How does redistricting matter?
Evidence from a quasi-experimental setting in Mexico[1]

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Abstract

Redistricting affects directly the translation of votes to seats, and is therefore one of the most politicized procedures within electoral management. Mexico's approach is unique – since 1996 an independent board has been creating plans algorithmically. Parties, however, are able to formulate hundreds of counter-proposals in a closed-door environment. We ask: *Why and when do political parties engage in the process, and what is the political consequence of their participation?* To address these questions, we analyze a unique data set comprising all the submitted partisan map proposals during the 2013 and 2017 redistricting rounds. Our analysis reveals parties' plans have surprisingly marginal partisan effects. We find a combination of redistricting criteria, demographic shifts, and voting preferences – rather than partisan gerrymandering – account for the stability of electoral outcomes.

Keywords: electoral management, redistricting, party strategic interaction, algorithmic optimization, gerrymandering.

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[2] We describe contributions to the paper using a standard taxonomy (Allen, Brand, Scott, Altman and Hlava 2014). A. Trelles (AT) and M. Altman (MA) were lead authors, having taken primary responsibility for writing. AT prepared the original draft and is the corresponding author (atrelles@brandeis.edu). E. Magar (EM) and M. McDonald (MM) contributed to writing through editing and review. All authors contributed equally to conceptualization. AT lead methodology, with contributions from MA. AT lead data curation, with contributions from EM.

1. INTRODUCTION

Democratic electoral institutions translate the people's will, expressed by their votes, into the selection of representatives that enact government policies. In redistricting — the periodic drawing of electoral boundaries to achieve ostensibly apolitical goals such as balancing districts' populations — the causal chain may be reversed. Politicians may draw electoral boundaries to allocate voters among their districts in ways affecting the number of legislative seats parties expect to win, the careers of incumbents, and representation for racial and other communities.

With so much at stake, scholars find the redistricting strategy known as *gerrymandering* may distort representation (Cox and Katz 2002, Engstrom 2006, Erikson 1972, Tufte 1973). Most studies focusing on the partisan implications of redistricting are based on the US experience (Lublin 1999, Shotts 2003, Gelman and King 1994, Abramowitz, Brad, and Gunning 2006, Cain 1985, Brady and Grofman 1991) or well-established democracies (Rositter, Johnston, and Pattie 1997ab and Jackman 1994). Overall, these studies find: i) redistricting usually affects substantive political representation, ii) partisan actors and legislators act with sophistication to maximize their expected seats through gerrymandering, and iii) they are generally effective in doing so – unless responsibilities are devolved to a strong independent body, such as a court or commission.

Very few studies, however, examine the internal workings and consequences of redistricting in third-wave democracies across the Global South. This is an unfortunate omission since several countries rely on *de jure* independent electoral commissions to renew electoral boundaries. According to the *Ace Electoral Knowledge Network*, approximately two-thirds (107 out of 165) of the countries that redraw electoral geography do so through a *de jure* independent electoral management body (EMB) or through a specialized electoral boundary commission. There is some work filling this gap. Handley and Grofman's (2008) work, for instance, offers a comprehensive examination of how

redistricting is carried out mainly in well-established democracies across the globe. More recently, single case studies have proved useful to have a better understanding of how redistricting relates to key outcomes in semi-competitive or consolidating democracies. Wong (2019), for example, explores how electoral boundary delimitation can be used to the advantage of ruling parties in electoral authoritarian regimes; Kasara (2014) studies the link between electoral geography and political violence in Kenya; and Daxecker (2020) examines the relationship between malapportionment and violence in India.

Still, we know little about the internal workings of formally independent electoral bureaucracies across third-wave democracies and the degree to which parties are capable of affecting electoral outcomes through redistricting in this type of setting. We examine Mexico's redistricting experience in the last two decades and the extent to which mainstream assumptions from the US literature are generalizable across the Global South. Specifically, we examine if recent changes in the electoral boundaries affected political representation and if political parties' participation maximizes their electoral returns.

We find Mexico to be an ideal case to study these questions because it has a relatively novel democratic experience and its independent electoral management board, Instituto Nacional Electoral (INE, formerly IFE), is recognized internationally as a regional role model.[3] Despite its reputation, Mexico's redistricting operated behind closed doors with direct channels for political parties to participate (Trelles et al., 2016).

Consistent with the conception of parties as self-interested and rational agents (Mayhew 1974), the high levels of partisan engagement in redistricting indicate that parties are trying to maximize their electoral returns. The discrepancy between a purportedly transparent process and the opaque partisan interaction raises a broad set of questions about the neutrality of the process as it occurred. We ask: *Why and how did political parties engage in Mexico's redistricting process? Were some parties more strategic than others when gerrymandering? If so, did they extract benefits in terms of electoral returns? If not, what explains their engagement?*

[3] See online appendix 1.1 for the evolution and context of redistricting in Mexico.

We analyze Mexico's redistricting using a novel dataset comprising all the plans proposed by political parties in the 2013 and 2017 redistricting rounds, heretofore unavailable outside the Mexican bureaucracy.[4] Our analysis offers unique insights into Mexico's redistricting, into the internal workings of an independent election board, and the ways in which parties strategically interact with electoral bureaucrats. We find that redistricting matters as an institution, but not in the ways US-derived theories would predict. Contrary to key assumptions derived from the US redistricting literature, we find strong evidence Mexico's redistricting affected marginally electoral outcomes, and that the process appears highly constrained by core rules based on drawing districts from *secciones* (i.e., precincts or voting districts), compactness, and a requirement to preserve municipal integrity. We conclude by offering some alternative explanations of partisan engagement in redistricting and emphasizing future avenues of research.

2. A UNIQUE TESTBED FOR PARTISAN INTERACTION

Mexico is relatively new to redistricting. Since the country's democratic transition following 71-year single-party rule by the PRI, elites granted redistricting authority to an independent electoral management board created in the early 1990s, which conducted redistricting in 1996, 2004, 2013, and 2017.[5] Mexico's redistricting appears less politicized than its northern neighbor, and has improved democratic representation in some areas, such as through considerations afforded to indigenous communities (Sonnlentier 2001 and 2013, Meng and Palmer-Rubin 2017, and Trelles 2017).

[4] Upon publication, the complete range of partisan counter proposals will be made publicly available. Please contact the corresponding author for questions and preliminary access to the data and replication code in our GitHub repository.

[5] The Federal Electoral Institute (IFE, now INE) has been redrawing Mexico's political geography of 300 majority districts across 32 states since 1996. After the 2014 electoral reform, the independent board changed names to National Electoral Institute (INE), reflecting its aggrandized authority over subnational elections. We avoid cluttering the text with acronyms by referring to the IFE/INE as "the independent board or EMB," or simply "the board" in the text.

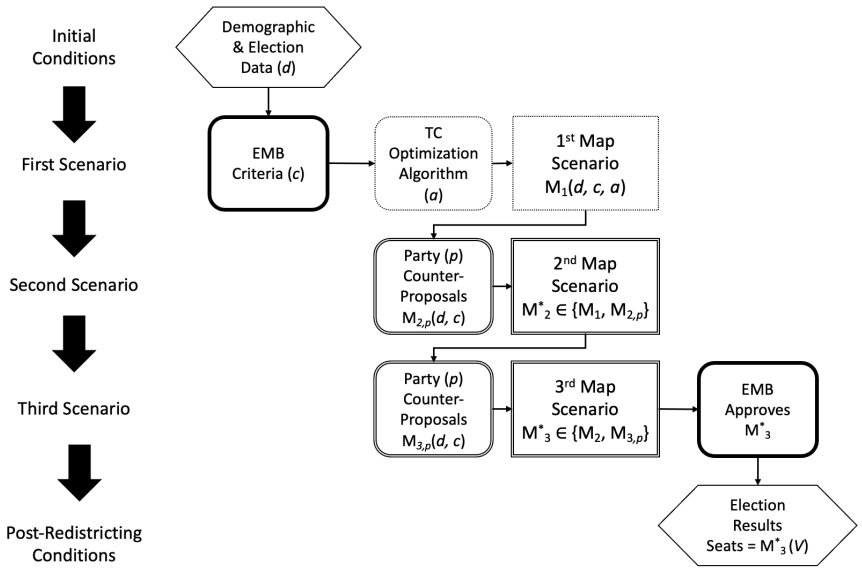
Mexico's EMB innovated beyond the U.S., where a majority of states have not fully delegated redistricting to an independent board and are still experiencing high levels of politicization (McDonald 2004 and 2008, Cain 2011). In the last three decades, Mexico's bureaucracy innovated further by employing customized automated algorithms to find redistricting plans deemed optimal on *a priori* criteria, and for political parties to react by suggesting alternative plans (Trelles and Martínez 2008 and 2012, Magar et al., 2017, and Trelles et al., 2022).

In 2013, the EMB completed the redistricting process, but IFE´s executive board rejected the proposed district boundaries as the process apparently became intertwined with the 2014 electoral reform.[6] Three years later, in 2017, the board repeated the process using the same legal framework and census information, but operationalized redistricting criteria in a slightly different way. Instead of optimizing with four restrictions (i.e., population balance, municipal integrity, traveling time, and geometric compactness), the EMB's technical committee decided to use only two (population and compactness). The rejection of the 2013 process and the implementation of a new process using slightly different criteria in 2017 offer a unique opportunity to evaluate how the redistricting process – including party strategic interaction – has affected electoral outcomes using a quasi-experimental design. While conducted four years later, INE completed redistricting using the same population data (2010 census) and the same normative framework. This offers us a way to analyze the effects of changes in the mid-level process – e.g., changes produced by the use of a slightly different algorithm and scoring of criteria. More importantly, however, this setting allows us to analyze the degree to which changes between the two rounds are confounded by party-learning/interaction effects.

[6] According to former IFE's President, Leonardo Valdés, it was the PAN that negotiated with the ruling party (PRI) to postpone the redistricting process after the 2015 mid-term election because the right-wing party believed they would lose seats to the PRI. In order to approve the reform, which was part of a political agreement called "*Pacto por México,"* the PRI agreed to postpone the federal redistricting until INE was established in 2014 and the 2015 election was conducted with the 2004 electoral geography. Interview of the leading author with Leonardo Valdés. Mexico City, April 2015.

We illustrate Mexico's redistricting in Figure 1. The process begins with the *executive board* defining the *legal criteria* and appointing a *technical committee* (TC) responsible for producing computer-optimized plans – the *first scenario* – for all thirty-two states. It ends with the *board's* approval of the *third* – final – *scenario* suggested by the TC (Trelles 2017 and Trelles et al., 2022). In-between, political parties represented within the electoral board engage in two sequential rounds by offering counter-proposals in each state. In the first round of interaction, the TC *evaluates* plans suggested by local and national political parties, *compares* them to the *first scenario* according to an explicit scoring function, and *selects* the best solution, which becomes the *second scenario.* In the second round of interaction, the TC compares the party proposed plans to the *second scenario* and selects a *third scenario* that is ultimately considered by the *board*.[7]

Figure 1. The Redistricting Processes in Mexico



[7] In the 2017 redistricting process, the electoral tribunal (TEPJF) mandated the EMB to include for the first time the public input from indigenous minority communities during the first round of counter-proposals (Trelles 2017). In this article, we omit the analysis of any observations derived from this consultation in order to focus on partisan strategic interaction.

Note: *The figure depicts the redistricting process focusing on maps (M) as the unit of analysis. The sequence on the left represents the first, second, and final scenarios created for each state (32x). The diagram on the right shows time by the direction of arrows; Subscripts 1-3 represent the first, second, and third stage of the process, respectively; The letter "M" represents a specific map that has been configured based on the demographic data (d) and the EMB's criteria (c). While the first scenario is configured via algorithmic optimization (a), the second and third scenarios are impacted by two subsequent rounds of partisan interaction (p). All proposals are constrained by restrictions d and c. The asterisk (*) denotes the winning map that has been selected by the TC from the specific subset of plans that were considered by the EMB in each state.*

Although plans are affected by the difference in (*ex-ante)* procedural decisions between the 2013 and 2017 processes (e.g., the EMB´s definition of rules and criteria, as well as the operationalization and instrumentation of the redistricting process), we focus on the overall (*ex-post)* effect introduced to the initial plan by the two different phases of strategic partisan interaction. In the next section we examine both the *ex-ante* and *ex-post* effects across the 2013 and 2017 redistricting processes.[8]

3. POLITICAL IMPLICATIONS OF REDISTRICTING AND INSTITUTIONAL CONSTRAINTS

3.1 Political implications

Do majority districts matter? Redistricting matters as an institution in Mexico because the country's electoral system has been predominantly majoritarian since the early 1900s. It was not until the 1960s that proportionality was introduced. Opposition parties had been marginalized from congressional representation because of vote dispersion across states and

[8] We compare the difference between the 2013 and 2017 *first scenarios* as a way to examine the *ex-ante* effect*,* as well as the difference between the *algorithmic* and *final plans* that were submitted to the *Consejo General* in 2013 and 2017 to analyze the *ex-post* partisan effect.

the absence of a compensation mechanism.[9] As a consequence of political negotiations, Mexico transitioned to a mixed-member electoral system (MMES) in 1978 when it increased the PR tier from 32 (out of 200) to 100 (out of the 400) seats in the legislature. Two years later, the *Cámara de Diputados* adopted its current configuration and increased the PR tier to 200 (out of 500) seats.

Even when 40% of the seats belong to the PR tier, the 300 majority districts have been key to preventing the party system's extreme fractionalization and maintaining the dominance of large political parties (Cox 1997). If Mexico used a nationwide PR electoral system, the balance of power in the legislature would be quite different. Based on the 2015 turnout, for instance, smaller parties traditionally obtaining no more than 10-15% of the seats in both tiers, such as PT, PNA, and MC, would have increased their congressional representation by approximately 63% (compared to the average number of seats they usually get under the current MMES). In contrast, the three dominant parties would have lost approximately 6% of their seats. The largest party at the moment – the PRI – would have lost 24% of its total share of seats. These differences show the substantial impact the presence of SMD – or the *institution of redistricting* – has on political representation and how larger parties tend to benefit from a seat bonus under the current MMES (Molinar and Weldon 2001 and Weldon 2005).[10]

What have been the political consequences of redistricting? Given the political consequences of *gerrymandering* in the United States and the high levels of partisan engagement we observed both in Mexico's 2013 and 2017 redistricting processes, we expect that partisan interaction would have had a meaningful impact on the electoral geography and, consequently, on electoral outcomes. In 2013, for instance, parties proposed

[9] In 1960, 32 *proportional representation* seats known as "*diputados de partido"* were introduced in the country's electoral system. 32 PR seats (out of the 200) were introduced in the lower chamber.
[10] In this paper we focus exclusively on the 300 majority districts and treat them as an independent group from the PR tier. We assume the country's *governability rule* adopted in 1996 (*la cláusula de gobernabilidad)* does not alter neither the criteria and rules used to produce algorithmic plans nor the parties' incentives to maximize their electoral returns in majority districts once an algorithmic plan has been generated.

a total of 522 alternative plans. In 2017, parties formulated a total of 463 counter-proposals. [11]

In order to assess the impact of the changes in the country's electoral geography after the 2013 and 2017 redistricting cycles, we analyze the hypothetical *seat allocation* among parties in the case a process had been different or if it had not happened at all (Jackman 1994). For both processes, we compare the *status quo* (if redistricting had not happened) with three different types of plans: *i)* the algorithmic solution *(first scenario), ii) t*he best lower-scoring plan during the interaction phase*,* and *iii)* the plan that was adopted by the EMB *(third scenario).* Then we offer a "perfect foresight" analysis to evaluate what would have happened if parties had maximized their seat allocation within all the valid maps that were considered.[12]

Table 1 depicts the different counterfactuals for the 2013 and 2107 processes in four different quadrants. The first two quadrants (top to bottom) are based on the 2015 electoral returns, while the remaining two (on the bottom) are based on the 2018 elections results. For example, the first column of the first quadrant (2013-2015) depicts the actor that suggested a plan. The *winner* column lists the seat allocation for each party with the plan that was selected by the TC in 2013. The *best* column lists the seat distribution if the best scoring plan had been adopted during the 2013 process. The *algorithm* column lists the seat allocation if the algorithmic solution (first scenario) had been adopted. Lastly, the *status quo* column shows the seat distribution among parties for the 2015 elections conducted with the 2004 map. The rest of the tables follow the same structure (comparing the *status quo* with the *algorithmic, best*, and *winning solutions*). The only difference is that the *second table* uses the 2015 election results with the maps considered in 2017, the third table uses the

[11] See online appendix 1.2 for a detailed description of the parties' behavioral expectations, interaction, and revealed preferences.

[12] We found no significant deviations across scenarios focusing at the state level (based on large and medium size states) or using *competitiveness* as an alternative metric to seat maximization. See online appendices 2.1 and 2.2 for an analysis based on the level of *competitiveness* and on *seat allocation* at the state level.

2018 elections with the 2013 maps, and the fourth table uses the same year elections with the 2017 maps.

Table 1: Counterfactual scenarios for the 2013 and 2017 redistricting plans based on the 2015 and 2018 elections

actor	winner	best	algorithm	status quo
2013 - 2015				
MC	10	10	10	10
MORENA	13	13	15	14
PAN	55	55	55	55
PRD	31	30	27	34
PRI	191	192	193	186
PNA	0	0	0	1
2017 - 2015				
MC	9	9	10	10
MORENA	15	15	15	14
PAN	54	53	52	55
PRD	29	29	29	34
PRI	193	194	194	186
PNA	0	0	0	1
2013 - 2018				
MORENA	217	217	217	217
PAN	68	68	70	68
PRI	15	15	13	15
2017 - 2018				
MORENA	220	221	218	217
PAN	66	65	67	68
PRI	14	14	15	15

Surprisingly, these counterfactual scenarios reveal that the two last redistricting rounds in Mexico had a marginal impact on the overall distribution of seats among parties. From the optimization point of view, the difference between using a two (in 2013) *versus* a four-restriction algorithm in 2017 had a minimal impact on parties' seat distributions (the

largest impact was a 3-seat loss difference for PAN). From the partisan engagement standpoint, the differences are also minimal. Even if redistricting had not happened in 2013 or 2017, results would have remained almost the same. The PAN, for instance, obtained 55 majority seats in the 2015 election with the 2004 plan (*status quo*). This same party would have obtained exactly the same number of seats under the three hypothetical scenarios (*algorithm, best, winner* solutions) during the 2013 redistricting round. In the 2018 election, this same party – the right-wing PAN – obtained 54 seats with the 2017 winning plan, and would have obtained 53 seats if the best solution had been adopted, and one less – 52 seats – if the EMB had selected the algorithmic solution. Lastly, from the administrative perspective, duplicating the redistricting process in 2017 with slightly different criteria was, to say the least, redundant.

While the institution of redistricting is responsible for a substantial swing affecting political representation by an average margin oscillating between 24% and 63%,[13] our results show that in the most extreme cases the margin of change in the seat allocation across all counterfactual scenarios oscillates between 0 and 17%.[14] The largest positive difference we identified due to a specific selection of boundaries was for the PRI, which won 5 and 7 seats in the 2013 and 2017 processes, respectively (using the 2015 turnout and comparing the winning plan with the 2004 baseline). The most affected party by the drawing of new lines was the PRD, which only lost 3 and 5 seats when comparing the same cycles and based on the 2015 election results.

When comparing the 2013 and 2017 winning solutions using the 2015 turnout, we found that parties were losing or winning a maximum of two seats (e.g., MORENA and the PRI won two seats each, while the PRD lost 2 with the 2017 plan). Similarly, when

[13] Compared to a purely PR election, for example, the PRI would have lost 53 seats, while smaller parties such as MC, PNA, PES, and PT would have won 7, 9, 9, and 9 additional seats respectively. Margin calculated as the difference between the 2004 baseline outcome and a hypothetical nationwide proportional allocation of seats using the 2015 turnout.

[14] For example, in most cases large and small parties lose or win 1 to 3 seats when comparing the *status quo* with the *winning plan* in both the 2013 and 2017 process. Difference calculated based on the results we present in Table 2.

analyzing the seat difference with the 2018 turnout we found that MORENA won only 3 districts, while PAN and PRI only lost 2 and 1 seats, respectively.[15] The similar distribution of seats using the 2013 and 2017 scenarios indicates that the district boundaries contributed little to the turnaround of party fortunes and that the large electoral swing from 2015 to 2018 – the 2018 MORENA "tsunami effect" – swamped the redistricting effects.

A second approximation to assess the overall impact of partisan interaction during the 2013 and 2017 redistricting cycles is to simulate a "perfect foresight" scenario for parties. Table 2 shows the widest range of outcomes that major parties could have chosen among all of the valid plans proposed in either 2013 or 2017 given the actual 2015 / 2018 results. That is, we compare what would have happened if the EMB adopted the best *versus* the worst map within the total universe of alternative plans that were considered by the TC.

Table 2: Perfect Foresight scenarios for the 2013 and 2017 redistricting plans based on the 2015 and 2018 elections

actor	max	min
2018		
MORENA	226	212
PAN	78	64
PRI	17	11
2015		
MORENA	15	13
MC	10	9
PAN	58	50
PRI	206	189
PRD	32	24

While a minor seat difference can be crucial for policy outcomes when a simple or qualified congressional majority is at play (Brady et al., 1973, Brady 1978 and 1988,

[15] *Ibid.*

Heberlig and Larson 2012, Campbell 2014, and Rogowski 2016), the overall difference between the *status quo* and the hypothetical counterfactual scenarios related to the 2013 and 2017 processes in Mexico do not seem to surpass the 10% difference of the 300 single majority seats. Results in table 3, for instance, reveal that the largest range, by far, is for PRI with the 2015 turnout – a 27 seat difference between the *worst-case* and the *best* electoral scenario for this party. The second-largest difference between the *worst* and the *best* plan is for both PAN and MORENA with the 2018 turnout – a range of 14 seats for each party. The rest are single-digit differences where the lowest two are for MORENA and MC – with 2 and 1 seat respectively – with the 2015 turnout.

3.2 Institutional and administrative constraints

Given that we find no meaningful differences in the allocation of seats among parties when comparing the *status quo* with either the 2013 and 2017 processes, or between both redistricting cycles, it is still uncertain which part of the process or combination of factors are constraining the outcomes (i.e., rules of the game, type of criteria, or optimization). We suspect that the rules to preserve municipal integrity and compactness, drawing districts from *secciones,* and the wide margin of population deviation permitted across districts (between +/- 10 and 15 %), are the main restrictions constraining the variation in the allocation of seats. In this section, we evaluate three hypotheses related to this *rule-binding* effect. Namely, *rigidity, municipal integrity, and interaction of rules with political demography*.

A first hypothesis explaining the lack of variation is related to the "rigidity" of the process. This hypothesis assumes that redistricting is a product combining multiple rules and procedures (i.e., trying to minimize the population deviation across districts while maximizing geometric compactness and municipal integrity) that must have a binding effect on the cartography. It also assumes that once an *algorithmic* solution is generated, it leaves very little maneuvering room for political manipulation. As the TC has refined the algorithm over the years with the intention of finding scenarios with a lower cost associated

with each map, bureaucrats and party representatives have acknowledged that it has become harder for parties to formulate more effective – *lower-scoring* – counter proposals.[16]

Consequently, a plausible explanation for the lack of variation in the outcome is that the proposition of *secciones* changed between the 2013 and 2017 *algorithmic* plans is very similar when compared to the baseline. Additionally, we would also expect that the vast majority of alternative plans suggested by political parties involve a marginal amount of *secciones* (e.g., < 5% difference of *secciones* between alternatives). That is, there is no impact on the allocation of seats because when the *algorithm* finds an "optimal solution," parties are unable to substantially alter the plans. Finally, it has become harder for parties to formulate *lower-scoring* plans – as the optimization has been "fine-tuned" by the bureaucracy – and we expect that a decrease in the proportion of *secciones* changed in every state plan between 2013 and 2017. We evaluate these statements with the following hypotheses:

> H1. The share of *secciones* changed by the algorithm in both 2013 and 2017 is minimal (*constraining effect of the process).*
>
> H2. The share of *secciones* changed in 2013, compared to the *status quo* (2004 baseline), is very similar to the change observed in 2017 (*constraining effect of the process remained the same).*

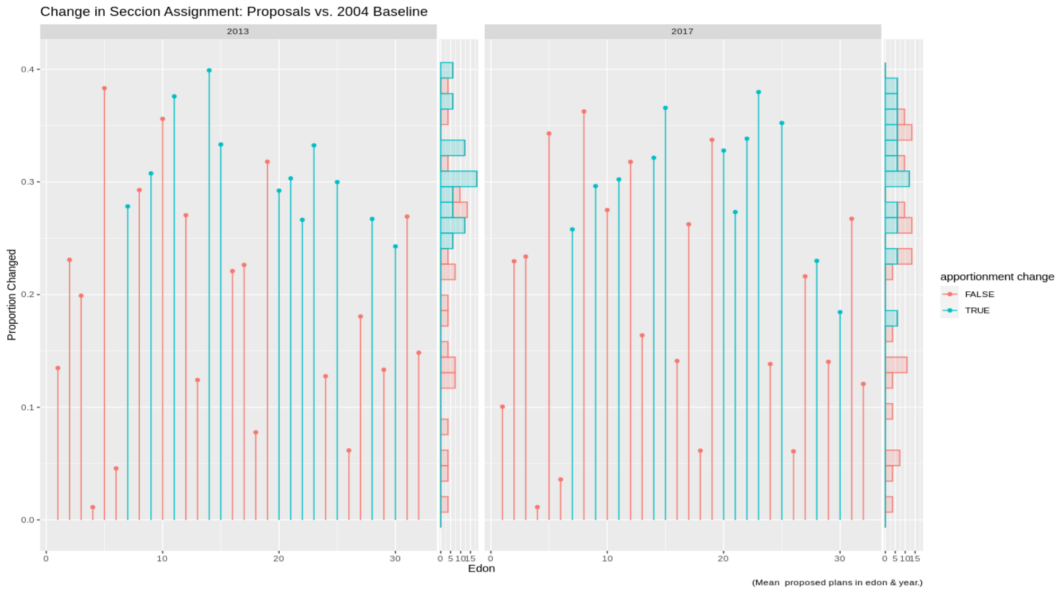
[16] In order to overcome this procedural constraint, the EMB adopted in 2017 a unanimity rule (*criterion 8)* allowing parties to formulate higher-scoring plans as long as no other party *vetoes* that solution (*unanimous solutions)*. Historically, the EMB has included "municipal integrity" as one of its main criteria when updating districts. The EMB, for instance, tries to minimize municipal splits and assigns prior to the optimization phase a district to those municipalities that have the sufficient population to be within the legal margin – e.g., +/- 10% to 15% deviation from the mean. In highly populated areas, however, municipalities need to be fractioned either because several districts are embedded within a single municipality or because a municipality does not have the sufficient population to receive its own district. Interview of the leading author with Miguel Rojano, INE's Director of Cartography and with Florencio González, PAN's representative at IFE's CNV. Mexico City, June 2019. For a detailed description of algorithmic efficiency for the same period see Trelles et al., (2022).

H3. The average change of *secciones* proposed by parties in 2017 was substantially less than in the 2013 process (*algorithm efficiency has translated into more constrained outcomes*).[17]

H4. Parties have been only able to offer solutions involving a marginal change of *secciones* (< 5%) in both 2013 and 2017 (*changing plans at the margin).*

Figure 2 shows the proportion of *secciones* (as a proportion of the total number of *secciones* in a state) that changed between the 2013 and 2017 processes. It depicts the proportion of *secciones* that changed comparing the *algorithmic* solution to the 2004 baseline cartography (*status quo*) across states in 2013 and 2017 (states that were affected by the apportionment phase – changing the total number of seats – are highlighted in blue).[18]

Figure 2. Proportion of *secciones* changed at the state level in 2013 and 2017



[17] See online appendix 5 for a description of algorithmic efficiency.

[18] See online appendix 3.1 for an analysis of *seccion deviation* by party and stage, as well as for a comparison of *seccion deviations* between *algorithmic* and *winning* plans in both 2013 and 2017 cycles.

Contrary to our expectations, results in figure 3 show that many of the states experienced substantial differences in the assignment of *secciones* between the *status quo* (2004 baseline) and the *algorithmic* solution. The proportion of *secciones* that changed in 2013 oscillated between 20 and 40 percent in both 2013 and 2017. Furthermore, this figure shows that while in most cases the average number of *secciones* changed in every state remained close, in some states the algorithm generated plans with substantial differences (e.g., in 2013, state 10 had approximately a 36% *seccion* difference with respect to the *status quo*, while in 2017 it was only 27%). Overall, our results indicate that the share of *secciones* that changed as a consequence of the optimization phase was substantial (contradicting H1), that the proportional change remained very close across processes (*confirming H2* and *against H3*), and that parties had formulated plans with a substantial deviation – of *secciones* – over time (*against H4*).

Surprisingly, these results show that even when the district lines are changing across states, the overall distribution of seats does not. This remains true across processes and shows that parties are engaging in redistricting for reasons unrelated to seat maximization – i.e., either because they are getting an unobserved side benefit or because they perceive that being involved in the process will minimize the possibility of being arbitrarily affected by either administrative or political *gerrymandering*.

A second hypothesis explaining the lack of variation in the observed seat allocation across parties is related to the administrative effort trying to preserve *municipal integrity* (or prevent municipal splits). The logic behind the adoption of this rule is that the approximately 2,500 municipalities are geographic entities bounded by administrative, economic, political, and cultural features.[19] Given that *municipal integrity* has been present

[19] Historically, the bureaucracy has deemed this criterion as one of the most relevant restrictions to be considered when renewing the electoral geography in Mexico (Trelles and Martínez 2007). Since 1996 it has been considered one of the key restrictions of the process. In 2004, for instance, *municipal integrity* was included for the first time in the optimization phase as the third (out of four) restrictions used in the algorithm. The other three restrictions being population balance, geometric compactness, and traveling time (INE 2005 and Trelles and Martínez 2007). In 2013, *municipal integrity* became the second (out of four) most important restriction in the algorithm – preceded by

in all redistricting cycles, that it has been given a high order priority, that the vast majority of municipalities in Mexico have substantial less population than the average electoral district (e.g., out of the 125 municipalities in the *EdoMex*, which is the most populated state in the country, only 12 of them have the sufficient population to have one or more electoral districts), and that each municipality has its own political and electoral dynamics, we believe this criterion might be one of the main restrictions affecting the lack of variation in seat allocation. If municipal integrity is constraining the effect on seat allocation, then we would expect the following hypothesis to be true:

> H5. The municipal party vote is larger than the necessary winning vote threshold at the district level in every state

Figure 3 depicts in red the median party vote required to win a municipality in each state and also the respective winning vote threshold necessary to win a district for the 2015 and 2018 elections using the 2017 electoral geography. The figure shows partial support for the hypothesis (H5). Given the demographic dispersion and the bureaucracy's effort to preserve *municipal integrity* (e.g., by using the municipal geography – instead of the *secciones* – as larger pieces to create districts), municipality splits in most plans are in a small range. However, a substantial number of municipalities exist in most states that, on their own, are large enough to swing the entire district to a party – depicted with red observations (box plots or dots) falling to the right of the median *winning vote threshold* portrayed in light blue. We found that 37 and 48 districts, respectively, contain unsplit municipalities that could carry the district for a single party by themselves.

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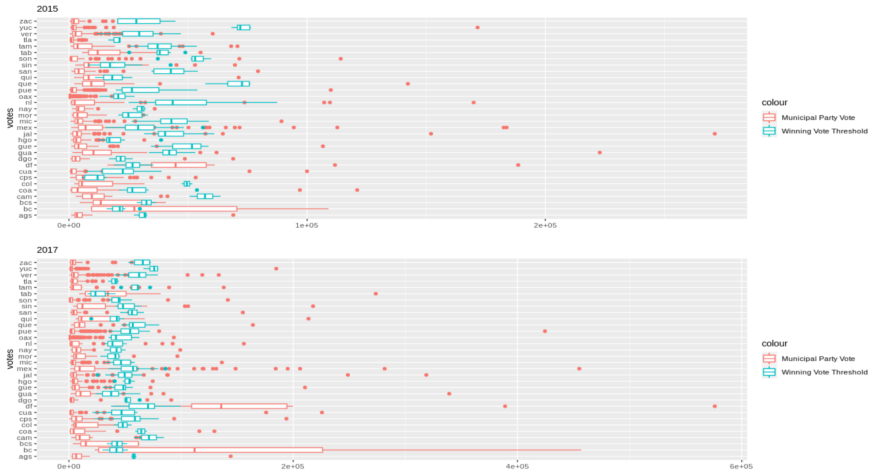
population balance and followed by *traveling time and geometric compactness* in the third and fourth place, respectively. In 2017, the TC decided to remove *municipal integrity* from the optimization phase. The bureaucracy, however, did an *ex-ante* classification setting apart – from the optimization – those municipalities that had the sufficient population to form a district within the allowed 10-15% population deviation margins and identifying those municipalities that had more than 40% of indigenous population.

Figure 3. Municipal vs winning vote threshold at the district level



Despite the difficulty to sort out which criteria were the most constraining restriction on the outcome variable, the correlation among the different redistricting criteria allowed us to identify those restrictions, such as municipal integrity, that were constraining the degrees of freedom parties have to influence the allocation of seats.[20]

We derive the following conclusions from this section: i) that the institution of redistricting matters, ii) that the partisan strategic interaction and the mapping negotiations between politicians and electoral bureaucrats had a marginal impact on the distribution of seats among parties, iii) that voter swings explain changes in the allocation of majority congressional seats over time, iv) that *municipal integrity* is an important constraint on the

[20] See online appendix 3.2 for the description of the correlation among redistricting criteria. Further analysis would be required to determine which rules and/or distributional patterns in particular explain the difference between the theoretical range of variation, and the very constrained variation during the mapping process itself. It is possible that the combination of *demographic patterns*, *contiguity*, *compactness,* and the use of *secciones* would have been sufficient to constrain the outcome. Looking at the role of municipalities in 2015 and 2018, we found that 37 and 48 districts, respectively, contain unsplit municipalities that by themselves could carry the district for a single party. This suggests that the *municipality rule* is sufficient to constrain at least that number of districts (10-15% of the total number of SMD). However, it could have constrained more (e.g., through indirect effects) and it might not have been necessary because the same results could have occurred with just the *contiguous*/*seccion* rule.

variation of seat allocation, but not the only one, and v) that the interaction of redistricting rules with intra-state political demography (i.e., voter distribution within states) are responsible for explaining the lack of variation we observe on the outcome variable.

4. EXPLAINING THE PARADOX – Partisan engagement in the absence of electoral impact

In the absence of a substantial *seat allocation difference* after both redistricting cycles, the fact that parties engaged in both processes remains puzzling. If their actions did not have a pronounced impact on the seat allocation among parties, *why did parties engage in redistricting the way they did?* In order to answer this question, we conducted semi-structured interviews with party representatives of major parties at the national and state level that were responsible for formulating counter-proposals during the 2017 round. We then analyze with the available data five alternative explanations and evaluate some of the hypotheses related to the high levels of partisan *strategic engagement (higher level)*.

4.1 The case of Yucatán

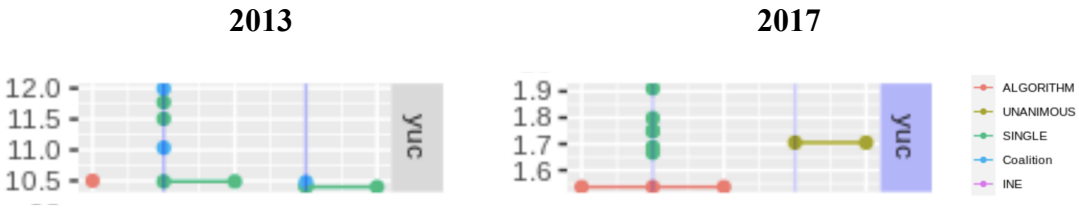
A close examination of the dynamics within a specific state and interviews with party representatives at the state level is useful to reveal why parties engaged in the process and the arguments they used to support their plans. Further, a *microlevel* analysis also serves to exemplify how technical experts evaluated partisan plans and to show how the operationalization of the rules affected the outcome.

We assume that parties are rational agents trying to maximize their electoral returns. When engaging, we also assume they expect to profit but never to be harmed by their own plan.[21] If true, we would expect that the parties' revealed preferences from the observed outcomes to be consistent with the parties' privately stated motivations during the interviews and with the publicly stated reasons in the EMB's records.

[21] See online appendix 4.1 for a prediction analysis based on state-level political strongholds and electoral returns.

We selected the state of Yucatán to analyze partisan interaction because this is one of the states where we identified an irregular pattern of play in 2017 involving: i) a universal lower-scoring *algorithmic* solution, ii) higher-scoring partisan alternative solutions in the second round, and iii) a *unanimity* solution that is below most of the partisan alternatives in the previous stage, but not all.[22] Figure 4 shows the cost associated with all plans formulated by different across all five stages of the process in Yucatán, namely the first scenario (*algorithmic* solution), the first round of partisan interaction, the TC's selection of a second scenario, the second round of partisan interaction, and the TC's selection of a *winning* plan (depicted horizontally from left to right).

Figure 4. Redistricting in Yucatán: Stages and Winners



In the case of the 2017 process, the algorithmic solution had an associated cost of 1.53, and six (out of nine) parties suggested 6 alternative plans through their local

[22] In 2013, the evaluation process in Yucatán worked as expected. We identified, however, that not all parties used the same strategy when engaging. The *algorithmic* solution scored 10.49, and the TC selected the plan suggested by the national-level PAN (CNV) with a score of 10.48. The local level PAN (CLV) proposed a higher-scoring plan of 11.505. In the second round, the national-level PAN was the only party that formulated a plan with even a lower score (10.39), which was accepted by the TC. Although the rules for considering partisan plans clearly state that if the same party submits two plans with a different cost (e.g., through its national and local representatives – CNV and CLV, respectively) the EMB would consider the one with a lower score, it is not clear why some parties endorsed the same plan through the local and national representative, other parties endorsed a plan through a single representative (the MC party only submitted a proposal in the first stage through the CLV in 2013), and others decided to split the ticket and formulate two different plans at the same stage.

representatives at the CLVs and two of them endorsed the lower cost algorithmic solution.[23] The TC argued that given that the algorithmic solution offered the lowest scoring plan, it would select it as the "second scenario." In the second round of observations, parties coordinated to override the institutional choice and, invoking criterion 8, all nine parties formulated a plan with a cost of 1.705. After evaluating this higher-scoring plan, the TC stated that the "second scenario or the algorithmic solution" still was "the plan with the lowest score and the one that best meets all the technical rules." As a consequence, experts recommended to the EMB the adoption of the algorithmic solution (1.53) as the final plan. The bureaucracy, however, decided to adopt the unanimous higher-scoring partisan solution instead (1.705).

We find five aspects of this process to be particularly interesting.[24] First, even when the TC recommended the adoption of the lower-scoring plan based on technical criteria, *administrative slippage* took place and the bureaucracy decided to adopt a higher-scoring solution based on political reasons, not technical ones. A closed-door bargaining conversation took place among local parties so that they would be able to agree on imposing a higher-scoring solution over the technocratic plan.

Second, the partisan behavior in Yucatán cannot be explained in terms of rational (*fully-informed, unbounded, and sophisticated*) behavior where parties are aiming to optimize an expected vote/seat curve. The zero-sum characteristics of this interaction make it difficult to understand both the parties' decision to adopt the *unanimity rule* and the reversal of PAN's revealed preference ordering over rounds. These types of decisions are impossible when parties are fully-rational and there are no side payments. Hence, we consider this as evidence that the default *rational-maximizing rationale model* is violated.[25]

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[23] While PAN and PNA endorsed the *algorithmic* solution (1.53), the rest of the parties offered higher-scoring alternatives: PRI (1.66), PVEM (1.68), MC (1.7491), PT (1.7498), PRD (1.7978), and MORENA (1.91).

[24] See online appendix 4.3 for a detailed description of the case study and the interviews conducted with party representatives.

[25] We also identified that the interaction of PT in Aguascalientes during the 2013 process is another case consistent with the "preference reversal phenomenon" (e.g., voting for plan A over Plan B in

Third, the case of Yucatán reveals that the implementation of criteria substantially constrains the possible outcomes. Given the way that the EMB has interpreted *municipal integrity*, the city of Mérida was going to be split, and the rest of the districts were pretty much fixed. The municipal integrity rule is limiting significantly the degrees of freedom in the mapping process in this state. When interacting with the *compactness* rule, it constrained, even more, the degrees of freedom of the algorithm. That is, based on INE's rules, the city of Mérida had to be split *horizontally* in order to be minimum scoring (a very similar *algorithmic* solution was proposed in 2013).

Fourth, the case confirms that parties engaging in the process are capable of, at most, improving competitiveness at the margins. In the case of Yucatán, most of the action took place around the capital, where parties were not expecting to create a major shift but were trying to make Mérida's southern district more competitive. Although incumbency is generally not considered an important factor in Mexico's redistricting process, we learned from our conversation with party representatives that there is a correlation between a candidate's level of support and the township that nominated them.

Lastly, in our conversations with party representatives, we identified a substantial difference between official explanations and real motives. While official explanations include an allegedly altruistic interest of parties to facilitate certain EMB's administrative procedures (i.e., poll worker recruitment), both the interviews with party actors and the quantitative analysis are consistent with the rationale that parties had a clear expected pattern of seat/vote maximization when engaging in the process.

In the following subsection, we analyze some alternative explanations of party behavior by looking at macro-level patterns of partisan interaction.

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one round and plan B over Plan A in the next round). Table 6.2 of the online appendix shows that in most cases the difference in party advantage with respect to the reversion point is small enough to be negligible. This means that it is possible that parties were willing to lower official score components that they didn't find meaningful for local administrative efficiency. However, in in at least one case a party did trade away an expected seat for unanimity, which is not explicable by purely administrative utility.

4.2 If it's not the seats, what is explaining the parties' behavior?

If parties are not engaging because they are maximizing seats, then why did they bother to formulate hundreds of alternative plans in each cycle? Based on our fieldwork experience and conversations with both bureaucratic and partisan actors, we were unable to identify a different rationale from the *seat maximization hypothesis* (e.g., obtaining a side payoff – different from receiving votes – that might be explaining their decision to participate in the process).[26] However, we put forward the following five alternative explanations of partisan engagement. While some of them can be partially discarded with the data we have, others still require further analysis. These explanations are: i) *parties as unsophisticated actors, ii) unusual elections*, iii) *maximizing the vote share at the margins*, iv) *undetected side payoffs*, and v) *building legitimacy through partisan inclusion*.

The first explanation – *unsophisticated actors* – is that parties thought that they would get something in return, but they did not. This hypothesis assumes that parties lack the sophistication to understand how the process works (e.g., that they are overly optimistic about the future impact of proposed changes) or that they were unable to accurately predict changes in the allocation of seats among parties based on previous electoral returns.

Overall, we find evidence suggesting that there was within-game irrationality in some states. The case of PAN's switching position between rounds in the 2017 process in Yucatán, the PT's reversal or preferences in the state of Aguascalientes in 2013, and the substantial increase of higher-cost unanimous solutions in 2017, all suggest that parties are not engaging in the process exclusively with a *seat-maximizing rationale*.

Despite these findings, however, we believe this is a relatively weak hypothesis because there is no evidence showing that parties systematically sponsored plans that would be considered counterproductive for their own electoral interest. If it is true that partisan interaction is not affecting the overall distribution of seats among parties as we are

[26]Multiple in person interviews with electoral bureaucrats, as well as with representatives of political parties within the EMB's surveillance commissions (CNV and CLV's) conducted between 2010 and 2020, confirm that parties engage in the process trying to maximize their electoral returns.

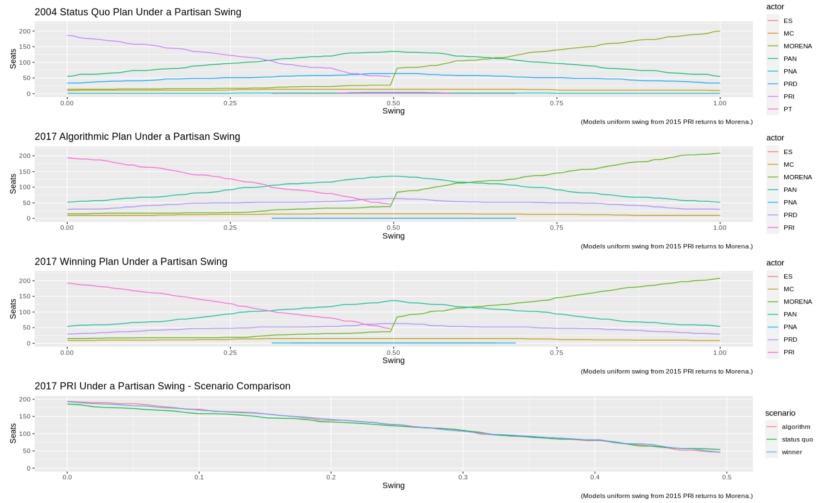
measuring it, the lack of variation in the allocation of seats also confirms that their engagement does not have any self-inflicting negative effect either. The overall results in section 3 show that the aftermath of redistricting had marginal implications for the allocation of seats among parties, which means that parties were not playing the game to maximize their expected seat returns but might be probably engaging for a different reason.

The second explanation – *unusual elections* – is that the lack of variation in the allocation of seats is due to atypical electoral results but that if elections had been typical, we would have been able to observe a substantial advantage – or disadvantage – for specific parties. That is, parties were expecting that under "normal or average" circumstances, party seat differences would have been radically different. Following the premise of "the PRI did not disappear, it only transformed itself (into MORENA)," which has dominated Mexican electoral politics after the establishment of the left-wing MORENA in 2014, we formulate the following hypothesis:

H.6 If the swing would have been more extreme, redistricting would have mattered.

In order to evaluate this hypothesis, we graphed bias responsiveness curves, or shifts across the 2015 election, simulating a uniform vote swing from PRI to Morena. Figure 5 compares the *status quo plan (2004)*, with the 2017 *algorithmic* and *winning* solutions (first three graphs from top to bottom) under a hypothetical uniform swing from PRI to MORENA based on the 2015 turnout. The bottom graph shows the number of districts that the PRI would have lost with the same uniform swing with the same three possible scenarios (*status quo, algorithmic, and winning plan)*.

Figure 5. Uniform partisan swing from PRI to Morena



These results show that a shift from PRI to MORENA benefits PAN until that shift is very large (> 50 %). And that the seats-votes response curve is not substantially different whether one uses the *status quo, algorithm, or winning plans*. Overall, this shows that some combination of other hypotheses (e.g., redistricting institution, political or demographic distribution patterns, and redistricting criteria) are determining the outcomes. It also shows that the specifics of the process, the algorithm, and party strategy during the interaction phase did not.

The third explanation – *maximizing vote share at the margins for winning districts* – is that parties, knowing that their input will not alter the seat allocation in a meaningful way, still play the game trying to maximize the expected vote share they receive in districts that they win. When asked about their strategy to formulate counter-proposals, party officials and representatives at the National Oversight Commission (CNV) explained that once the *algorithmic* solutions were revealed in each state, they would cross-reference the maps with previous electoral returns at the *sección* level, and would formulate plans that would maximize their vote returns within seats they control.[27] If this hypothesis is true, we would expect the following:

[27] Interview of the leading author with Juan Molinar and with Florencio González, PAN's representative at IFE's CNV. Mexico City, October, 2013 and June 2019, respectively.

H7. The *vote margins* for engaging parties in projected winning districts will be higher under the proposed plan compared to the *status quo* (*algorithmic* solution from the first scenario or the *second scenario* selected by the TC).

Table 3 depicts the revealed preference analysis for counter-proposals made by major (PRI, PAN, PRD) and minor parties (MORENA, PVEM, PT, ES MC, PNA) in both years. The columns offer the summary statistics (mean, standard deviation, and range) for the three metrics we develop to compare plans focusing on *vote share, seat,* and *competitive margin* differentials. We also include a composite score that represents the parties' weighted objectives under the standard theoretical model where increases in the following are lexically preferred: number of winning seats > number of competitive seats >, the margin in competitive seats > margin in winning seats. [28]

Table 3. Party counter-proposal – Revealed Preference Analysis

Counterproposal Differences by Actor Type - Theoretical Predictors		
Characteristic	**major**, N = 376[1]	**minor**, N = 498[1]
Proposer Seat Change	-0.0027 (0.2910) [-2.0000-2.0000]	0.0000 (0.0000) [0.0000-0.0000]
Competitive Seat Change	0 (1) [-4-4]	0 (1) [-4-1]
Proposer Win Margin Change	0.0021 (0.0190) [-0.0376-0.2854]	0.0000 (0.0008) [0.0000-0.0159]
Proposer Competive Margin Change	0.000 (0.006) [-0.023-0.020]	-0.001 (0.005) [-0.018-0.016]
Total Proposer Score Change	-12 (372) [-2,300-2,100]	0 (0) [0-0]
[1] Mean (SD) [Minimum-Maximum]		

[28] In addition we examined counterproposals for differences in municipal splits and in compactness scores. See appendix 6 for details. These differences were neither substantive nor statistically significant.

These results confirm that the overall impact that proposing parties have on seat differentials is marginal. Surprisingly, they also show that the impact is also marginal for both the *winning* or *competitive margin* differentials (which is evidence against H7). This can be considered partial evidence showing that even when parties allegedly were looking to improve their chances of winning (or keeping) a seat in subsequent elections, the overall impact is minimal (the coefficients are very small for both major and minor parties). In the case of major parties, the range in all three dimensions includes negative values, which means that in some cases parties were actually receiving fewer votes, losing seats, or making districts slightly less competitive.[29]

The fourth explanation – *undetected side payoffs* – is perhaps the most challenging because it cannot be ruled out with the information we have. First, there is no circumstantial evidence showing that an alternative payoff is what is motivating engagement (e..g, obtaining a financial benefit). Second, there is no registered – formal or informal – allegation from electoral bureaucrats or political actors participating in the process showing that an alternative payoff, other than preserving strongholds or maximizing the parties' electoral returns, was present. Third, although the country's PR compensation mechanism has the potential to influence the behavior of smaller parties, we rule out this factor as an alternative explanation because larger parties' actions are significantly constrained by the rules of the game.[30] That is, even when parties suggested hundreds of alternative plans in both processes (Trelles et al., 2022), they were not capable of substantially altering the distribution of seats. Consequently, the lack of variation in seat allocation could not have altered the share of seats obtained by parties and it is unlikely to explain their behavior.[31]

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[29] Results show composite competitive margins assuming parties have a strategy to increase the number of competitive districts (Owen and Grofman 1988). We evaluated this metric using a +/- range between 2% and 8%.

[30] In Mexico's MMES, proportionality affects how smaller parties engage in redistricting because they access political representation through the vote share they obtain – regardless of its dispersion across districts and states, not through the districts that they win.

[31] The recurrent violations to the "*governability rule"* aiming to prevent the 8% over-representation margin between the proportion of votes is a consequence of the MMES design and the *ex-ante* rules adopted to draw districts, not a byproduct of partisan behavior during the redistricting process

Finally, the fifth explanation – *building legitimacy through partisan inclusion* – outlines the possibility that parties have accepted the rules governing the redistricting game as long as they are still able to impose their preferences – by having the EMB accepting *higher-scoring* plans. Their presence and activism within the EMB have allowed them to directly become their own *watchdogs* while allowing the bureaucracy to indirectly benefit from the reputation developed around the implementation of a process that, so far, has not been challenged by political actors.

Although we cannot evaluate this hypothesis from the available data, the EMB has indirectly benefited from executing a technically complex process that is highly susceptible to becoming politicized without being questioned by political parties. While parties have historically acknowledged bureaucratic constraints – e.g., selection of criteria, operationalization of the rules, and the use of algorithmic solutions – limiting their capacity to alter results in their favor, they still "legitimize" the process by overseeing that no opponent obtains an intentional or administrative advantage.[32]

(Murayama 2020). If parties were completely excluded from the process, the algorithmic solution would also yield an electoral cartography with very similar results.

We also discard turnout as an alternative explanation to party behavior because there is evidence showing overall participation trends moving in opposite directions after redistricting cycles. After the 1996 redistricting, for instance, elections became more competitive but midterm turnout dropped almost 8.3% (from 66% in 1991 to 57.7% in 1997), and subsequently 16.4% (from 57.7% to 41.3% in 2003). In contrast, turnout began increasing after the 2004 redistricting. In 2009 it increased 3.5% (from 41.3% in 2003 to 44.8%). After the 2017 cycle turnout increased 4.67% (from 48% in 2015 to 52.67% in 2021) but it has never reached back the levels of the 1990s. More research is required to explore the potential relationship between redistricting cycles, competitiveness, and turnout at the *seccion/district* level. However, we indirectly interpret the results displayed in Table 3 as preliminary evidence showing that redistricting has a marginal impact on the overall levels of competitiveness. Consequently, since the main effect of redistricting on participation would be mediated through competitiveness (Geys 2006, Indridason 2008, Zazueta and Cortez 2014, De Paola and Scoppa 2014), it is unlikely that *ex-post* variation in turnout explains party behavior in redistricting cycles.

[32] The adoption of the unanimity rule (*criterion 8)* for the 2017 process, for instance, was a consequence of the active partisan engagement during the 2004 and 2013 cycles. The EMB had to adopt a "more flexible" rule enabling the TC to consider *higher-scoring* plans as "valid" (Trelles et al., 2022). That is, by playing the redistricting game, parties have become part of the rule making process and have been able to suggest *higher-scoring* alternative plans. This type of rule modification, for instance, would have been unlikely if the process had been fully insulated from the

5. DISCUSSION

Our analysis reveals that Mexico's redistricting process has had a marginal impact on electoral outcomes. Approximately every decade, the bureaucracy has met its primary goal by reducing malapportionment and rebalancing the population across the 300 SMD (INE 2019). It has also successfully managed to include political parties in the process, avoided the politicization we have traditionally observed in the United States, and has increased the number of *consensus* solutions despite *violating* higher-order principles by validating *higher-scoring* partisan plans.

A first approximation at lower-level *actions* reveals that parties have an explicit interest in participating in the redistricting process by suggesting hundreds of alternative solutions to *algorithmically* generated plans. The high level of activity, the significant amount of bureaucracy resources spent in 2013 and 2017, and our preconception of parties as agents whose primary interest is maximizing their electoral returns, invited us to audit this process with great detail and examine the political consequences of their intervention.

Contrary to the aggressive *gerrymandering* that has been identified in many of the states across the U.S., we found that the *actions* and *strategies* of parties in Mexico are inconsequential for the main dimension we consider in our study (seat allocation). At most, we found that parties were aiming to improve their winning margins by slightly increasing their *vote share* or the levels of *competitive*ness in districts that they expected to win.

We find these results to be surprising because they indicate that the "mood of the party" was set well before the guests arrived. We find that while the institution of redistricting – compared to pure proportionality – has a substantial impact on political outcomes, the *optimization* and *partisan bargaining phases* did not. We do find evidence, however, suggesting that voter swings, along with the interaction of rules (i.e., *municipal integrity*) and the intra-state political demography (e.g., voter distribution within states), matter much more for political outcomes than the way in which the district lines are being drawn.

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parties or if they had willingly opted out of a process. This suggests that parties have been able to impose their preferences on the electoral bureaucracy and the EMB has indirectly benefited by legitimizing the process through partisan consensus building, dialogue, and engagement.

Contrary to what most spectators of the process would think, either by previous knowledge on the topic or by observing the micro-level actions of the parties, our findings reveal that outcomes are being predetermined in the rule-setting phase and way in advance the *optimization* or the *partisan interaction phase* begin. This finding is particularly relevant because it shows how the adoption of redistricting rules (i.e., *seccion* base geography, margins of population deviation, and municipal integrity) can substantially constrain the type of outcomes we observe in redistricting.

While partisan behavior during Mexico's redistricting process is not being driven by seat maximization, their engagement confirms the *watchdog* role they play within the electoral bureaucracy. Overall, both the parties and the bureaucracy have found a "higher benefit" associated with the inclusion of parties in redistricting. By engaging in the process, parties have learned how to "play the game," audit the process and become aware of what opposing parties are doing, ensure that they are not being victims of administrative or partisan *gerrymandering*, and have become capable of *vetoing or endorsing* higher-scoring plans. In exchange, the bureaucracy has been able to successfully implement a technically complex process while minimizing politicization, facilitating *consensus* solutions, and legitimizing the process through partisan inclusion.

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ONLINE APPENDICES

Appendix 1. *Contextualizing Redistricting in Mexico*

1.1 The evolution of electoral boundary delimitation in Mexico

Electoral technocrats and political parties have been captivated by redistricting since Mexico held their first competitive elections in the 1990s. Every cycle, the EMB invested significant bureaucratic, technological, and administrative resources to execute redistricting (INE 2019). The 2013 and 2017 redistricting cycles, for instance, took the EMB 24 and 38 months to complete, respectively (IFE 2012 and INE 2019). According to the EMB's registry of voters, the financial cost for the 2013 process was approximately 1.5 million dollars. It involved the multilateral cooperation of external institutions – e.g., the census bureau (INEGI) and the National Commission for the Development of Indigenous Communities (CDI), and a multi-stage effort within the electoral bureaucracy – e.g., the EMB's cartography department (CD), the IT department (UNICOM), the national and local surveillance commissions (CNE and CLVs), the registry of voters (DERFE), the technical committee (TC), the general council (JGE), and executive board (*Consejo General*).[33]

[33] The redistricting timeline includes activities such as: i) planning deliberations held by JGE, DERFE, and CD, ii) collecting, updating, and curating demographic information provided by INEGI and CDI at the *sección* (census tract equivalent) and municipal level by the CD and DERFE; iii) identifying indigenous communities of interest by the DERFE and CD; iv) organizing redistricting colloquiums with scholars and practitioners to identify best practices and international standards by the DERFE and CD, v) creating a TC formed by experts in a relevant field for redistricting (i.e., demography, statistics, anthropology, mathematics), vi) defining the rules, methodology, stages, and criteria by the TC, vii) approving of the rules and criteria by the DERFE, JNE, and Consejo General, viii) developing, testing, and executing the software and platforms required by the CD, DERFE, TC, and UNICOM, ix) generating algorithmic plans for the 32 states by CD, DERFE, and TC, x) organizing consultation forums with indigenous communities by DERFE, xi) receiving and evaluating the counter proposals formulated by political parties in two separate rounds by the TC, xii) selecting the final plan in each state (x32) by the TC, xiii) approving the final redistricting scenario and assigning the district headquarters by the JGE, and xiv) approving the redistricting plans by the EMB's executive board.

Mexico's political parties have also been captivated by the redistricting process. First, Mexico's transition from a purely majoritarian system to a *mixed-member electoral system* (MMES) in the late 1970s gradually increased the presence of opposition parties in the legislature through proportional representation (PR) seats (Weldon 2005).[34] Along with the local alternation in power in several northern and central states during the 1908s and1990s, the 300 *single-member majority districts* (SMD) increasingly became more competitive (Lujambio 2000). The ruling party, which used to win over 90% of the seats during the 1960s, 1970s, and the early 1980s, lost its majoritarian status in the mid-1990s.

After the inception of MORENA in 2014 and its arrival to power in 2018, the PRI became a minority party in the legislature obtaining less than 10% of the SMD seats. While proportionality has historically allowed minority parties to access legislative representation, the SMD tier has systematically overcompensated parties that are able to secure a larger share of votes across states and has been maintained to prevent extreme fractionalization of the party system (Cox 1997, Lujambio 2000, and Weldon 2005). The increasing competitiveness in the SMD tier, however, has created incentives for major parties to pay close attention to when and how district lines are being drawn.

Opposition parties – i.e., PAN and PRD, for instance, raised concerns about malapportionment in the 1980s and 1990s. Mexico's population increased 21% in the decade, from roughly 67 million in 1980 to 84 million in 1990. Internal migration and *demographic shifts* across states made the apportionment phase of redistricting particularly relevant for opposition parties whose electoral strongholds are found in central and northern states, and where demographic shifts were significantly larger than in its southern

[34] This 1978 electoral reform was the first step to move the country towards a more competitive electoral playing field (Lujambio 2000). The reform added 100 proportional representation (PR) seats to the 300 single-member majority districts (SMD). In 1987, 100 more PR seats were added to reach the lower chamber's current size – 200 PR seats and 300 single-member majority districts (Trelles 2007). The ruling party had previously introduced a minimum "representation quota" in 1963 in order to guarantee the presence of opposition parties (*Diputados de Partido) in the legislature.*

counterparts (Michel and Ribardière 2017, Sobrino 2018, and Pérez-Campuzano et al., 2018). [35]

The number of districts assigned to Mexico City (*CDMX*) and the State of Mexico (*EdoMex*), for instance, experienced the largest population shifts. The former went from having 30 districts in 1996 to 27 in 2004, and 24 in 2017. *EdoMex*, which is the country's largest state, went from having 36 districts to 40, and then to 41, respectively. This state had a significant population imbalance within its congressional districts prior to the 2013 and 2017 redistricting cycles (using 2004 districts based on the 2000 census results). Approximately one-fourth of its districts were beyond the +/- 15 % maximum deviation allowed by statutes.[36]

Population shifts across states have forced parties to accept reapportionment as a loss for some and a gain for others. *Mexico City,* for instance, became a stronghold of the left-wing PRD in the mid-1990s, while *EdoMex* remained a PRI stronghold until recently. The parties have come to recognize redistricting as a necessary and effective mechanism for eliminating district-level asymmetries and ensuring the "one person-one vote principle" across the country's 300 SMDs.

Mexico's electoral management system was designed as a consequence of a generalized sentiment of mistrust towards the ruling party due to the flagrant interference in elections (Scott 1964, Johnson 1978, Schedler 2002, Levitsky and Way 2010, Woldenberg 2012, Langston 2017, and Cantú 2019). Among many other administrative procedures (i.e., voter registration or mechanisms to guarantee the secrecy of voting), parties considered redistricting a key policy for guaranteeing a "leveled" electoral playing field (Lujambio and Vives 2008). Prior to 1996, for instance, redistricting was implemented by the *Comisión Federal Electoral* (CFE), a board presided by Mexico's Minister of the Interior (SEGOB)

[35] Subsequently, the country's population has increased from 83.9 million in 1990 to 127.9 in 2020 (INEGI).
[36] The 2010 population of EdoMex was 13,798,573 and the average district was supposed to have approximately 345,000 habitants each.

and *de facto* controlled by the executive branch. Consequently, the process was viewed by opposition parties as neither transparent nor neutral (Trelles and Martínez 2007).[37]

The 1996 redistricting process took place the same year the EMB became fully independent from the executive branch. The process also took place in the preamble of the 1997 midterm election where the ruling party – the *Partido Revolucionario Institutional* or PRI – lost for the first time its majoritarian status in the legislature. A few years later, in 2000, the country culminated its democratic transition with its first peaceful alternation in power (Lujambio and Vives 2008). This increasingly competitive environment incentivized the parties to function as "*watchdogs*" that would legitimize the process by guaranteeing the neutrality and transparency of key administrative decisions (Estévez et al., 2008).

In order to prevent partisan *gerrymandering*, the EMB included in 2004 a "*geometric compactness*" restriction that ranked second in order of importance after the "equal population" criteria (IFE 2004, Trelles and Martínez 2007). In the preamble of the 2014 electoral reform, opposition parties demanded that the responsibility to renew the electoral geography across the 32 states was centralized in a national-level bureaucracy that would apply the same rules and criteria across states in order to minimize the political interference of state-level actors.

As a way to ensure transparency and neutrality in redistricting, a national and thirty-two local oversight commissions (CNV and CLVs, respectively) have served as the main internal consultation mechanism allowing parties to closely monitor, audit, and participate in all stages of the process.[38] Since 1996, all parties have engaged in the process

[37] The CFE was responsible for delineating the electoral cartography of the 300 federal districts in 1978. The ruling party won 296 out of the 300 SMD in the 1979 midterm election. Three years later, the same party won 299 seats. In 1985, the PRI won 289 of the SMD. It was not until the 1988 election when the PRI lost for the first time a two-thirds qualified majority by obtaining 234 out of the 300 SMD (Trelles and Martínez 2007).

[38] The National Oversight Commission is known as the *Comisión Nacional de Vigilancia (CNV)* and the Local Oversight Commissions are known as the *Comisiones Locales de Vigilancia (CLV)*. Both the CNV and the CLVs are partisan internal consultative instances formally built-in within the electoral commission (Trelles 2018). This administrative configuration affects partisan interaction because parties are able to formulate counter-proposals both through the CNV and through the CLVs in each state (e.g., the PRI has a representative at the main EMB's headquarters in Mexico City via

and have formulated suggestions to algorithmically produced maps through these national and local representations. In 2013, for instance, parties proposed 522 alternative plans and in 2017 they suggested 463 maps, which reveals the high levels of interest parties have in the process.

In the last three decades, there have been relevant technological, administrative, and socio-political changes affecting the ways in which parties engage in the process (Trelles 2017). During the 1996 process, for example, the EMB used a desktop machine in the main headquarters to run a heuristic optimization algorithm and only parties represented at the CNV were informed through printed maps how districts had changed. In contrast, during the most recent 2017 redistricting round the EMB was able to share online algorithmically produced plans with all parties. This software also had map-editing capabilities allowing parties to visualize maps and compare their own plans – and scoring functions – with those submitted by other parties.

The administrative-level rules that have been used to renew electoral boundaries have also changed over time. While in 1996 it was hard to compare maps using quantitative metrics, IFE´s Cartography Department developed a software interface for the 2004 process that allowed the *technical committee* (TC) to compare and evaluate plans based on a quantitative parameter allowing them to quantify each of the restrictions included in the cost function. In the 2017 cycle, the EMB decided to introduce "*criterion 8,"* a rule allowing parties to endorse a map with a higher associated cost as long as no party opposed that alternative. This new rule has incentivized parties to compromise and build consensus around plans that are preferred to the algorithmic solution despite having a higher cost.

The changing socio-political environment has also had implications for how parties formulate counter-proposals. The rise of independent voters over time has made it harder for parties to cultivate stable regional strongholds and, consequently, parties are less certain of their long-term partisan adepts at the district level (Moreno 2018). Additionally, violence

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the CNV, and it also has representatives at the EMB's state offices through each of the 32 CLVs). If the same party suggests different plans for a state through these instances, the EMB considers the plan with the lowest score.

is rapidly transforming the country's political landscape. In 2004, for instance, drug cartels' territorial disputes were not a significant factor that parties considered when formulating counter-proposals. According to INE's cartography director, the spike of violence in certain municipalities during Calderón and Peña Nieto's administration, however, has affected the rationale used by parties and the EMB to create scenarios both in the 2013 and 2017 processes.[39]

In sum, the level of awareness and the number of actors participating in the process has significantly increased over the years. Redistricting has evolved from a process where only a few electoral technocrats rebalanced the population across districts, to a more inclusive process that has gradually adopted different mechanisms to include the opinion of both local and national parties (respectively represented in the CNV and CLVs), as well as of minority communities – e.g., indigenous majority districts in 2004 and public consultations in 2017. The development of a computer-based capacity to process optimization, the emergence of online mapping technology, and the electoral tribunal's ruling on citizens' rights and representation have gradually contributed to making redistricting a more inclusive process (Trelles 2017).

1.2 Parties' behavioral expectations and preliminary evidence of interest in the process

We assume that parties are rational, self-interested, and rent-seeking maximizing agents (Mayhew 1974). This assumption is based on the strategy described to us by partisan actors in the 2013 process and from fieldwork experience in the 2004 redistricting round. PAN's former representative at the National Oversight Committee (CNV) confirmed that once the TC shared with them the *algorithmic* solution for each state, in consultation with the party's national headquarters – the *Comité Ejecutivo Nacional* or CEN, they used previous electoral returns to rank *secciones* based on their level of competitiveness. When formulating a plan,

[39] Interview of the leading author with Miguel Rojano, INE's Director of Cartography. Mexico City, June 2019.

they prioritized moving those *secciones* where they had a clear advantage trying to *maximize their vote share, while beating the cost function.*[40]

Following the logic of revealed preference analysis (RPA), a method built on the Weak Axiom of Revealed Preference (WARP) used to infer preferences from a rational actor (Samuelson 1948, Varian 2006), we assume that if plan p_1 is chosen by a party from a set of plans P = $\{p_1, p_2, \ldots p_n\}$, then the plan must be preferred over all other plans in the set.[41] We make an additional assumption that parties prefer their own counter-proposal to those of all other parties during that round – even if these proposals were technically simultaneous. In other words, we assume that parties can analyze potential plans to the extent other parties are not better able to determine their own interests.

In order to match these behavioral expectations with the observed outcomes, we analyze engagement on two different levels: *higher level (strategies)* and *lower level (actions)*. Following the RPA logic, we expect that activity in these two levels to be aligned with the outcomes. On one hand, a party's *strategy* to engage should vary depending on the characteristics of each party and the environment of electoral competition at the state level (we analyze this level – likelihood of engagement based on the type of party, vested electoral interest, and coalition status – in section 4.1 of the online appendix). On the other

[40] Fieldwork interview of the leading author with Florencio González, PAN's representative at IFE's CNV. Mexico City, June 2019.

[41] The RPA method has been used as a heuristic for evaluating redistricting plans in the research on United States redistricting (Kousser 1991 and Gronke and Wilson 1999). Courts and litigants have also informally used the method of revealed preferences when examining the characteristics of plans that were rejected to illuminate why a particular plan was accepted. For example, an Arizona court found probative value in an Arizona commission's failure to adopt a proposed plan with more competitive districts over one with fewer (such districts are a constitutional requirement in the state). *Minority Coalition for Fair Redistricting, et al.* v. *Arizona Independent Redistricting Commission* CV2002-004380 (2003). Altman et al., (2015) formalize the reliability by applying this method to redistricting using causal graph analysis.

This method does not require distributional assumptions: we can observe which plans were chosen and which were available deterministically. However, reliably inferring revealed preference requires the core assumption that parties do not make perverse counter-proposals (for strategic or emotional reasons). In other words, parties make proposals that they expect would render a better payoff than the status quo, if the proposal were adopted.

hand, their *actions* should respond to either a vote share or seat maximizing strategy (e.g., formulating an alternative solution when the expected return is positive compared to the *status quo* – the *algorithmic* solution presented as the *first scenario* or the plan selected by the TC as the *second scenario*). This activity is depicted in figure 1 by the two *lined quadrants* defined as $M_{2,p}$ and $M_{3,p}$, which represent the total share of counter proposals that were submitted by political parties.

Lower level (*actions)* are *prima facie* evidence that parties are interested in redistricting. Table 1.2.1 depicts the total number of plans proposed by parties and the variation observed when looking at the patterns of play during the 2013 and 2017 cycles ($M_{2,p}$ and $M_{3,p}$).[42] If parties would have proposed a plan for every instance where they were entitled to do so (e.g., at two different levels – CNV or CLV; in each of the two rounds; and in each one of the 32 states), the total universe of observed plans would have been 896 partisan plans in 2013 ($M_{2,p}$ and $M_{3,p}$ = 448 per round) and 1,152 plans in 2017 ($M_{2,p}$ and $M_{3,p}$ = 576 per round).[43] Instead, the data reveals that parties engaged *selectively* – they did not suggest a plan at every level, stage, or round. In 2013, for instance, parties proposed a total of 522 alternative plans, which represent approximately 58.25% out of the universe of 896 possible plans. In contrast, parties were less active in 2017 than in 2013, formulating a total of 463 counter-proposals during the 2017 redistricting process, which represent 40.2% out of the universe of 1,152 possible plans.[44]

[42] The variation in the engagement among parties, stages ($M_{2,p}$ and $M_{3,p}$), and processes (2103 vs 2014), as well a description of the engagement among parties at the national and local level (CNV vs CLVs) can be found in appendix 1.3.
[43] The number of registered parties increased from 7 to 9 for the 2017 redistricting process.
[44] Upon publication, the complete range of partisan counter proposals will be made publicly available. Please contact the corresponding author for questions and preliminary access to the data and replication code in the following GitHub repository: https://github.com/MIT-Informatics/mex-open-map/tree/master/StrategyPaperAnalysis

Table 1.2.1 Counter proposals formulated by parties in the 2013 and 2017 redistricting processes

actor	Accepted	% Win
2013		
MC	86	27.47253
PAN	82	57.60870
PNA	47	22.91667
PRD	88	17.77778
PRI	84	33.33333
PT	63	18.75000
PVEM	65	29.85075
2017		
ES	47	76.27119
MC	53	72.30769
MORENA	45	71.42857
PAN	50	82.25806
PNA	49	72.88136
PRD	57	70.58824
PRI	60	61.11111
PT	47	75.86207
PVEM	55	68.65672

Note: The *success rate* in parenthesis reports the share of plans that were adopted by the TC in the first and second rounds of partisan interaction. Prepared by authors with information from the Federal Electoral Institute.

While the traditional three large parties (PAN, PRI, PRD) formulated more than 80 plans in 2013, smaller parties (PT, PVEM, PNA), except MC, formulated approximately 30% fewer plans that same year. In contrast, the variation in the total number of plans suggested by each party was significantly less in 2017. The PRI, for instance, was the most active party formulating 60 plans, while MORENA was the least active one and formulated 45. That is, there was a difference of only 15 plans between the most and least active party in 2017 – *versus* a difference of 41 in 2013.

The varying levels of *effectiveness* (the number of plans that were actually adopted by the TC) are also intriguing. Interestingly, the *success rates* were quite different between 2013 and 2017. While in 2013 the right-wing PAN was the most effective party in formulating winning scenarios (with a 57% success rate), the rest of the larger (PRI and PRD) and smaller parties (PT, PVEM, MC, PNA, MORENA, and ES) became significantly more effective in the next redistricting cycle. The PT, which is a relatively small left-wing party, formulated 12 winning scenarios out of 63 in 2013 (18% success rate). In 2017, however, the same party-endorsed 36 winning alternatives over a total of 47 plans proposed (75% success rate). Similarly, the left-wing PRD formulated only 15 winning scenarios, out of a total of 88 alternatives in 2013 (17% success rate). In contrast, they became significantly more effective and formulated 39 successful plans out of 57 in 2017 (70% success rate). Overall, these results show parties were more active in 2013 compared to 2017 (formulating 522 vs 463 plans, respectively) but also significantly less effective in getting their preferences adopted by the TC (average success rate of 29% vs 72%, respectively).

Given the high levels of partisan engagement at this level, we expect that this interaction would have had a meaningful impact on the electoral geography and, consequently, on electoral outcomes. Following Jackman's (1994) approach to analyze the overall impact of redistricting, we look at the *seat differences* among parties using different plans. Based on the RPA logic, we would expect both 2013 and 2017 final plans to be different from the algorithmic solutions. That is, we expect the *seat distribution* among parties to be different in those cases where a party –or group of parties – endorsed a plan that prevailed over an algorithmic solution. In the following section, we analyze the overall political implications of redistricting – and plan differences between the 2013 and 2017 cycles – based on the seat allocation among parties.

1.3 Party interaction by stage and level

Table 1.3.1 depicts the total number of partisan plans proposed by parties at the stage level ($M_{2,p}$ and $M_{3,p}$) during the 2013 and 2017 processes. These results show the varying levels of *effectiveness* when parties formulated alternative plans (numerators represent the number of plans that were adopted by the TC)**.** Interestingly, the success rates were quite different between 2013 and 2017. While in 2013 the right-wing PAN was the most effective party in formulating winning scenarios, the rest of the larger (PRI and PRD) and smaller parties (PT, PVEM, MC, PNA, MORENA, and ES) became significantly more effective in the next redistricting cycle. The PT, which is a relatively small left-wing party, formulated 6 winning scenarios out of 63 in 2013.

In 2017, however, the same party endorsed 30 winning alternatives over a total of 47 plans proposed. Similarly, the left-wing PRD formulated only 15 winning scenarios, out of a total of 95 alternatives, in 2013. In contrast, they became significantly more effective and formulated 31 successful plans out of 57 in 2017. Overall, these results show parties were more active in 2013 compared to 2017, but also significantly less effective.

Table 1.3.1 Partisan counter proposals formulated by stage in the 2013 and 2017 redistricting processes

2013				2017		
Party	***1st Round*** ($\lambda_{1,13}$)	***2nd Round*** ($\lambda_{2,13}$)	***Total*** ($\lambda_{1+2,13}$)	***1st Round*** ($\lambda_{1,17}$)	***2nd Round*** ($\lambda_{2,17}$)	***Total*** ($\lambda_{1+2,17}$)
PAN	19/42	21/40	**40/82**	13/20	23/30	**36/50**
PRI	2/28	14/56	**16/84**	8/27	20/33	**28/60**
PRD	5/48	10/47	**15/95**	12/22	19/35	**31/57**
PT	2/32	4/31	**6/63**	6/17	24/30	**30/47**
PVEM	1/20	10/45	**11/65**	9/22	21/33	**30/55**
MC	1/38	8/48	**9/86**	10/22	21/31	**31/53**
PNA	1/19	7/28	**8/47**	9/20	20/29	**29/49**
MOR	-	-	**-**	8/20	16/25	**24/45**
ES	-	-	**-**	9/19	21/28	**30/47**
Total	**31/227**	**74/295**	**105/522**	**84/189**	**194/274**	**278/463**

Note: Denominator reports the number of counter-proposals made, numerator how many were adopted. Prepared by authors with information from the Federal Electoral Institute.

We also found significant variation in party behavior between the national and local level. Table 1.3.2 depicts the partisan plans aggregated by level (*national vs local).* The ratio in each cell represents the plans accepted in relation to the total number of plans submitted by each party. These differences confirm that political parties have learned to play the redistricting game and that state level parties – represented across the 32 CLVs – have become more effective players over time.

Table 1.3.2 Partisan counter proposals formulated by level in the 2013 and 2017 redistricting processes

2013				2017		
Party	***National (CNV)***	***Local (CLVs)***	***Total***	***National (CNV)***	***Local (CLVs)***	***Total***
PAN	34/46	6/36	**40/82**	2/3	24/47	**26/50**
PRI	8/30	8/54	**16/84**	1/4	27/56	**28/60**
PRD	8/56	7/39	**15/95**	5/14	26/43	**31/57**
PT	4/27	2/36	**6/63**	2/2	28/45	**30/47**
PVEM	7/28	4/37	**11/65**	1/2	29/53	**30/55**
MC	7/49	2/37	**9/86**	0/1	31/52	**31/53**
PNA	4/12	4/35	**8/47**	0/0	29/49	**29/49**
MOR	-	-	**-**	0/0	24/45	**24/45**
ES	-	-	**-**	0/0	30/47	**30/47**
Total	**72/248**	**33//274**	**105/522**	**11/16**	**248/437**	**259/463**

Note: Denominator reports the number of counter-proposals made, numerator how many were adopted. Prepared by authors with information from the Federal Electoral Institute.

In 2013, for instance, the total number of partisan plans formulated at the state level – through parties represented at the 32 CLVs – was very similar to the number of plans suggested by parties at the national level (274 vs 248, respectively). That same year, national level parties represented at the CNV, compared to their local counterparts, were *twice as effective* in getting their plans accepted (72 vs 33, respectively). Surprisingly, this pattern dramatically changed in the 2017 round. National level parties almost disappeared from the redistricting scene (from 248 in 2013 to only 16 plans in 2017) and local parties almost doubled the number of proposed plans (from 274 in 2013 to 437 in 2017).

Out of the total universe of counter-proposals that could have been made in 2013 (more than one thousand), for instance, political parties decided to put forward approximately five hundred alternative maps.[45] This reveals that parties went through an internal strategic decision-making process, that they opted out in some cases because they preferred the *status quo,* or manifested their interest to support an alternative plan to be considered by the TC. In the 2004 process, it was clear that local and national level parties faced coordination problems. Before the EMB developed an online platform to discuss counter proposals (pre-2013), the discussions being held by technical experts in IFE's headquarters in Mexico City, did not always consider key socioeconomic or geographical accidents at the local level.

One of the most emblematic cases was the adoption of a map in the northern state of Sonora, where one of the districts (*district number 4 based on Guaymas*) ran northeast from the Sea of Cortés all the way to Bavispe, a border town with the state of Chihuahua. It includes 39, out of the state's 72 municipalities, that are socioeconomically diverse and, more importantly, the district is split in half by *Sierra Madre Occidental (*a mountain range with an elevation of more than 8,000 feet*).*[46] This also reveals that local and national parties, despite sharing the same party label (e.g., the party members of one party like PRI represented at IFE vs the party members of that same party in the northern state of Sonora), might face coordination and information asymmetry problems and have a different perspective of political geography, competitiveness, campaigning logistics.

[45] The total number of counter proposals in a redistricting process can be calculated by multiplying the total number of registered parties by the total number of states, by the number of rounds included in the process, and by the number of oversight instances each party has within the EMB (e.g., the local and national level oversight commissions, respectively referred to as CNV and 32 CLVs in this paper).

[46] Interview with Otto Claussen Iberri, Mayor of Guaymas and PRI's candidate in Sonora's federal district 4 in 2018. See: https://es.wikipedia.org/wiki/Distrito_electoral_federal_4_de_Sonora

Appendix 2. Competitiveness and state level analysis

2.1 Competitiveness as an alternative metric to seat allocation

We analyze if there are any "winners and losers" based on the number of competitive seats between the 2013 and 2017 redistricting cycles.[47] Table 2.1.2 compares the three different alternatives that were considered by the EMB (*algorithmic, best,* and *winning* plans) based on the 2015 and 2018 turnout. Results show that the 2017 redistricting cycle produced slightly less competitive seats based on both the 2015 and 2018 turnout. Based on the 2015 turnout, for instance, the *algorithmic* solution in 2013 produced 39 competitive seats, while the 2017 *algorithm* produced 8 less competitive districts (with the 2018 turnout the difference was of only one district). When comparing the number of competitive seats among the universe of *winning* plans based on the 2015 turnout, the 2013 cycle produced 33 competitive districts while the 2017 redistricting produced only 26. With the 2018 turnout, there were 22 competitive districts in the 2013 cycle and only 17 with the 2017 plans.

Table 2.1.1: Competitive seats based on the 2013 and 2017 redistricting plans

scenario	comp_2015	comp_2018
2013		
winner	33	22
best	32	21
algorithm	39	19
2017		
winner	28	17
best	32	17
algorithm	31	20
2004		
status quo	33	22

[47] Competitiveness is defined as a 4% (or less) margin between this first and second place.

Table 2.1.2 examines the sensitivity of the competitiveness results to variations in the threshold used to classify sensitive districts. There is no substantive change. While the number of districts identified as competitive change substantially when changing the threshold from 2% to 4% -- the variation in the total number across scenarios plans remains negligible under the 2015 election scenario, and quite small under the 2018 scenario. Further using an 8% yields no differences in predictions.

Table 2.1.2: Competitive seats based on the 2013 and 2017 redistricting plans. Robustness check.

Competitive Seats under Multiple scenarios		
scenario	comp_2015	comp_2018
2013		
winner	60	43
best	61	47
algorithm	61	36
2017		
winner	60	37
best	62	29
algorithm	59	37
2004		
status quo	62	47
Margin = 4%		

Competitive Seats under Multiple scenarios		
scenario	comp_2015	comp_2018
2013		
winner	60	43
best	61	47
algorithm	61	36
2017		
winner	60	37
best	62	29
algorithm	59	37
2004		
status quo	62	47
Margin = 8%		

Which parties sponsored plans with competitive districts? Table 2.1.3 reveals the distribution of competitive seats endorsed by each party –or group of parties (*coalition* and *unanimity*). While the number of *winning* plans with competitive seats endorsed by a *coalition* of parties stayed very close across processes, the number of *winning* and *best* competitive plans endorsed by the right-wing PAN almost disappeared in 2017 (from 18 and 11 to 0 and 2, based on the 2015 and 2018 turnout respectively). The PRD significantly increased the number of *best*-scoring competitive alternatives in 2017 (9 and 4), but only sponsored a single plan with a *winning* competitive district in 2017 based on the 2015

turnout. Lastly, table 6 shows that the number of competitive seats in *winning* plans that were sponsored by parties *unanimously* more than doubled in 2017 (from 3 and 3 in 2013 to 9 and 7 in 2017).

Table 2.1.3: Competitive seats based on the 2013 and 2017 redistricting plans among parties

scenario	comp_2015	comp_2018
2013 - Coalition		
winner	10	7
best	5	2
2013 - INE		
winner	1	0
best	1	0
2013 - PAN		
winner	18	11
best	17	10
2013 - PRD		
winner	0	0
best	4	7
2013 - UNANIMOUS		
winner	3	3
best	3	3

scenario	comp_2015	comp_2018
2017 - Coalition		
winner	11	4
best	0	1
2017 - INE		
winner	3	2
2017 - PAN		
winner	0	2
2017 - PRD		
winner	1	0
best	9	4
2017 - PVEM		
winner	1	2
2017 - UNANIMOUS		
winner	9	7
2017 - PRI		
best	1	3

Overall, the analysis of competitiveness shows that the 2017 cycle was more restrictive in terms of having individual parties (i.e., the PAN) pushing forward an agenda with a slightly higher number of competitive seats (18 and 11 in 2013, based on the 2015 and 2018 turnout respectively, vs 0 and 2 in 2017). It also shows that consensus solutions around competitive seats were more common in 2017 than in 2013. This last finding is probably explained by the adoption of the unanimity rule (*criterion 8*) for the 2017 cycle.

2.2 Political implications in the State of Mexico (EdoMex) and Guanajuato

We analyze seat differentials in two cases where we would expect changes in the algorithm and partisan interaction would be more pronounced given that they can be considered medium to large states in terms of the total number of districts in each state. On one hand, we selected the most populated state in the country –*El Estado de México (EdoMex)* – and, on the other, we picked a mid-size state, *Guanajuato*, with 40 and 15 districts, respectively. We also compare district plans based on the level of competitiveness to diagnose the overall impact of redistricting using an alternative metric.

In order to analyze seat differences at the state level, table 2.2.1 depicts the result for Mexico's most populated state, the *Edomex,* which was assigned 40 districts in the 2004 redistricting cycle, and 41 in 2013 and 2017. Given its demographic density and its growth over time, this is one of the states where changes in the electoral geography should have a more pronounced effect on the distribution of seats among parties.[48] This table compares the seat distribution among parties based on a hypothetical (academic) plan favoring the PRI, the two scenarios considered by the EMB (*winning plan* and *algorithmic solution*), and the previous plan approved in 2004 (*status quo*).[49]

[48] According to INEGI's decennial census, the total population for this state was 13.09 million in 2000, 15.17 in 2010, and 16.99 million in 2020.

[49] Partisan plans were created using *District Builder* and presented at the *IV Congreso Internacional de la Asociación de Estudios Parlamentarios (AMEP)*, *El Poder Legislativo y la calidad de la democracia,* April 17-19, 2013. Mexico City, sponsored by *Universidad Iberoamericana*, *UNAM, ITAM, and UAM*.

Table 2.2.1 Comparing party plans (2013 / 2017) vs an academic *gerrymandering* exercise favoring the PRI in the State of Mexico (*EdoMex*)

Mexico State -- Comparing Party Plans & Academic Gerrymandering Excercise

ACTOR	WINNER	ALGORITHM	STATUS QUO	ACADEMIC
2013 - 2015				
MORENA	1	1	1	0
PAN	3	3	4	3
PRD	3	3	4	3
PRI	34	34	31	34
2017 - 2015				
MORENA	1	1	1	0
PAN	3	2	4	3
PRD	3	3	4	3
PRI	34	35	31	34
2013 - 2018				
MORENA	38	39	38	36
PAN	1	1	0	2
PRI	2	1	2	2
2017 - 2018				
MORENA	37	37	38	36
PAN	1	1	0	2
PRI	3	3	2	2

Results in table 2.2.1 show marginal differences in the distribution of seats in *EdoMex*. Based on the 2015 turnout, the PRI would have obtained 34 out of the 40 seats with the 2013 EMB´s *algorithmic solution*, the 2013 *winning plan* selected by the TC, or its best hypothetical scenario maximizing seat returns (*academic solution*). Results are almost identical when comparing the *status quo* and the *academic plan* with the 2017 *algorithmic solution* and *winning plan*. Based on the 2018 turnout, the seat distribution among parties in the *EdoMex* remains almost the same across the four scenarios of 2013 and 2017 (the PRI is slightly better – by one district in the *winning* category and two districts in the *algorithmic* category – with the 2017 plans than with the 2013 scenarios).

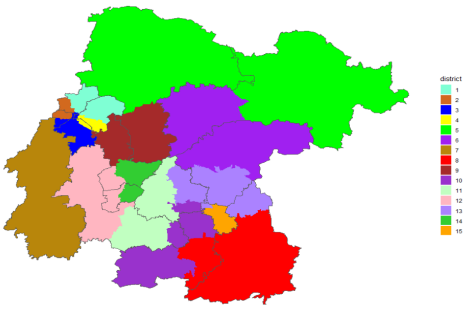
Figure 2.2.1 (a, b, c, and d) depicts the 2013 and 2017 electoral cartography for the *algorithmic* and *winning* solutions in the state of Guanajuato, a traditional stronghold of the right-wing party (PAN). The maps show how the electoral geography changed within and across redistricting cycles. The comparison of the 2013 vs 2017 *algorithmic solutions (2a* vs

2c), for instance, shows map differences that are a consequence of the EMB/TC's decision to operationalize rules differently – despite both solutions being produced using the same 2010 baseline population, but with a different optimization. The comparison within processes (2a vs 2b and 2c vs 2d) also shows the boundary difference due to the interaction phase that took place between parties and bureaucrats. These changes, however, had a marginal implication in the distribution of seats across parties. Under the 2013 plan and using 2015 turnout, PAN wins 14 seats and MORENA 1 with the *algorithmic* solution. After parties engaged in the process, PAN won all 15 seats. With the 2017 plan, despite the changes in the north-western municipality of *León*, PAN kept all 15 seats in both the *algorithmic* and *winning* solutions.[50]

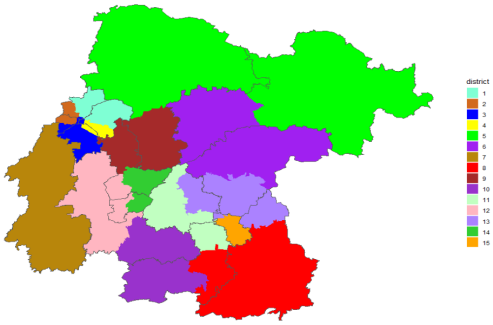
[50] The 2017 records show that, regardless of a higher-scoring plan minimizing municipal splits in the city of Celaya and partitioning differently the city of León (the *algorithmic solution* offered a solution with a cost of 7.351 while the final plan – endorsed by 8 out of 9 parties – was 7.699), the parties invoked *criterion 8* and the political outcome remained the same. For the detailed arguments see: *Análisis y Evaluación del escenario final de distritación federal que realiza el Comité Técnico para el Seguimiento y Evaluación de los Trabajos de Distritación en Guanajuato*. INE: Registro Federal de Electores. 2017

Figure 2.2.1 (a, b, c, and d). Comparing algorithmic and winning plans in Guanajuato

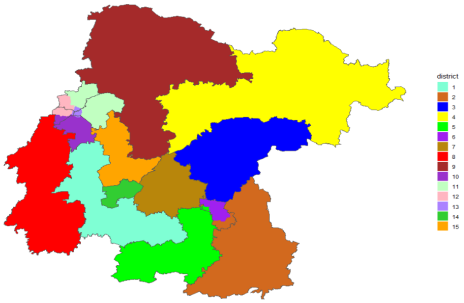
a. Algorithm 2013



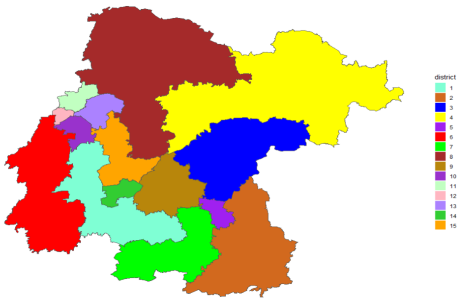
b. *Winning 2013*



c. Algorithm 2017



d. *Winning 2017*



Appendix 3. Institutional constraints

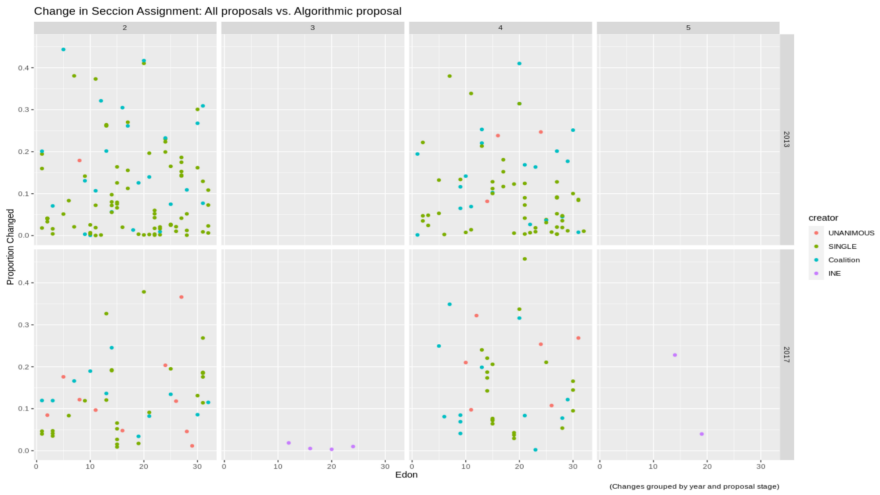
3.1 *Seccion* differentials by actor at the stage and plan level

Figure 3.1.1 shows all the counter-proposals suggested by parties considered in each stage by the TC compared to the *algorithmic* solution.[51] The different colors depicted in the

[51] In figure 3.1.1 the first and second round of partisan interaction are depicted as stages 2 and 4, the algorithmic solution is portrayed as stage 1, and the second and third scenarios are depicted as stages 3 and 5 – where the EMB selected a winning plan.

legend represent the creator of the plan, namely: the bureaucracy *(INE), a* single party, a coalition of parties, or a plan endorsed unanimously by all parties. This figure reveals two patterns of partisan engagement. On one hand, it shows that an important number of partisan plans suggested alternatives that were above the 20% difference with respect to the *algorithmic* solution. It also shows that most of the interactions taking place in 2013 were skewed towards the 0 - 20% range, that they were mostly formulated by individual parties, and that the first round ($M_{2,p}$) had the highest number of plans (9) that were above the 30% difference. On the other, it shows that 2017 plans were more evenly distributed within the 0 - 45% range, and that they were formulated either by a coalition of parties or unanimously endorsed (*contradicting H3)*.

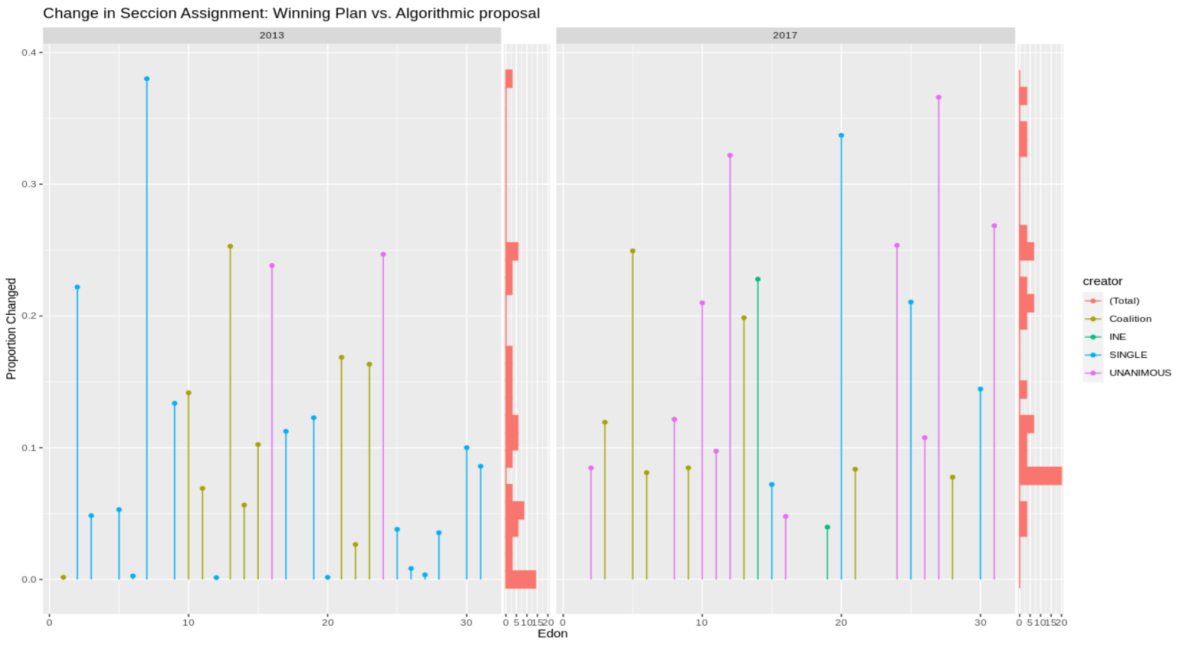
3.1.1 Seccion differentials by stage



These findings reveal not only that the rules have not constrained the capacity of parties to formulate counter-proposals with a substantial deviation – of *secciones* – over time (*against H4*), but that the adoption of slightly different procedural rules (i.e., *criterion 8)* has encouraged less individualistic engagement and more consensus-building among parties endorsing plans that are suggesting a substantial change in the number of *secciones* across districts.

Figure 3.1.2 compares the change in secciones of the winning plans vs the algorithmic solution in 2013 and 2017. The different colors represent the creator of the winning plan. Results in this figure confirm that while the winning plans supported by a coalition of parties remained almost the same across the 2013 and 2017 processes (8 and 7, respectively), the number of unanimous solutions increased significantly in 2017 (from 2 to 10). As a consequence, the proportion of *secciones* that changed in those states where this type of solution prevailed tends to be higher (e.g., while in state 27 the proportion of *secciones* changed by a single party winning proposal was approximately 1%, in 2017 the proportion of changes increased to approximately 36% – contradicting H3).[52]

3.1.2 *Seccion* differentials comparing the winning plan vs the algorithmic solution

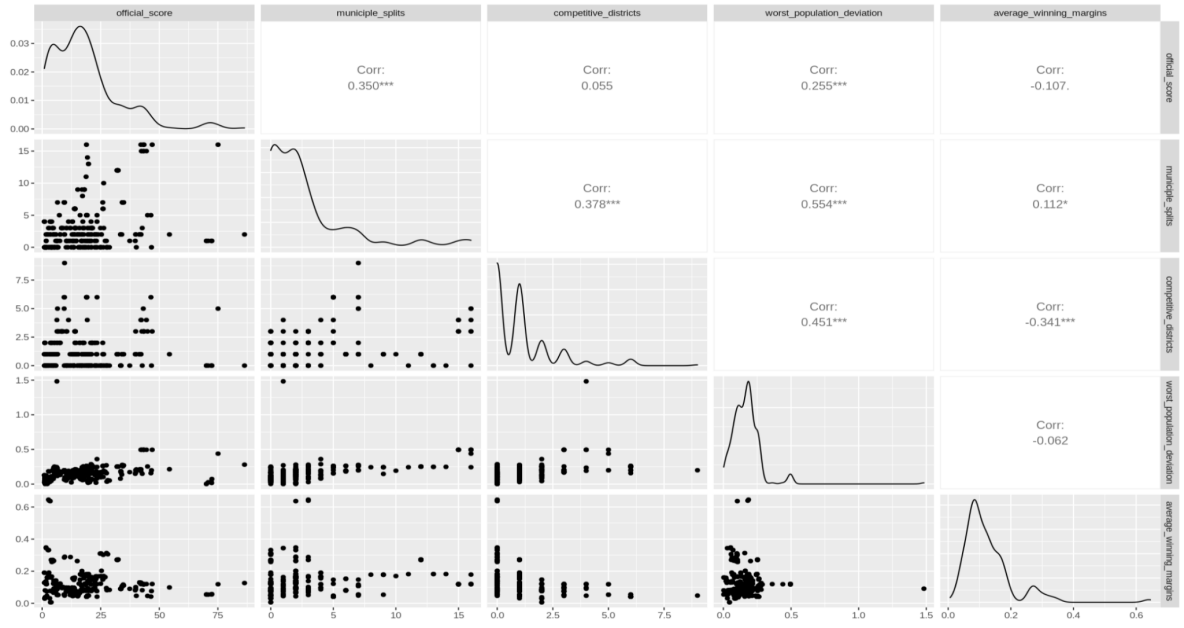


[52] As noted by Trelles et al., (2022), even when the algorithm became more effective in finding lower cost solutions in 2017, parties have increasingly adopted an exception rule (*criterion 8)* to endorse higher-scoring plans.

3.2 Tradeoff analysis of redistricting criteria

Figure 3.2.1 shows the "tradeoff" between criteria in proposed plans (i.e., the score associated with the cost function, the deviation of the population across districts, the number of municipal splits[53], the level of competitiveness, and the average winning margins). As expected, the official score is correlated with population deviation (e.g., less deviation decreases the cost function). The number of *municipal splits* is also correlated with population deviation but, more importantly, it correlates with the level of competitiveness, which is partial evidence showing that municipal integrity is constraining partisan gerrymandering.

Figure 3.2.1 Tradeoff between redistricting criteria in proposed plans



[53] We use two methods to measure the municipal splits. First, for all plans we compute the number of splits based on official INE census boundaries for municipalities. Second, we extract INE's official split core from additional documentation provided only for party submission in the 2017 round. In a few cases these differ substantially, likely because of undocumented rules that INE used to exclude selected municipalities from the calculation. The analysis is based on the INE scores where available, and the computed scores where INE did not provide any official scores. However, the conclusions do not change if only computed scores are used.

A hypothesis for explaining the lack of variation in the allocation of seats is that the *interaction of rules with political demography* is constraining the parties' capacity to *gerrymander*. We evaluate this hypothesis using the theoretical limits of *gerrymandering*. That is, we compare the variation in the allocation of seats between a hypothetical – extremely aggressive – *partisan gerrymandering* strategy, which is only limited by the "equal" population constraint (allowing a +/- 15% deviation), and the variation observed with the interaction between pre-mapping redistricting rules (e.g., the choice to use *secciones*, contiguity, municipal boundaries) and the geographic distribution of electoral support within each state. We state this hypothesis in the following way:

> *H8.* The interaction of rules with political demography is constraining the variation in the allocation of seats (if rules did not have an effect, the difference in the variation between the *pre* and *post-rule* application maps would tend to be closer to zero).

Table 3.2.1 depicts the "tradeoff" between criteria in proposed plans.[54] We define "*mapping freedom*" as the range between the theoretical minimum and maximum possible seats a specific party could obtain during the mapping process – assuming the parties were sophisticated enough to find the possibilities left. We define "*distribution freedom*" as the variation in the number of seats conditional on the level of support parties receive in a specific year (e.g., the number of votes parties received within each state). The "*difference of the pre-mapping constraints"* (change 2018-2015) is defined as the difference between the *distribution freedom* and *mapping freedom.* This is the remaining variance that is

[54] We acknowledge that calculating the actual limits of *gerrymandering* is an NP-hard problem given that *secciones* need to be treated as discrete units (Altman and McDonald 2010). The continuous problem, however, is tractable and provides a bound on the discrete problem. We treat this as a telephone-book *gerrymander* with perfect foresight and assume that we could assign each person to a district separately. We only consider population balance within a +/- 15% deviation but no other restrictions or criteria are considered (including contiguity). We assume parties can accurately predict who would turn out and how they would vote. Finally, we assume voting behavior is deterministic for the 2015 and 2018 elections and that it does not change by the potential assignment of voters to a different district.

attributable to some combination of *pre-mapping redistricting rules* (e.g., the choice to use *secciones*, contiguity, municipal boundaries) and their interaction with the geographic distribution of electoral support within each state. Given the existence of multiple parties and low turnout, it is theoretically plausible to minimize a party's seats – assuming it does not matter what seats are won by other parties. This explains why the lower theoretical boundaries are so low across the board and do not vary substantially. The freedom of choice demonstrated by the mapping process (and available in theory over each year), however, varies significantly among parties.

Table 3.2.1 The tradeoff between redistricting criteria in proposed plans

ACTOR	MIN_SUBMITTED	MAX_SUBMITTED	MIN_THEORY	MAX_THEORY	MAPPING_FREEDOM	DISTRIBUTION_FREEDOM
2015						
MC	9	10	0	31	1	31
MORENA	13	15	0	52	2	52
PAN	50	58	1	147	8	146
PRD	24	32	0	79	8	79
PRI	189	206	11	241	17	230
2018						
MC	0	0	0	3	0	3
MORENA	212	226	23	271	14	248
PAN	64	78	2	194	14	192
PRD	0	0	0	1	0	1
PRI	11	17	0	138	6	138
CHANGE: 2018-2015						
MC	-9	-10	0	-28	-1	-28
MORENA	199	211	23	219	12	196
PAN	14	20	1	47	6	46
PRD	-24	-32	0	-78	-8	-78
PRI	-178	-189	-11	-103	-11	-92

As expected, and confirming H8, these results show that the theoretical limits on minimal party seats are pretty low. That is, if the objective was to eliminate a party, and the only rule was equal population, this could theoretically be accomplished. As we have argued in section 3.1, there is substantial possible variation in the seat allocation based on the institution of redistricting (e.g., comparing a MMES and a nationwide PR system). Most

of that effect, however, is eliminated by the adoption of redistricting rules and the distribution of support before any mapping/bargaining occurs. The 2018 swing in voter loyalty (distribution of support), for instance, significantly changed the upper bound of the theoretical distribution – by increasing to 219 and 47 seats for Morena and PAN, respectively, and by decreasing it to 103 and 78 seats for PRI and PRD, respectively.

Appendix 4. Party strategic interaction

4.1 Predicting party behavior based on political strongholds and electoral returns

In this subsection, we analyze party behavior from the higher level (*strategy)* perspective. We ask, *why do parties engage in redistricting despite the marginal political implications on electoral returns?* In order to evaluate the motivations behind parties' strategy to engage (*dependent variable)*, we use three different measures as predictors of engagement assuming that parties are more likely to formulate a counter-proposal in those cases where they have a vested political interest – either because they are the ruling party, they are the second force competing for power in a particular state (and are interested in boosting electoral competitiveness), or because they are part of a state-level coalition running along with a major competing force in every state.

We believe that the parties that are ruling a state – or those that are competing for power – are more likely to engage in the process compared to those parties that play a marginal role and are not competitive in that particular state. Since smaller parties tend to rule (or have previously ruled) significantly fewer states than the traditional three largest parties (PRI, PAN, and PRD), we control for coalition formations at the state level in election years prior to the redistricting process. We assume that parties in the coalition will coordinate and endorse similar plans to support their well-entrenched running mates in every state.

As a proxy measure of the parties' vested interest at the state level, we use the following three dimensions: i) *ruling party*; ii) *coalition formation*; and iii) *vote returns.* The first one captures a party's "strategic position" based on its ruling condition (*ruling vs*

opposition) and the level of competitiveness (e.g., if the state has recently experienced alternation in power once or multiple times). The second dimension focuses on the formation of state-level coalitions (e.g., while larger parties might have incentives to protect strongholds in a single-member majority system, smaller parties that are usually interested in competing within the PR tier might have an indirect incentive to endorse the same counter-proposal that their coalition mates shortly before or during the redistricting cycles). The third dimension captures the parties' level of support based on the proportion of the *vote share* received prior to redistricting in every state.

After evaluating several hypotheses, treating a party's decision to "engage" in the redistricting game as our *dependent variable,* we did not find any substantial results.[55] Table 4.1.1 shows the percentage of entry – operationalized as a binary decision to formulate a plan or not in a specific state, regardless of the stage, year, or level – based on the parties' strategic position. Surprisingly, the probability of partisan engagement is extremely high (above 90 percent) for almost all parties. Except for the second strategic position (significant at the 0.1 level), the prediction of entry – or intensity of engagement – based on the parties' strategic position or *vote share* received at the state level prior to each redistricting cycle was not statistically significant.

[55] We test for the likelihood of participating in redistricting (formulating a counterproposal) based on the parties' "strategic position" in each state. We treat *engagement* both as a binary and ordinal dependent variable (*single* vs *intensity of engagement*). Each political party had an equal opportunity to participate in both the 2013 and 2017 processes and they were able to decide: i) if the participated in the process, ii) the number of times they formulated a counter proposal, iii) the states where they decided to propose a plan, iv) the timing of their intervention during the first and/or second round, and v) the channel used to formulate a counterproposal (*national versus local representatives)*. We use the "strategic positions" to predict whether a parties engaged in the process by either proposing at least one plan (a binary DV) or if they engaged with a "higher intensity" and proposed plans in a single or multiple stages and levels (ordinal DV ranging from 0-4). For a detailed description of this analysis refer to appendix 4.2.

Table 4.1.1 Likelihood of entry by the parties' strategic position

actor	1	2	3	4	5	6
MC	100	100	100	-	96	96.8
PAN	100	100	92.9	100	100	100
PNA	85.7	93.3	100	66.7	91.7	75
PRD	100	100	66.7	66.7	94.4	96.3
PRI	100	100	85.7	100	100	100
PT	80	100	100	100	76	89.3
PVEM	95.7	100	75	100	83.3	100
ES	-	100	100	-	87.5	84.6
MORENA	-	-	-	-	84.2	76.9

Despite the variation we identified previously at the lower level (individual *actions* depicted as $M_{2,p}$ and $M_{3,p}$ in figure 1), we suspect that the null findings are probably explained due to the high level of partisan *engagement* and the low-cost entry parties have for suggesting plans.

4.2 Modeling Partisan Engagement in 2013 and 2017

The selective strategy of partisan interaction described in tables 1 shows that parties are perceiving redistricting as a "high-stake" process to secure future electoral returns. Consequently, we test this assumption by evaluating if parties were more likely to engage when they had vested interests in a particular state (i.e., based on their ruling or competing status for the governorship, on the vote share received in previous elections, and on their role in a coalition as a major or minor party). We treat a party's decision to "play" the redistricting game as our *dependent variable.* Each political party had an equal opportunity to participate in both the 2013 and 2017 processes and they were able to decide: i) if the participated in the process, ii) the number of times they formulated a counter proposal, iii) the states where they decided to propose a plan, iv) the timing of their intervention during

the first and/or second round, and v) the channel used to formulate a counterproposal (*national versus local representatives)*.[56]

Regardless of the stage, level, or year, we evaluate the probability of partisan entry based on the party's "strategic position." We use this measure as a proxy for a party's influence/power in a state based on its ruling condition and the level of competitiveness – number of alternations in power – in every state prior to redistricting. We defined six unique ordinal "strategic positions," where the first position (1) corresponds to cases where parties have a clear vested interest given their "single-party rule" status, whereas six (6) corresponds to a scenario where parties are less likely to participate in the process given that they have never ruled a particular state, that there has never been alternation in power, and they represent a minor political force in that same state.[57]

We also include the "*vote share returns"* obtained by all parties in the years preceding each redistricting process. Based on interviews with partisan representatives at the EMB, we suspect that parties used prior electoral returns at the state level to react to the algorithmic solutions and used this information to formulate alternative plans. For example, parties with higher levels of electoral support in a specific state – e.g., 60% or higher – are more likely to engage in the process than those parties that have traditionally received a lower vote share –e.g., less than 30%.

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[56] We use the "strategic positions" to predict whether a parties engaged in the process by either proposing at least one plan (a binary DV) or if they engaged with a "higher intensity" and proposed plans in a single state or at multiple stages and levels (ordinal DV ranging from 0-4), see H3.

[57] The "strategic positions" are defined as follows: 1. Party a) Controls during redistricting year b) has controlled state in all previous observed periods; 2. Party a) Controls during redistricting year b) has NOT controlled state in all previously observed periods; 3. Party a) DOES NOT control during the redistricting year b) has NOT controlled state in all previously observed periods c) has won a MAJORITY of previous elections in observed time period; 4. Party a) DOES NOT control during the redistricting year b) has NOT controlled state in all previously observed periods c) has won a MINORITY of previous elections in observed time period; 5. Party a) DOES NOT control during the redistricting year b) has NOT controlled state in all previously observed periods; 6. Party a) DOES NOT control during the redistricting year b) has NOT controlled state in all previously observed periods c) has won NONE of the previous elections during the time period d) another party has won ALL previous elections.

In order to account for the alignment of what we define as "major" and "minor" parties, we include information about state level coalitions that formed shortly before or during the year the redistricting process took place (Olmeda and Devoto 2019).[58] In order to integrate coalitions into the "strategic position" framework, we assume that minor parties will adopt the same "strategic position" of the major party in the coalition or that all member parties assume the "strategic position" which is highest among the member parties in the coalition. For example, if PRI has a strategic position of one (1) and it forms a coalition with PVEM, which has a "strategic position" of six (6), all coalition members are considered to have a "strategic position" equal to one (1).

Assuming that partisan behavior is driven by a self-interest electoral maximization strategy, we evaluate the following hypotheses:

> H9. *[Engagement / Ruling Party]:* A political party, or coalition of parties, with a higher "strategic position" will be more likely to propose a redistricting plan in a state compared to those parties holding a lower position, regardless of the redistricting process stage or the level of government from which the party is proposing.

> H10. *[Intensity of Engagement / Ruling Party]* A political party, or coalition of parties, with a higher "strategic position" are more likely to engage in multiple stages and levels in a state compared to those parties holding a lower position.

[58] "Major" parties are those which have generally held power in each state for a majority of the time frame considered in this analysis such as PRI, PRD, and PAN. "Minor" parties are those that have not held power or have recently formed and started to compete in the redistricting process such as PVEM, Nueva Alianza (PNA), Encuentro Social (ES), PT, MC, and MORENA. The state level coalition data was generously provided by Olmeda and Devoto (2019).

H11. *[Intensity of Engagement / Vote Share]:* Parties with higher electoral returns are more likely to engage in the process compared to other parties that have received a lower vote share at the state level.

To evaluate hypothesis nine treating engagement as a binary dependent variable, we use a cumulative link model (CLM) as described by Christensen (2018).[59] The CLM method allows for ranked ordinal categorical data to be incorporated into a logit regression model, while standard logit models do not account for ordinal rankings (e.g., first strategic position being of higher order than 6). For hypotheses ten and eleven we use an ordinal logistic regression to evaluate the relationship between the intensity of engagement and the parties' vested interest based on either their strategic position (H10) or the past vote share they received in a particular state (H11). Table 4.2.1 shows the results for the models related to our three hypotheses.

Table 4.2.1. Predicting partisan engagement in the 2013 and 2017 redistricting processes

Strategic Position	*H9. Engagement (Y/N) / Ruling Party*	*H10. Engagement Intensity / Ruling Party*	*H11. Engagement Intensity / Vote Share*
1	-0.520	-0.824 ****	-
2	1.615*	0.834 ***	-
3	0.554	-0.174	-
4	-1.045	0.013	-
5	1.135	0.185	-
Vote Share	-	-	0.005 **

Note: The CLM was used for H9 (binary DV), while an ordered logistic regression was used for H10 and H11 (ordinal DV ranging from 0-4). Reported p-values: .001(****), .01(***), .05(**), and .1 (*).

The first model shows that only the second "*strategic position*" was a significant predictor of engagement (treated as a binary DV) at the 95% level. Since each category of

[59] Constructed in the R package *ordinal*.

the independent variable is treated as a binary variable, the first category is dropped (included as beta_0). The negative coefficient indicates that parties in the second "position," are less likely to propose a redistricting plan (have E (Y =1|X)) compared to the "strategic position" previous to it (e.g. the second "position" is less likely to propose than the first). The rest of the "strategic positions" do not have a significant effect on a party's decision to engage. The relative difference between the first and second positions, while significant, is negligible probably due to the fact that when engagement is treated as a binary *dependent variable,* parties unconditionally propose plans at a rate of 90%.

Similarly, the prediction of entry – or intensity of engagement – based on the *vote share* parties received at the state level prior to each redistricting cycle was not statistically significant.

4.3 The case of Yucatan

The records reveal that parties used a wide range of arguments related to administrative and socioeconomic characteristics to invoke *criterion 8*.[60] Beyond showing their interest in the state's capital (the city of Mérida) electoral boundaries, these stories provide very little information allowing us to infer their real motivations. For example, the arguments offered by the parties centered around how Mérida, which concentrates two federal districts, should be split. Traditionally, these two districts split the city vertically (East-West), while the *algorithmic* solution offered a horizontal (North-South) split.[61] The right-wing PAN, which has traditionally been the second competing force to the PRI in the state and a dominant force in the capital, argued the following to justify its "flipping" decision from the first to the second stage: i) the partisan higher-scoring plan (1.705) will allow INE's district headquarters to remain in the municipalities where they are currently located, ii) the

[60] See: *Análisis y Evaluación del escenario final de distritación federal que realiza el Comité Técnico para el Seguimiento y Evaluación de los Trabajos de Distritación para el estado de Yucatán*. INE: Registro Federal de Electores. 2017.
[61] See figure 4.3.1 a. and c. for cartographic output.

adoption of the higher-scoring solution will allow the EMB to maintain a lower population deviation in the future, considering a higher expected population grow in certain areas of the city, and iii) the lower-scoring algorithmic solution offering a North-South split of the city would create a northern district concentrating *higher-earning residents*, which "usually do not get involved" in participating as poll workers on the election day. None of these arguments are related to a *seat/vote maximizing electoral strategy* and very similar reasons were posed by the rest of the parties.

What drove parties to interact the way they did in Yucatán? After talking to the party representatives at the state level, the PAN representative explained that during the first round of interaction their party was trying to offer a lower-scoring solution that would allow them to maintain a safe district in the north of Mérida with a horizontal split. After a conversation with the PRI representative, however, he confirmed that the PAN accepted a vertical split of the capital because they realized that their party would still be able to retain the capital's northern district while becoming more competitive in the southern district of Mérida. In exchange, the PRI would try to minimize PAN's historic advantage in the northern district of the capital.[62] In the 2018 election, results confirm that the PAN benefitted from "switching" positions between the first and second round. The PAN won the northern district with a safe margin of 29,405 (12%) votes and managed to win the southern district by only a 98 (0.04%) vote difference.[63] If the *algorithmic* lower-scoring plan had prevailed in 2017, PAN would have only been able to retain one of the two capital's districts (the northern district of Mérida) in the 2018 and 2021 elections.

These explanations partially justify the actions of some of the parties (e.g., either in an administrative sense when arguing that their plans will solve problems related to

[62] Interview of the leading author with Gabriel Mena and Leandro Espinosa, PAN and PRI representatives at CLV during the 2017 round. November 16, 2021.
[63] In the 2018 election, for instance, PAN won the two districts of Mérida, and lost the other three rural districts to the PRI (Progreso, Valladolid, and Ticul). In 2021, the PAN retained the two districts of the capital and won the east rural district with headquarters in Valladolid. MORENA, which replaced PRI as the second force in the state after 2018, won the rural districts with headquarters in Progreso and Ticul.

bureaucratic organization or by learning that they could benefit from what other parties are proposing when invoking unanimity).[64] However, they reveal that the logic used by parties when engaging is not being driven exclusively by a *vote/seat maximizing rationale.*

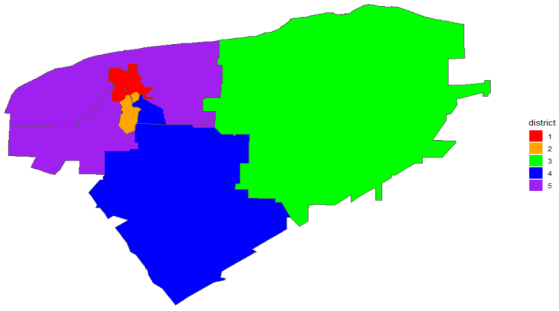
In the light of the 2018 and 2021 electoral results, for instance, it is difficult to explain why did the PAN endorse the *algorithmic solution* in the first round (splitting Mérida horizontally) if an alternative plan (with a vertical split of Mérida) was clearly allowing them to win both districts – *versus* winning only the northern district of the capital in both the 2018 and 2021 elections (as shown in figure 4.3.1).[65]

[64] The official arguments by the parties provide little information for inferring their real motives. These arguments are most plausibly understood as rhetorical appeals to INE – so at best they provide information on what the parties believed INE valued.

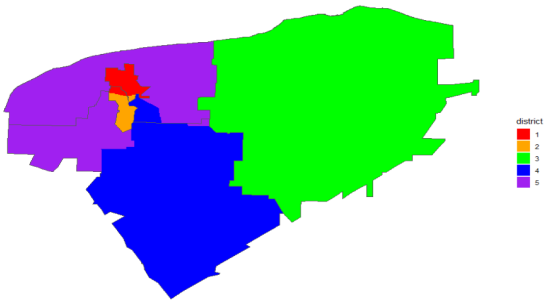
[65] It is not clear why the right-wing PAN moved away from its first-order position or why they did not propose their ideal plan in the first stage of the process.

Figure 4.3.1 (a, b, c, and d). Comparing algorithmic and winning plans in Yucatan for the 2013 and 2017 redistricting cycles

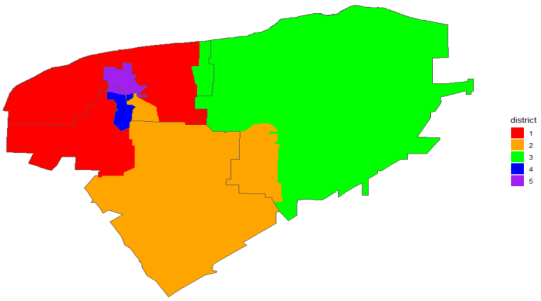
a. **Algorithm 2013**



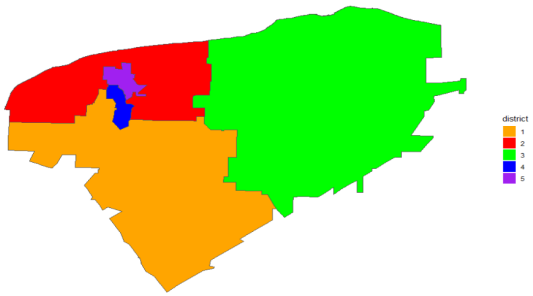
b. Winning 2013 (PAN Endorsed)



c. Algorithm 2017



d. Winning 2017 (PAN endorsed)



Note: Maps elaborated by the authors with information from the Instituto Nacional Electoral.

It is also surprising that both the other dominant forces at the state level – the PRI, MORENA, and its smaller coalition allies – did not opt to veto the higher-scoring unanimous solution. More surprisingly, perhaps, is the fact that they were the main actors supporting the higher-cost vertical (East-West) divide that would end up benefiting the PAN´s electoral rentability in the state's capital (as shown in Table 4.3.1).

Table 4.3.1 (a and b). Political implication of party interaction in Yucatán during the 2013 and 2017 redistricting cycles (using 2015 and 2018 turnout)

a. **2015 Turnout**

Party	Algorithm (2013)	Final Plan (2013)	Algorithm (2017)	Final Plan (2017)
PRI	4	4	4	4
PAN	1	1	1	1

Note: Using 2015 turnout. Table calculated by the authors. Cells report the number of districts won by each party.

b. **2018 Turnout**

Party	Algorithm (2013)	Final Plan (2013)	Algorithm (2017)	Final Plan (2017)
PRI	3	3	3	3
PAN	1	2	1	2
MORENA	1	0	1	0

Note: Using 2018 turnout. Table calculated by the authors. Table calculated by the authors. Cells report the number of districts won by each party.

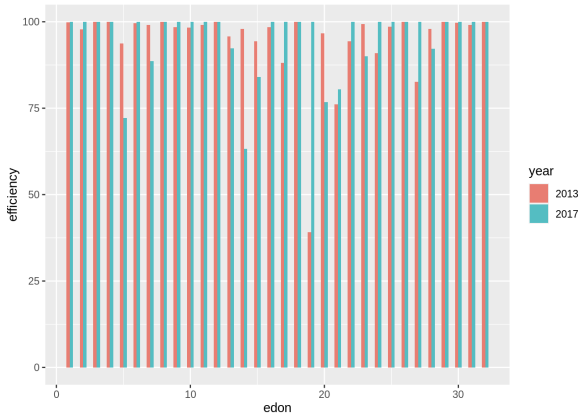
Appendix 5. Algorithmic efficiency and score difference in the 2013 and 2017 processes. [66]

From the optimization standpoint, algorithmically produced plans were more successful (*effective*) in 2017 than in 2013. In the former, the EMB adopted 9 unchanged automated plans, while in the latter it only adopted 5. Since a lower score is associated with a more *efficient* plan (in terms of maximizing the restrictions), we would expect that plans with lower scores to be preferred to plans with a higher cost. Figure 5.1 shows not only that this

[66] This section is based on the Trelles et al., (2022) analysis of the process.

did not always happen (either because a rule was violated or a *socioeconomic* consideration was made by the TC), but that the patterns of interaction and evaluation of plans significantly changed at the state level yielding to different outcomes.

Figure 5.1 Algorithmic Score Efficiency by State and Year



Even more surprising, is that the proportion of unexpected winners was disproportionately high in 2017. Results in table 5.1 show that while in 2013 only in 15% of the cases the algorithmic solution was adopted, algorithmic success increased to 28%. They also show that the optimum solution found by the computer was rejected in more than two thirds of the cases in both years (84.38% in 2103 and 72% in 2017). Furthermore, it reveals that in a large number of cases, especially in 2017, 72% of the time the best score was not adopted.

Lastly, we find that unanimous endorsed plans were extremely more common in 2017 (22% vs 3%) – due to the adoption of *criterion 8,* but also that the EMB/TC adopted a significantly higher number of plans in 2017 that were not the "best-scoring plan" and that were not endorsed unanimously by all actors (31% vs 19%). This evidence shows that despite there was an improvement across processes in terms of algorithmic efficacy, the best solutions were either rejected because parties were able to beat the algorithm in 2013 or because both the EMB/TC and political parties (via *criterion 8*) rejected the algorithmic solution.

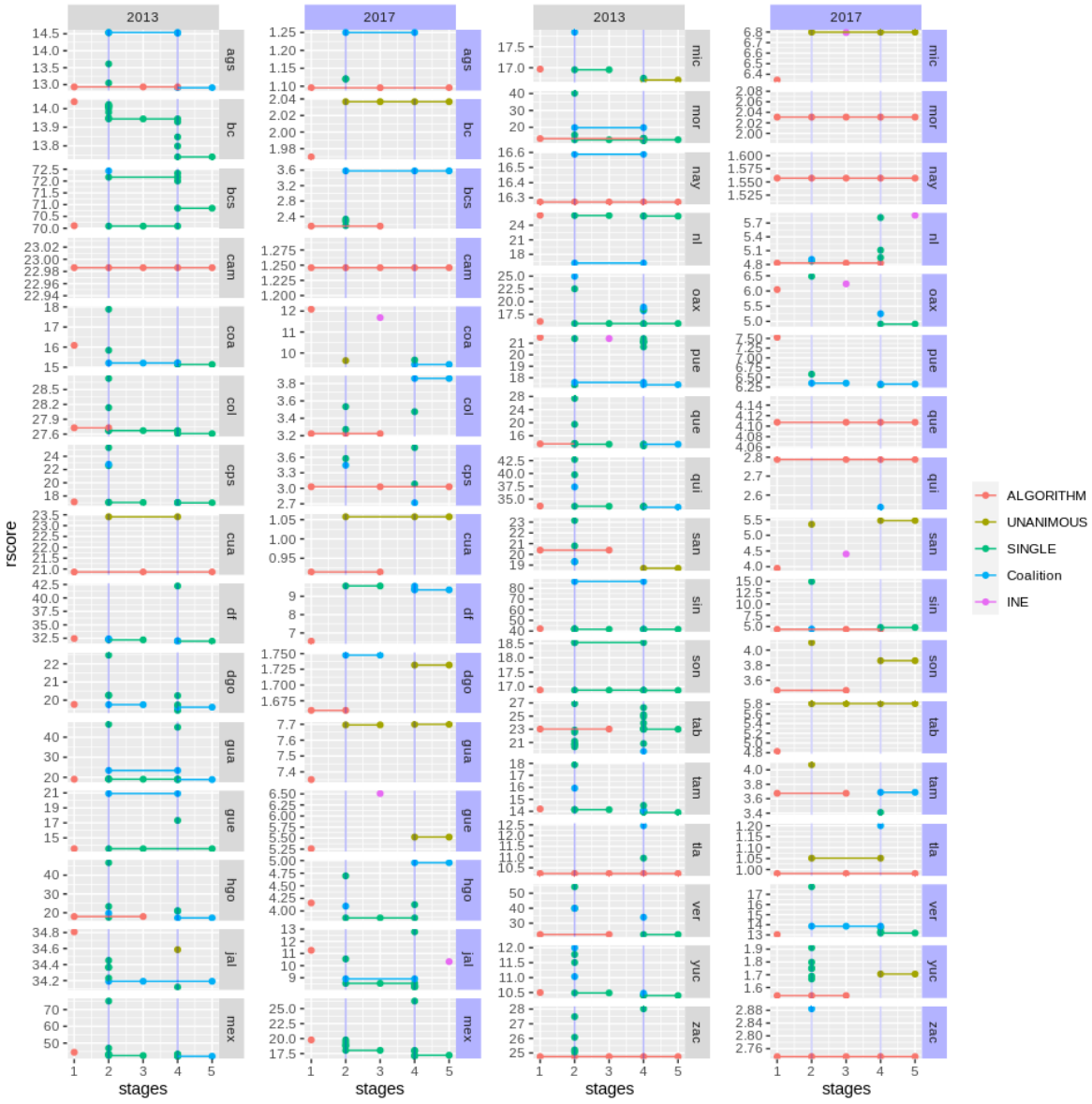
Table 5.1 Unexpected Winners

BEST SCORE LOST	ALGORITHM LOST	UNANIMOUS - NOT BEST	NO AGREEMENT & NOT BEST
2013			
28.12%	84.38%	3.12%	18.75%
2017			
71.88%	71.88%	21.88%	31.25%

Note:N=32 per year.

Finally, the figure shows how the adoption of *criterion 8* in 2017 made the adoption of consensus and unanimous plans a more frequent solution. This clearly affected the adoption of more "efficient," but facilitated the negotiation between parties and reduced the apparent administrative rule violations observed in 2013 when the TC adopted plans with a higher cost. Although in 2017 only two cases were observed in states 14 and 19, the final plans were introduced by the EMB despite partisan or automated plans with lower scores were documented. Figure 5.2 summarizes the 2013 and 2017 redistricting cycles by stage.

Figure 5.2 Redistricting Process Stages and Winners[67]



***Note**: Figure created by the authors. Source: IFE/INE reported scores during the 2013 and 2017 redistricting processes.*

[67] Figure 2b displays competitions in all thirty-two states in both years. The figure reveals that bogh partisan and bureaucratic actors engaged differently in 2013 and 2017.

Appendix 6. Proposal Differences Details

Table 6.1 Counterproposal Differences by Actor Type

Counterproposal Differences by Actor Type		
Characteristic	**major**, N = 376[1]	**minor**, N = 498[1]
score_difference	1.36 (5.30) [-9.86-44.17]	1.21 (5.01) [-9.86-44.17]
Unknown	9	11
split_difference	-0.04 (0.69) [-3.00-7.00]	-0.05 (0.56) [-3.00-3.00]
Unknown	9	11
competitive_difference	0 (1) [-4-4]	0 (1) [-4-1]
Unknown	9	11
proposer_competitive_margin_difference	0.000 (0.006) [-0.023-0.020]	-0.001 (0.005) [-0.018-0.016]
Unknown	9	11
population_difference	0.009 (0.074) [-0.107-1.291]	0.008 (0.030) [-0.107-0.137]
Unknown	9	11
win_difference	0.000 (0.005) [-0.027-0.023]	0.000 (0.005) [-0.025-0.019]
Unknown	9	11
proposer_win_difference	0.0021 (0.0190) [-0.0376-0.2854]	0.0000 (0.0008) [0.0000-0.0159]
proposer_seat_difference	-0.0027 (0.2910) [-2.0000-2.0000]	0.0000 (0.0000) [0.0000-0.0000]
Unknown	9	11
competitive_margin_difference	0.001 (0.005) [-0.016-0.019]	0.001 (0.005) [-0.016-0.018]
Unknown	9	11
proposer_composite_difference	-12 (372) [-2,300-2,100]	0 (0) [0-0]
Unknown	160	494
compactness_difference	-0.02 (0.34) [-1.24-1.16]	-0.05 (0.33) [-1.24-0.91]
Unknown	234	245

[1] Mean (SD) [Minimum-Maximum]

Table 6.2 Unanimous Proposals - Differences vs Reversion

Unanimous Proposals: Difference by Year (Major Parties)		
Characteristic	**2013**, N = 17[1]	**2017**, N = 58[1]
score_difference	-0.11 (1.27) [-1.69-2.54]	0.32 (0.74) [-2.45-3.01]
split_difference	0.00 (0.00) [0.00-0.00]	-0.22 (1.01) [-3.00-2.00]
competitive_difference	0 (1) [0-2]	0 (1) [-2-4]
population_difference	-0.01 (0.04) [-0.06-0.07]	0.01 (0.03) [-0.02-0.09]
win_difference	0.001 (0.005) [-0.004-0.008]	0.000 (0.006) [-0.016-0.019]
proposer_win_difference	0.005 (0.019) [-0.022-0.073]	0.002 (0.013) [-0.029-0.064]
proposer_seat_difference	0.0000 (0.5000) [-1.0000-1.0000]	0.0000 (0.0000) [0.0000-0.0000]
competitive_margin_difference	0.001 (0.006) [-0.003-0.016]	0.000 (0.006) [-0.014-0.016]
proposer_composite_difference	-77 (494) [-1,000-1,000]	-6 (89) [-200-400]
Unknown	4	22
compactness_difference	NA (NA) [Inf–Inf]	0.00 (0.30) [-1.16-0.30]
Unknown	17	5

[1] Mean (SD) [Minimum-Maximum]

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