# Transparency, Automated Redistricting, and Partisan Strategic Interaction: The Case of Mexico[*]

Alejandro Trelles[†]lat44@pitt.edu
Micah Altman escience@mit.edu
Eric Magar emagar@itam.mx
Michael McDonald michael.mcdonald@ufl.edu

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## Abstract

In the U.S. redistricting is deeply politicized and often synonymous with gerrymandering —the manipulation of boundaries to promote the goals of parties, incumbents, and racial groups. In contrast, Mexico's federal redistricting has been implemented nationwide since 1996 through automated algorithms devised by the electoral management body (EMB) in consultation with political parties. In this setting, parties interact strategically and generate counterproposals to the algorithmically generated plans in a closed-door process that is not revealed outside the bureaucracy. The way that redistricting has played out so far in Mexico raises a number of questions: Were the plans produced algorithmically, in fact, optimal with respect to the selected criteria? How did partisan counterproposals differ from the bureaucratic solution? What influence did parties have on the final plan? Can automated and partisan interactive models generate relatively fair and unbiased plans? We address these questions by analyzing a novel dataset that has never been available outside of the EMB and that comprises the entire set of plans proposed by political parties during the 2013 redistricting process. Our analysis offers a unique insight into

the internal workings of a purportedly autonomous EMB and the institutional challenges derived from the lack of transparency in drawing electoral maps.

Electoral institutions in democratic settings usually serve the purpose of translating the peoples' will, expressed by their votes, into the selection of representatives that enact policies. In redistricting — the periodic drawing of electoral boundaries, ostensibly to achieve seemingly apolitical goals such as balancing districts' populations — the causal chain can be reversed. The drawing of new electoral boundaries may allocate voters to districts in ways that affect the number of legislative seats parties are expected to win, the careers of incumbents, and representation for racial and other interest groups. With so much at stake, scholars have found the redistricting process can distort representation, through an eponymous strategy known as gerrymandering (**????**).

Some state governments in the US have sought to remove the opportunity for politicians to engage in gerrymandering by shifting redistricting authority from state legislatures to independent boundary commissions; although some commissions' rules and membership continue to produce highly politicized outcomes, while others less so (**??**). Mexicans decided to overcome this challenge by delegating redistricting authority to the EMB[1], an independent election management board created in the early 1990s. Mexico has innovated beyond the U.S. by employing self-tailored automated algorithms to find redistricting plans deemed optimal on *a priori* criteria, and for political parties to react by offering counter-proposals (**?**). Here, we examine the extent to which technocrats supplanted politicians (**?**) by analyzing a novel dataset describing partisan interaction within the EMB in the 2013 redistricting process.

Even if we believe electoral officials are politically neutral, the rules by which they operate may not constrain political manipulation (**???**). Furthermore, criteria may embody subtle second order biases that produce a predictable political outcome (**?**). Rather than removing political bias, redistricting by commission may perpetuate it in a different guise. In the past, the degree of political manipulation during Mexico's redistricting has been difficult for an outsider to assess. Mexico's EMB conducts redistricting behind closed doors, without public scrutiny, much less public participation (**??**).[2] The media and public are provided insufficient information to assess

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[1]In the following lines we refer to both the Federal Electoral Institute (IFE) and the National Electoral Institute (INE) as Mexico's electoral management body (EMB). IFE was founded in 1990, but it was transformed into INE with the 2014 electoral reform.

[2]The lack of information in previous redistricting rounds, even within the EMB, generated nonfunctional districts. In 1997 and 2006, for instance, electoral commissioners received complains — from several local election commissioners and party representatives in states like Sonora and

if the final plan embodies political mischief — for example, how the plan produced by automation methods is amended before the new plan is formally adopted by the EMB's Council General (**?**).

In 2015, as in 1997 and 2006, the EMB employed an algorithmic redistricting process based upon criteria agreed amongst electoral commissioners before plans were drawn. The EMB used the 2006 algorithm (a simulated annealing combinatorial optimization heuristic) with the same four input parameters (population balance, compactness, municipal integrity and traveling time across districts), but with a slightly reweighted overall scoring function to optimize (**??**). [3] As in 2006, the base geography was modified so that the algorithm could not partition: a) municipalities that had the sufficient population to form a district, and b) minority municipalities with at least 40% of indigenous population [4].

The last redistricting process in advance of the 2015 election offers an opportunity to assess the robustness of Mexico's redistricting process. For the first time, the EMB created a central repository of all redistricting plans housed on a web-based map sharing tool. The EMB granted us access to the tool and provided to us the demographic and cartographic data, allowing us to analyze all redistricting plans formally introduced throughout the process. A large number of plans were produced, more than in any previous redistricting, and the EMB's Technical Redistricting Committee enabled strategic interaction between entities by allowing them to observe counter-proposals formulated by other parties through the platform. [5]

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Chihuahua — arguing that they where not allowed to participate in the redistricting process and that several districts, despite being "optimal," where splitting communities or had major geographical accidents making them dysfunctional for organizational and campaign purposes (**?**).

[3]In 1997 the algorithm was known as the "heuristic model" (it was an algorithm that aggregated *secciones* from West to East and from North to South in each state balancing population and trying not to split municipal administrative divisions (traveling time, compactness and minority districts were not in the picture yet); in 2006, the EMB used a simulated annealing algorithm for the first time (a heuristic with a cost function that aggregated *secciones* departing from a randomly chosen seed that evaluated results under a high-low "temperature" dynamic. It was in this round (2006) where four differently weighted criteria were introduced for the first time; In 2015, the EMB decided to use again the simulated annealing algorithm and the same 4 criteria weighted slightly different. Bee hive optimization was considered by the technical committee, but was discarded because the cost function was not improved significantly.

[4]25 minority districts were created in 2015 and 28 in 2006

[5]The idea of partisan interaction was introduced in the International Redistricting Seminar celebrated at IFE in Mexico City in November 2012. The EMB had allowed parties to formulate observations in 1996 and 2005, but no interaction platform existed so that parties could observe what others were proposing. The authors of this paper introduced the idea during the presentation of the Public Mapping Project Mexico (www.publicmapping.org), an open source web based platform that allows citizens and parties to analyze redistricting scenarios, observe what other users are proposing, and formulate counterproposals in order to optimize the criteria established by the legal framework and allow the authority in charge of redistricting to automatically rank and evaluate

In the end, despite consensus within party representatives at the EMB to endorse the final plan (they actively participated in the process), unexpected partisan resistance in the three major national party headquarters (PAN, PRI and PRD) stalled adoption of the EMB's final plan and ushered in a set of reforms to the Mexican electoral system in early 2014. The way that redistricting has played out so far in Mexico and the last set of electoral reforms —especially the reintroduction of legislative reelection starting in 2018 and the centralization of local congressional redistricting in a single national electoral management body (INE)— raise a number of questions: Are the adopted redistricting criteria politically neutral? Were the plans produced algorithmically, in fact, optimal with respect to the selected criteria? How did partisan counterproposals differ from the algorithmic solution? What influence did parties have on the final plan? Can automated and partisan interactive models generate relatively fair and unbiased plans?

In this work we answer these questions and assess Mexico's redistricting process in search of partisan effects on representation by inspecting data that has never been available outside of the Mexican government. It comprises the machine generated plans and two rounds of strategic counter-proposals made by political parties. In the following lines we discuss how differences across parties affected their participation in the redistricting process; what do their choices tell us about their incentives; how was a machine-based solution affected by human interaction; and the extent to which the process can be validated by the public given the existing levels of transparency.

# 1 Rules of the Game and Challenges for Transparency

Mexico adopted a mixed-member electoral system for the lower house of Congress in 1978. In the first election, three hundred single-member districts were drawn to elect three-fourths of the chamber by plurality rule. [6] That proportion fell to three-fifths since 1985, but the number of single-member districts (300) has not changed. Districts were not redrawn until 1996, coinciding with the first free and fair national

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counterproposals.

[6]In order to simplify our argument, we decided to leave out of this analysis boundary delimitation for proportional representation seats. PR boundary delimitation has taken place in 1979, 1982, 1985, 1997, and 2006 and we discuss these changes and its effects on representation in the following article: Eric Magar, Alejandro Trelles, Micah Altman, and Michael McDonald. 2015. The Effects of PR Boundary Delimitation on Representation: The Case of Mexico. Working Paper. University of pittsburgh.

election in 1997 (**??**). A third redistricting occurred in 2005, and a fourth process took place in 2013, but was aborted. In the following lines we refer to district maps by the first year they were in use, not by the actual year they were drawn.[7]

Mexico's redistricting process has incorporated machine-assisted mapping since 1997. Details have changed, but the broad contours have not (**?**). Although a purportedly autonomous EMB has been in charge of supervising and administrating the boundary delimitation process, the lack of transparency and information availability do not allow the public scrutiny to ensure that the configuration of electoral maps will remain unbiased (**?**). We identify three major stages of the redistricting process that we believe are the main challenges for Mexico's electoral authority: a) the apportionment of seats to states; b) the design of an optimization algorithm; and c) the strategic assessment of computer-generated district blueprints by a technocrats with active, but limited involvement of political parties.

**a) Apportionment**. This is the first stage of the process where a fixed number of seats (300) are redistributed among the 32 states.[8] Restrictions, reminiscent of the U.S., apply: no state may have fewer than two seats; the sole redistributive criterion above that minimum is state population; and no district may cross state boundaries.

In contrast with the U.S., there has been no public debate about alternative methods of apportionment that could be used (**??**). The Hamilton method of largest remainders is used (**?:10**). The quota $Q$ (or price of a seat) is the nation's population divided by 300, the number of seats. A first allocation is made by dividing each state's population in the last general census by $Q$, rounded down. States with populations $< 2Q$ nonetheless get two seats. Unallocated seats, if any, are awarded to states with largest fractional remainders.

The first problem derived from this stage is that malapportionment is introduced. In previous rounds (1996 and 2006), for instance, persistent malapportionment was explained, in part, by the allocation of two seats to small states (**?**). Relative overrepresentation of tiny Southern Baja and Colima was substantial, but only until recently. Population growth in these stats has since ameliorated malapportionment. Yet, relative over-representation remains substantial in migrant-worker-exporter Zacatecas up to 2003, and in the Federal District of late. Both states have rapidly lost

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[7]Despite maps were actually drawn in 1978, 1996, 2005, and 2013, we use years to name the different maps, sticking to the convention of using not the date when boundaries were actually redrawn and accepted, but that of the first election the map was (or would have been) used. Thus, there is a "1979 map" actually drawn in 1978, a "1997 map" drawn in 1996, a "2006 map" drawn in 2004–05, and a "2015 map" drawn in 2013, but never used.

[8]The Federal District, where Mexico City resides, is not recognized as a state in the constitution, but is treated as one for the purpose of apportionment and redistricting.

population relative to the remaining states.

A second problem, as discussed in (**?**), distortions have been usually introduced in this stage when the census counts that are used for redistricting are allowed to become out of date (also see **?**). The constitution mandates the use of the census for redistricting, but sets no obligation to redistrict in a timely manner when new population counts become available. As a consequence, drawing a new map for 2015 with data from the year 2010 injects a fair amount of "creeping malapportionment" into the new plan at its inception (**?**). With this in mind, it is puzzling that the redistributive nature of apportionment has not pushed for the adoption of alternative methods. The seventeen states that were under-represented in 2006 jointly controlled a majority (162) of single-member districts; fourteen of them have always been in this situation.

**b) Optimization**. The formula for redistricting has two phases. In the first phase municipalities — also known as *municipios* (the lowest elected offices, similar to counties in the U.S.)— that have at least 40% of indigenous population or that, by their population size, qualify to conform a district (within the respective +/- 10% or +/- 15% deviation allowed) are identified and cannot be split during the optimization process. Both of these criteria, indigenous population and municipal integrity, are embedded in the redisctricting agreements approved by the EMB's General Council in 2004 and 2013 ((**??**)).

In the second phase, a new map is drawn from the base geography using an optimization algorithm supplied with a formal cost function. The optimization algorithm runs three separate times, initialized from different random seed maps. It makes marginal changes to boundaries, repeatedly reassigning geographical blocks — *secciones electorales* — between districts, and systematically checking tradeoffs between criteria in a formal cost function. Cost-minimizing district maps for each state are thus generated and the map with the lowest cost is selected as the first scenario ("scenario 1") (**?**). [9] Other restrictions also apply: contiguity is a must and no district can have enclaves.

The simulated annealing optimization heuristic used to generate the 2015 map, had a slightly reweighted overall scoring function from the previous redistricting, but included the same four criteria: population balance (with a weight of .4), municipal boundary preservation (.3), minimization of traveling times inside the district (.2),

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[9]The building blocks are more than 66 thousand *secciones electorales* into which the Mexican territory is subdivided. *Secciones* are analogous to U.S. census tracts, but somewhat bigger. Median *sección* population in the 2010 census was 1,280 persons, with a maximum at 79,232.

and maximization of district compactness (.1).[10] The EMB would tolerate population deviations of up to +/- 15% across districts, and deviations above that threshold with proper justification (**?**). The EMB began working on this process on August, 2012 and almost one year later, the technical committee presented the 2015 map proposal ("scenario 1") on July 17, 2013.

An issue with the optimization is the discretion the EMB granted to select, operationalize, and weight criteria in the cost function. The formal legal framework mentions that districts should have population balance and that minority districts with indigenous population should be considered, but it does not specify the sequence, methods, components or rules of the game to be followed during the redistricting process. The spirit behind using a differentiated weighing system for the four components (population balance, municipal boundary preservation, traveling times inside the district, and district compactness) was to prioritize the relevance each component. However, the components are not normalized, making it impossible for the algorithm to weight them properly and for the technical committee to compare the cost contributed by each component.

In 2006, for instance, the technical committee decided that if the value associated to the cost function for two scenarios was the same, population growth at the district level would be considered in order to determine which map should prevail. [11] Furthermore, while population was defined in the EMB's redistricting agreements ((**??**)) as the only first order and most important criterion it gave it a weight of only 40%, compared to the 60% aggregated value it gave to the other three components. [12] It is in these details where we believe there is an important gap and an opportunity for the EMB to increase significantly the levels of public awareness, eliminate areas of opacity, and improve the technical justification around the different stages of the process.

A second problem is the gradually changing criteria with no apparent technical or legal justification. As described above, in 1997 the EMB used a "heuristic model" that aggregated *secciones* from West to East and from North to South in each state bal-

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[10]In the previous round (for the 2006 map) the four criteria were the same but they were wighted slightly different (relative weights): population balance (.4), district compactness (.3), municipal boundary preservation (.2), and traveling times within the district's municipal headquarters (.1).

[11]This criterion — population growth — had no legal basis and it was used in 2006 in Mexico City (DF) to determine that the municipality of Coyoacán should receive an additional district, instead of Iztapalapa ((**?**)).

[12]As described in (**?**), an alternative weighing system for the same four components could have been used (e.g. population balance (.7), district compactness (.2), municipal boundary preservation (.06), and traveling times within the district's municipal headquarters (.04).

ancing population and trying not to split municipal administrative divisions ((**?**)).[13]; In 2006, the EMB used a simulated annealing algorithm for the first time that had a cost function — restricted by four differently weighted components — that aggregated *secciones* departing from a randomly chosen seed; In 2015, the same simulated annealing heuristic was used, but the priority of components changed ((**??**)).[14]

After the 2014 electoral reform, Mexico's election management board acquired national administrative attributes and, among other things, became responsible for electoral administration in the 32 states, including the redistricting processes for local legislatures.[15] In 2015, INE was given charge of redistricting five states (Aguascalientes, Baja California, Durango, Tamaulipas and Zacatecas); in 2016 they will renew the cartography in eight states (Chihuahua, Hidalgo, Oaxaca, Puebla, Quintana Roo, Sinaloa, Tlaxcala and Veracruz); and two more in 2017 (Coahuila and Nayarit). For redistricting at the local level, the EMB made two major changes: a) they decided to use a beehive optimization search algorithm; and b) they decided that during the the first phase of the optimization process they would consider indigenous population, municipal boundary preservation and traveling time across municipal headquarters to identify municipalities that would not be split by the algorithm. For the second phase of the optimization, the EMB decided to use only two — instead of four — components (with the respective weights): a) population balance (1) and b) district compactness (.5).(**?**) In the cost function, the former received twice as much of the weight compared to the latter to reflect the priority of the components. It is unclear what the optimization method, weighing system or components will be used if the EMB decided to renew the 300 federal electoral districts for the 2018 election.

So far the EMB has not been able to justify these changes and, given the lack of transparency and public awareness surrounding the redistricting processes, we consider this ambiguity to be a major challenge for the EMB. Although automated redistricting has been applied by Mexico's EMB for almost two decades,[16] the process is far from being transparent and its rigidity to allow different social actors — civil society, interest groups, regional parties, media, NGOs, academics — to engage, au-

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[13]Traveling time, compactness and minority districts were not in the picture yet

[14]Population balance remained the most important component with a weight of (.4), but compactness went from being the second order component with a weight of (.3) to the last place (.1), municipal boundary preservation became the second most relevant component (.3), and traveling time shifted from being the less important component in 2006 to the third place in 2015 having a weight of (.2).

[15]Before 2014, each state had its own autonomous EMB

[16]Compared to other countries that periodically update their constituency boundaries, Mexico's redistricting processes are usually not challenged in courts.

dit, understand and actively participate in these processes, represents an important risk for redistricting to become a highly politicized process, especially when legislative reelection is reintroduced in 2018.

A third problem derived from the optimization stage is the wide margins allowed for population deviation. Neither the constitution nor the electoral law specify that a population deviation should be allowed between districts. It was the EMB, through the agreements approved by its General Council, that approved a deviation of up to +/- 15%.[17]. In 2006, for instance, districts in 23 of the 32 states where allowed to have a deviation of up to +/- 15% while the rest was allowed only to have a deviation up to +/- 10% ((?)). As with the population growth criterion, there is no legal basis — or technical justification — that determines why having districts where populations exactly at the bounds of the ±15 spread — which basically means that citizens at the bottom end would be worth one-third more in Congress than those at the top end — is something desirable or reasonable, especially when the main objective of the redistricting process is ostensibly to safeguard the "one person, one vote" principle.

Unequal-sized districts has been a common practice in Mexico in spite of the automated application of clear quantitative redistricting criteria since 1997. In fact, Mexican parties in general, and the EMB in particular, have been remarkably tolerant of this practice. As a consequence, this form of malapportionment is related, in some degree, to states' imbalanced apportionment in Congress, which perforce creates size differences across states' mean district sizes. But size inequality within states is also prevalent and substantial ((?)). We recognize that small deviations around a state's mean district population are unavoidable, especially as a map ages. But what constitutes significant deviation depends on the political context. Courts in the U.S. have struck down new congressional district maps bearing less than 1% differences without proper justification (?). Redistricting authorities generally view a *de minimus* population deviations of as little as one or zero persons between congressional districts as desirable to inoculate against litigation. In stark contrast, the EMB has allowed deviations up to 15% (since 1997) above or below mean state district size ((??)) and, surprisingly, no party has ever challenged this practice in Court.

**c) Assessment**. The third stage of the redistricting process begins once the first scenario produced by automation has been formally presented by the EMB's technical committee — appointed by the Council General — and distributed to political parties.

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[17]In states where the district average population deviated less than 5% from the national average, a deviation of up to +/- 15% was allowed, whereas in states with deviations above 5%, a margin of only +/- 10% was permitted ((??))

In two rounds, technical experts comment on the maps and political parties observe and suggest modifications.[18] Amendments are proposed to the first scenario, and those that are adopted by the technical committee are then used as a starting point for another round of partisan observations to produce a second scenario. Parties are invited again to propose a second round of amendments and, once they have been analyzed and discussed by the technical committee, a final plan is presented to the Council General to be formally approved.

In both, 2006 and 2015 rounds, the technical committee decided that the assessment of plans would: a) consider the value associated to the cost function. That is, plans with a lower cost were preferred to alternatives with higher values;[19] and b) do not consider counterproposals — even if they had a lower cost — that compromised any of the decisions that were made during the first phase of the optimization process (i.e. splitting municipalities with a high concentration of indigenous population or municipalities that had the population to form a district and that were previously identified as such by the committee).

In the 2015 round, the EMB invited two sets of institutional actors to participate in the process: the seven national parties represented in the National Surveillance Commission (NSC) and the same seven parties represented in each of the 32 state-based Local Surveillance Commissions (LSC).[20] Compared to the 2006 process, the inclusion of the LSCs allowed the active participation of local bureaucrats and party representatives at the state level. The development of a web-based mapping tool was extremely useful for EMBs bureaucrats in Mexico City's headquarters to receive party counterproposals across the country in real time.

The web-based platform was major innovation made in the 2015 round that allowed parties to participate, interact and observe in real time the counterproposals made by other parties and electoral bureaucrats (CNV and LSCs). This permitted the EMB to infer party preferences and allowed parties to have a degree of influence in the plans. If the automation algorithm produced the objectively best plan, perhaps these interactions would have been moot. However, with the automation the parties' counterproposals show that humans can improve the cost function over the machine-generated plans ((?)). This stage also gave party representatives at the state level, for the first time, the possibility to make explicit demands to incorporate community

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[18]This stage took approximately four months. It began in July 2013 and concluded in October 2013.

[19]As discussed below, this rule has not always been followed

[20]Involving the LSC allowed the EMB to be more aware of local issues and interests across the 32 states.

and local interests in the new plans.

As it occurs in most administrative processes, mistakes took place during the assessment process. In both 2006 and 2015 redistricting rounds, miscommunication between the EMB and parties was evident. Most parties —especially at the local level — submitted counterproposals with the idea that plans that did not improve the cost function, but that had a social or communitarian justification, were going to be considered by the committee. In 2006, for instance, the private secretary of the governor of Oaxaca (a state ruled back then by the PRI), through its party representative at the CNV, sent a petition to consider an alternative map to the committee asking not to consider the cost function. In the state of Michoacán, the governor sent a similar petition, signed by all political parties, asking the technical committee to consider a plan with a much higher cost function value, but that was more "reasonable" in terms of representing community interests in the state's capital. In the 2015 round, political parties presented a significant number of counterproposals with a higher cost than the one obtained for the first and second scenarios arguing in favor of community interests. In both cases, the technical committee decided to consider only those counterproposals that were equal or decreased the value of the cost function.

At the same time, some parties formulated counterproposals with cost functions below the first and second scenarios, but that were rejected by the committee. After interviewing former members of the technical committee and to electoral officials, what explains these cases is that parties had access to a software that allowed them to split all municipalities, even those with a high concentration of indigenous population or that had the population to form a district, and that were previously identified by the committee in the first phase of optimization. There have been several cases in the 2006 and 2015 redistricting rounds where the golden rule of using the value associated with the cost function as a reference to decide which plan is "better" has been broken. This has happened in the state of Jalisco in 2006 (against PAN) and in Baja California Sur (against MC), Durango (against PRD), Morelos (against PRD), Querétaro (against PRD) and Tabasco (against PRI and PVEM) in 2015, and are precedents that affect the perception of different actors regarding the consistency, objectivity and transparency of the rules being applied by the EMB. From our perspective, this is a major challenge that the EMB needs to solve in the subsequent redistricting rounds.

Among the lessons to be learned from the evolution of automated redistricting: a) The rules of the game —for all three major stages of the process — need to be clear.

If they change over time, there needs to be a legal and technical justification; b) Consistency. All rules and procedures should be applied in the same way across cases and over time to decrease the levels of uncertainty; c) Communication between electoral officials and political parties needs open and formal procedures should be available for all parties. All actors should be able to express their interests and understand how to communicate them formally. At the same time, the authority should be clear in how those interests will be processed; d) Transparency, information availability and public scrutiny are crucial to guarantee the impartiality of redistricting; e) New forms to receive and evaluate public input during the redistricting process need to be developed. So far, the redistricting process in Mexico is restricted to electoral bureaucrats and political parties. However, both parties and the EMB can benefit by opening the process to the public. The recent electoral reform, for instance, allows independent candidates to compete for legislative offices. However, political parties are the only actors allowed to participate in the redistricting process. Other social voices and interest groups could be considered during the redistricting process if the proper channels are developed.[21]

# 2  Partisan Strategic Interaction

Political parties interact strategically with mapmakers, and other parties, and propose amendments to the computer-generated plans, but these amendments must improve the overall cost score to be considered for adoption. Table 1 summarizes the two rounds of amendments that took place in preparation for the 2015 map. There were a total of 534 counterproposals made for the 2015 map (more than twice of the counterproposals made for the 1997 and 2006 maps). 236 counterproposals were made to the first scenario (157 from the LSC and 79 form the NSC) and 308 were made to the second scenario (139 by the LSC and 169 by NSC).

Parties were active, making 75 counter-proposals each on average. Although we expected that all 7 parties would behave as rational self-interest maximizers and strategically make competitive counter-proposals to the first automated scenario, the right-of-center PAN was, by far, the most successful. Nearly half of their 82 proposals were accepted, compared to about one-fifth for the other major parties (PRI and PRD).[22] Amendments originated in both national (7 parties at the National Surveil-

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[21]By experiences in other countries, we know that new mapping technologies and the use of web based platforms make public mapping both feasible and convenient.

[22]After talking with party representatives at the CNV, and former members of the technical committee, it seems that this is partly because PAN was the most technically prepared party. On

| Party | national | state | total 1st | national | state | total 2nd | Total |
|-------|----------|-------|-----------|----------|-------|-----------|-------|
| PAN | 17/22 | 2/20 | 19/42 | 17/24 | 4/16 | 21/40 | 40/82 |
| PRI | 0/0 | 2/28 | 2/28 | 8/30 | 6/26 | 14/56 | 16/84 |
| PRD | 3/27 | 2/21 | 5/48 | 5/29 | 5/18 | 10/47 | 15/95 |
| PT | 1/12 | 1/20 | 2/32 | 3/15 | 1/16 | 4/31 | 6/63 |
| PVEM | 0/0 | 1/20 | 1/20 | 7/28 | 3/17 | 10/45 | 11/65 |
| MC | 1/17 | 0/21 | 1/38 | 6/32 | 2/16 | 8/48 | 9/86 |
| PNA | 0/1 | 1/18 | 1/19 | 4/11 | 3/17 | 7/28 | 8/47 |
| IFE | 0/0 | 1/9 | 1/9 | 0/0 | 5/13 | 5/13 | 6/22 |
| Total | 22/79 | 10/157 | 32/236 | 50/169 | 29/139 | 43/308 | 111/544 |

Table 1: Counter-proposals to the first and second scenarios at the National and Local Surveillance Committees. Denominator reports the number of counter-proposals made, numerator how many were adopted. Prepared by authors with information from the Federal Electoral Institute.

lance Commission) and state level (same 7 parties represented at 32 Local Surveillance Commissions).[23] Activity at the amendment stage was enhanced by the internal web-based map-sharing tool, which standardized counter-proposals and enabled parties to observe each others' amendments — improving information for strategic behavior. The final proposal for Council General approval was presented on October 15, 2013. In the midst of a major electoral reform that took place in December that year, the Council General, driven by the pressure of the three major parties (PAN, PRI and PRD), chose not to decide before the end of the year. The 2015 midterm election, it was soon after learned, would be held with significantly outdated districts (based on the 2000 census results).

We investigate how the 2015 redistricting process unfolded in Figure 1. For each of Mexico's thirty-two states we plot the overall score for each proposed redistricting plan (the value of the algorithm's cost function for the three scenarios are black points, numbered). The optimization objective is to produce a plan with the least cost, so plans with lower values are better than plans with higher values. The first scenario resulted from the optimization algorithm prior to party feedback, the second and third from party amendments. Colored points are party counteproposals to the second scenario, blue for the PAN, red for the PRI, yellow for the PRD, grey for the best offer by a minor party.[24] Brown points represent two or more counter-proposals

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the other, other parties have followed an appointment system for their representatives at CNV and the LSCs based on party quotas and camaraderie, rather than professionalization.

[23]The full set of parties represented in each committee were PAN, PRI, PRD, PT, PVEM, MC and PNA.

[24]The same analysis for party reactions to the first proposal would reveal another interesting

with equal scores, with one protruding petal for each plan. The cost function is expressed relative to the value of the second proposal.

In all but one state (Baja California Sur, BCS), the progression of scenarios is towards improving the cost function, as the third and final scenario has a lower score than either of the two prior scenarios.[25] We observe numerous instances where humans "beat" the machine, by offering counter-proposals that improve the first scenario's score. These plans demonstrate how redistricting is a complex integer optimization problem where optimization algorithms can become stuck in local optima (**?**). Where the adopted amendments to the first scenario improve the score greatly — as is the case in Hidalgo (Hgo), Puebla (Pue) and San Luis Potosí (San) — the second round of counterproposals fails to further improve the previous round given that the opportunities to improve the cost function are fewer. Still, we cannot know for certain if these final plans are the global optimum since the algorithm departed from a randomly chosen seed and redistricting is such a challenging optimization problem.

There are three instances where the PRD offered a counter-proposal improving upon the first scenario and all other amendments, but the amendment was rejected: Durango (Dgo), Morelos (Mor), and Queretáro (Que). Two identical plans proposed in Tabasco (Tab) similarly are the objectively best plans, but are rejected. In these three instances, a second round of partisan observations fails to find better plans. This provides further evidence of how automated algorithms are challenged by the complexities of redistricting. More importantly, the existence of these better plans demonstrates that politics is present in the process, likely to the detriment of the PRD.

Several proposals have identical scores to the first scenario, and there are several instances where two proposals have identical scores. If two scenarios were tied, the technical committee would adopt the proposal that had lower cost values associated to the most relevant criteria — population, followed by municipal boundary delimitation, traveling time and compactness at the end (**?**). Further investigation may reveal subtle differences between these seemingly-similar plans, such as the assignment of

aspect of negotiation. A successful amendment in the first round sets the starting point for the optimization process towards the second round, and this might lend important proposal power. PAN was, by far, the most successful party in the first round.

[25]In the case of BCS the algorithm first scenario had a cost function of 70.10687929, and PAN representative at the CNV made the counterproposal with the lowest value (70.09024166) during the first round of observations, which became the departing scenario for the second round of observations. In that second round, the PAN made a second counterproposal with an associated cost of 70.84932449. Despite another party, Movimiento Ciudadano (MC), had a preference for the scenario of 70.09024166, the technical committee decided to stay with the second proposal of the PAN.
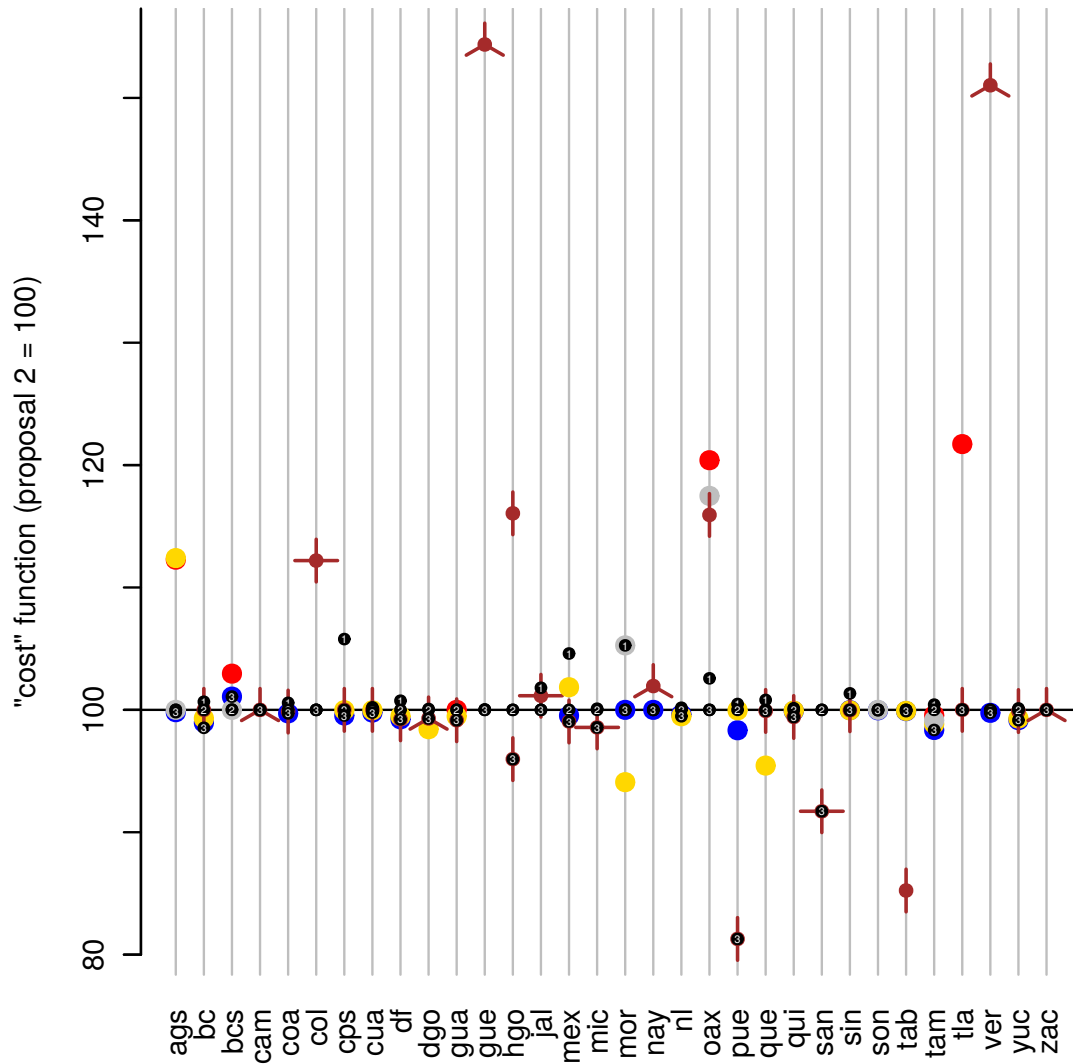
## Proposals and counterproposals



Figure 1: Map proposals towards 2015 by state. Black, numbered points indicate the value of the algorithm's cost function for the three map scenarios. The cost function is expressed relative to the value of the second proposal. Colored points are party counterproposals to the second proposal, blue for the PAN, red for the PRI, gold for the PRD, grey for the best offer by a minor party. Brown points report overlaps of two or more counter-proposals, one protruding petal for each overlap.

| Similarity between | min | 25% | median | 75% | max |
|---|---|---|---|---|---|
| first 2015 proposal and status quo | 0.128 | 0.419 | 0.584 | 0.755 | 1 |
| final 2015 proposal and status quo | 0.125 | 0.437 | 0.643 | 0.805 | 1 |
| first and final 2015 proposals | 0.174 | 0.705 | 0.967 | 1 | 1 |

Table 2: District similarity before and after the failed 2015 redistricting

two *secciones* to different districts that has minimal changes on the overall score. We also observe numerous instances where parties propose plans that score worse than the first scenario. In many cases, as in 2005, parties decided — even if the cost function of their counterproposal was higher than the departing scenario — to present their plan and try to argue that their plan represented better specific communities or that responded better to geographical or socioeconomic characteristics not considered by the optimization algorithm.

# 3    The 2006 Map and the 2015 Proposals

A new map is a full description of district boundary changes. The common way to visualize a map is by drawing it. We look at maps differently, with focus not in the physical lines and line changes but in their political consequences. Putting the 2006 map and the 2015 final proposal drawings side to side reveals boundary shifts. But unless the drawing is more data rich, assessing even the relatively simple question of how similar districts were before and after redistricting visually is a challenge.

A similarity index (**?**:15–7) offers grounds for assessment. Measurement identifies the parent district or single largest contributor of population to every new district. The *s*imilarity index divides the population that *p*arent and *n*ew district share in *c*ommon by their joint population: $s = c/(p+n-c)$. The range is zero (district shares no population at all with parent) to one (districts are identical). Table 2 describes the change that the 2015 map would have brought in the 300 single member districts, comparing the EMB's initial and final proposals with the 2006 map. Also compared are the final and initial 2015 proposals themselves.

Six percent of districts entertained no change in boundaries whatsoever vis-à-vis the status quo (18 districts in the initial proposal, 19 in the final), and twice as many had at least nine-tenths of the population in common (40 districts in the initial, 44 in the final proposal). Inspecting which districts were *a priori* chosen for marginal or no change might reveal systematic distortions of the automated redistricting algorithm. Party feedback left 39 percent of districts in the EMB's first proposal intact,

| | min. | 25% | median | 75% | max |
|---|---|---|---|---|---|
| district volatility | .08 | .19 | .25 | .31 | .52 |
| mean PAN margin | $-.49$ | $-.23$ | $-.10$ | .01 | .28 |
| mean PRI margin | $-.43$ | $-.09$ | $-.01$ | .07 | .28 |
| mean PRD margin | $-.51$ | $-.31$ | $-.21$ | $-.04$ | .39 |

Table 3: 2006 map district volatility and party margins in three congressional elections

and 62 percent with up from nine-tenths of the population in common. Inspecting which districts the parties targeted for major amendment — presumably a partial reinstatement of a preferred status quo district — should shed further light into the subject. Note how median district similarity with the 2006 map augmented from first to final proposal. So did the third quartile. Accepted counter-proposals therefore reconstituted portions of status quo districts. This seems consistent with a view where parties protect strongholds that the algorithm may have split, but further analysis must be done.

Noting that victory margins began widening in the mid-1960s, **?** saw gerrymandering as one possible explanation by incumbents influencing the preservation of safe districts. While the argument opened the heated incumbency advantage debate, the intuition may guide our inquiry. District volatility should capture a key element for analysis of map similarities. District $d$ volatility is $v_d = 1/2\sqrt{\sum_{p=1}^{P}\sum_{t=2}^{3}(v_{d,p,t} - v_{d,p,t-1})^2}$ with $p$ indexing the competing parties and $t = 1, 2, 3$ for the 2006, 2009, and 2012 congressional elections respectively.[26]

Mexican party strength is not proportional to the formidable entry barriers they enjoy and massive public subsidies they receive yearly (**?**). Evidence of this is their inability to cultivate loyal voters. District volatility is remarkably high, as shown in Table 3. The median district saw 25 percent of votes change party hands between 2006 and 2012, which is an approximate read of the index reads. With so many volatile districts, parties should attempt to redress strongholds that automated redistricting split beyond recognition. How were strongholds affected by the initial 2015 proposal? To what extent did party counter-proposals redress them? This should be a promising line of inquiry.

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[26]The measure of volatility proposed is inspired in measures of disproportionality, replacing the seats–votes difference with vote first differences. It is a squared version of a Loosemore-Hanby index (**??**).

# 4    Conclusion

Mexico is perhaps unique among democracies in the use of automated redistricting to draw new district boundaries. A strain of redistricting reformer in the United States is "let the computer do it." Theoretically, government can adopt objectively neutral criteria, they can be operationalized, a cost function that weights these criteria can be computed, and a computer can attempt to minimize the cost function. Mexico's experience illuminates some of the potential pitfalls with the automated redistricting approach.

First is the selection of criteria to use during redistricting. Without clear legal guidance, Mexico's electoral management board has adopted criteria in an adhoc manner. ? shows how *prima facia* neutral criteria — in his example equalizing road mileage within districts — effectively implemented a racial gerrymander by splitting a minority community residing in an urban area. While our analysis cannot reveal how Mexico's similar travel distance criteria operates in practice, the fact that Mexico's parties have over successive rounds of redistricting modified the bundle of criteria leads us to suspect that the parties have prior beliefs over how the criteria favor particular outcomes of interest to them.

Second is the operationalization of the criteria. The choice of Mexico to permit a rather expansive 15% population deviation, coupled with the often sizable lag in years between a national census and a redistricting, effectively injects a substantial amount of malapportionment into the districts. The most recent failure to adopt a new plan despite substantial malapportionment harkens back to the pre-1960s failures in the United States that ultimately forced the U.S. Supreme Court to force states to draw new districts. Then, states forestalled redistricting to the benefit of existing political hegemons with their power bases located in rural areas. Redistricting in Mexico —or the lack of it —similarly appears to be politically motivated in that redistricting is not directly tied to a new census. Furthermore, the generous malapportionment that results both from the stale census and the permissive population deviations adopted by the EMB suggests political considerations are present.

Third is the computation of the cost function. Once criteria have been chosen and operationalized, for automation to work a cost function must be computed for a computer algorithm to minimize. Like the criteria and their operationalization, the weighted components of the cost function have changed over time. This again suggests to us that the parties have priors over how balancing criteria translate into outcomes. A subtle point is that the operationalization of the criteria is also effectively part of

the weighing function. Simply, if two equally weighted criteria have values that are orders of magnitude different, then the criteria that is scored with the higher values will be effectively given more weight.

Fourth, and perhaps most important, is the limitations of the optimization algorithm in the context of Mexico's redistricting process. If the algorithm produced a map that was the objectively best on the scoring function, perhaps the process would end once the computer provided a solution. In practice, redistricting is a complex partitioning problem with many local optima that can trap an optimization algorithm, even one that is a sophisticated simulated annealing algorithm allowed to burn in for a month (**?**). Once map solutions were presented to the technical committee and the parties, humans were able to improve upon them. We cannot stress this enough: despite their increasing popularity in social sciences to reveal "truths" about the political process, automated redistricting algorithms have greatly under-appreciated limitations and likely do not support the claims their proponents make. The consequences for practical applications are twofold. First, redistricting by computer does in itself not guarantee an optimal solution will be found; the map a computer finds may be nothing more than a quasi-random draw. Second, because the computer produces non-optimal solutions, the process is open to manipulation. The political parties will draw plans that may improve upon the cost function. They are under no obligation to make all the plans they discover public. Since we cannot observe these private plans, we may assume that parties will only present amendments that improve their position.

We believe that greater transparency can inoculate against some of the issues we raise. Mexico's electoral management board implemented a web-based map sharing tool in the last failed redistricting. This tool was only available to those who were formally part of the process. Not only can map-sharing tools be made available online, but also software applications that would allow the public to become a partner in the process. Having more eyes on the redistricting problem may yield more solutions that beat the optimization algorithm, further reducing opportunities for manipulation, and would further allow the public to look under the hood to understand more fully the political consequences embodied the choice of criteria, their operationalization, and their weighting in the cost function.

# Appendix

## Elasticity

How elastic a district is to a party's statewide (nationwide?) vote swings is interesting. Elasticity should shape redistricting preferences. A district is highly elastic for the PAN when small shifts in the party's vote statewide correspond to sharp district vote hikes. It is inelastic when it corresponds to more modest district vote changes. Negative elasticity is even conceivable, the district vote growing when the rest of the state shrinks. Local effects on mobilization and voting can move against state effects. If every *sección* in the district is a microcosm of the state's electorate, unit elasticity ensues.

The measure regresses a party's three-year vote change in the *sección* $\Delta_s$ on the the parent state vote change $\Delta_e$ thus:

$$\Delta_s = \sum_{d=1}^{D_e} \alpha_d + \beta_d \Delta_e. \tag{1}$$

Fixed effects for each district are considered, fitting separate $\alpha_d$ and $\beta_d$ regression coefficients for every district (indexed $d$). The model is estimated for every state separately because doing it nationwide involves too many *secciónes* (67k) and parameters (600) for my machine.
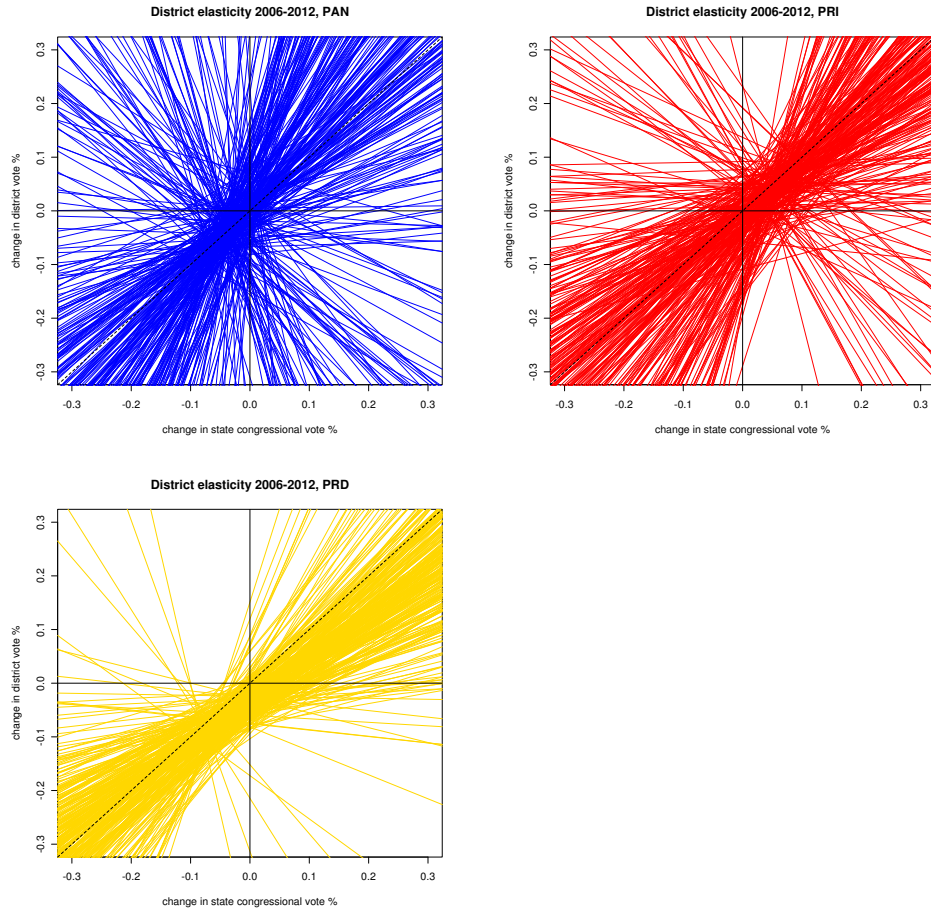
Figure 2: Parties' district elasticities