Redistricting of Alabama

Final Project Report

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Executive Summary

Overview:

Alabama is one of the states of our country that has gone through a redistricting phase every 10 years since around 1973 when apportionment was introduced. This includes the present where Alabama has done redistricting due to population deviations and political affiliation from the 2010 census to the 2020 census, where Alabama has 7 districts for its 67 counties. Criteria for redistricting to take effect are demanding with close to equal populations in each district created and the districts cannot be separated by ethnicity or race. They must also abide by the Voting Rights Act and Constitutional Rules on Race.

Findings/Methods Used:

Alabama's immense amount of counties have been redistricted with a population deviation below 1% to satisfy federal criteria. The following districts have the following populations: District 1 - 716,265, District 2 - 721,577, District 3 - 715,957, District 4 - 719,597, District 5 - 715,042, District 6 - 719,925 and District 7 - 715,899. Using the power of Operations Research and Programming, a new district plan has been formed from the starting integer minimizing problem.

Summary:

Through methods of Integer Programming optimization using Gurobi, a future example redistricting plan has been developed for upcoming periodic 10-year censuses that happen for the districting for the state of Alabama.

Introduction

Every 10 years, a known process known as reapportionment and redistricting occurs due to varying populations in the states over years and years. After the 2010 and 2020 apportionments, Alabama has had 7 districts continuously over the years since the 1973 redistricting first occurred. There is, however, a difference when it comes to how redistricting affects the state every 10 years, of the 67 counties, some have changed political affiliation due to population and political battles, leading to changes in what counties are a part of the 7 districts as well as population deviations and percentages. The example below shows the differences in redistricting for the state of Alabama from 2010 to 2020 after their respective census.

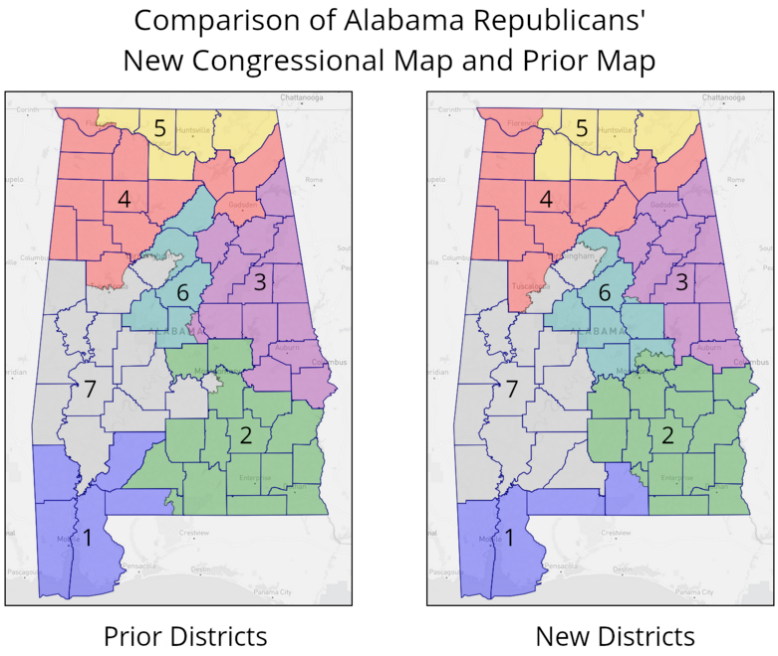


Image 1: Comparison of redistricting of Alabama from the 2010 census to the 2020 census from political affiliation. Taken from:

https://ballotpedia.org/Redistricting_in_Alabama_after_the_2020_census

Problem Statement

Satisfying State and Federal criteria/laws is already hard enough when it comes to redistricting, however, a solution needs to be developed regarding optimization for which counties go into each of the 7 districts while following Alabama's criteria. An optimization model will be put in place to solve the increasing population and redistricting overall, all while abiding by the policies involved.

The Criteria

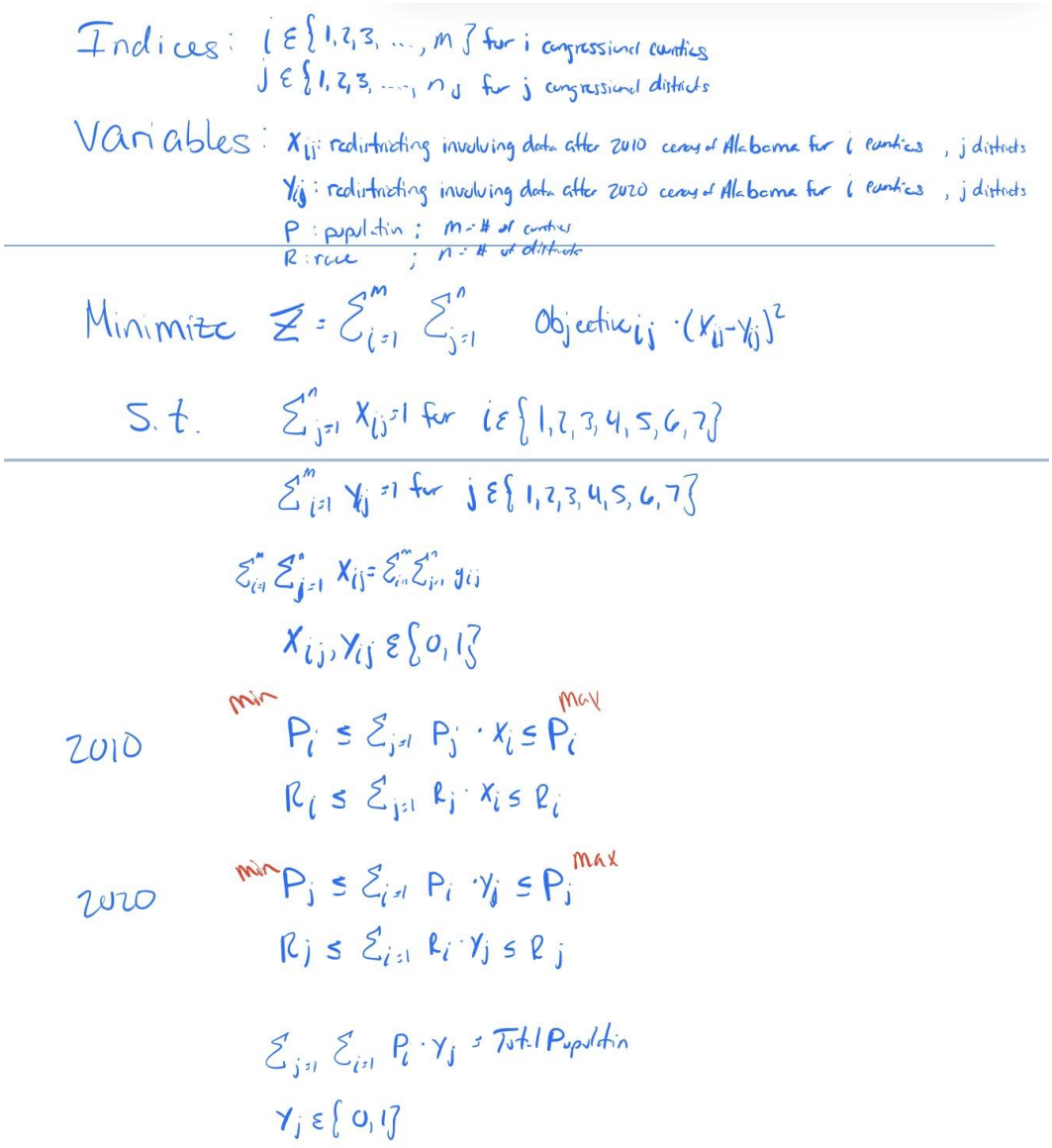
- **Federal Criteria**
    - The federal criteria stipulate that each district must have almost equal populations and may not discriminate based on race or ethnicity. (Less than a 1% population deviation)
    - Alabama must have close to equal populations in each district created and cannot separate the district by ethnicity or race. They must also abide by the Voting Rights Act and Constitutional Rules on Race.
- **State Criteria**
    - As for state criteria, any revision to the redistricting plan must be drafted by the reapportionment office.
    - Every draft for the redistricting plans that are introduced at any session of the legislature and are not prepared by the Reapportionment Office must be presented to the Reapportionment Office for a review of proper form and an entry to the Legislative Data System at least 10 days before the introduction.
- **Resources**
    - Citations: Country and State Documents
        - Eckman, Sarah J. “Congressional Redistricting Criteria and Considerations - CRS Reports.” *Congressional Redistricting Criteria and Considerations*, 2021, crsreports.congress.gov/product/pdf/IN/IN11618.
        - Rules, Senate. “The Alabama Legislature.” *Alabama Legislature*, 2023, alison.legislature.state.al.us/senate-rules-index?search=Redistricting.

OR Model (Words)

- **Indices**:
  - $i \in \{1,2,3,...,m\}$ is for congressional counties
  - $j \in \{1,2,3,...,n\}$ is for congressional districts
- **Parameters**:
  - m: is for the number of counties in Alabama Σ
  - n: is for the number of districts in Alabama
- **Variables**:
  - x_i is the 2010 redistricting for Alabama, i counties and j districts
  - y_i is the 2020 redistricting for Alabama, i counties and j districts
  - p_i is the population for each district i
- **Explanation of the Model's Math below**
  - The goal is to minimize the number of people in each of the districts based on the populations of each of the counties
  - Constraints:
    - Counties Population
    - Districts Population
    - Balance constraints to make the counties and districts somewhat equal
    - Some Binary Variables
  - Population Constraints for the values from 2010
  - Race and Ethnicity Constraints for the Values from 2010
  - Population Constraints for the Values from 2020
  - Race and Ethnicity Constraints for the Values from 2020

- Total Population Constraint

OR Model (Math)



Python/Gurobi Code

- Here is the link to our code: (Also Submitted Separately)
  - https://colab.research.google.com/drive/1jguXJkdtnuKzUjvVpV5MMDdseFEmsQAA#scrollTo=O6U3NhDrzRYg&line=1&uniqifier=1

Experiments

The computer we used to run our code was a Dell Precision 5560 which has a RAM space of around 32 GB. The Gurobi version installed on this computer is the newest one, which is 11.0.0 the academic version.

Plans and Maps

Our main objective is to be able to produce a congressional redistricting map that will be able to satisfy every constraint. During this, we plan to make every district as equal as possible with the main factors of population, race, and ethnicity. Looking at this draft from a tool for creative redistricting and filling in estimations for the 7 district population from the code in different colors for Alabama, we can see a 0.53% population deviation, which satisfies the federal criteria for a population deviation less than 1%.

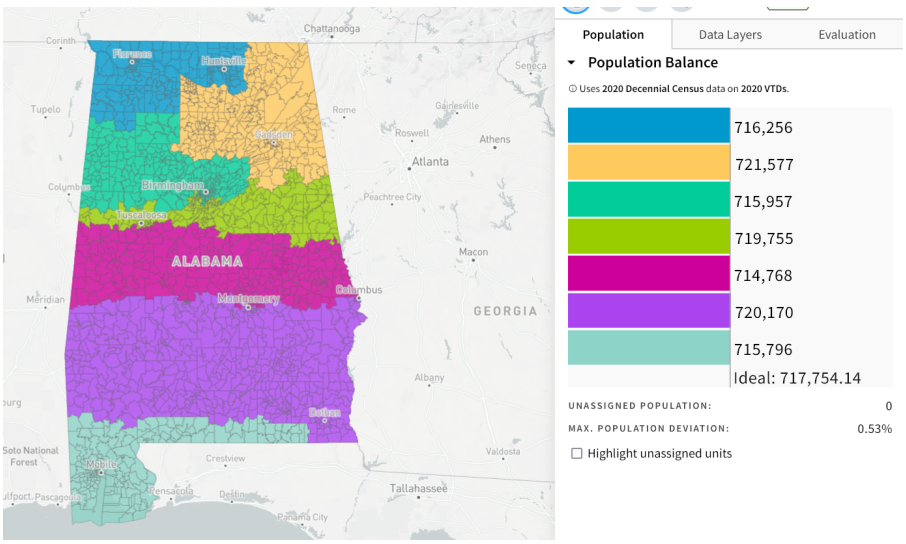


Image 2: A rough schematic of our redistricting of Alabama with the code values.

https://districtr.org/plan/214956

Evaluation of Plans

Our values from each district are as follows, District 1 - 716,265, District 2 - 721,577, District 3 - 715,957, District 4 - 719,597, District 5 - 715,042, District 6 - 719,925 and District 7 - 715,899. With that, they were able to meet all the requirements of each constraint which are the population, race, and ethnicity. Within the plan, there were some limitations which were making sure each population was within a certain percentage of each other so that other districts were not more populated or more racially populated than others.

Conclusion

In conclusion, we had a new district map which had made 7 new districts. Each of these district were similar in population with an ideal population value of 717,754. Each of these was also based on the races in each country as well as ethnicity. The results for each district were listed above and have the corresponding values for each of the 7 districts.

References

Buchanan, A. (2023). *OR redistricting resources*. Austin Buchanan. https://austinlbuchanan.github.io/OR-redistricting-resources/

Eckman, Sarah J. "Congressional Redistricting Criteria and Considerations - CRS Reports." *Congressional Redistricting Criteria and Considerations*, 2021, crsreports.congress.gov/product/pdf/IN/IN11618.

Rules, Senate. "The Alabama Legislature." *Alabama Legislature*, 2023, alison.legislature.state.al.us/senate-rules-index?search=Redistricting.

Pedia, B. (2023). *Redistricting in Alabama after the 2020 census*. Ballotpedia. https://ballotpedia.org/Redistricting_in_Alabama_after_the_2020_census

R, D. (2023). *Population Balance*. Districtr. https://districtr.org/plan/214956

GitHub Repository

Link to our GitHub where all project files are located:

https://github.com/Hadiubeidat2003/Alabama-Redistricting-Fa23-HU-MG