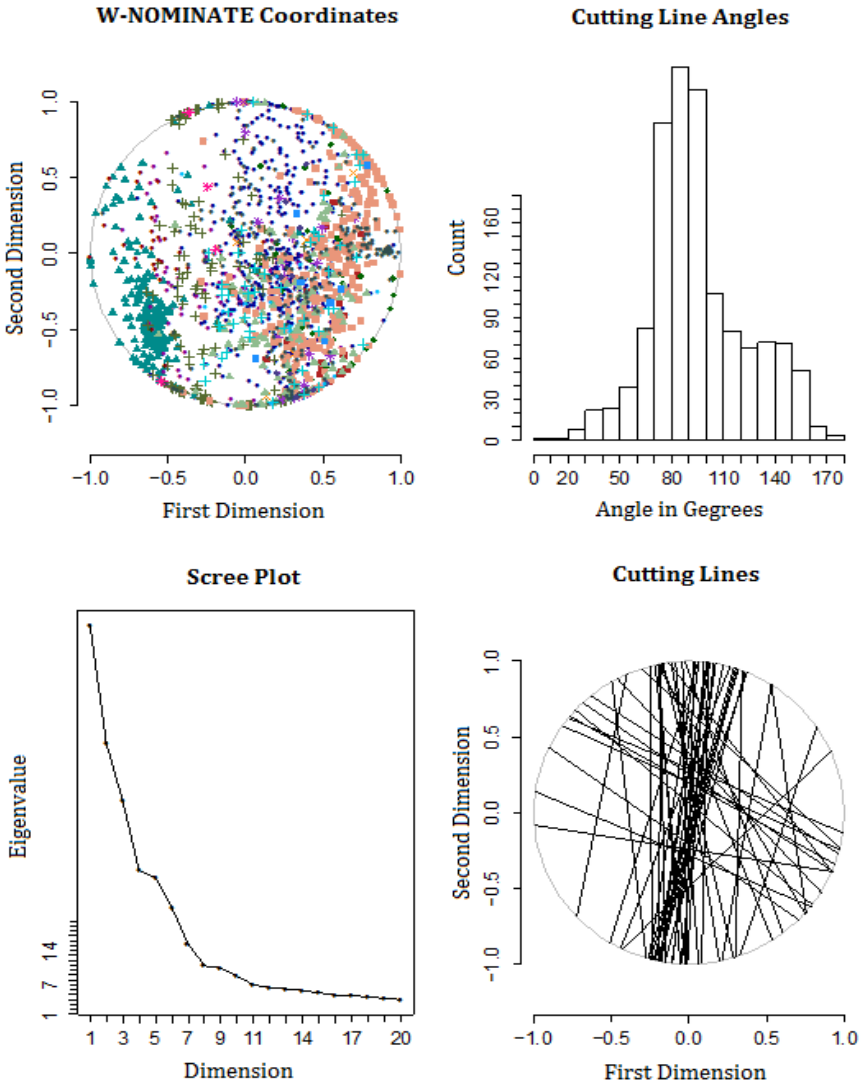
Aggregated effect for parties

Figure 01 is a graphical summary of the calculations for the House in the 1989–2010 period. The "coordinates circle" contains the disposition of the

members of the House with a different symbol for each party. PT is represented by the green triangles, PSDB the green circles, PFL-DEM the orange squares, and PMDB the blue circles. Note that PT members are dispersed on the left, PSDB and PMDB members somewhat on the center, and PFL-DEM members on the right. This is just a descriptive plot to help the visualization of legislators in the ideological space. Because the number of representatives is much larger than that of senators, a comparison between the coordinates shown on Figures 01 and 02 is not sufficient to test the hypothesis. The plot showing cutting-line angles indicates that the first dimension is well-suited to explain the cleavage in the House, *i.e.*, most of the bills separate legislators in the economic left-right spectrum. This plot just shows the distribution of cutting lines. We can see the cutting-lines plot below, and an explanation will be given presently. The screen plot shows the factor analysis in which gains in explanation are still to be obtained when we increase the dimensionality of the legislatures in the model. In contrast to U.S. legislatures, Brazilian legislatures present a higher dimensionality, for the line flattens out only after the eighth value. At each value on the horizontal axis, the value on the vertical axis shows the gain in explanation moving away from the previous dimensionality. We can see that substantive gains in explanation can be achieved using two dimensions instead of one, or four instead of three, for example. After the eighth dimension no significant gain is obtained. Still, for the purposes of this study, this higher dimensionality does not represent a threat, since finding polarization on the first dimension will already evince confirmation of the hypothesis. Finally, the cutting lines displayed are a random sample of how legislators were separated in the roll calls, and we can again see that most of them separate legislators in the first dimension. As the Euclidean distance is used, these lines are the separating hyperplanes in two dimensions[15]. Note that superimposing the cutting lines plot on the coordinates plot results in the separation of PT members and PFL-DEM ones. Even the more horizontal lines separate these two sets of legislators, which indicates that among the four main parties in Brazil, PT is the most fiscal and social liberal party, while PFL-DEM is the most fiscal and social conservative one.

[15] A *hyperplane* $H_a^\alpha \in \mathbb{R}^n$ is the set of points $\mathbf{x} \in \mathbb{R}^n$ such that $\langle a, x\rangle = \alpha$, with $\boldsymbol{\alpha} \in \mathbb{R}^n$, and $\alpha \in \mathbb{R}$; *i.e.*, $H_a^\alpha = \{x: \langle a, x\rangle = \alpha\}$. The hyperplane H_a^α *separates* two sets $\mathbf{X}$, and $\mathbf{Y}$ if for every $\mathbf{x} \in \mathbf{X}$, $\langle \mathbf{a}, \mathbf{x}\rangle \geq \alpha$ and, for every $\mathbf{y} \in \mathbf{Y}$, $\langle \mathbf{a}, \mathbf{y}\rangle \leq \alpha$.

Figure 01. House of Representatives 1989–2010

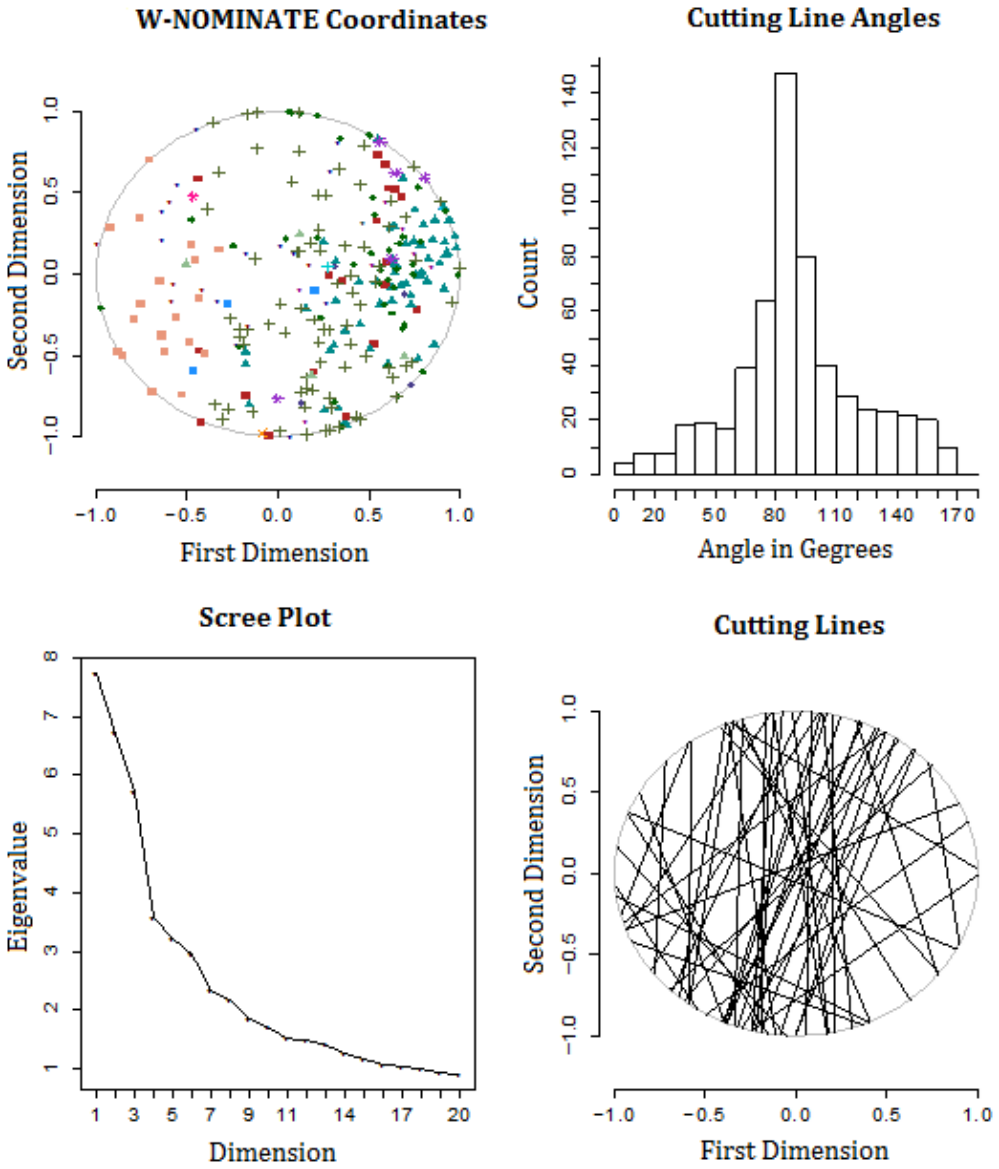


Source: CEBRAP, Banco de Dados Legislativos.

WNOMINATE applied to the 1,858 legislators and 1,611 votes in the House from 1989 to 2010 have a Correct Classification of 89% of the votes in a single-dimension linear model, and 90% in a two-dimension linear model. This means that the model correctly predicts how a legislator is going to vote. When using only one dimension the model is wrong in only 11% of the predictions, and 10% when using two dimensions. There are two more technical measures that should be reported; the *APRE*=0.55 and *APRE*=0.59 for one and two dimensions respectively, and *GMP*=0.76 and *GMP*=0.79 going from one to two dimensions[16].

[16] The Aggregate Proportional Reduction in Error (APRE) explains the behavior of legislators who voted with the minority. This measure is defined by

Figure 02. Senate 1989–2010



Source: CEBRAP, Banco de Dados Legislativos.

$$APRE = \frac{\sum_{j=1}^{q}(minority\ vote - classification\ errors)_j}{\sum_{j=1}^{q}(minority\ vote)_j}$$

Here the results are 0.55 and 0.59 in one and two dimensions, respectively. An APRE equal to zero means that the model does not explain anything, while an APRE equal to 1 means that the model provides a perfect classification. The Geometric Mean Probability (GMP) demonstrates whether the overall classification is accurate, with the model being better than an educated guess. In other words, a fair coin toss would correctly predict half of the time how a legislator would vote, and the GMP shows whether the model is better than a fair coin toss. Formally, following Poole (2005), we have that:

$$"L = \sum_{i=1}^{p}\sum_{j=1}^{q}\sum_{\tau=1}^{2} C_{ij\tau} ln P_{ij\tau},$$

where τ is the index for Yea and Nay, $P_{ij\tau}$ is the probability of voting for choice τ, and $C_{ij\tau} = 1$ if the legislator's actual choice is τ, and 0 otherwise". Then we have

$$GMP = e^{L/pq}.$$

dimensionality is small.

Figure 02 shows a similar picture for the Senate. Now the orange squares represent the PT, the green diamonds are the PSDB, the green triangles the PFL-DEM, and the green crosses the PMDB. Again, the coordinates, cutting line angles, and cutting lines plots show that the first dimension does a good job in separating legislators that behave in a polarized way. In the same period, for 273 legislators and 752 votes in the Senate, the Correct Classification in one and two dimensions are 88% and 89% respectively, the APREs are 0.44 and 0.46, and the GMPs are 0.74 and 0.77.

Table 01. Party-clustered effect (1989–2010): 1^{st} coordinate mean

	Party			
	PT	PSDB	PFL-DEM	PMDB
House	-0.60	0.36	0.51	0.21
	(0.19)	(0.37)	(0.25)	(0.25)
Senate	-0.63	0.43	0.60	0.24
	(0.17)	(0.39)	(0.29)	(0.33)
t-test: Senate – House				
sample mean	-0.03	0.11	0.10	0.02
95% C.I.	(-0.07 , 0.00)	(0.04 , 0.18)	(0.06 , 0.14)	(-0.02 , 0.06)
p-value	0.09	0.00	0.00	0.42

Source: CEBRAP, Banco de Dados Legislativos.
Note: Cells show *WNOMINATE* mean aggregate estimates with standard error in parenthesis.

Table 01 shows the first coordinate estimates for the parties' aggregated means, taking the whole period of study into account. All of the estimates are as expected. PT's coordinate for the Senate is to the left of its coordinate for the House, and for all the other three parties, the coordinate for the Senate is to the right of the coordinate for the House. Remember that PMDB was a center-right party for the majority of the time period considered in the study, so it is reasonable that it would receive positive coordinates estimates.

A *t-test* was run with the null hypothesis being that there was no increase in the "extremeness" in the legislators' behavior in the Senate compared to the House. The increase in the polarity was found to be statistically significant with a 95% level for PSDB and PFL-DEM, with a 90% level for PT, and statistically insignificant for PMDB. This statistical analysis therefore presents evidence that legislators in the Senate are more polarized than in the House, and therefore hypotheses 01 and 02 are not falsified by these results. These results become

blurred, however, when parties are disaggregated by legislature and also when studying the coalitions instead of parties.

Time series for parties

The effect of each separate party in each legislature is explored below. There were six legislatures in the period studied, two chambers, and the categorization party/coalition. Hence, there are 24 sets of estimates. In practically all of them, the Correct Classification is around 90%, the APRE is 0.6 and the GMP is 0.75. The exception is with the Senate, where the APRE for the years 1991–1994 is around 0.2.

Figures 03 to 06 display the behavior of each party separately, in the House and in the Senate. They cover all the legislatures since redemocratization, excluding the two most recent ones[17]. The previous result remains unequivocal to the behavior of legislators from PT only. In every legislature, the senators from PT were more polarized than their colleagues in the House, *i.e.*, the PT's coordinates in the Senate are to the left of the PT's coordinates in the House[18]. The hypothesis is verified for PSDB in the first three legislatures only, and fails for the last three. PFL's behavior was in accordance with the expectations in the periods 1989–1990 and 1999–2002 only. Finally, PMDB demonstrated more polarized behavior in the Senate in 1995–1998, 2003–2006, and 2007–2010.

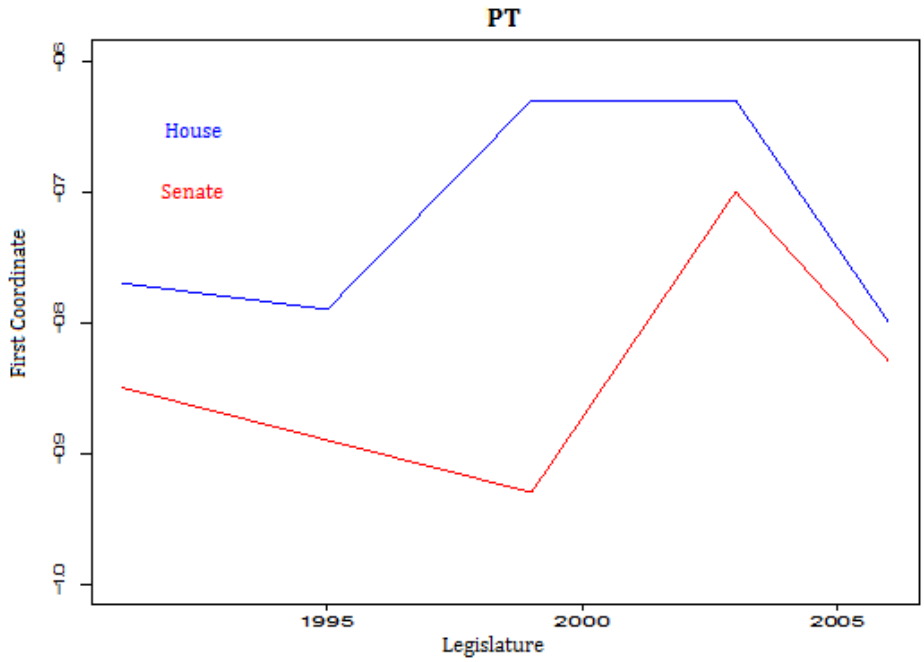
As a simple measure of success of this hypothesis, the instances where the polarization was as expected were counted and divided by the opportunities to be as expected, *i.e.*, the number of times a party behaved as it "should" was added and divided by the total number of possible times a party could have behaved as it "should". Consequently, out of 23 opportunities to corroborate the claim, 13 successes were observed; a 56% rate of success. Separating this by parties' orientations, the right-wing parties had 14 opportunities and the polarization in the Senate was higher in only four instances. It is noteworthy though, that for the

[17] In 1986, the 48^{th} legislature was elected with the main task of writing the current Constitution. That was done in 1987–88, the presidential elections took place in 1989, and the first directly-elected president since 1961 began his mandate in March 1990. The data set keeps records from the roll calls since 1989, the year the Constitution entered into force.

[18] PT had no senator in the 1987–1990 legislature, so a comparison is not possible for that party in this period.

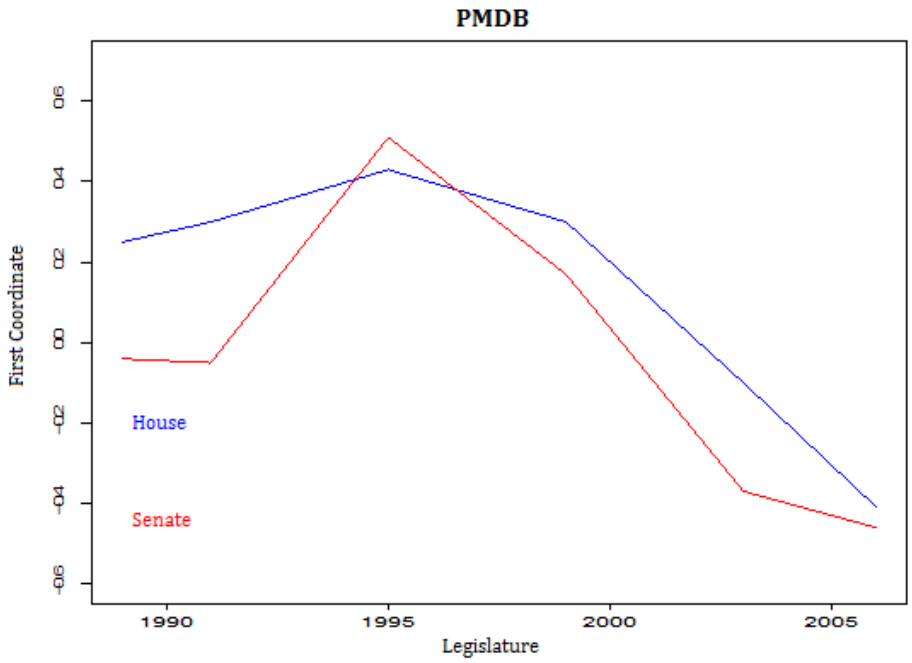
left-wing parties, the behavior was in accordance with the hypothesis in all nine opportunities. This may indicate that there is a heterogeneous treatment effect that influences the legislator's behavior more strongly when he is a member of a left-wing party.

Figure 03. PT parliamentary behavior in Congress 1995-2010



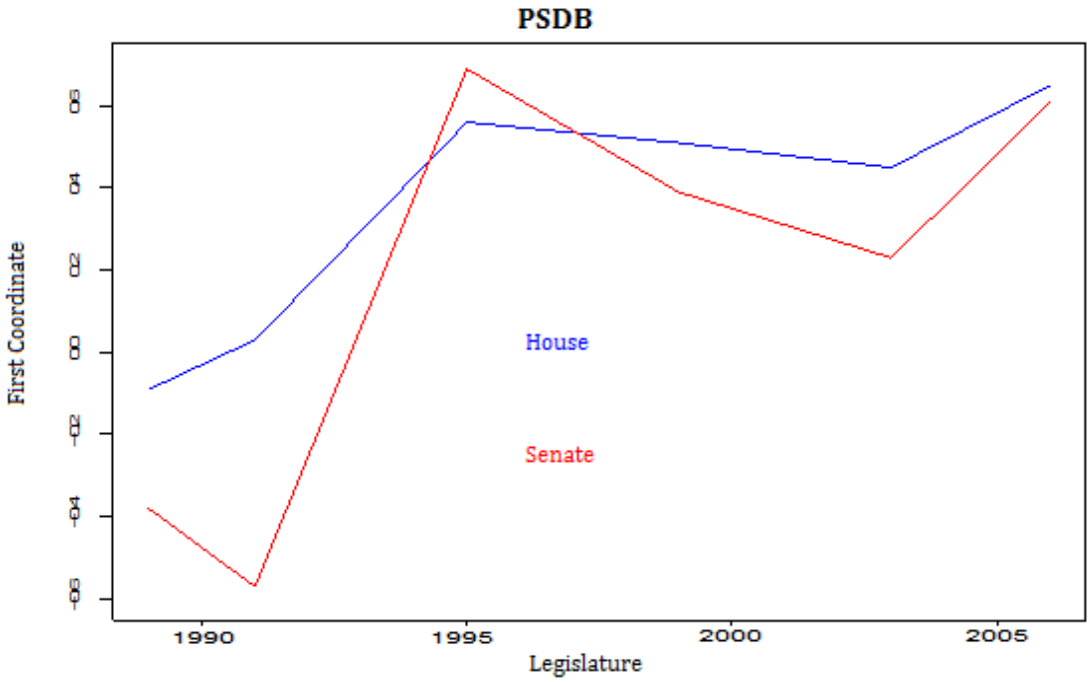
Source: CEBRAP, Banco de Dados Legislativos.

Figure 04. PMDB parliamentary behavior in Congress 1995-2010



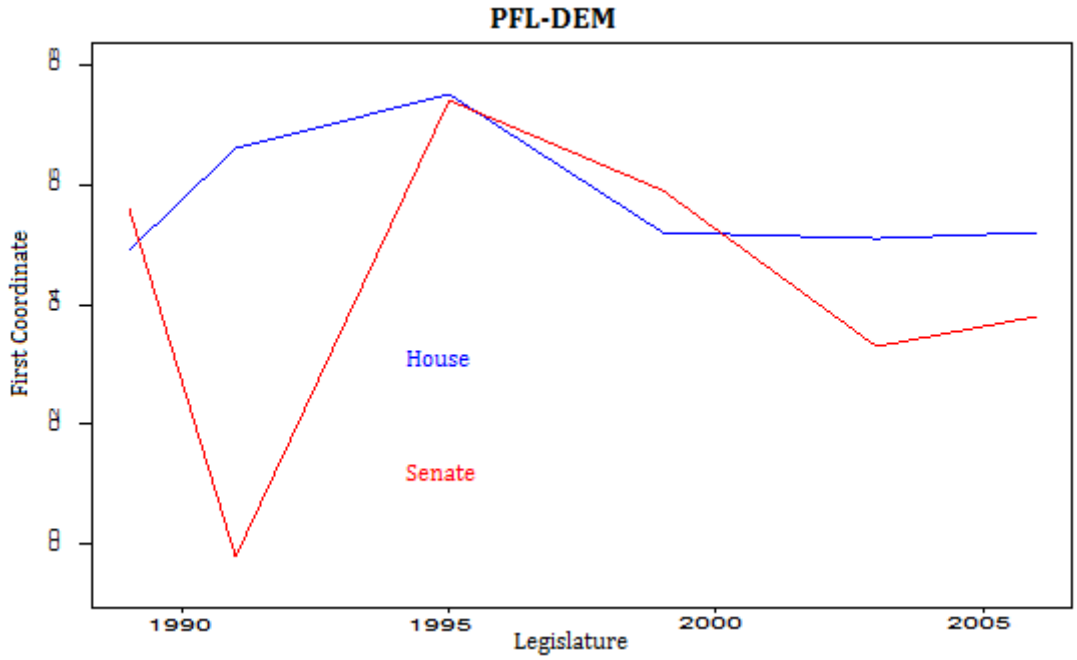
Source: CEBRAP, Banco de Dados Legislativos.

Figure 05. PSDB parliamentary behavior in Congress 1995-2010



Source: CEBRAP, Banco de Dados Legislativos.

Figure 06. PFL-DEM parliamentary behavior in Congress 1995-2010



Source: CEBRAP, Banco de Dados Legislativos.

Aggregated effects for coalitions

Although a presidentialism, Brazil presented so far somewhat parliamentary dynamics in the Congress. Given the multiparty system, the

presidents had to gather votes in Congress beyond their own parties in order to pass their legislative agendas. Hence, every government had to form a coalition; one can then separate the legislators as in a two-party system.

The coalitions were recorded in the data set as government and opposition, and not as the left and right *per se*. However, one can use the ideological orientation of the president to label each coalition. As shown in Leoni (2002), the first three presidents since the comeback of direct elections; Fernando Collor, Itamar Franco and Fernando Cardoso had *WNOMINATE* coordinates to the right in the left-right spectrum. The last president in the period studied, Luiz da Silva, was a member of the House in 1987–1990, and his *WNOMINATE* coordinate calculated during this period is -0.96. The president during the democratic transition was José Sarney, who then became a senator, and his first coordinate in the period 1991–1994 is 0.15. Hence, the first three government coalitions, covering the 1989–2002 period, were classified as right-wing coalitions, and the last two, covering the 2003–2010 period, were classified as left-wing ones[19].

First, the estimation used all the coalitions in the period studied, *i.e.*, not separated by legislature. The *WNOMINATE* single-dimension linear model applied to the House presented a Correct Classification of 89%, an Aggregate Proportional Reduction in Error of 0.55 and a Geometric Mean Probability of 0.76. For the Senate the respective values are 91%, 0.60, and 0.79.

Table 02 shows that the right-wing coalitions are more polarized in the Senate than in the House, according with hypothesis 03, but hypothesis 04 is not confirmed, *i.e.*, left-wing coalitions are not more polarized in the Senate than in the House. The *t-test* states that the difference in the polarization is statistically significant at the 95% level in the right-wing case, and at 90% level for the left-wing coalitions. Interestingly, the broad result is somewhat inverted when the estimations were run with disaggregated legislatures.

[19] Itamar Franco was Fernando Collor's vice-president and took the office in the period 1992–1994 after a presidential impeachment. Fernando Cardoso was president from 1995 to 2002, and Luiz da Silva held office from 2003 to 2010.

Table 02. Coalition-clustered effect (1989–2010): 1^{st} coordinate mean

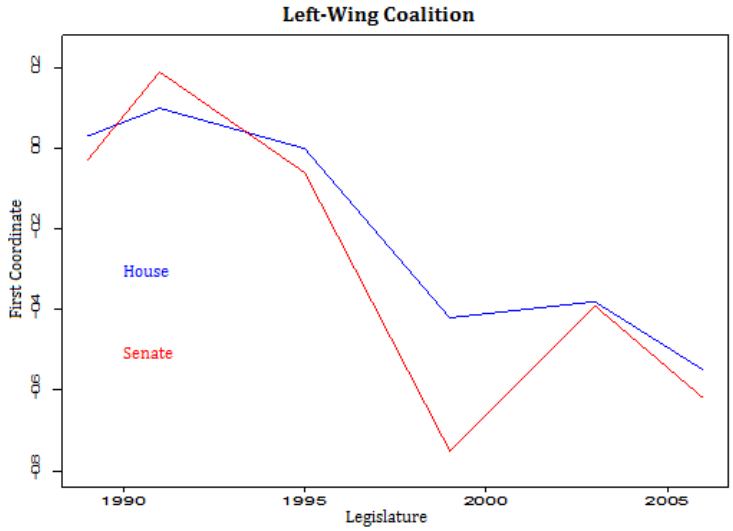
	Coalition	
	Left	Right
House	-0.08	0.36
	(0.45)	(0.30)
Senate	-0.04	0.43
	(0.52)	(0.35)
t-test: Senate – House		
sample mean	0.05	0.06
95% C.I.	(-0.01 , 0.10)	(0.03 , 0.10)
p-value	0.09	0.00

Source: CEBRAP, Banco de Dados Legislativos.
Note: Cells show *WNOMINATE* mean aggregate estimates with standard error in parenthesis.

Time series for coalitions

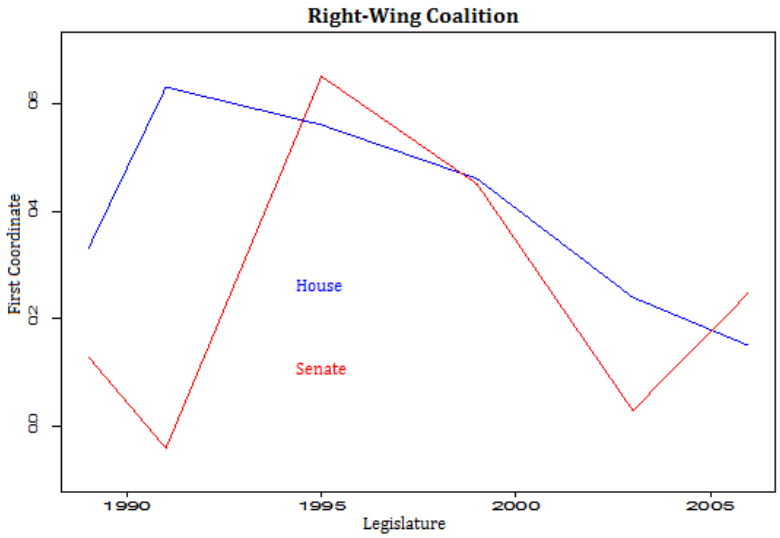
Figures 07 and 08 display the legislators' behavior aggregated by coalitions and disaggregated by legislature. Here, the members of left-wing coalitions are more polarized in the Senate than in the House. It should be noted that this has not been verified for the 1991–1994 period only. Conversely, the right-wing coalition is more polarized in the Senate in only two occasions; 1995–1998 and 2006–2010. The odd behavior observed in the 1991–1994 period by the left-wing coalition, with positive coordinates, and by the right-wing coalition in the Senate, with negative coordinates, may be explained by the politico-institutional crisis that took place in 1992, when corruption scandals resulted in a loss of support for the president in the Congress, culminating with his impeachment.

Figure 07. Left-wing government coalitions parliamentary behavior



Source: CEBRAP, Banco de Dados Legislativos.

Figure 08. Right-wing government coalitions parliamentary behavior



Source: CEBRAP, Banco de Dados Legislativos.

Conclusion and future research

Political polarization is an important issue in American and European politics, and has been under scholarly investigation for some time now. It also appears to be an increasingly important feature of Brazilian politics, one that is talked about in journalistic accounts and informal chats but yet to receive much attention in academia. This paper investigates whether electoral rules affect polarization in the Brazilian legislative branch. Specifically, I compare the plurality-majority rule used in the Senate with the proportional rule used in the House of Representatives.

The hypothesis that the plurality-majority rule induces more polarization is supported by data, but not to its full extent. In the comprehensive test, using the aggregate data for almost all legislatures in the democratic period, the Senate treatment had a positive effect in causing its legislators to behave more extremely. This claim is not as apparent as when the data by legislature and coalition are separated. In general, left-wing parties and coalitions are more affected by the treatment than their right-wing counterparts.

Comparing the comprehensive treatment effects of the aggregated cases with the heterogeneous ones in the legislature-by-legislature instances is difficult because of software specificities. The particular issue lies in fixing fiscal and social conservative legislators in the complete data set in order to determine the polarity

result in different coordinate estimates from the estimates in the disaggregated data sets. This occurs because the particular legislators chosen in the first case are not in every legislature, forcing other choices.

This problem of the same party or member of the Congress in different legislatures may be resolved in a dynamic estimation, for example, using *DW-NOMINATE* and a common space for the legislatures. Also with dynamic methods, and using the fact that some members of the House eventually became members of the Senate, this experiment could be performed in order to compare directly, *i.e.*, in the same person, the effect of the control and treatment. Again, this would require the assignment of a common space, but for both chambers. Finally, one can extend the analysis for all of the parties, to explore whether there is a similar effect of the electoral rules on polarization for the small parties in the Congress.

As a last note, I do not make any judgment of value here regarding political polarization. It may be sometimes good or sometimes bad. I use the terms found in the literature. Hence, one should not think that words like *extremists*, *moderates*, and *polarized* have any value hierarchy in this paper. They might have in some of the studies mentioned, but not in this paper. The analysis in this paper is mostly descriptive, and somewhat inferential. There is no attempt to recommend any particular institutional design.

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