Congressional Redistricting of West Virginia Report

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Executive Summary

Congressional redistricting is the process of redrawing the boundaries of electoral districts for seats in the United States House of Representatives. This process occurs every ten years following the decennial census. The goal is to ensure that each congressional district has roughly equal population representation, as population distribution can change over time. This report will show how I went about the redistricting of the congressional districts in West Virginia. By first analyzing the federal and state criteria for congressional redistricting, I was able to develop a program that accommodates the constraints with the objective of minimizing cut edges.

Introduction

Congressional redistricting is a complex process which directly impacts the distribution of power in the U.S. House of Representatives and can influence. A census is taken every 10 years which determines whether a state will need to redraw their congressional districts. Based on the results of the census the state may have to redraw their congressional districts adhering to federal and state criteria. This is done to eliminate bias to any demographic or geographical location by breaking each state into districts of nearly equal populations. Because of the constraints held by the federal and state governments, an optimization model is the best solution.

Criteria

Federal Criteria

- Each district must have a nearly equal population in relation to one another (Apportiontment Clause, Article 1, Section 2, U.S. Constitution).
- Each district must not intentionally negatively impact minority voting (Voting Rights Acts, 1965).

State Criteria

- Districts must be compact, contiguous, and maintain political subdivisions (Article 6, Section 4, Constitution of West Virginia).

The states additional requirements outside of the federal criteria are meant to support local communities and those who have common interests.

Problem Statement

I will develop a districting plan for the state of West Virginia that follows the guidelines and constraints held by the federal and state government using operations research.

Operations Research Model

In words

The objective of this program is to minimize the cut edges while keeping counties whole.

Sets:

- C, the set of counties/nodes (0,1,2,…,54)
- J, the set of districts, k (0,1)
- E, the set of edges (1,2,…,e)
- N(i), the set of neighbors of county i

Indices:

- i, county
- j, district
- u and v, counties being checked for contiguity

Parameters:

- P_i, the population of county j
- $totpop_j$, the total population of district j
- e, the total number of edges
- n, the number of counties/nodes
- k, the total number of desired counties
- L, the lower bound of maximum population deviation
- U, the upper bound of maximum population deviation

- M, the number of counties – the number of districts +1

Variables:

- X_{ij} = 1 if county i is in district j
    - 0 if otherwise
- y_{uv} = 1 if there is a district boundary between counties u and v
    - 0 if otherwise
- r_{ij} = 1 if county i is the root of district j
    - 0 if otherwise
- f_{ij} = 1 if flow is sent from county I to district j
    - 0 if otherwise

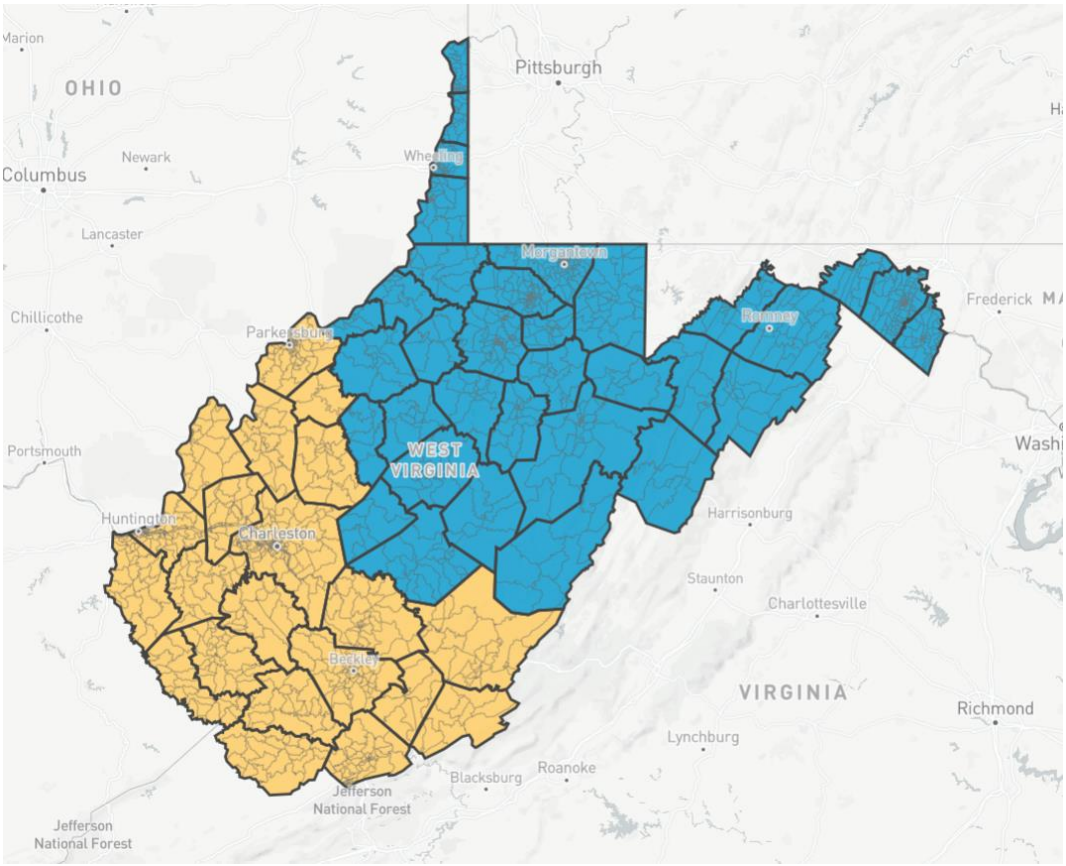
Words	**Math**
Minimize cut edges	$\text{Min} \sum_u^n \sum_v^n y_{uv}$
Each county i is assigned to one district j	$\text{S.T.} \sum_i^n x_{ij = 1 \mid} \forall_j \in J$
Each district j has a maximum population U	$\sum_i^n P_i X_{ij} \leq U \mid \forall_j \in J$
Each district j has a minimum population L	$\sum_i^n P_i X_{ij} \geq L \mid \forall_j \in J$
An edge is cut if u is assigned to district j but v is not	$x_{uj} - x_{vj} \leq y_{uv} \mid \forall_u \in E, \forall_v \in E, \forall_j \in J$

Each district has 1 root	$\sum_i^n r_{ij} = 1 \mid \forall_j \in J$
If node I is not assigned to district j it cannot be its root	$r_{ij} \leq x_{ij} \mid \forall_j \in J, \forall_j \in C$
Only send flow to a root	$\sum_{j \in Ni}(f_{ij} - f_{ji}) \leq 1 - M \times \sum_j^k r_{ij} \mid \forall_i \in C$
Do not send flow across cut edges	$f_{ij} + f_{ji} \leq M \times (1-y_{ij}) \mid \forall_i \in E, \forall_j \in E$

Experiments

The model was coded and optimized using Gurobi Optimizer version 11.0.0 and Jupyter Lab. The model was run on a Dell 5560 laptop, which has an 11th Gen Intel(R) Core(TM) i7-11800H @ 2.30GHz CPU. The model was solved in 0.49 seconds.

Map



View map here

Evaluation

The model meets all of the federal and state requirements. District 0 (yellow) has a population of 899,234 while district 1 has a population of 894,482. This equates to a population deviation of 0.26%. This shows that the model was able to satisfy the constraints of having near

equal population and being compact and continuous. However, the model is unable to account for maintaining communities of common interests.

Conclusion

Using a model that minimized cut edges I was able to find a potential plan for congressional redistricting in West Virginia. The program meets all the criteria held by federal and state governments, excluding maintaining the communities of interest. The districts created had a near equivalent population with a 0.26% population deviation which is below the 1% deviation required to meet the criteria.

Work cited

Redistricting Criteria. (2021). Retrieved December 11, 2023, from Ncsl.org website: https://www.ncsl.org/redistricting-and-census/redistricting-criteria

Buchanan, Austin. “Districting Examples 2020.” *Github*, 4 April 2022, https://github.com/AustinLBuchanan/Districting-Examples-2020. Accessed 11 12 2023.

Voting Rights Act, 1965

Apportionment Clause, Article 1, Section 2, U.S. Constitution