IE 3311 Final Report

Redistricting Kansas

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Team JMC

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I. Executive Summary

This project holds the overarching goal of utilizing the comprehensive data derived from the 2020 Census specifically tailored for the state of Kansas. Our primary objective is to meticulously redraw the existing congressional districts, ensuring an accurate reflection of the latest demographic shifts within the state and to keep the population bounds at a 1% deviation (+/-0.5%). The proficient JMC team, composed of individuals named Jade, Mason, and Christian, was strategically engaged as dedicated redistricting consultants, entrusted with the pivotal task of enhancing the geographical and demographic representation in Kansas. Our collaborative efforts culminated in the creation of a robust congressional redistricting plan, meticulously crafted to withstand legal scrutiny. This meticulously formulated plan adheres to traditional redistricting principles, meticulously ensuring factors such as population balance, contiguity, and compactness, in addition to full compliance with both state and federal laws.

It is essential to note that in the state of Kansas, redistricting traditionally rests upon the state legislature. Tasked with the responsibility, the state legislature relies on the invaluable insights derived from census data to discern the nuanced shifts in population dynamics over the years. Subsequently, they embark on a judicious process of adjusting district lines, meticulously aiming to maintain a delicate equilibrium in terms of the number of residents in each district. The overarching objective is to preclude any specific area from gaining an undue surplus or deficit in political influence. This meticulous and deliberate redistricting process significantly impacts the overall composition of the legislature, consequently shaping the individuals who ultimately represent the diverse populace in the sphere of government.

II. Introduction

Redistricting Kansas pertains to updating the map for voting areas. Picture Kansas as a big puzzle, and each piece of that puzzle is a district where people vote. Now, every ten years, after a nationwide headcount called the Census, we get new information about where people live. This information helps us see if some areas have more people now, or if some have fewer.

This is a process of adjusting those puzzle pieces to make sure each one has roughly the same number of people. This way, it's fair and everyone's voice counts equally. We developed a plan to rearrange the districts, making sure it follows the rules and legal guidelines. Normally, the state government is in charge of this puzzle, and they use the Census data to figure out where people have moved and how the population has shifted over the years. The main goal is to maintain a balance so that no one area ends up with too much or too little political influence. Ultimately, the redistricting process plays a significant role in determining who represents you in the government, shaping how your voice is heard in the decisions that affect your community.

III. Kansas Redistricting Criteria

Not only in Kansas but for the entire United States, it is required that redistricting must abide by the federal constitutional provisions concerning the population and the prohibition of discrimination. Section 2 of the 1965 Voting Rights Act prohibits plans that discriminate on the

grounds of race, whether intentionally or unintentionally, in order to reduce the minority vote, in addition to population equality.

The state criteria for Kansas according to Kan. Const. Art. 10, § 1, lists reapportionment of senatorial and representative districts. Each of the four seats on the Kansas House of Representatives and 165 seats on the Kansas Senate are elected from political subdivisions known as districts. U.S. Senators are not elected from districts but from the states as a whole. Kansas redistricting takes place every 10 years after the completion of the U.S. Census.

Redistricting according to the legislature states that it must be reasonably compact in shape, which means they shouldn't be unnecessarily elongated or oddly shaped. Compactness helps prevent gerrymandering, which is manipulating district boundaries for political advantage. It must also be contiguous; all parts of a district must be connected without any non-contiguous areas, and this ensures that districts are geographically cohesive.

They should also Preserve Political Subdivisions, aiming to keep intact political subdivisions like counties, cities, or towns whenever possible. This helps maintain local representation. Preserving Communities of Interest is required to make an effort to keep communities with common interests or characteristics together within the same district. This helps maintain effective representation for those communities.

Lastly, Avoiding Pairing Incumbents is not a primary factor, and generally not a legitimate reason for redrawing district boundaries. In addition, state legislative districts are subject to the principle of equal representation. This principle is based on the 14th Amendment of the United States Constitution.

IV. Problem Statement

The problem statement is to create a congressional redistricting that can withstand legal evaluation and adhere to both state and federal regulations. The main goal is to minimize the population disparity between the most and least populous districts. To accomplish this, certain limitations will be imposed, such as assigning each county to one of three districts, ensuring that the population of each district falls within the range of the lowest and highest population of a Congressional District, and determining whether a county should fully contribute to a specific district or not. It is essential to consider counties as a whole when calculating their population for the purpose of forming a Congressional district.

V. OR Model (in words)

For the integer program, the objective is to minimize the total amount of cut edges. The constraints for this program include:

- Assign each county to one particular district.
- Assign each vertex to a district.

- Make each district have a population between L & U.
- Assign each county to a specific district and every cut edge is either 0 or 1.
- Assign each district to one root.
- Assign a vertex for a county to consume the flow when it is not assigned to a root.
- Assign cut edges to not have any flow.
- The value of flow must be positive.
- Assign the value of the root to be 0 or 1.

VI. OR Model (in math)

Sets: C is the set of counties in Kansas

Indices: I is a county in Kansas

J is a district in Kansas

Parameters: Pi is the population in given county I

K is the number of districts (k = 4 in our case)

L = the district with the lowest population

U = the district with the highest population

Variables: $x_{ij} = \begin{cases} 1 & \text{if county i is assigned to district j (i } \epsilon\ C \text{ and j } \epsilon\ (1,2,3)) \\ 0 & \text{otherwise} \end{cases}$

$y_{ij} \begin{cases} 1 & \text{if edge } e \epsilon E \text{ is cut} \\ 0 & \text{otherwise} \end{cases}$

r_{ij}=a root of a county assigned to a specific district

f_{ij} =the flow of given a county assigned to a specific district

Minimize the total amount of cut edges	Min $\sum_{e\epsilon E} y_e$
Make edge $e = \{u, v\}$ cut when vertex u is assigned to district j	subject to: $x_{uj} - x_{vj} \leq y_e$ $\forall_e = \{u, v\}\epsilon E,\ \forall_j \epsilon \{1,2,\dots,k\}$
Make each vertex $i\ \epsilon\ assigned$ to a singular district	$\sum_{j=1}^{k} x_{ij}$=1 $\forall_i \epsilon V$
Make the population of each district between parameter L and U	L$\leq \sum_{\mathrm{i}\ \epsilon\ C} p_i \leq$ U $\forall_j \epsilon \{1,2,\dots,k\}$
Each county assigned to a specific district and every cut edge is either 0 or 1	$x_{ij} \epsilon \{0,1\}$ $\forall_i \epsilon V,\ \forall_j \epsilon \{1,2,\dots,k\}$ $y_e \epsilon \{0,1\}$ $\forall_e \epsilon E$
Make every district have a singular root	$\sum_{i\epsilon V} r_{ij} = 1$ $\forall_j \epsilon \{1,2,\dots,k\}$

Vertex $i\epsilon V$ must not root to any district j	$r_{ij} \leq x_{ij}$ $V_i \epsilon V, \forall_j \epsilon \{1,2,\dots,k\}$
Make vertex i consume flow when it is not a root	$\sum_{u\epsilon N(i)} (f_{ui} - f_{iu}) \geq 1 - M \sum_{j=1}^{k} r_{ij}$ $\forall_i \epsilon V$
Prevent flow across cut edges	$f_{ij} + f_{ji} \leq M(1 - y_e)$ $\forall_e = \{\mathrm{i,j}\}\epsilon \mathrm{E}$
Make the flow a nonnegative value	$f_{ij,}\ f_{ji} \geq 0$ $\forall_{\{i,j\}} \epsilon E$
Make each root either 0 or 1	$r_{ij} \epsilon \{0,1\}$ $\forall_i \epsilon V, \forall_j \epsilon \{1,2,\dots,k\}.$

VII. Python/ Gurobi code

Please see attached code files to see the full code for our project.

VIII. Experiment Discussion

The optimization model was written, combined and solved using the Gurobi application (Version 10.0.2) Jupyter Notebook, and the coding language used was Anaconda. The model runs on a Microsoft Surface Pro 7 Laptop, which contains 8 GB of Ram and an Intel(R) Core (TM) i5 – 8250U CPU @ 1.60GHz processor. The program used is a program with Geopandas and Contiguity. The program identified the number of cut edges as 32 edges. The program solved this model in 8477 seconds. The model is solved to optimality.

IX. Plan(s) and Map(s)

The proposed plan includes district one (0) consisting of the following counties: Greeley, Phillips, Pawnee, Clay, Republic, Seward, Ford, Marshall, Lincoln, Finney, Stanton, Sheridan, Ellis, Reno, Wabaunsee, Comanche, Logan, Harper, Norton, Thomas, Hamilton, Osborne, Hodgeman, Trego, Cloud, Dickinson, Lane, Cheyenne, Wallace, Kiowa, Haskell, Rice, Morton, Rush, Washington, McPherson, Ness, Grant, Edwards, Morris, Rooks, Barber, Decatur, Sherman, Gray, Barton, Clark, Saline, Kingman, Geary, Scott, Jewell, Wichita, Stevens,

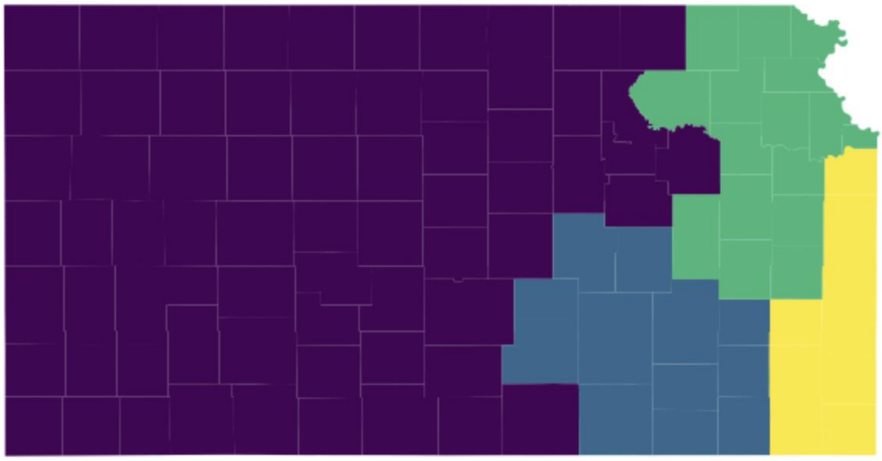
Graham, Kearny, Gove, Smith, Russell, Rawlins, Riley, Stafford, Ottawa, Meade, Mitchell, Ellsworth, Sumner, and Pratt.

District two (1) consists of the counties: Montgomery, Woodson, Chase, Cowley, Butler, Chautauqua, Harvey, Wilson, Elk, Sedgwick, Greenwood, and Marion.

District three (2) consists of the counties: Franklin, Jackson, Doniphan, Wyandotte, Lyon, Pottawatomie, Atchison, Brown, Jefferson, Nemaha, Osage, Leavenworth, Anderson, Shawnee, Coffey, and Douglas.

District four (3) consists of the counties: Bourbon, Cherokee, Crawford, Allen, Johnson, Labette, Linn, Neosho, and Miami.

The map shown below represents the new congressional districts for Kansas with the **purple** being **district one**, the **blue** being **district two**, the **green** being **district three** and the **yellow** being **district four.**



X. Evaluation of Plan(s)

This proposed plan meets the criteria, maintaining a 1% deviation where each districts population remains at 750,000(+/-7,500). This further illustrates that Kansas population is continuing to decline, with more residents leaving the state rather than moving in. This plan also adheres to traditional redistricting principles, ensuring factors such as population balance, contiguity, compactness, in addition to full compliance with both state and federal laws and is not discriminated upon race. The districts are compact, consisting of 32 cut edges, where the edges that are cut are those whose endpoints i and j belong to different districts. Gerrymandering has also been eliminated in this plan.

XI. Conclusions

After finishing our model by using Gurobi to develop our cut edges program, we created the optimal 4 districts within the state of Kansas. The populations of each of these districts include 712,582, 712,119, 714,395, 714,022. The maximum population deviation remained under the

required 1% that allowed a 0.5% margin for the upper and lower bounds. In addition to that, we were able to abide by all of the state and federal criteria that was researched in depth. Ultimately, the team would recommend that the state of Kansas should embrace this redistricting plan for the improvement of their total population deviation, reduce the possibility of gerrymandering, and ensure the compactness of the districts.