IEM 4013

We KAN Do It

Kansas Redistricting Plan

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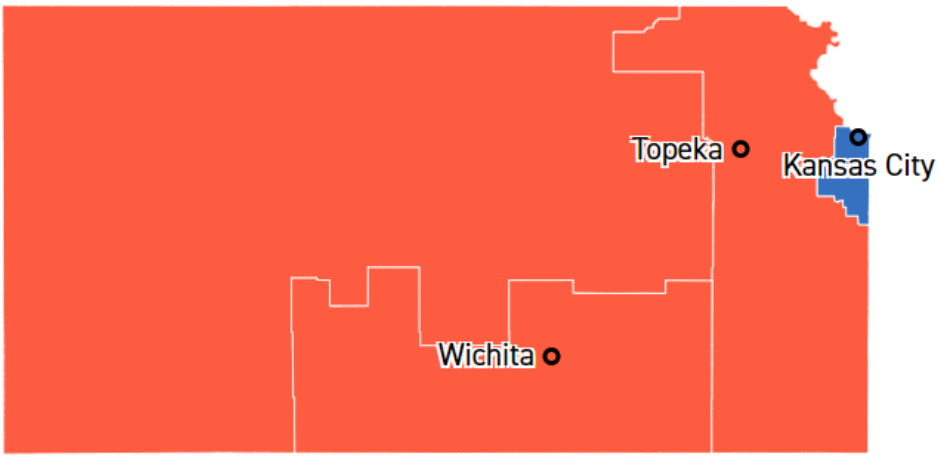
Executive Summary

Congressional districts play a vital role in American government. Every few years, congressional districts are redrawn in order to stay up to date on the current population. This project seeks to develop an optimization model to create a redistricting map for the state of Kansas. We began by researching some historical data for Kansas. We looked at some past historical maps as well as the current redistricting laws. The Federal Government requires that the population deviation between counties is less than 1%. The state of Kansas requires districts to be as close to the ideal population as possible, districts be compact as possible, districts be contiguous, and communities of interest are preserved. Kansas also requires counties be kept intact unless necessary for population balance. For our optimization model, we decided to keep all counties intact. This helped to keep our code simple as well as helped to preserve communities of interest. We created an IP model as a structure for our code. Then, we coded it in Python utilizing the Gurobi package. We added constraints for each of the Federal and State requirements. Our code took 30 minutes to run on a 16 gig RAM processor. We came up with a congressional map with a deviation of 0.4%. We believe our map is an optimal solution for the state of Kansas' congressional districts.

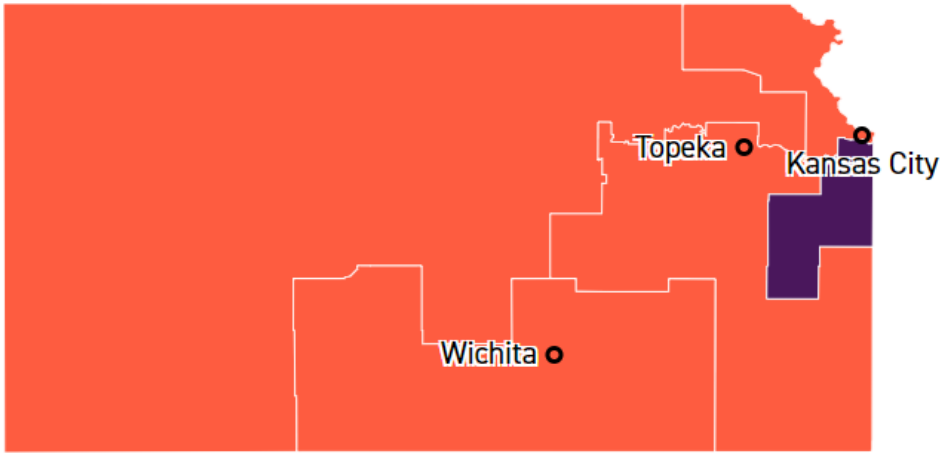
Introduction

Since 1964, the United States Census Bureau has been collecting data on the characteristics of American voters for every national election. The information regarding how many citizens of voting age are registered, race, voting, group quarters population, and occupancy status is critical for the process of congressional redistricting. We have used this information to propose an optimal redistricting plan in Kansas that abides by Federal and State laws.

We analyzed the population of the counties of each city county, voting district, tract, and Census blocks. Additionally, we compared our future redistricting plan with that of the Kansas Legislative Research Department and the past Congressional maps. The 2020 Census Kansas population is 2,940,865. They were apportioned a total of 4 U.S. congressional districts, unchanging from 2010 Census. A 2.69% change in population occurred since the last census, adding 77,052 people to be represented. Kansas enacted their most recent congressional boundaries in 2022. The old map is below representing red to be strong republican, and blue to be strong democratic.



The new 2022 Kansas Congressional Map is below with purple representing the competitive district.



We believe that the map maker thought keeping farmland and large cities together was important. These district populations have similar ideals which makes it a better overall representation of Kansas. There are three split counties: Wyandotte, Pawnee, and Jackson counties. The population in each Kansas district is required to be as equal as possible, the current populations are 733,038, 731,232, 737,384, and 732,928.

Criteria

The Federal redistricting laws are as follows:

- The population balance must be less than 1%.
- The Voting Rights Act requires that minority populations are not intentionally separated between districts.

The State redistricting laws are as follows:

- Since 2012 districts should be as close to the ideal population of 713,280 as possible.

- Plans should not have the purpose nor the effect of diluting minority voting strength.
- The general interests and values of "communities of interest" should be preserved.
- Counties should not be broken up unless it is necessary for population distribution.
- Districts should be as compact as possible. There is not a requirement for how this is measured.
- Districts should be contiguous.

Problem Statement

Federal and State congressional districting requirements are challenging to balance. Currently, Kansas has three split districts, and an average of ten percent population distribution. We planned to improve this by imposing all to the best of our ability including keeping counties whole. Our primary objective is to keep districts compact. The constraints we plan to impose are to keep the population deviation below 1%, keep communities of interest intact, and to make districts contiguous.

Experiments

Gurobi computation time:

- With a deviation of 3% the Gurobi and Python combination code took a total of 255 seconds (about 4 and a half minutes) to complete. With a deviation of 1%, the code took 1552 seconds (roughly 26 minutes) to complete.

How many times can it rerun? What about with changes?

- Rerun as many times as possible, but it took a total of 43 tries to correctly get the code to display the counties connecting as being "True." The code can now be rerun as many times as needed. We reran it multiple times to test different deviations. The smaller the deviation percentage, the longer the code took to run.

How many gigs of RAM?

- The RAM, while running the program, was 9.7/15.8 (or 61%). This statistic was in the Task Manager setting of the laptop running the code.

Memory issues?

- The computer that we ran the code on did not have any issues with memory. We had multiple tabs open; the only issue is that it may have taken a bit longer to run the code with all the tabs and programs that were running in the background.

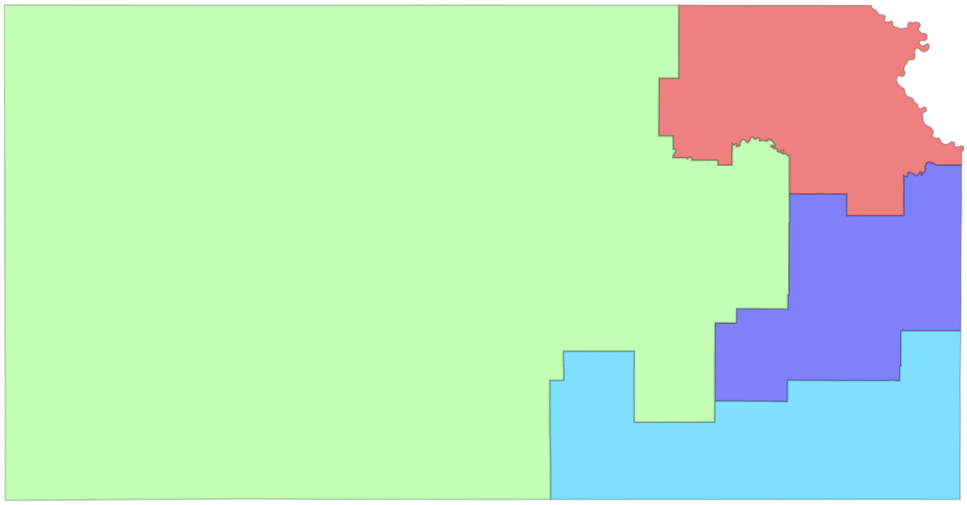
Integer Programming Model

Indices:	'i' = county {1, 2..., 105} 'j' = district {1, 2, 3, 4} 'u' and 'v'= counties that share a border
Parameters:	p = population of a county 'i' k= number of districts d = deviation $LB = \left(1 - \frac{d}{2}\right) \cdot \frac{\left(\sum_{i=1}^{105} p\right)}{k}$ $UB = \left(1 + \frac{d}{2}\right) \cdot \frac{\left(\sum_{i=1}^{105} p\right)}{k}$

Variables:	x_{ij} = binary {1 if county 'i' is in district 'j', 0 Otherwise} y_{uv} = binary {1 if adjacent counties 'u' and 'v' are in different districts, 0 Otherwise} r_{ij} = binary {1 if count 'i' is the 'root' of district 'j', 0 Otherwise}
Objective: Minimize cuts for compactness.	$min \Sigma y_{uv}$
Each country is in one and only one district.	s.t. $\sum_{i=1}^{105} \sum_{j=1}^{4} x_{ij} = 105$
The total population in the district must be between LB and UB.	$\sum_{i=1}^{105} x_{ij\ for\ all\ i\ in\ UB}$ $\sum_{i=1}^{105} x_{ij\ for\ all\ i\ in\ LB}$
All districts are contiguous.	$\sum_{i=1}^{105} r_{ij} = 1\ for\ all\ j = \{1,\ 2,\ 3,\ 4\}$
Deviation is less than 1%.	d = .01
Variables must be positive.	$x_{ij} = \{0,1\}$ $y_{uv} = \{0,1\}$ $r_{ij} = \{0,1\}$.

Districting Plan

Our plan for redistricting is outlined in our python file. The proposed map is as follows:



Evaluation of Plan

We believe our plan meets all the legal requirements. The largest population deviation is 3,237. This resulted in a 0.4% deviation. This meets the federal requirement of a population balance of less than 1%.

We did not split up any counties in our redistricting plan. This complies with the Kansas law that counties are to be kept together unless necessary. It also is an attempt to maintain communities of interest.

We added constraints to keep all counties contiguous. Our objective helped keep our counties compact. If you refer to our map in the previous section, the states are organized in visually pleasing clusters.

To be in accordance with the voting rights act, we wanted to make sure minorities were not being diluted. The minority population of Kansas is 24.36%. Since this is so small, this is not an issue.

Lastly, we wanted to be sure to keep communities of interest intact. District #2 (the green district on the map) is mostly farmland. We wanted to keep farm owners in the same district because they are an important community of interest in Kansas. We also wanted to make sure large cities were kept intact. The Kansas City metro, which is the largest city in Kansas, is all within one county. The second largest city in Kansas is Wichita. This is also all within one county. Both of these cities will be kept intact with our constraint to keep all counties in one and only one district.

We were limited in our knowledge of major communities of interest in Kansas. Our plan could be improved upon with additional constraints that better preserve communities of interest.

Conclusion

Overall, we believe all of the objectives have been met for the new redistricting plan. All legal requirements are being followed, and we have a relatively small population deviation between districts. The final proposed district map can be found on page 9 of this report. After some experimentation, we found that the code takes 30 minutes to run. This was the most surprising finding of this project. All in all, we accomplished our goal of developing an optimization model for a new redistricting map for Kansas.

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