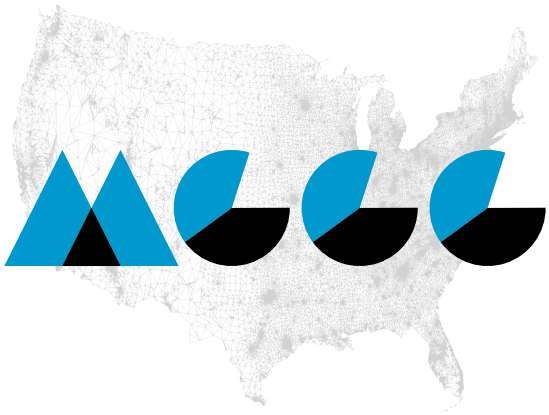
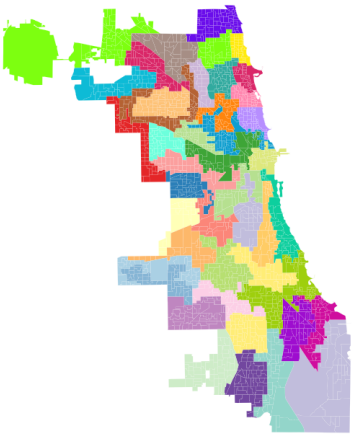
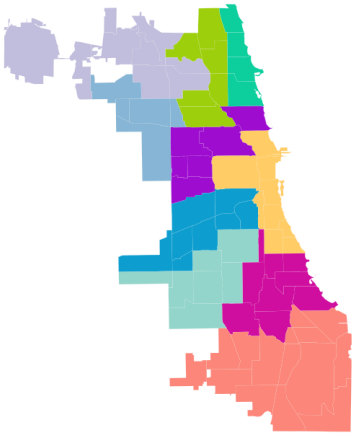
Study of Reform Proposals for Chicago City Council



Abstract

Many observers agree that the Chicago City Council ward system suffers from problems of gerrymandering, intense segregation, vestiges of machine politics, and inefficiency. In this report, we apply mathematical models to analyze the current ward plan and compare several reform proposals to address its problems. Our findings strongly support a transition to multi-member wards with ranked choice voting to secure and sustain fair representation.





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Contributors

This report was undertaken by the Metric Geometry and Gerrymandering Group, an interdisciplinary research effort focused on the mathematics of redistricting. Research contributions for this project were made by Hakeem Angulu, Ruth Buck, Daryl DeFord, Moon Duchin, Howard Fain, Max Hully, Maira Khan, Zach Schutzman, and Oliver York.

1 Introduction: Reforming the Chicago City Council

Today, Chicago is ripe for civic reform in many areas of governance, with mayoral candidates in this year's election weighing in on bold proposals from an elected school board to civilian oversight of police to various anti-corruption measures, including campaign finance reform. A bold plan for fairer city council representation must be part of the same conversations.

For nearly 100 years, the Chicago City Council has been comprised of 50 elected officials called aldermen, elected to four-year terms from 50 single-member districts known as wards. Today these 50 aldermen represent Chicago's roughly 2.7 million residents amid rapid changes in city demographics and politics, driving rising calls for reform. In this report, we study the Chicago City Council system and several alternative structures for its design.

The system suffers from many widely acknowledged problems. The wards are perceived to be gerrymandered, with eccentric boundaries that preserve some traditionally favored neighborhoods but wind awkwardly through other parts of the city, denying Austin and Little Village the political stability that Bridgeport and Beverly have enjoyed for years [36]. They also tend toward extreme malapportionment by the end of their ten-year cycle, with the largest ward having twice the population of the smallest, flouting the Constitutionally recognized principle of "One Person, One Vote." Further, we will demonstrate that the current wards are massively racially segregated, far beyond the levels that would be expected in a 50-ward plan, and exhibit high levels of economic stratification as well. And legacy policies like "aldermanic privilege"[1] combine with carefully chosen lines to entrench some aldermen beyond the reach of accountability to their voters, creating what some have described as a system of fifty fiefdoms. Finally, some have argued that the City Council's size is bloated and have looked for opportunities to find efficiencies in its design and administration.

To counter these problems of **gerrymandering**, **hyper-segregation**, **entrenchment**, and **inefficiency**, we will consider several reform proposals.

- Re-draw the lines in the current 50-ward system;
- Shrink the city council from 50 members to 30 or fewer;
- Move from single-member districts to multi-member districts;
- Move from plurality elections to ranked choice voting.

With a combination of qualitative and quantitative analysis, we study the transformative prospects of these proposals. We find that ranked choice voting and multi-member districts, while they can in principle be implemented separately, combine to provide a powerful reform solution.

We begin in §2 with a brief survey of the mechanics of districting and single-member, multi-member, and ranked choice voting. In §3, we describe the preparation of demographic, economic, and electoral data for this report. We review recent voting patterns in the City Council in §4.

[1] Aldermanic privilege is the longstanding power of city councillors to exercise tight control over zoning, property sales, and city services in their wards [32].

To illuminate how single- and multi-member districts might perform differently, we then construct hundreds of thousands of examples, by hand and by algorithm. Comparative findings are presented in §5. We have built a web portal at `districtr.org/chicago` to enable readers and the general public to explore the relationship between district structure and demographics.

Finally, using ranked choice voting data from three comparison cities (Oakland, CA; Minneapolis, MN; and Cambridge, MA), we have built a model to predict demographic dynamics of multi-member voting in Chicago. This model hinges on the empirical finding that surpassing a numerical threshold secures a high likelihood of group representation (see §5.3.1). For instance, in a district that elects 5 representatives, a demographic group with at least $1/6$ of the voters is highly likely to see a candidate from that group elected.

In the end, we arrive at the very clear conclusion that **multi-member districts with ranked choice voting provide a superior solution for Chicago in every civic dimension considered here**. We consider ten-ward districts electing 3 or 5 members each, which can maintain the current city council size of 50 aldermen or provide a means to contract to 30, and we offer some arguments in favor of each. We find it easily possible to create ten-ward districts that meet all traditional districting criteria, even while holding Chicago's community areas completely intact.

2 Background on election systems

2.1 Election systems: single-member, multi-member, ranked choice

To an extent that can be surprising, the system of election has a controlling effect on the outcomes, when voter preferences are converted into representation. In the United States, voting for the House of Representatives is done in 435 single-member districts, as currently mandated by law. (Here, "single-member" means that the district elects just one representative.) But for local elections, many choices are available: whether to use districts, what size of districts to form, and how to take the single or several choices of the voters and aggregate them into an election outcome.

We will say that a candidate is running at large (rather than in a particular district) if every resident of a jurisdiction can cast a vote for them. For non-districted city councils, where all candidates run at large, the most common mechanism for election is multi-member plurality voting: every resident casts as many votes as the size of the council, and the winners are the candidates who receive the most votes [11]. Sometimes a jurisdiction is split into districts that are themselves multi-member, where each district elects several representatives. The number of representatives elected is called the district magnitude. Current and historical examples are provided in §2.3.

However the electoral units are structured, there is a separate decision about how to record voter preferences. Ballots may let voters choose a single candidate, several unranked candidates, or a ranked list. In this report we mainly compare the casting of a single vote to ranked choice voting (RCV). A final structural decision to make in a ranked choice system is how to combine the preference data into an outcome. In mathematics, the specialty called social choice theory is centered on the selection of an aggregation algorithm, and there are dozens of choices that have been considered, including pairwise comparison, Schulze beatpath, and many more. We will focus on "transferable voting" systems below.

The most popular voting system for selecting one candidate from voters' ranked preferences is

a form of transferable voting called instant runoff voting (IRV). Its mechanism is simple: if any candidate has a majority of first-choice votes, that candidate is elected. Otherwise, the candidate with the fewest first-choice votes is eliminated from contention and their votes are redistributed to their voters' second choices. The process continues until some candidate receives a majority of votes or all ballots are exhausted. If the district elects multiple representatives, we apply a simple modification called single transferable vote (STV). To elect k candidates, we set the threshold for election at $\frac{1}{k+1}$ of the votes that were cast. Any candidate whose first-choice votes surpass the threshold is elected, and their excess votes are proportionally allocated to their voters' next choices. If needed, the least popular candidates are eliminated, and all of their votes are redistributed. We continue until we have selected k winners. For more details on all of these systems, see the City Council Election Manual provided at [11].

2.2 Structural exclusion of minorities

Plurality voting to elect multiple candidates is well known to systematically exclude minorities—political, racial, or other—from access to representation. The reason is straightforward: if the majority group in a jurisdiction votes as a bloc for a certain set of candidates, then these candidates are guaranteed to have more votes than any others, so they will consistently win. This explains why Santa Clara, CA had an all-White six-member city council for decades, despite its nearly 40% Asian population [20]; or why Lowell, MA long maintained an all-White nine-member city council despite over 20% Asian and over 17% Hispanic residents [16].

Recently, such plurality systems have been subject to legal challenges all over the country under the federal Voting Rights Act of 1965 or local variants like the California Voting Rights Act. In order to challenge an electoral system for denying a minority group the opportunity to elect a candidate of choice, one must establish a pattern of racially polarized voting (RPV). That is, it must be demonstrated that the minority race tends to vote cohesively and the majority also votes cohesively in a way that blocks the minority-preferred candidate from being elected. This is difficult to prove because the secret ballot prevents us from learning directly how members of different racial groups tend to vote. For decades, researchers have tried to infer racial voting patterns by correlating the racial balance of each precinct to the balance of its votes. A simple way to carry out this inference would be to simply fit a line to the data; this is sometimes called (Goodman's) Ecological Regression, or ER. But the dominant method used in courts today is called King's Ecological Inference, or EI. We have created a user-friendly interface to perform ER and EI estimates at `vrdi.shinyapps.io/ei-app/` Selected results of ER and EI analysis on recent mayoral results are described in §4.3, showing substantial patterns of racial crossover voting amidst lingering evidence of racial polarization.

Not only racial groups, but any group in the numerical minority, is vulnerable to this effect. For instance, Vermont uses districts electing from one to six candidates each for its State senate. The six-member district, or "six-pack," has a history of giving roughly 1/3 of its vote share to Republican candidates, but Republicans are completely shut out of representation. This effect of plurality voting works exactly the same way as the "fencing out" of people of color described above.

Lawsuits and controversy have shone a light on structural problems with plurality voting [22]. This adds to concerns raised by elections in which large candidate pools lead to vote-splitting, especially for people of color [5, 17]. Chicago's recent first-round mayoral election of February 2019 also featured an intimidatingly large slate of candidates with no clear favorite, leading to calls to consider ranked choice voting in the Chicago Tribune, the Chicago Sun-Times, and on Chicago PBS.

2.3 Brief history of multi-member and ranked choice elections in U.S.

Many people are surprised to hear that transferable voting has been used in U.S. cities in the past and is increasingly in use today, and that multi-member districts are and have always been a fixture of American politics. In fact, ten states currently use multi-member districts for their legislatures, and 14.7% of all state legislators are elected from those districts [4]. Here we will briefly detail the interrelated histories of multi-member districts and transferable voting at the city level.

STV was adopted by 24 cities between 1915 and 1948 [28]. Borrowing from its use abroad, STV in the U.S. was regarded as a Progressive-era reform for reducing the power of machine party politics. The primary intent of STV is to achieve election results that are in greater proportional correspondence to voter preferences, thus increasing the electoral representation for minority preferences, whether those are racial, partisan, or track with another issue or shared community interest. STV is sometimes branded as "proportional representation," or "PR," for this reason.

Ohio cities were early adopters of transferable voting, with Ashtabula taking up STV in 1915 and Cleveland and Cincinnati following suit in 1921 and 1924 [28]. Cincinnati became emblematic of the fraught racial politics of proportional representation. The city first elected a Black candidate to the 9-member city council under STV in 1931, though the population was only 10% Black at the time, increasing to two Black elected members by the 1950s. This success at achieving diverse racial representation would be its downfall: backlash to the early Civil Rights Movement resulted in repeal of Cincinnati's STV system in 1957 following an openly racist campaign [3].

The election of minor-party candidates has also led to backlash against transferable voting. New York City adopted STV in 1936, hoping to quell Tammany Hall corruption. However, after Communist Party candidates were elected to the 25-member City Council in the early 1940s, a Red Scare campaign in the burgeoning Cold War ended STV in 1947 [3].

Transferable voting returned to New York City in the 1970s in a state-mandated reorganization of the city's Board of Education, following community turmoil and teacher strikes. STV was put in place to elect members of 32 new community school boards. Despite concerns about low turnout and insufficient voter education, STV led to Black, Hispanic, and Asian share of seats achieving and even exceeding those communities' share of the population. The community school boards stayed in place for decades until a state-level reorganization in 2002 gave control of the City's Board of Education back to the mayor, where it remains today [26].

Cambridge, MA—an affluent city of just over 100,000 with a significant immigrant population—is now the only U.S. city to use STV for all city council and school board elections, as it has done since 1941. The first Black candidate was elected to the 9-member Cambridge City Council in 1963, when Black residents constituted just 5% of the population.[2] Save for the 1968-69 term, at least one Black councilmember has served ever since. At the time of writing, three of the nine city councillors are people of color—a close match for the estimated 35.9% non-White city population.

At last count, eighteen U.S. localities already use RCV in local elections or have voted to implement it, in addition to the state of Maine, which began using RCV for statewide elections in 2018 [12]. These cities range from tiny Basalt, CO to sizeable Memphis, TN and San Francisco, CA. Below, we will pull RCV data from three comparison cities—Minneapolis, Oakland, and Cambridge—to investigate the relationship between demographics and vote outcomes.

[2]Since the district magnitude is 9, the election threshold is $\frac{1}{10}$, or 10%. This is an instance of the more general observation that surpassing the threshold is usually sufficient but often not necessary to elect minority candidates. See §5.3.1.

We note that there is also a multi-member history in Illinois and even in Chicago. From 1870 to 1980, the IL House of Representatives was divided into three-member districts that each used a cumulative voting system.[3] Finally, the Chicago City Council itself was established in the 1837 city charter with a total of six wards: two single-member and four two-member districts. From 1839–1889, the number of wards grew steadily, with each ward electing two members. From 1889–1923, the city had 35 two-member districts. The current system of 50 single-member districts has been in place since 1923 [14].

3 Data

3.1 Data units, collection, preprocessing

The primary source for demographic information in the United States is the Census Bureau, which breaks down the country into small units called census blocks—in cities, these are frequently identical to city blocks. There are 99,042 census blocks in Cook County, with 46,357 of these in Chicago itself. The Census makes data available for census blocks in a geographical information systems (GIS) format called a shapefile, presenting both the spatial information about the location and geographical dimensions of each block and the racial demographics of the residents. This data is collected every ten years, and we will use the 2010 Census data in most of the analysis below. Another source of information is the American Community Survey (ACS) which gives a five-year rolling average of demographic and other information on the basis of more limited sampling. The smallest geographic unit at which ACS data is released is the block group, a higher level of the Census hierarchy. There are 3993 census block groups in Cook County and 2181 block groups within Chicago itself, so difference in size between blocks and block groups is roughly a factor of 20.

Districts (such as Chicago's wards) are electoral units of a jurisdiction. A second system of administrative units is the collection of precincts, which have their own election officials and actually carry out the provision, collection, and tabulation of ballots. Precincts are the smallest level at which election results are reported to the public. Chicago currently has 2069 precincts that are divided into 50 wards.[4] Every four years, all 50 wards hold a simultaneous election in an odd-year election that also includes the mayoral race, and each ward chooses an alderman to sit on the City Council. Chicago uses a runoff system: if no candidate receives a majority of the votes in a given ward, then a second election is held several weeks later to choose between the top two vote-getters.

Chicago also has 77 officially designated community areas, which were drawn in the 1920s by social scientists at the University of Chicago in an attempt to better reflect social and political divisions in the city than the existing census divisions [33]. These community areas are still used by the city government and act as a proxy for major neighborhoods, or historical communities of shared interest, in our analysis.

[3] Under cumulative voting, sometimes called a semi-proportional system, each voter was allocated three votes. These three votes could be evenly distributed among three candidates, or could be "plumped," with a voter casting two or three votes to support a single candidate. In theory, this method could have facilitated representation of political minorities who "plumped" their votes together to support a candidate of choice.

[4] A major reprecincting was undertaken in Chicago following the 2010 Census, with the number of precincts dropping from 2570 to 2069 in a single move. A change of this magnitude is quite unusual, and we have been unable to discover the story behind the reorganization.

Chicago election results data were downloaded from the Chicago Board of Election Commissioners [6]. Shapefiles of Chicago precinct, ward, and community area boundaries were downloaded from the City of Chicago Open Data Portal [8]. We incorporated election data from three comparison cities that employ ranked choice voting: Oakland, Minneapolis, and Cambridge. Election data for Oakland and Minneapolis were obtained from the Ranked Choice Voting Resource Center Data Clearinghouse [24]. Cambridge's election data was provided to us by Theo Landsman of FairVote. We retrieved the precinct shapefile for Minneapolis from Minneapolis Open Data [9]. The precinct shapefile for Oakland came from the Official Election Site of Alameda County [2] and we obtained Cambridge's precinct shapefile from Cambridge GIS [7].

Demographic/economic data was downloaded for Chicago, as well as for the three RCV cities, at the census block level from the 2010 Decennial Census and at the block group level from the 2009–13 and 2013–17 ACS five-year estimates [35]. Census block and block group shapefiles were downloaded from the Census Bureau's TIGER/Line Shapefiles database [34].

We used a variety of sources to determine the racial IDs of candidates, including campaign websites, newspaper articles, and the knowledge of local officials and activists. Racial ID for sitting Chicago aldermen was determined by membership in the Chicago Aldermanic Black Caucus and the Chicago City Council Latino Caucus.

Demographic data for all four cities was aggregated from the census block level to precincts (as well as to wards and community areas for Chicago) using open-source preprocessing software developed at the 2018 Voting Rights Data Institute (`github.com/mggg/maup`). For the city of Chicago, more recent demographic data from the ACS was also aggregated and/or prorated onto larger units from the census block group level. Several vertices of the Cambridge precinct shapefile had to be manually edited using QGIS to repair the shapefile topology prior to proration. QGIS was also used to merge precincts in Oakland from the shapefile in order to match precincts in the election data. The RCV election data were converted from ballot images to cast vote records (CVRs) using spreadsheet operations for Cambridge and Minneapolis and a Python script for Oakland. Another Python script was used to clean the data for all three cities by removing duplicate votes and reformatting the data so that each ballot cast was listed only once with a column for first, second, and third choice candidate. All scripts and data for this project are publicly available at `github.com/mggg/chicago`

3.2 Racial demographics and population shifts

Throughout this report, we will largely mirror Census racial and ethnic categories in our racial language, using Black to refer to Black non-Hispanic population; White for White non-Hispanic; Asian for Asian non-Hispanic; and Hispanic for all people designated with the Hispanic ethnicity (whatever their race).

While citywide demographics give the appearance of near parity between White, Black and Hispanic populations, Chicago is a famously highly segregated city. Of its 2069 voting precincts, 563 are more than 90% Black while 1054 have less than 10% Black population. The Black population of Chicago is concentrated into two main areas, one on the West Side (including Austin and Garfield Park) and the city's large and historic South Side Black community. Chicago's Black population has declined since 2000, a trend which is observable in the difference between the 2010 Decennial Census data and the 2013-2017 ACS estimates shown below.

Race	2000 (Census)	2010 (Census)	2009-2013 (ACS)	2013-2017 (ACS)
Black (non-Hispanic)	36.4%	32.4%	31.9%	30.1%
White (non-Hispanic)	31.3%	31.7%	32.2%	32.7%
Hispanic	26%	28.9%	28.7%	29%
Asian (non-Hispanic)	4.3%	5.4%	5.7%	6.2%
Two or More Races	1.6%	1.3%	1.3%	1.7%
Amer. Indian/Alaska Native	0.1%	0.2%	0.1%	0.1%
Some Other Race	0.1%	0.2%	0.2%	0.2%
Nat. Hawaiian/Pacific Islander	0.03%	0.02%	0.02%	0.02%
Total Population	2,896,016	2,695,598	2,706,101	2,716,450

While less densely clustered than the Black population, the Hispanic population—largely and increasingly of Mexican extraction, but also with a visible Puerto Rican presence—is concentrated in three areas: the Northwest Side (including Hermosa and Humboldt Park), the Lower West Side (from Pilsen and Little Village to Midway Airport), and the far South Side (especially South Chicago). It is important to note that despite the significant Hispanic share of population in Chicago, it is a younger population and has lower rates of citizenship than other demographic groups, leading to a lower share of voting-eligible population. This weakens the community's power as a voting bloc relative to White and Black populations in the city.

Chicago's White population comprises 31.7% of the city's population and has traditionally been concentrated in ethnic enclaves—Polish, Irish, and so on. The fourth largest racial group in the city is the Asian population, at 5.4% in the 2010 Census and 6.2% in the 2013–2017 ACS. The city's Chinatown shows up clearly on the choropleth of Asian population (Fig 2), but in fact it is candidates of Indian backgrounds who have had more visibility as candidates. One such candidate, Ameya Pawar, has served in the city council since 2011.

Demographic shifts have been unevenly distributed around the city, with a significant drop in Black population particularly visible in the last decade (compare Figs 1,2).

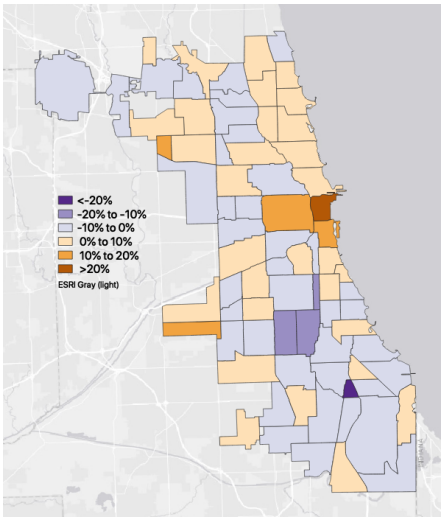

Figure 1. Population shifts in community areas between the 2009–13 and the 2013–17 ACS.

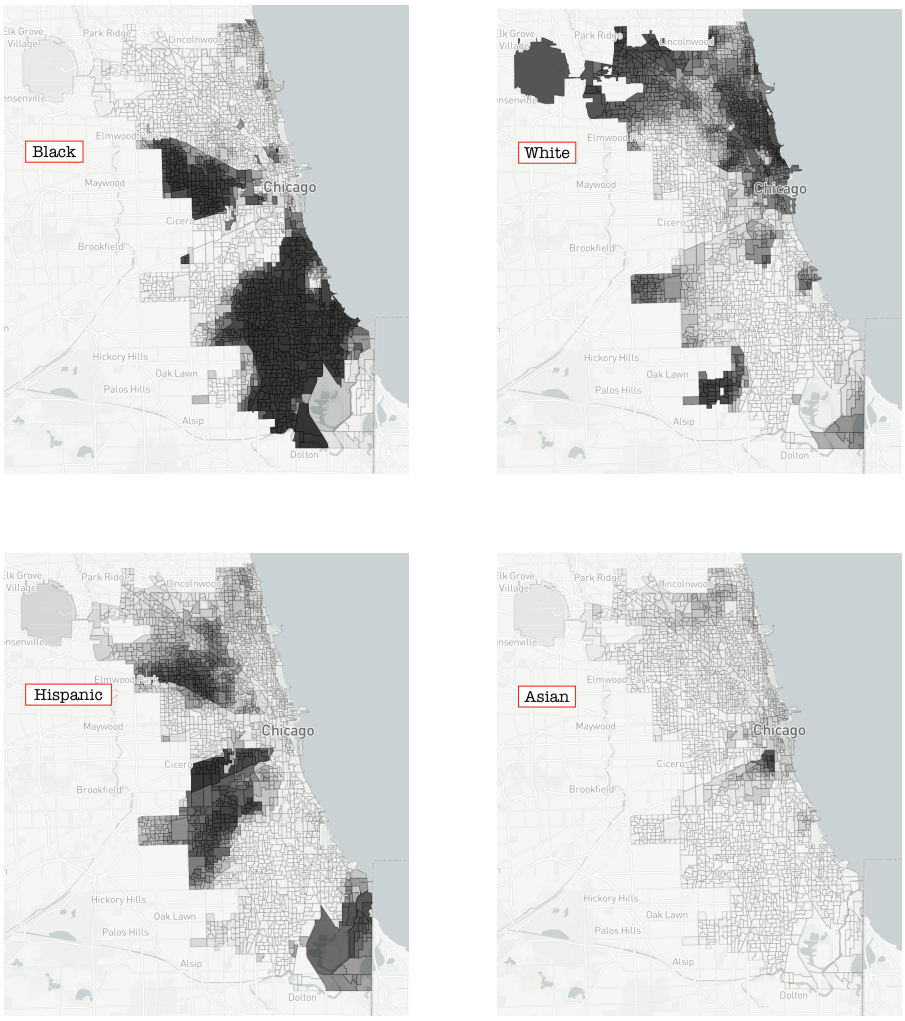

Figure 2. Choropleths of the four largest racial groups in Chicago.

3.3 Concentrations of poverty and wealth

Another dimension of rapid change in Chicago is in the distribution of affluence and poverty in the population. Part and parcel of the demographic transformation is a trend toward gentrification, the dismantlement of housing projects and other key elements of the social safety net, and allegations of a single-minded focus on the interests of business and wealth in the mayor's office.

Though the current wards contain about 40 precincts each on average, which should even out the differences observed at the precinct level, they do little to reduce the economic segregation—tied, as it is, to the racial segregation in the city. The affluence chart has a striking visual correlation to the plot of White population (compare Figs 2B,3B), and race ties closely to other conditions for social mobility as well, including violence, incarceration rates, and lead exposure [18].

Below, in §5.3.2, we will address the potential of reform plans to reduce the economic segregation in the city.

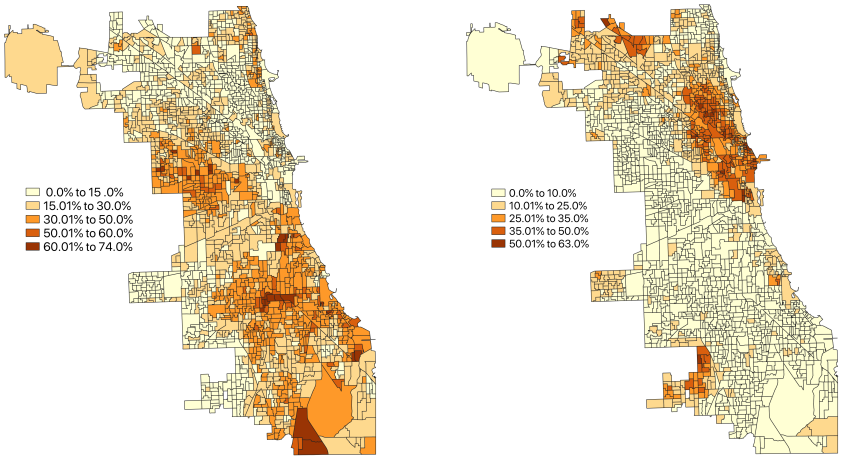

Figure 3. The left-hand figure displays rates of poverty from the 2013–17 ACS, showing the proportion of households in each precinct with less than $20K in annual income (compared to a citywide level of 21.33%). On the right, rates of affluence, showing the proportion of households with more than $150K in annual income (citywide 12.8%).

4 Demographic patterns in Chicago aldermanic elections

4.1 Racial rigidity in the current ward system

Due to the extremely high levels of segregation in the current plan as well as incumbent entrenchment and barriers to candidacy, the racial composition of the wards is skewed towards single-race dominance and that is highly predictive of representation. In particular, a significant number of wards never have viable candidates from multiple racial groups run for alderman.

44 of 50 wards are currently represented in the City Council by someone of the ward's largest racial group. (The current makeup reflects the outcome of the 2015 race, since the 2019 aldermen-elect have not yet been seated.) Here is a snapshot, showing a lock-step pattern of racial rigidity whose interruptions often reflect the importance of connections within Chicago's political class.

- 18 out of 18 majority-Black wards are represented by a Black alderman.
- 10 out of 14 majority-Hispanic wards are represented by a Hispanic alderman. One of the exceptions is the legendary Ed Burke, the powerful White alderman who has represented the now-majority-Hispanic Ward 14 continuously since 1969. Another is Deb Mell in Ward 33, who took over the alderman seat long held by her father Richard Mell and is the sister-in-law of former IL Gov. Rod Blagojevich. Marty Quinn, a former campaign strategist for powerful IL House Speaker Michael Madigan, ran unopposed in Madigan's own Ward 13, now nearly 2/3 Hispanic. The last exception is Susan Sadlowski Garza, the daughter of a prominent Chicago Labor leader, who is married to a Latino man, Raul Garza. Sadlowski Garza represents the 63.2% Hispanic Ward 10 and is the only one of the four White aldermen in majority-Hispanic wards to hold membership in the Chicago City Council Latino Caucus.
- 13 out of 14 majority-White wards are represented by a White alderman. The exception is majority-White Ward 47, represented by Ameya Pawar, the first Asian-American alderman elected in the

history of the Chicago City Council [1].

- The only four wards in which no group has a majority are all plurality-White. 3 out of 4 are represented by a White alderman. The fourth, Ward 1, is represented by the Vice Chairman of the Chicago City Council Latino Caucus, Joe Moreno.

As these facts suggest, Latinx Chicago is considerably underrepresented relative to population proportions. While making up nearly a third of the city's population, Latinos hold 22% of seats (11 of 50). One of these Latino aldermen was appointed, not elected, to take over the seat of a retiring White alderman. We note that no Black candidates at all won elections in 2015 outside of wards that had a majority-Black population. No current ward has an Asian plurality, and only one Asian-American alderman has ever been elected to the city council.

Modest but encouraging changes will take place as the 2019 electees are seated. As in the 2015 elections, each of the 18 majority-Black wards elected a Black candidate, but the 2019 cycle saw Black candidates also win election in majority-White Ward 47 and plurality-White Ward 49. In Ward 47, sitting alderman and sole Asian councillor Ameya Pawar decided not to seek re-election in order to run for City Treasurer. African-American candidate Matt Martin defeated White candidate Michael Negron in a runoff election to replace Pawar, after dispatching seven other White candidates in the first round.

In the 14 majority-Hispanic wards, the number of Hispanic representatives ticked up from 10 to 11 in 2019, due to the narrow defeat of Deb Mell, the well-connected (and LGBT-identified) White candidate in Ward 33, by Puerto Rican youth educator and community activist Rossana Rodríguez Sánchez. The candidates finished 81 votes apart in the first round and apparently just 14 votes apart in the runoff. The ward includes the immigrant-heavy Albany Park neighborhood and overall records a very slight Hispanic majority in population numbers, which becomes only a slight Hispanic plurality when voting age population is considered. Meanwhile, Ed Burke (Ward 14) defeated two Latino candidates outright, despite the scandals and federal corruption charges that have kept him constantly in the news for months.

A few results are notable in the wards with White majorities and pluralities. In majority-White Ward 40, Hispanic candidate and community organizer Andre Vasquez defeated nine-term White incumbent Patrick O'Connor. In plurality-White Ward 1, Daniel La Spata, a White candidate, defeated Hispanic incumbent Joe Moreno. This election was marred by credible allegations of troubling behavior by both candidates, from racist photographs of La Spata to allegations of sexual harassment and corruption on the part of Moreno. And finally, in the plurality-White Ward 49, Maria Hadden, an LGBT-identified Black woman, defeated Joe Moore, the seven-term White incumbent, to become the first openly gay Black woman elected to Chicago's City Council.

4.2 Candidate availability

Certainly part of the reason for the extremely close correspondence between the racial composition of the ward and its representation is the availability of candidates. Only 16 out of 50 aldermanic elections in 2015 had candidates of multiple racial backgrounds, as far as we can discover.[5]

[5]To highlight a few: In Moreno's White-plurality Ward 1, the Latino candidate defeated one Asian and two White candidates. Majority-Hispanic Ward 23 saw a White candidate of Polish heritage (Michael Zalewski) defeat a Latino and a White opponent in an election where he was accused of using racist campaign ads [15]. Ward 47 saw a candidate of Indian origin

In 2019, despite a few headline-grabbing outcomes, the numbers are not much different; we are able to identify only 18 out of 50 wards with candidates of multiple races.

Candidate availability has an enormous impact on representation that goes well beyond the simple truism that you must run in order to be elected. The mere presence of candidates of color on the ballot has knock-on effects for future political ambition in a jurisdiction [31]. Exposing more voters to more diverse slates of candidates provides robust benefits for civic health.

4.3 Racial crossover voting

Once, Chicago was notorious for its racially rigid voting patterns. In 1983, Harold Washington, by then a longtime legislator, became the first African-American to secure the Democratic nomination for mayor. A large percentage of the City's White residents, including many who had been life-long Democratic voters, switched over to vote for Republican Bernard Epton, who had campaigned on the nakedly racist slogan "Before it's too late!" Washington narrowly overcame that resistance to be elected.

This polarization persisted in Chicago with a longevity and fierceness that set it apart from other cities. Writing in 2006, political scientist Zoltan Hajnal identified Chicago as one of "a select number of cities where racial tension remains high, voting continues to be highly racially polarized, and few new white voters begin to support black leaders despite years of black leadership," concluding that "Chicago represents perhaps the most famous case of ongoing white resistance" [13].

As we write, we are fresh off of the 2019 mayoral election, which provided a clear demonstration of the willingness of White voters to choose a Black candidate—even with mainstream White candidates available. Two Black women, Lori Lightfoot and Toni Preckwinkle, advanced to the runoff round of the mayoral election, each with significant levels of White support. Figure 4 shows estimates of White voting levels in the city as a whole with respect to the top four candidates in White support. The technique used here is ecological inference (King's EI) applied to White vs non-White support for each candidate in turn.

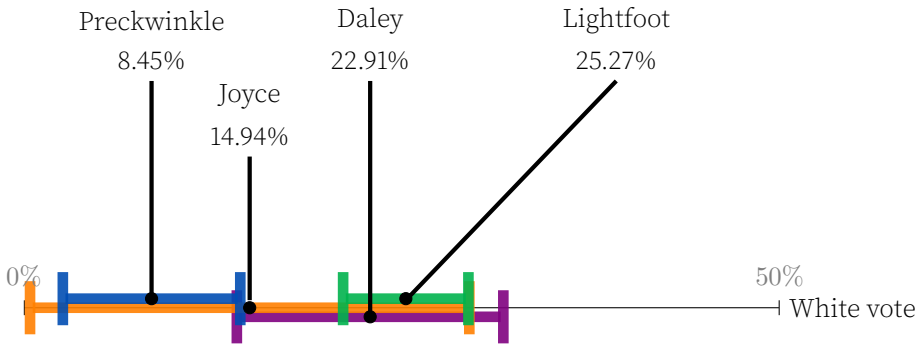

Figure 4. Ecological inference estimates, with highly overlapping confidence intervals, between two White and two Black candidates.

(Ameya Pawar) defeat two White candidates, despite the relatively low percentage of Asian population in the ward (6.1%). And finally in Ward 50, which is 44.9% White and 22.4% Asian, a White woman (Debra Silverstein) defeated two Asian candidates (Shajan Kuriakose and Zehra Quadri, both of Indian descent).

Both runoff candidates transcended the racially rigid voting patterns that Chicago has been associated with for decades. Neither Preckwinkle nor Lightfoot showed heavily regional voting, but rather each had a citywide and racially diverse base of support. Figure 5 shows the marked contrast between Jerry Joyce, a White candidate whose support is highly clustered (not only in the whitest precincts, but in one enclave of those), and Lightfoot, whose support extends across race and place.

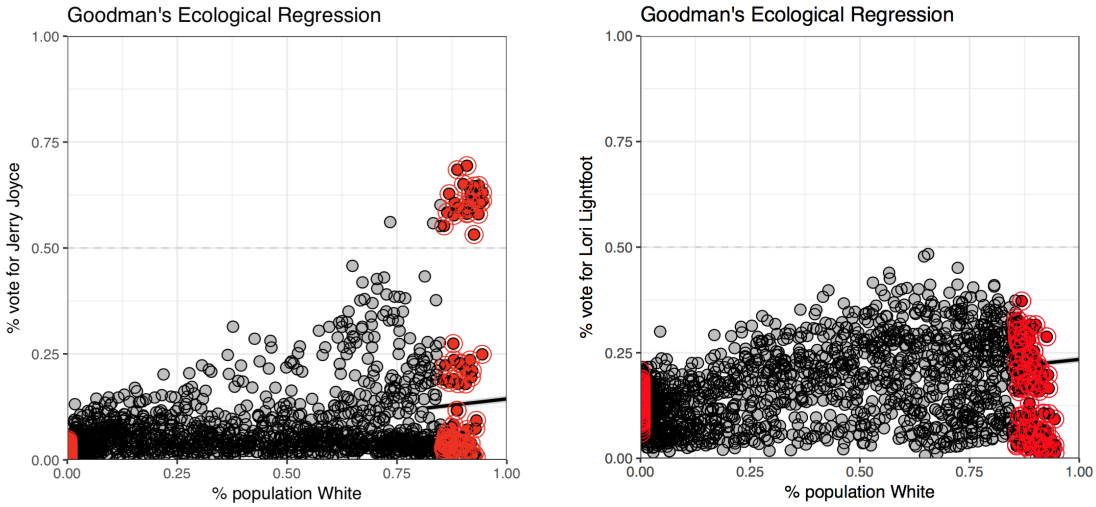

Figure 5. Regression estimates of mayoral vote by precinct illustrate White/POC voting patterns for Jerry Joyce and Lori Lightfoot. The precincts marked in red are the 5% with highest White population share and the 5% with lowest share.

These emerging patterns of substantial racial crossover voting further support the hypothesis that a hyper-segregated ward system, and not extreme voting polarization, is entrenching the racially rigid representation in the current council.

5 Generating alternative city council districts

In order to make inferences about the current districting plan and to study the effects of moving to multi-member wards, we will compare the plan to several types of legally valid alternatives.

To begin, we created a public web app (`districtr.org/chicago`) to experiment with district design, and to let other users try their hand at creating districting plans of different kinds for Chicago. In addition, we have used the open-source package GerryChain (`github.com/mggg/GerryChain`) to algorithmically generate large sets of districting plans for comparison, using a technique called a Markov chain. (See [10] for a survey of the Markov chain approach.)

5.1 Three ensembles of districting plans

To compare the existing system of single-member wards to a hypothetical multi-member system, we randomly generate large and diverse collections of possible plans by computer, requiring contiguity

and population balance, and with an algorithmic lean towards compact districts, described below. These collections of alternative plans are called "ensembles," and we construct them in three styles.

- 50×1 ensemble — each plan has 50 single-member districts built from precincts
- $10 \times m$ ensemble — each plan has 10 multi-member districts built from precincts
- $10 \times m$ CA ensemble — each plan has 10 multi-member districts built from community areas

At this stage, we do not specify m (the number of aldermen elected from each district), because it is irrelevant to the task of dividing the city into ten parts. Later, to project electoral dynamics, we'll consider $m = 5$ and $m = 3$ in turn. The ensembles contain 100,000 of each kind of plan, generated using the Markov chain Monte Carlo (MCMC) implementation in GerryChain. The starting points and the steps for these random processes use a recursive tree partitioning method described in [21].

We have presented maps of some plans with notable properties in Appendix A.

5.1.1 Population deviation

Chicago's wards are required by state law to be redrawn after each decennial census to maintain population balance. Local plans are generally expected to deviate from no more than 5% in either direction from ideal district size (1/50 of Chicago population, or 53,912 by Census 2010 numbers). With respect to 2010 Census population, the current plan has every ward within 5% of ideal district size, as is typically allowed in local districting plans. This plan was approved by the City Council in 2012 and was then subject to a lawsuit on the grounds of excessive population deviation; the U.S. Court of Appeals upheld the plan, finding its population balance to be acceptable.

In all three runs, we similarly limited the valid plans by requiring that population deviation stay within 5% of ideal. In the case of $10 \times m$ ensembles, this means each of the ten districts must have 9.5–10.5% of the city's population. This is in keeping with Supreme Court precedent regarding the measurement of population deviation in multi-member districts.

5.1.2 Compactness

Compactness is the principle that district shape should be regular and even rather than eccentric and contorted. One way to measure this is with a statistic called "cut edges": how many pairs of building blocks (precincts or community areas) are adjacent to each other in the city, but are separated into different districts by the plan? A very winding and eccentric district has to be cut out from many neighbors, driving up the number of cut edges. We have chosen a Recombination Markov chain (explained further in [21]) which has a natural weighting toward compact districts. We further enforced a compactness constraint on the randomization, limiting the number of cut edges to twice the number present in the seed plan.

The visually apparent gerrymandering in the current ward plan is captured by this metric. The current plan has 1391 cut edges out of 5638 total edges present in the precinct map—in other words, one out of every four edges has been cut. By contrast, a typical computer-drawn plan achieving all the other traditional districting principles with under 1250 cut edges. In fact, not a single plan in the algorithmic ensemble has as poor of a compactness score as the current enacted plan.

5.1.3 Communities of interest

Another traditional districting principle, rising in importance around the country, is that the districts should hold the communities in the population intact, so that groups with a shared interest can have a stronger voice as a significant bloc of a representative's constituency. This is another well-known area of weakness for the current ward system, which has seen communities of color and areas of high violence particularly likely to be cut in pieces and to have their ward assignment pattern change drastically with each decennial redistricting (see [36], or visit `vlplab.com/redistricting` for a visual demonstration).

To make it clear that effective districting plans can be designed while holding communities intact, we have used Chicago's 77 community areas as unsplittable building blocks in the $10 \times m$ CA ensemble. The community areas are too large to be divided into 50 wards without creating intolerable discrepancies in population between different wards. It is easily possible, however, to collect community areas into ten multi-member wards whose populations are close to equality—deviating by no more than 5% from the ideal number of residents per alderman, and in some cases by substantially less. In fact, it is possible to get every ward to within 1.63% deviation while holding every single community area intact. (Achieved in our ensemble by plan #87557.)

5.2 Racial and economic balance in districting plans

For each districting plan in these three ensembles, we computed the racial demographics of each ward in the plan using 2010 census data, and the economic statistics based on the 2013–2017 ACS.

It is well known that majority-minority districts can be an effective tool in securing representation in a winner-take-all (single-member) system. This does not necessarily require significant racial skew, because a second racial group may have almost the same share of the population. A more significant marker of segregation is a unit in which only one racial group surpasses 1/4 of the population. We will call such a unit "segregated." An even more extreme situation is one where only one racial group exceeds 1/6 of the population, and such a unit may be called "hyper-segregated." In Figure 6, we measure what share of the units are segregated by this definition. We see that the precincts of Chicago themselves show high levels of segregation, with 76.2% of precincts segregated. This reflects the well-known reality of block-by-block racial separation in the city, a legacy of governmental and lending policy as much as chosen living configurations.

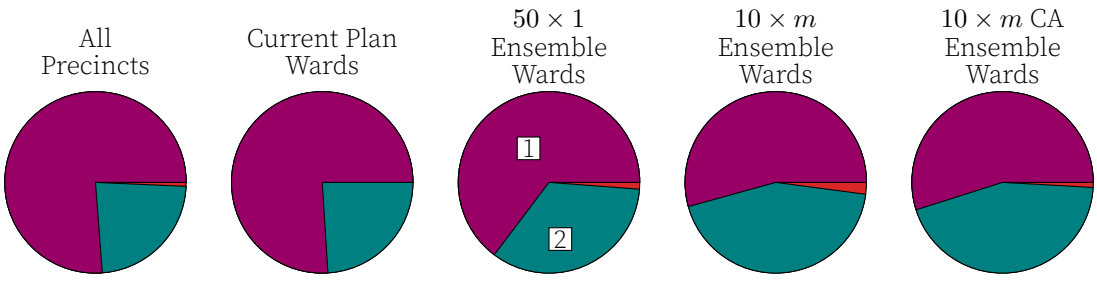

Figure 6. How many racial groups exceed $1/4$ of the population? Segregated units (where only one group exceeds that level) are shown here in the purple share of each chart, labeled $\boxed{1}$. (Compare Figure 10, which shows that only 0.1% of alternative plans are as segregated as the current plan.)

One should expect that combining precinct building blocks into larger geographic aggregations would reduce the levels of segregation. As expected, most random ways of combining precincts into wards do mitigate segregation: across the 50×1 ensemble, the share of segregated wards drops to 65%. But the current districting plan is **just as segregated as the precincts themselves**, with 76% of its wards qualifying for that label. The wards in multi-member plans are much less likely to be segregated; there, the share of segregated wards is closer to half.

For multi-member districts of magnitude 5 using ranked choice and STV, a major shift happens when a group hits 1/6 of the population. As explained in §2.1, that is an important "election threshold": any candidate with at least 1/6 of first-place votes is automatically elected. As the second collection of charts (Fig 7) makes clear, a significant share of $10 \times m$ wards—nearly 20% overall—are highly diverse, having three groups over $1/6$ of the population. In a 10×5 plan, this leads to the likely election of candidates of choice of multiple groups, rather than zero-sum voting behavior.[6]

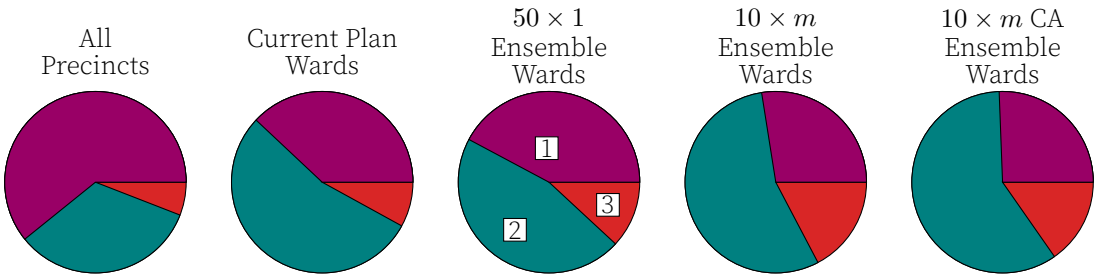

Figure 7. How many racial groups exceed $1/6$ of the population? An answer of $\boxed{1}$ indicates a hyper-segregated unit. This viewpoint also favors the move to multi-member wards. Also note that $1/6$ is the election threshold for districts of magnitude five ($m = 5$) using STV. If ten wards elect five aldermen each, the last two charts show that within-ward diversity will be significantly improved, with a high likelihood of multiracial representation from $\boxed{2}$ or $\boxed{3}$ groups.

In terms of economic segregation, the story is slightly different. Let us define a unit to have concentrated wealth if at least 25% of its households have over $150K in annual income, and concentrated poverty if at least 25% of households earn under $20K. We can use the share of units with these kinds of concentration as a measure of economic segregation. In the current plan, nearly half of the wards show these kinds of economic concentration (10% of wards have concentrated wealth while 38% have concentrated poverty). This is not that different from the 50×1 ensemble (12%/36%), and this is only lightly mitigated by moving to larger wards in the $10 \times m$ ensemble (9%/34%) or $10 \times m$ CA (11%/31%).

The biggest difference is one of opportunity. The multi-member ensembles offer the option to select plans that provide far greater economic parity while maintaining all the other districting criteria, including the priority for keeping community areas intact. Many plans in the $10 \times m$ CA ensemble uphold all districting criteria while minimizing economic segregation—for instance, Plan #5848 (seen in Appendix A) has no wards at all with concentrated wealth, and only 1 ward with concentrated poverty (0%/10%). This is far better than what is achievable with 50-ward plans: in the 50×1 ensemble, the very least economic segregation ever observed among 100,000 sampled plans is 18 wards with concentrated wealth or poverty (10%/26%).

[6] We note that only 11 out of 2069 precincts have all four racial groups in proportions exceeding $1/6$ of population. Since neither that rate nor the rate observed in any ensemble exceeds a half of a percentage point, the four-races case is omitted from the plots.

5.3 A stochastic model for demographic projections

Elections always have a degree of randomness, and there are especially many uncertainties when it comes to the outcomes in multi-member districts. The largest uncertainties are attached to the question of candidate availability: candidate emergence, candidate quality, and the possibility of campaigning together or in slates would all seriously impact the outcomes; we have severely limited information on likely scenarios. To handle this, we have selected a model in which candidate availability is implicit rather than an explicit parameter; instead, the model relies heavily on the empirical sufficiency of demographic groups exceeding an election threshold.

5.3.1 Reasoning from comparison cities

In the ranked choice elections in our comparison cities, our data contains 1396 precinct-election pairs in total. We implemented a STV voting mechanism to elect slates of five candidates from the preference schedule assembled from these real ballots. With these 1396 pairs as data points, 590 pairs had above 1/6 Black population and at least one Black candidate. A Black candidate was elected in 87.12% (514) of those precincts. (And all of the exceptions were in a single election.) 1130 pairs had above 1/6 White population and a White candidate. A White candidate was elected in 99.82% (1128) of those precincts. 130 pairs had above 1/6 Asian population and an Asian candidate. An Asian candidate was elected in 93.08% (121) of those precincts. 94 pairs had above 1/6 Hispanic population and a Hispanic candidate. A Hispanic candidate was elected in 98.94% (93) of those precincts.

Chicago outcomes can not be directly matched to RCV outcomes in comparison cities because of insuperable problems with candidate availability in the training data. In particular, out of the 21 elections we studied, only six had even one Hispanic candidate, so the data reflects this with a severe shortage of Hispanics elected. But even considering the data quality issues, we find that the predictive value of surpassing the election threshold is strong.

To obtain demographic projections, we calculated expectations and conducted 10,000 simulated elections each from 50×1, 10×5, and 10×3 setups. Details of model design are described in Appendix B, as well as a sensitivity analysis that bolsters confidence in the findings.

One strength of this model is that it does not assume that all members of a racial group citywide will have the same voting preferences, but rather compares residents of a precinct to people in similarly diverse precincts. Thus, the model takes turnout tendencies as well as class patterns into account, to the extent that those track with racial demographics at the level of residential neighborhoods.

5.3.2 Results

The current city council balance (18 Black, 11 Hispanic, 20 White, and 1 Asian alderman out of 50 seats) relies on already-outdated districts which exacerbate Chicago's significant segregation and have soared to an estimated population imbalance in which some wards are now twice the size of other wards, less than four years since they took effect. From the moment of its creation, it was an outlier among ways to draw 50-ward plans, using far less compact wards and locking in far higher racial rigidity than a typical alternative plan. With the demographic shift toward declining Black population share, a new 50-ward plan in 2020 is sure to see a reduced number of majority-Black

wards. The new trend that White voters are willing to vote for candidates of color will have much less compensating impact in a 50-ward plan than with larger and more diverse wards.

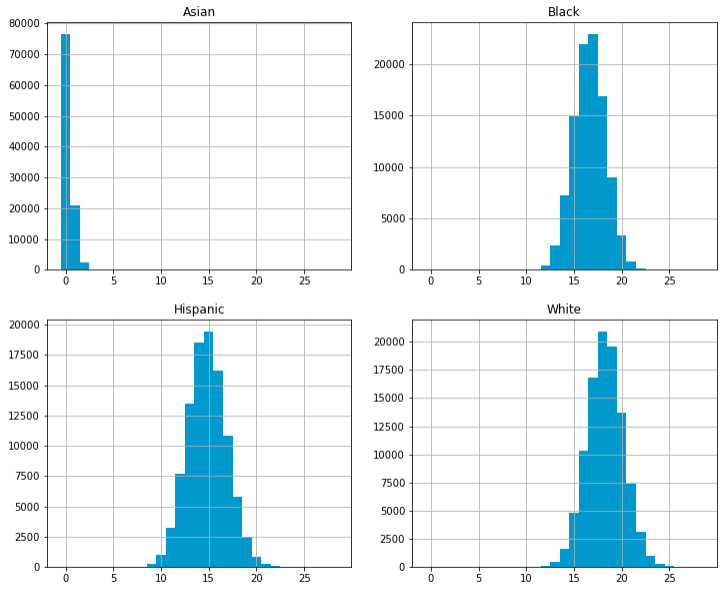

Figure 8. Results of 100,000 simulated elections in our $10 \times m$ ensemble with $m = 5$, showing how many members of each racial group are projected to be elected out of 50 aldermen in this election system.

Projections from our stochastic model allow us to compare the results if a 50-ward plan were to be redrawn (50×1), or if 10-ward plans were chosen to elect five members each (10×5) or three members each (10×3). As before, the variants marked "CA" are plans generated with the requirement to keep community areas intact while preserving population balance. Corresponding to these probabilistic outcomes, we can record probability distributions for racial composition of the elected council in terms of population-balanced wards and 2010 Census numbers, as well as expected demographics of representation (Figure 8, Table 1).

	50×1	10×5	10×5 CA	10×3	10×3 CA
Asian	0.83 (1.7%)	0.26 (0.5%)	0.13 (0.3%)	0.1 (0.3%)	0.09 (0.3%)
Black	15.58 (31.2%)	16.63 (33.3%)	17.03 (34%)	10.26 (34.2%)	10.77 (35.9%)
Hispanic	14.32 (28.6%)	14.83 (29.7%)	14.99 (30%)	8.93 (29.8%)	8.89 (29.6%)
White	19.26 (38.5%)	18.27 (36.5%)	17.85 (35.7%)	10.71 (35.7%)	10.24 (34.1%)

Table 1. Expectation statistics for Council composition over ensembles of 100,000 plans. This table is best interpreted as a comparison of structural tendencies among these different election systems, addressing possible worries that multi-member systems erode representation for minority groups. On the contrary, multimember systems will tend to expand representation while also providing strong opportunity for political coalitions across communities of color.

In our assessment, this model successfully captures reasonable comparative projections of demographic performance for typical plans of different types, with one exception: we judge Asian electability to be systematically underrated by the threshold-based approach.[7] Our best projection is that 1-2 Asian aldermen would be expected in any of the multi-member plans, and that these would come from wards with a White population plurality.

The reasons for the differences observed here have to do with how the racial groups are differently distributed and clustered around the city. For instance, Black segregation is far more pronounced than Latino segregation in Chicago. Over the 100,000 ways to cut up the city into 50 wards, we find Hispanic to be the second-largest racial group in over 47% of possible wards, whereas Black is the second-largest group in only 20%—Black population is far more likely to be in the 1st or 4th position. This helps explain why single-member districts are especially brutal for Hispanic representation: there's no electoral reward for second place in the current system.

We emphasize that our model is fueled by probabilistic draws over ensembles of 100,000 plans, and that actual outcomes would be heavily influenced by plan selection, candidate availability, campaigning, and many other factors. Nonetheless the numbers reflect real, systematic consequences of voting systems interacting with population dynamics.

[7] Asian residents are the third most prevalent racial group in about 25% of wards across the full $10 \times m$ ensembles. In a ward that elects five aldermen, we judge that this provides a significant opportunity for election, even if Asian population falls short of the technical election threshold of $1/6$. The ranked choice data from comparison cities bears this out.

6 Conclusions

The current districting plan has many flaws, leaving numerous opportunities for reform. Among these, we find multi-member, ranked choice systems to offer attractive remedies.

6.1 Gerrymandering

Carefully crafting ward boundaries to secure preferred electoral outcomes is a problematic vehicle for public policy goals. When fighting against the natural tendencies of small districts, line-drawing can often require contorted boundaries, which generate public skepticism and mistrust. Furthermore, this drives a need for major changes after every census, which has created a burden of fractured communities and representational instability that has fallen disproportionately on communities of color and those with fewer resources [36].

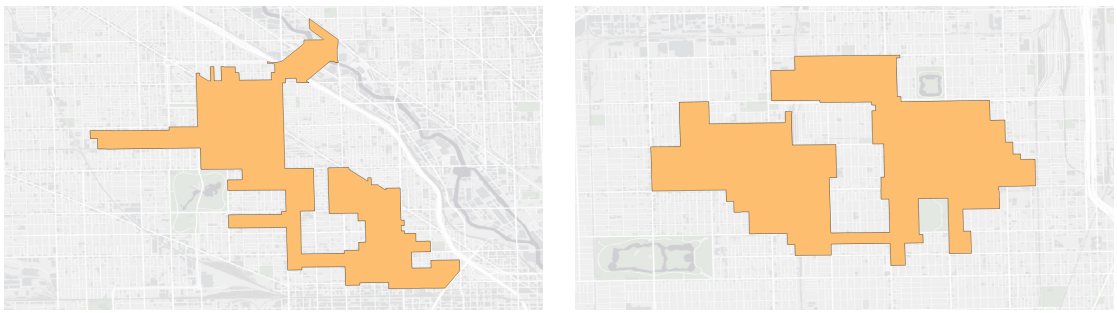

Figure 9. Two contorted wards in the current plan: Ward 1 (left) and Ward 16 (right).

A major and quite simple advantage of multi-member districts is less line drawing in the first place, while maintaining diverse representation that is relatively robust to population shifts. This has many benefits, including bringing to the most impoverished neighborhoods some of the "political stability" that has been selectively enjoyed by favored neighborhoods in the last half-century.

6.2 Segregation and population dynamics

The current ward plan can be characterized as massively segregated in comparison to the neutral districting alternatives. The plan has 38 wards (76% of the city) in which only one racial group exceeds 25% of the population. Indeed, in those wards, the prevalent racial group has an average of 74.24% of the population. This is far beyond any legitimate rationale of seeking majority-minority wards, far beyond any reasonable interpretation of providing “opportunity to elect," and can only be characterized as extreme racial packing. In the entire ensemble of 100,000 plans drawn according to the traditional principles, this is the largest such number ever observed.

The multi-member alternatives were seen above to improve dramatically on 50-ward plans, both in terms of racial segregation and in opportunities for economic parity (see §5.2).

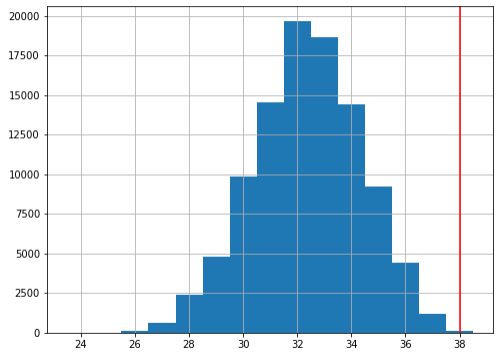

Figure 10. Only 104 of the 100,000 50-ward plans (0.1% of total) have levels of racial segregation as high as the current plan, which features 38 segregated wards (in which only one racial group exceeds 25% of the population).

Another problem with a system relying on many small districts is the tendency to drift towards wild levels of malapportionment (i.e., unequal population in the districts) over the ten-year census cycle. For instance, Chicago demographer Rob Paral computed that by the time of the 2010 Census, population had shifted so greatly that Ward 42 grew to 78,742 residents while Ward 3 had shrunk to 40,506, even though they were nearly balanced in Census 2000 terms [23]. For the voting age population (VAP), the disproportions are even more severe: Ward 42 had 74,781 while Ward 3 had 30,662. That means that the power of a vote is off by a factor of more than two. Larger districts compensate these tendencies, substantially mitigating the malapportionment.

Finally, it is clear that many more Chicagoans will have candidates of choice on the ballot in the multi-member structures—far more of the city will live in wards where candidates come from diverse backgrounds—which will promote coalition and unity campaigns and break down racially rigid patterns of representation.

6.3 Entrenchment and responsiveness

Another problem with the current wards is a pattern of entrenchment, fostering a system in which there are low incentives for new candidates to run for office, especially if they are not of the dominant racial group of their ward. In 2015, of the 50 seats, 45 sitting aldermen ran for re-election. In 2019, 46 incumbents ran for re-election. This means that entering the city council typically has required defeating an incumbent outright, or securing major institutional backing in the scrum when a seat opens up—this is one reason that turnover has so often produced new candidates with close family ties to their predecessors, or who are insiders in their own right.

Especially with higher magnitudes, multi-member plans significantly reduce the entry barriers for new aldermen; in the 10×5 system, it would suffice to be listed first on just 17% of ballots, and indeed it is typical in our ranked-choice comparison data to find that the fifth candidate elected has only about 10% of the first-place vote (because they are still ranked favorably by many more voters). With these reduced election thresholds, aldermen also have increased incentive to be attentive to the needs of more geographically dispersed groups of constituents, who now are numerically

sufficient to elect a candidate of choice. And, relatedly, a much increased share of voters will see one or more of the candidates that they chose be successfully elected, which stands to improve the engagement and identification of the electorate with their aldermen.

Any move to larger districts will provide a jolt to the system by presenting even longtime aldermen to new voters. In addition, the multi-member wards will necessitate an end to the problematic practice of "aldermanic privilege" by creating shared accountability and reduced opportunities for patronage and quid pro quo.

We emphasize that the many benefits for coalition governance presented by a changed system can only be fully realized with a concomitant investment in candidate recruitment and leadership training programs. As political scientists Reny and Shah note in a recent article, "The extant research on nascent political ambition suggests that individual factors, such as resources and experience, contribute more to the decision to run than contextual factors, such as open seats, partisan or racial composition of electoral districts, or term limits, for example" [25]. This is particularly true in communities of color, where cynicism about access to power poses its own barriers to political ambition.

6.4 Efficiency

Some have argued that reducing the size of the city council would be an efficiency measure, noting that the only large American city with a larger council than Chicago's current 50 is New York City, with 51 members. Of the remaining cities in the top twenty by population, Indianapolis has 25 city councillors; Los Angeles, Houston, Philadelphia, and Jacksonville have 15-20; San Antonio, Dallas, San Jose, Austin, San Francisco, Charlotte and Denver have 10-14; and Phoenix, San Diego, Columbus, Fort Worth, Seattle, and El Paso have 7-9.

However, at a time when many cities are rethinking their electoral structure, any decision to reduce council size should be made deliberately. Larger councils have numerous advantages, especially in a ranked choice setting, where higher district magnitudes create lower thresholds for election, making the system more dynamic, responsive, and diverse.[8] Furthermore, a large and dynamic city council can launch politically engaged Chicagoans toward higher office, opening up a talent pipeline that has been restricted because of the heavy entrenchment described above.[9]

Even on the simple level of the size of each representative's constituency, consider that even with 50 aldermen, there were 53,912 city residents per alderman at the time of the last Census. By contrast, the U.S. House was founded with the principle that the ideal number of constituents per representative would be 30,000 or 40,000. Reducing the size of the council as low as 15 members, as Bill Daley and others have called for, would increase the constituency size to nearly 180,000, making it harder for local concerns to find a voice in city governance.

The shift to ranked choice voting would have some costs; it would certainly call for a citywide education campaign about the mechanisms and reasons for the new voting system, and might require an investment in new voting machines among other transitional implementation costs. As mentioned above, a reform plan should also budget for candidate recruitment and leadership train-

[8] Some quantitative research has found that larger city councils create higher levels of minority representation, even in single-member districts [19].

[9] Bobby Rush, Luis Gutiérrez, and Chuy Garcia are three recent success stories of political mobility through the city council.

ing programs, in light of the necessity of diverse candidate availability to secure the promise of a new system. (Of course, such programs are sorely needed even if the 50-ward system is retained.)

Though there are costs, multi-member districts with ranked choice do provide significant efficiencies in other ways. They would allow for a major simplification in ballot styles from 50 to 10, reducing some associated administrative burden and cost, and would allow for more flexible placement of polling places or vote centers. And, crucially, ranked choice voting eliminates the need for runoffs, providing a major savings for the city. Just as important, it eliminates the primary rationale for runoffs by precluding vote-splitting problems among candidates with overlapping support and by promoting coalition voting through structural features.

6.5 Summary recommendations

Every single consideration discussed in this report favors the move from single-member plurality elections to multi-member districts with ranked choice voting. The many civic benefits are enumerated above, including better optics of district shape, holistic rather than delicately engineered diversity, better proportionality, lower entry barrier for new members, increased responsiveness to smaller constituent groups, opportunities for improved economic parity, and an end to the "fiefdom" era of city government.

Ten districts can easily be used to produce a city council with either 30 or 50 members, by electing either 3 or 5 members per district. For that decision, our evidence is more split. A 30-member council offers some cost/efficiency benefits for city administration and tends to provide slightly higher representation for African-Americans (see §5.3.2), simply as an artifact of the actual current patterns of demographic distribution. On the other hand, maintaining the 50-member council is likely to produce demographics closer to the proportions of residents, has a lower election threshold, which produces more multi-racial representation within wards and lower entry barrier to newcomers, and has a more manageable number of residents per alderman. Both the 10×5 and the 10×3 structure function substantially better than the 50-ward system to maintain diverse council membership for the long term, particularly in the face of the current trend of diminishing Black population share.

We emphasize that our findings show that ten-ward plans can easily be constructed to be contiguous, compact, population-balanced, and to significantly reduce racial and economic segregation, while providing more community cohesion and a terrain more favorable to coalition campaigns. The examples in Appendix A show that even the requirement of preserving community areas entirely intact can be done with no cost to other major districting goals and principles.

At this moment of extraordinary opportunity for change, we hope that data-driven modeling can offer evidence and support for civic reformers and community groups as they explore transformative proposals for a new Chicago.

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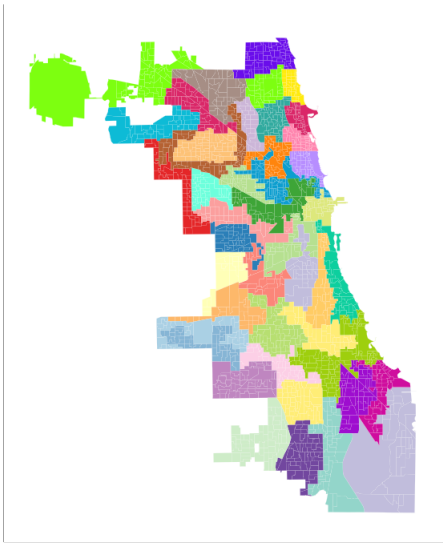
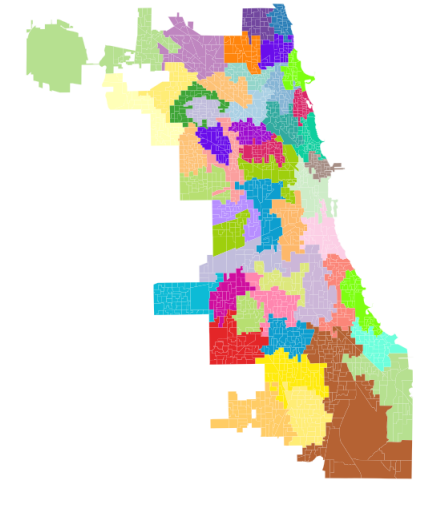
A Appendix: Samples of districting plans

Finally, we offer visuals to illustrate some of the variety in the ensembles we have generated.

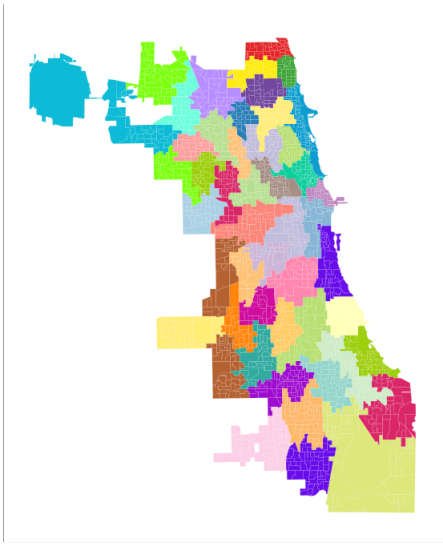
50 × 1 Ensemble (100,000 plans)



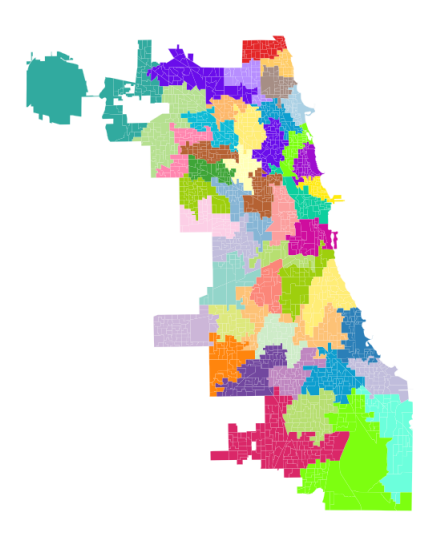
Current Enacted Plan
46 wards with a majority race
38 segregated wards
19 wards with concentrated poverty
13 wards with concentrated wealth



Plan #55139
Fewest wards with a majority race (34)

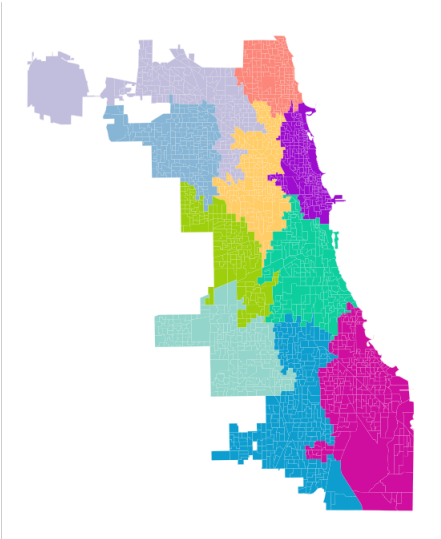


Plan #6084
Fewest segregated wards (26)

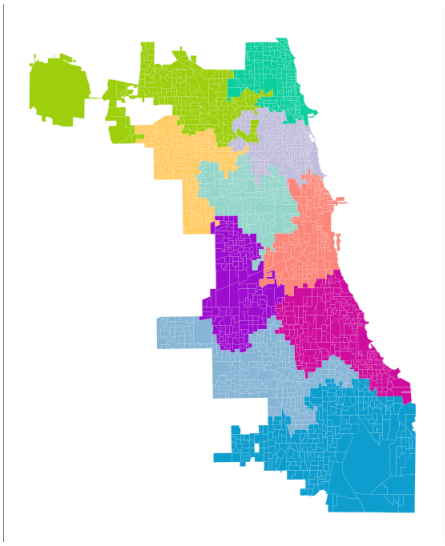


Plan #12816
Most economic parity
(13 ward with conc. poverty, 5 with conc. wealth)

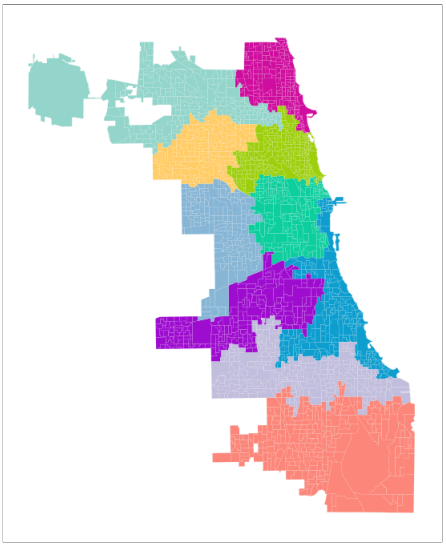
$10 \times m$ Ensemble (100,000 plans)



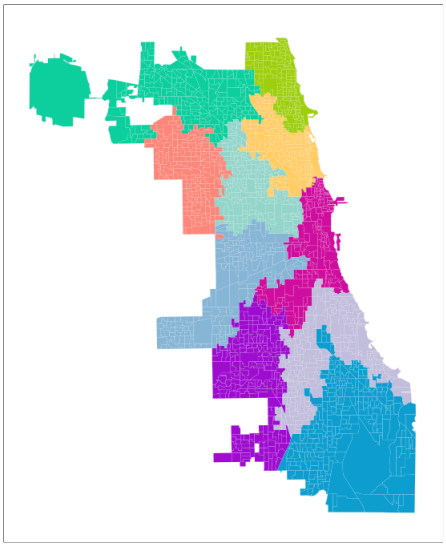
Plan #8698
Fewest wards with a majority race (3 of 10)



Plan #205
Most economic parity
(1 ward with conc. poverty, 0 with conc. wealth)



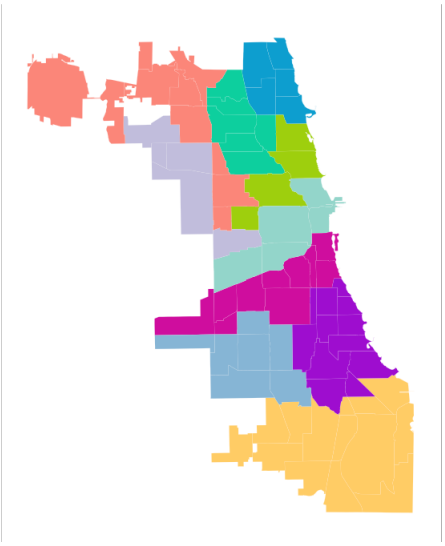
Plan #8178
Fewest hypersegregated wards (0 of 10)



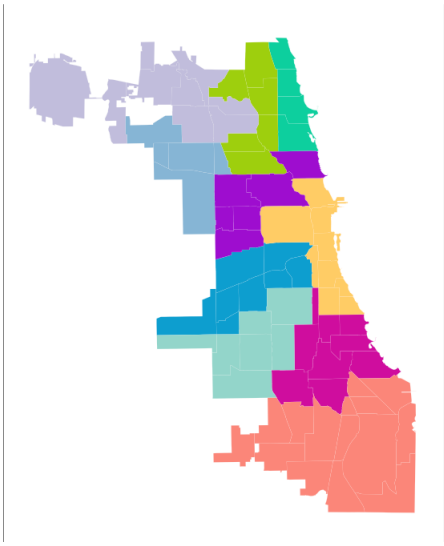
Plan #55213
Most highly diverse wards (6 of 10)

"Concentrated poverty": $\geq 25\%$ of households under \$20K annual income; "Concentrated wealth": $\geq 25\%$ of households over \$150K annual income; "Segregated": only one racial group exceeds $1/4$ of population; "Hypersegregated": only one racial group exceeds $1/6$ of population; "Highly diverse": three racial groups exceed $1/4$ of population

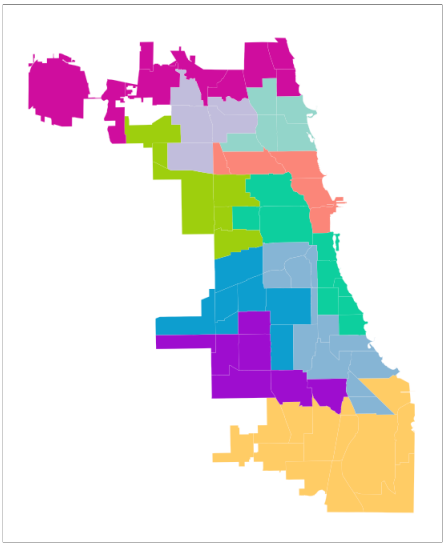
$10 \times m$ Community Areas Ensemble (100,000 plans)



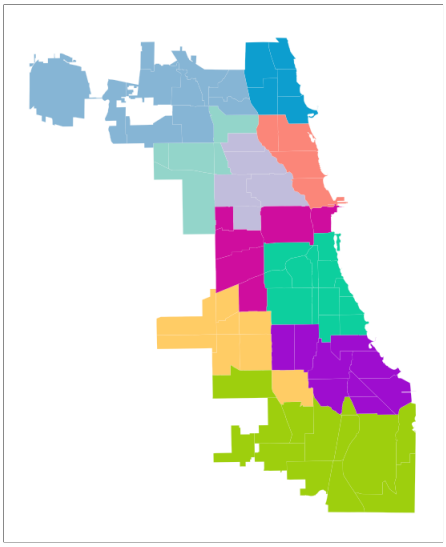
Plan #1042
Fewest wards with a majority race (3 of 10)



Plan #5848
Most economic parity
(1 ward with conc. poverty, 0 with conc. wealth)



Plan #937
Fewest hypersegregated wards (0 of 10)



Plan #25218
Most highly diverse wards (6 of 10)

"Concentrated poverty": $\geq 25\%$ of households under \$20K annual income; "Concentrated wealth": $\geq 25\%$ of households over \$150K annual income; "Segregated": only one racial group exceeds $1/4$ of population; "Hypersegregated": only one racial group exceeds $1/6$ of population; "Highly diverse": three racial groups exceed $1/4$ of population

B Appendix: Stochastic election model design

The model design is to sort by the the number of racial groups over the election threshold and the presence of a strict majority, then assign a probability distribution on the outcomes. For instance, in the magnitude-five setting, if only one racial group surpasses the $1/6$ threshold, we assign 5-0 and 4-1 election outcomes probability 60% and 40%, respectively, with respect to the first and second most prevalent racial group. To denote this efficiently, we'll divide into cases. Case 1: only one racial group exceeds threshold; Case 2: two groups exceed; Case 3: three groups exceed. Majority means that some group exceeds 50% of population; Plurality means that none does. An outcome of a-b-c indicates a members of the most populous group, b of the second group, and c of the third.

50×1 — using threshold of $1/4$

Case 1 Maj	1-0, 0-1	(.98,.02)
Case 1 Plur	1-0-0, 0-1-0, 0-0-1	(.8,.18,.02)
Case 2 Maj	1-0-0, 0-1-0, 0-0-1	(.8,.18,.02)
Case 2 Plur	1-0-0, 0-1-0, 0-0-1	(.6,.3,.1)
Case 3 Plur	1-0-0, 0-1-0, 0-0-1	(.5,.3,.2)

10×5 — threshold is $1/6$

Case 1 Maj	5-0, 4-1	(.6,.4)
Case 1 Plur	5-0-0, 4-1-0, 4-0-1, 3-1-1	(.5,.4,.05,.05)
Case 2 Maj	4-1-0, 3-2-0, 2-3-0, 3-1-1, 2-2-1	(.6,.3,.05,.03,.02)
Case 2 Plur	4-1-0, 3-2-0, 2-3-0, 3-1-1, 2-2-1	(.5,.35,.1,.03,.02)
Case 3 Maj	3-1-1, 2-2-1, 2-1-2	(.6,.3,.1)
Case 3 Plur	3-1-1, 2-2-1, 2-1-2	(.5,.35,.15)
Case 4 Plur	2-1-1-1, 1-2-1-1, 1-1-2-1	(.5,.35,.15)

10×3 — threshold is $1/4$

Case 1 Maj	3-0-0, 2-1-0, 2-0-1	(.90,.08,.02)
Case 1 Plur	3-0-0, 2-1-2, 2-0-1	(.6,.38,.02)
Case 2 Maj	2-1-0, 1-2-0, 3-0-0, 1-1-1	(.7,.15,.1,.05)
Case 2 Plur	2-1-0, 1-2-0, 3-0-0, 1-1-1	(.65,.25,.05,.05)
Case 3 Plur	1-1-1, 2-1-0, 3-0-0, 2-0-1, 1-2-0	(.9,.05,.02,.02,.01)

We draw a random plan from the appropriate ensemble; then for each ward, we use a $[0, 1]$-valued random variable to decide on an electoral outcome. By summing this over the 10 or 50 wards in the plan, a slate of representatives is chosen. One set of outcomes is shown in Figure 8, and the full report of expected outcomes for all five election variants is provided in Table 1.

B.1 Sensitivity analysis

These probability assignments draw empirical justification from the aldermanic election outcomes described in §4.1 and the ranked choice data from comparison cities described in §5.3.1. To be sure that the results don't overly depend on the setup, we performed a sensitivity analysis for these assignments, including over 200 variants. Most alterations result in fractional changes to the mean number of seats for each group. Full data and code for the stochastic model and sensitivity analysis can be found at `github.com/mggg/chicago` . Further analysis will be provided in future work.