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The Congressional Redistricting of the State of Nebraska

Project Report

IE5318

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Summary:

In light of Nebraska's changing demographics and the recently released 2020 Census data, a thorough reevaluation of congressional districts is desperately needed. With changing demographics, boundary redrawing becomes necessary to guarantee just and equal representation for the state's diverse population. Our suggested approach, which is based on adherence to both state and federal regulations, seeks to uphold legal requirements and transparency ideals while navigating the difficulties present in this redistricting process. To solve the problem of county division, our approach finds innovative ways to maintain county integrity while meeting population balance requirements. By using advanced mapping tools, it is possible to analyze population distribution precisely and recommend districts that, when feasible, follow county lines.

Our objective is to minimize the number of cut edges between counties while understanding the value of maintaining local identity and community cohesion. Our goal is to preserve the geographic and cultural integrity of Nebraska's various regions by carefully placing district boundaries to the state's current county lines. Using Python and Gurobi, we can precisely analyze the distribution of the population and create district recommendations that balance the population while respecting county boundaries. Our redistricting recommendations are fair and adaptable to the state's changing demographics using a data-driven approach.

This report will include the state and federal redistricting laws and criteria, as well as the OR model created for this optimization problem. The objective and constraints will be stated followed by a math model of the Nebraska redistricting optimization problem. In addition, we will also include the Python code using Gurobi solver, the objective output, and discuss our proposed plans and maps of redistricting Nebraska.

Table of Contents:

Introduction:

The process of drawing new boundaries for state and congressional legislative districts is known as redistricting. By ensuring that each district maintains a roughly equal population, this crucial project upholds the idea of one person, one vote. The objective is to maintain legal requirements for fair representation while accounting for population and demographic changes, as determined by census data. The process's goal is to create fair and representative political districts, which requires striking a careful balance between federal and state laws, community integrity, and public input. Our dedication to drawing a congressional district map for Nebraska that respects local communities, takes into account the state's changing demographics, and adheres to the ideals of justice and equal representation does not waver even as we maneuver through the difficulties of redistricting.[1]

The redistricting process in Nebraska is an important and dynamic process that takes place in reaction to changes in demographics and population trends. This important project, which is carried out every few years after the U.S. Census, entails reevaluating and modifying the state's legislative and congressional district boundaries. The main goal is to keep representation fair and equitable by making sure that every district represents a reasonable portion of the population. In addition to taking into account the complex interplay between federal and state laws, Nebraska's redistricting process takes into account county integrity, compactness, and conformity to the law. The redistricting process is a crucial tool for influencing Nebraska's political climate and preserving democratic representation as the state adapts to the changing needs of its diverse populace.[2]

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[1] Loyola Law School. (2021, October 16). What is redistricting? All About Redistricting. https://redistricting.lls.edu/redistricting-101/what-is-redistricting/

[2] Library, T. L. R. (n.d.). Redistricting. Legislative Reference Library | Legislation | Redistricting. https://lrl.texas.gov/legis/redistricting/lrlhome.cfm#:~:text=Redistricting%20refers%20to%20the%20process,of%20equalizing%20population%20among%20districts.

Criteria:

State legislatures or redistricting commissions are given specific guidelines to follow when drawing boundaries during the redistricting process. These standards are meant to guarantee equity and uniformity while also making the districts simple to recognize and comprehend.[3] There are two criteria that congressional redistricting needs to stay within:

a. Federal Criteria:
    i. One–Person, One–Vote Principle: Guarantees that the population of each district is approximately equal to that of every other district in the state, thereby fostering equal representation.
    ii. Compliance with the VRA (Voting Rights Act): Prohibits the creation of district lines that would lessen racial or ethnic minorities' ability to vote.[4]

b. Nebraska's Criteria:
    i. Compactness: Possessing the smallest possible distance between each constituent part
    ii. Contiguity: Every area within the district is eventually connected to the other areas within the district.
    iii. Preservation of counties and other political subdivisions: Lines should not be crossed when creating districts, county, city, or town.
    iv. Preservation of communities of interest: Geographical places, like a city's neighborhoods or a state's regions, where the people living there share political views that might not line up with the limits of a political subdivision, like a county or city. [5]

[3] Redistricting in Nebraska. Ballotpedia. (n.d.). https://ballotpedia.org/Redistricting_in_Nebraska
[4] Publications. ACRU. (2021, May 29). https://theacru.org/publications/
[5] (2021). (rep) (p. 3). Congressional Redistricting Criteria and Considerations

v. Preservation of cores of prior districts: To the greatest extent feasible, districts should be kept as they were originally drawn. Consequently, there is representational continuity.

vi. Avoiding pairing incumbents: Staying away from districts that would lead to incumbents running against each other.[6]

The state criteria vary between states, however the criteria stated above is Nebraska's criteria. In Nebraska, the state legislature is responsible for drawing the boundaries of both the congressional and state legislative districts. A redistricting plan must be approved by a simple majority and is subject to the governor's veto[7]. During the most recent redistricting cycle, the Redistricting Committee passed a legislative resolution that included extra rules to protect the historic districts' cores, outlaw the use of partisan data, and forbid purposeful favoritism or disfavoritism of any party, organization, or individual.[8]

Problem Statement:

We have a complex challenge in Nebraska's congressional redistricting process as we address the demographic changes identified by the 2020 Census. A careful approach to districting is required due to the convergence of federal and state requirements, such as the requirement for contiguity, equal or nearly equal populations, maintaining core of prior area divisions, and the preservation of political subdivisions. The task is made more complex by the U.S. House's insistence on nearly equal population distribution, which contrasts with the allowable deviation (+/-5%) of Nebraska's House and Senate districts. Furthermore, accuracy is required by the strict guidelines for state House districts, especially those pertaining to county integrity. Creating a redistricting plan that satisfies legal requirements while also

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[6] NCSL. (n.d.-a). Summary redistricting criteria. National Conference of State Legislatures. https://www.ncsl.org/redistricting-and-census/redistricting-criteria

[7] Redistricting in Nebraska. Ballotpedia. (n.d.). https://ballotpedia.org/Redistricting_in_Nebraska

[8] The Trustees of Princeton University. (n.d.). Nebraska | Gerrymandering Project. Princeton University. https://gerrymander.princeton.edu/reforms/NE

taking into account the state's changing demographics and diverse communities is a challenging task. Finding a balance between state and federal regulations, the need for open and fair representation, and other factors is a complex problem that calls for careful thought and creative solutions.

OR Model (in words & in math):

Our goal in Nebraska's redistricting is to preserve the core of prior districting efforts as much as possible. This means that while creating districts, we will try to respect county lines and accommodate preserving counties previously districted together in the latest approved legislative plan. But we also have legal obligations to follow, such as those pertaining to contiguity, demographic balance, and other issues, which may come first. Our objective is to come up with a fair approach that complies with the law and respects counties. We can apply a Linear Programming (LP) technique to create an optimization model for congressional redistricting. Sets, indices, parameters, and variables are frequently included in the model preamble. The model preamble and the redistricting problem formulation are shown in the following simplified form:

i. Sets:

i : Sets of counties i = [1,2, ….93]

j: Sets of districts j = [1,2,3]

ii. Indices:

i: County index

j: District index

iii. Parameters:

P_i : Population of county

P_j: Population of district

k: Total number of districts

iv. Decision Variables:

Letting y_e (a binary decision variable) denote an edge that is cut between two counties, while x_{ij} (also a binary decision variable) represents whether county i is assigned to congressional district j.

y_e: Binary variable indicating whether there is a cut edge between two counties

x_{ij}: Binary variable indicating county i as assigned to district j

Where,

$$y_e \ [\ \begin{matrix} 1\ ;\ if\ an\ edge\ is\ cut \\ 0\ ;\ otherwise \end{matrix}\ ]$$

$$x_{ij} \ [\ \begin{matrix} 1\ ;\ if\ county\ i\ is\ assigned\ to\ district\ j \\ 0\ ;\ otherwise \end{matrix}\ ]$$

- Objective Function:

The main objective in our Nebraska congressional redistricting exercise is to draw congressional districts that uphold the important concept of population balance. Our goal is to reduce the population differences between districts so that each has about the same amount of people living in it. To do this, we will create an objective function that, with compactness in mind, aims to minimize the edges between counties is a part of two districts; cut edges. absolute deviations between each district's actual population and is within 5% deviation the ideal population target. We aim to construct congressional districts that adhere to the one-person, one-vote principle, therein by minimizing the number of cut edges between counties. This will guarantee that every vote has equal weight and maintains the fundamental values of democracy. This strategy will give Nebraska a solid basis for a redistricting plan that is both equitable and compatible with the law. The objective function is quantified below for the mathematical modeling:

$$\min \sum y_e \qquad \forall e$$

- Constraints:

The constraints include population balance, contiguity, compactness, and avoiding county division to the greatest extent possible. To maintain the one-person, one-vote concept, we will impose restrictions to ensure that the population in each congressional district closely follows an ideal population target with minimal variations. With the goal of achieving a balanced representation, the permissible variation will normally be set at less than 1%. To guarantee that every congressional district is composed of continuous geographic units, we will impose contiguity limitations. As a result, districts will adhere to the concept of compactness and logical geographic boundaries, preventing them from becoming fractured or unconnected. These limitations will guarantee that districts are efficiently planned and have a compact form. We will enforce constraints to avoid the division of counties if Nebraska demands that counties be whole inside congressional districts to the greatest extent feasible. Respecting the political and administrative boundaries at the county level requires doing this. In an optimization problem involving redistricting, constraints usually correspond to requirements related to justice and law. Here are the constraints Nebraska's redistricting:

i. Population Balance:

$$\sum_j x_{ij} = 1$$

$$\sum_i P_i \cdot x_{ij} \geq \left(\frac{\sum_i P_i}{D}\right) \cdot (1 - target\ deviation)$$

$$\sum_i P_i \cdot x_{ij} \leq \left(\frac{\sum_i P_i}{D}\right) \cdot (1 + target\ deviation)$$

The state of Nebraska has a total population of 1,826,341, and is allotted 3 congressional districts (hence, k = 3). This suggests a constraint restricting the redistricting of the counties to fit within the populations shown below as the Lower Bound (L) and the Upper Bound (U).

L = 0.995 x (608,780.33) = 605,737

U = 1.005 x (608,780.33) = 611,824

ii. Contiguity and Geographic Compactness:

$x_{ij} + x_{ik} < 1$ for i, j, k where i is not directly adjacent to both j and k

iii. Preservation of communities:

$$\sum_{i \text{ in community}} x_{ij} = 1 \quad \text{for each } j \text{ representing a district}$$

Python/Gurobi Code:

See attached code for the optimization of the above model yielding the updated map below in the "Plans and Maps section".

IE5318 Final Project Code - Nebraska Re

Experiments:

The goal of the computational experiments on Nebraska's redistricting with Gurobi and Python is to minimize the number of cut edges between counties by developing an optimization model. Gurobi is a potent optimization solver that can be used to determine the best solution given specific goals and limitations. Here is a talk that outlines the essential procedures for assembling and executing these kinds of computational experiments. The computing attributes of the computer that was used to conduct the code are as follows:

i. RAM: 16.0 GB

ii. Processor Speed: 2.70 GHz

iii. Gurobi Optimizer Version: 10.0.3

iv. Jupyter Notebook: 6.5.4

v. Population:

   a. Lower Bound: 605737

   b. Upper Bound: 611824

   c. Total Population of Nebraska: 1826341

vi. Ideal District Population in Nebraska: 608780. 3333333334

vii. Objective Value (The Number of Cut Edges): 19

viii. Time Required to Solve the Optimization Model: 6.88 seconds

ix. District Population Number:

   a. District 1: 608839

   b. District 2: 609327

   c. District 3: 608175

Plans and Maps

Figure 1 Nebraska general districting layout, generated by davesredistricting.org

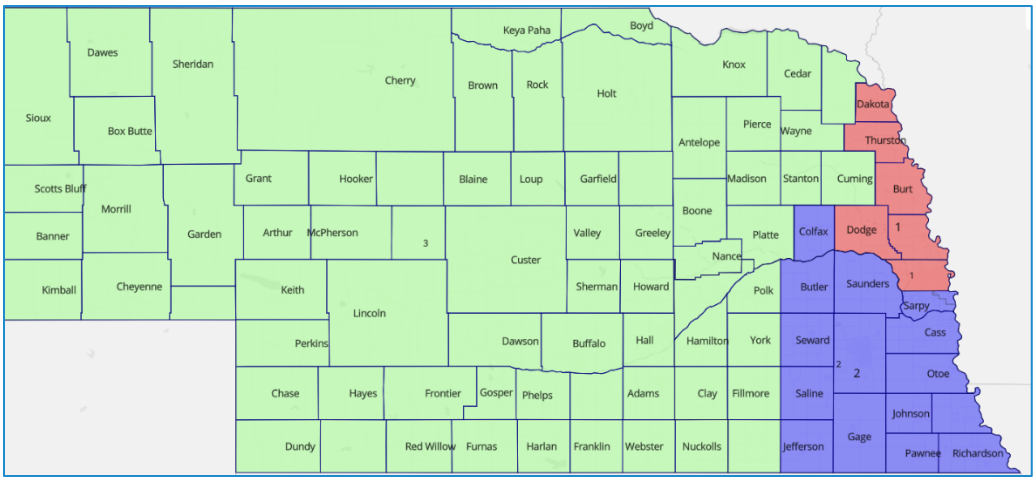

Figure 2 Nebraska districting layout with county borders and callouts, generated by davesredistricting.org

Based on our redistricting Gurobi analysis, the number of cut edges is 19.

1. The total population of District 1 population is 608,839 and contains the following six counties ['Burt', 'Dakota', 'Thurston', 'Dodge', 'Washington', 'Douglas']

2. The total population of District 2 is 609,327 and contains the following fifteen counties ['Saunders','Pawnee','Colfax','Seward','Richardson','Saline','Jefferson','Otoe','Sarpy', 'Cass', 'Johnson', 'Butler', 'Nemaha', 'Gage', 'Lancaster']

3. The total population of District 3 is 608,175 and contains the following seventy-two counties ['Dawson', 'Thomas', 'Antelope', 'Garfield', 'Sioux', 'Deuel', 'Boyd', 'Thayer', 'Hitchcock', 'Banner', 'Furnas', 'Clay', 'Merrick', 'Brown', 'Arthur', 'Sheridan', 'Wayne', 'Cuming', 'Garden', 'Keith', 'Pierce', 'Sherman', 'Dundy', 'Stanton', 'Cheyenne', 'Box Butte', 'Wheeler', 'Lincoln', 'Hooker', 'Red Willow', 'Grant', 'Chase', 'Scotts Bluff', 'Greeley', 'Webster', 'Cherry', 'Boone', 'Dawes', 'Frontier', 'Nuckolls', 'Kearney', 'Dixon', 'Howard', 'Keya Paha', 'Logan', 'Cedar', 'Loup', 'Polk', 'Blaine', 'Kimball', 'Gosper', 'Harlan', 'Phelps', 'Hamilton', 'Knox', 'Morrill', 'Hall', 'Valley', 'Madison',

'Franklin', 'Nance', 'Hayes', 'York', 'McPherson', 'Perkins', 'Rock', 'Adams', 'Holt', 'Platte', 'Fillmore', 'Custer', 'Buffalo']

Evaluation of Plans

The proposed map for Nebraska satisfies both federal and state criteria while executing the objective function. All three districts are constructed to achieve near-equal populations that fall within the population deviation limit. Our proposal also fulfills compactness and contiguity requirements while attempting to preserve the core of historically approved districting maps. Our suggested redistricting plan seeks to promote equitable and effective representation for the various communities that make up the state

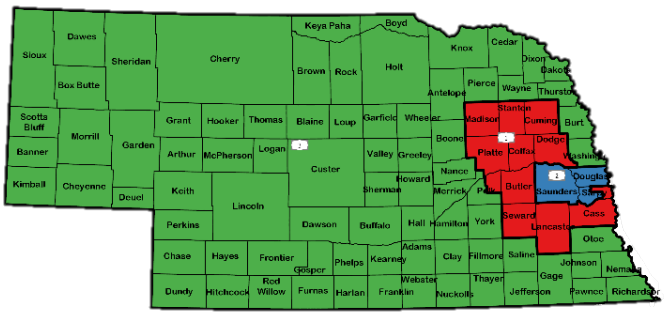

Figure 3: Nebraska's District Map Today

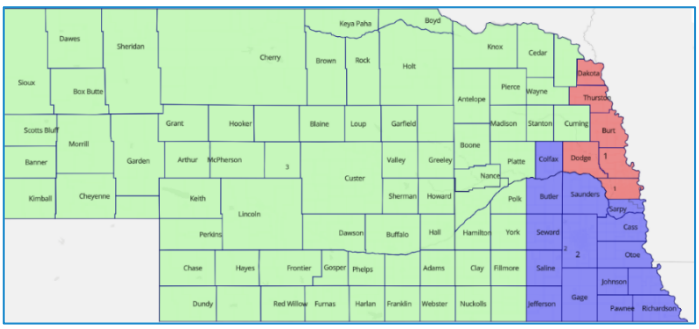

Figure 4: Nebraska's Proposed District Map

of Nebraska by carefully balancing legal requirements, population equity, and geographic factors. The maps shown above in Figure 3 and Figure 4 show the comparison side by side between Nebraska's district map today and our proposed map of Nebraska's districts. Our proposed map minimizes the number of cut edges between counties while keeping the population numbers in each district very close to one another.

Conclusion:

In conclusion, this report shows a proposed congressional redistricting that would minimize the number of cut edges between counties. According to our code, the number of cut edges is 19, whereas district one contains 6 counties, district two contains 15 counties and district three contains 72 counties.

Within the larger framework of representative democracy, the plan aims to preserve local identities and community cohesion by giving priority to the preservation of county integrity. The proposed districts' reliability is further improved by the deliberate application of sophisticated mapping technologies and demographic analysis tools, which minimize disturbances to the current county boundaries while promoting the ideal population balance. Essentially, the goal of the proposed congressional redistricting plan is to promote a democratic system that is responsive to the needs of Nebraskans, while also navigating the difficulties of the redistricting process. The plan aims to create districts that respect the state's unique geographic and cultural features by reducing the number of cut edges between counties, ultimately fostering a more cohesive and representative political landscape.