Maine Redistricting Plan

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Summary Letter:

Contained within the rest of this report is a proposed plan for redistricting the state of Maine. Currently Maine has a very even population split in their congressional districts, but the districts use precinct lines. This can be confusing to the residents that would like to know where each district begins and ends because most people don’t know where precinct lines are drawn. On the other hand, most people do know where their county lines are drawn. This is why I have chosen to draw the districts using county lines at the cost of a slightly larger population deviation and a lack of contiguity.

Introduction:

Redistricting is a process that is necessary to the function of many government systems. The main goal should be to keep the congressional districts within the legal guidelines, but often times this power is misused to redraw district lines to favor the current majority party. Luckily, there are other, more non-partisan, ways to do this. For example, it is possible to create mathematical models to calculate districts that meet all of the legal requirements to create a much impartial district map that is more representative of the local population. The goal of this project is to create a model of this process to prove its efficacy.

Redistricting Requirements:

Federal: Population deviations of no greater than 1%, must comply with the voting act

Voting act requirements:

* No intentional racial discrimination
* Must have a compelling reason for racial consideration
* Cannot limit a minority group’s ability to elect candidates of choice

Problem Statement:

Maine is looking to adopt a new impartial district map.

OR Model in Words:

The model designed for Maine’s congressional districts is rather simple. Its main 2 functions are making sure that each county is only assigned to one district and ensuring the population of the 2 districts is within a 1% deviation from each other. It will start with the largest counties first, then when it reaches the population bounds it can add the rest of the counties to the other district and check if it is within bounds as well.

OR Model in Math:

County assignments

k = number of congressional districts = 2

h = number of counties = 16

c = County number = {1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16}

j = Congressional district number = {1,2}

Constraints:

∑kj=1xcj =1

Population balance model

Ideal = Total Pop/k = 1,372,000/2 = 681,179.5

L = .995\*Ideal = 683,067

U = 1.005\*Ideal = 689,932

Constraints:

L ≤ ∑hc=1pcxcj ≤ U

Python Code:

Attached .ipynb file as well pasted below

# Importing gurobi and data

import gurobipy as gp

from gurobipy import GRB

total\_pop = 1362359

# County populations

p = [211972,152199,123642,57777,16800,35237,303069,55478,40607,29456,67105,50477,111139,36699,31095,39607]

# Gurobi Model

m = gp.Model("p1")

# Adding variables

x = [m.addVar(vtype=GRB.BINARY, name="x1"),

m.addVar(vtype=GRB.BINARY, name="x2"),

m.addVar(vtype=GRB.BINARY, name="x3"),

m.addVar(vtype=GRB.BINARY, name="x4"),

m.addVar(vtype=GRB.BINARY, name="x5"),

m.addVar(vtype=GRB.BINARY, name="x6"),

m.addVar(vtype=GRB.BINARY, name="x7"),

m.addVar(vtype=GRB.BINARY, name="x8"),

m.addVar(vtype=GRB.BINARY, name="x9"),

m.addVar(vtype=GRB.BINARY, name="x10"),

m.addVar(vtype=GRB.BINARY, name="x11"),

m.addVar(vtype=GRB.BINARY, name="x12"),

m.addVar(vtype=GRB.BINARY, name="x13"),

m.addVar(vtype=GRB.BINARY, name="x14"),

m.addVar(vtype=GRB.BINARY, name="x15"),

m.addVar(vtype=GRB.BINARY, name="x16")]

# Adding Objective

m.setObjective(sum(x),GRB.MAXIMIZE)

# Adding Constraints

# Upper Population Bound

m.addConstr(p[0]\*x[0]+p[1]\*x[1]+p[2]\*x[2]+p[3]\*x[3]+p[4]\*x[4]+p[5]\*x[5]+p[6]\*x[6]+p[7]\*x[7]+p[8]\*x[8]+p[9]\*x[9]+p[10]\*x[10]+p[11]\*x[11]+p[12]\*x[12]+p[13]\*x[13]+p[14]\*x[14]+p[15]\*x[15]<=684586,"c0")

# Lower Population Bound

m.addConstr(p[0]\*x[0]+p[1]\*x[1]+p[2]\*x[2]+p[3]\*x[3]+p[4]\*x[4]+p[5]\*x[5]+p[6]\*x[6]+p[7]\*x[7]+p[8]\*x[8]+p[9]\*x[9]+p[10]\*x[10]+p[11]\*x[11]+p[12]\*x[12]+p[13]\*x[13]+p[14]\*x[14]+p[15]\*x[15]>=677772,"c1")

# Optimizing the model

m.optimize()

# Printing Results

for v in m.getVars():

print('%s %g' % (v.VarName, v.X))

print('Obj: %g' % m.ObjVal)

# Population For districts

p1=p[2]+p[3]+p[5]+p[7]+p[8]+p[9]+p[10]+p[11]+p[12]+p[13]+p[14]+p[15]

print("District 1 Population:",p1)

print("District 2 Population:",total\_pop-p1)

District 1 Population: 678319

District 2 Population: 684040

Experiment:

Gurobi Optimizer version 10.0.3 build v10.0.3rc0 (win64)

CPU model: Intel(R) Core(TM) i5-10300H CPU @ 2.50GHz, instruction set [SSE2|AVX|AVX2]

Thread count: 4 physical cores, 8 logical processors, using up to 8 threads

Optimize a model with 2 rows, 16 columns and 32 nonzeros

Model fingerprint: 0xec22cef6

Variable types: 0 continuous, 16 integer (16 binary)

Coefficient statistics:

Matrix range [2e+04, 3e+05]

Objective range [1e+00, 1e+00]

Bounds range [1e+00, 1e+00]

RHS range [7e+05, 7e+05]

Found heuristic solution: objective 9.0000000

Presolve time: 0.00s

Presolved: 2 rows, 16 columns, 32 nonzeros

Variable types: 0 continuous, 16 integer (16 binary)

Root relaxation: objective 1.291481e+01, 1 iterations, 0.00 seconds (0.00 work units)

Nodes | Current Node | Objective Bounds | Work

Expl Unexpl | Obj Depth IntInf | Incumbent BestBd Gap | It/Node Time

0 0 12.91481 0 1 9.00000 12.91481 43.5% - 0s

H 0 0 12.0000000 12.91481 7.62% - 0s

0 0 12.91481 0 1 12.00000 12.91481 7.62% - 0s

Explored 1 nodes (1 simplex iterations) in 0.02 seconds (0.00 work units)

Thread count was 8 (of 8 available processors)

Solution count 2: 12 9

Optimal solution found (tolerance 1.00e-04)

Best objective 1.200000000000e+01, best bound 1.200000000000e+01, gap 0.0000%

x1 0

x2 0

x3 1

x4 1

x5 0

x6 1

x7 0

x8 1

x9 1

x10 1

x11 1

x12 1

x13 1

x14 1

x15 1

x16 1

Obj: 12

Plan Map:

<https://districtr.org/plan/214228> A map of maine with blue and yellow squares

Description automatically generated

Evaluation:

The proposed plan does follow all requirements for redistricting the state of Maine, however it does not follow the normal conventions of compactness and contiguity. This is due to the OR model not taking either of these factors into account. Another limitation of this plan is that it considers the county as a whole unit rather than the precincts within. This means the population deviation only got as low as .4% rather than the near zero that the current district plan for Maine has.

Conclusions:

In doing this project it has been discovered that using county lines to draw congressional districts is not an ideal way to accomplish the goal but is a perfectly adequate solution if the state wishes to use it. The lack of contiguity might also cause some confusion when looking at the district map as well, and while it is perfectly legal to organize the districts in this way it is certainly not the convention.