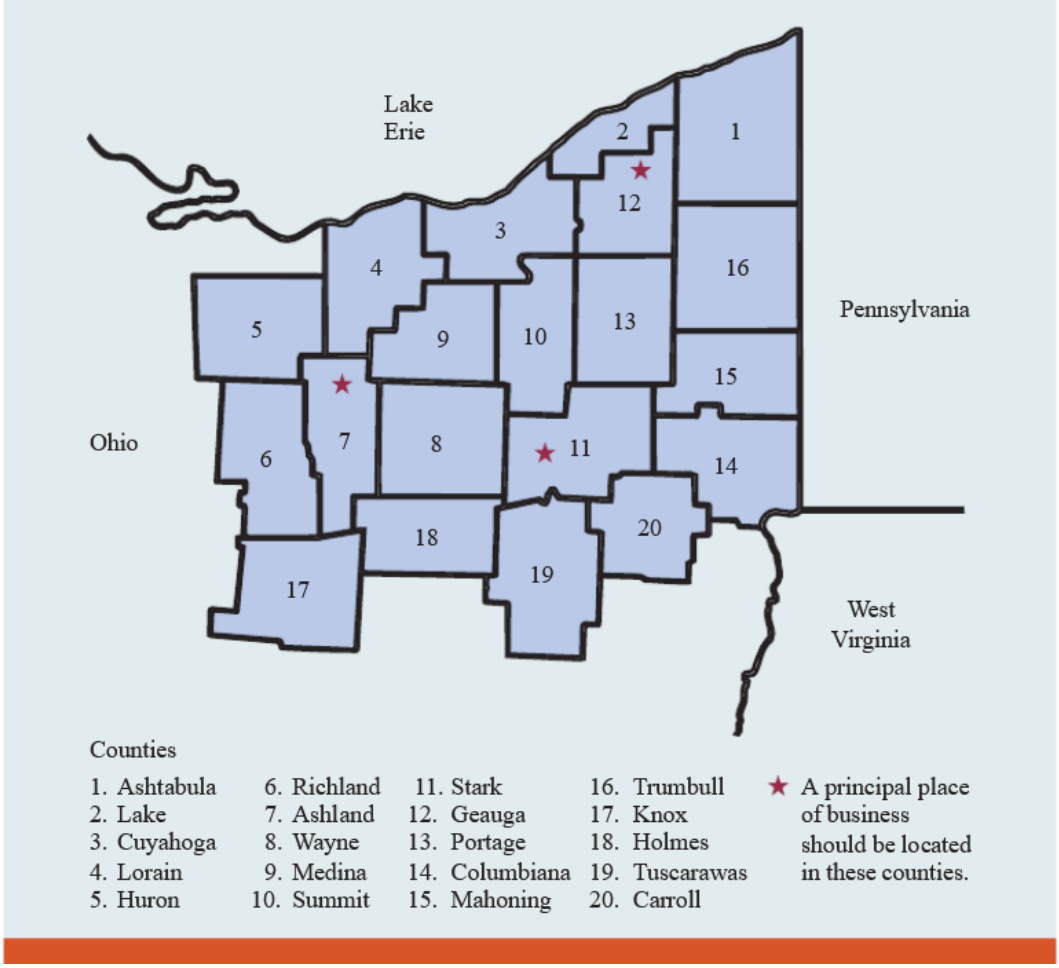
A Teaching Resource: an optimization case study with extensions for analytics

A small case study, “Strategic Planning in Bank Location,” was introduced by Sweeney, Mairose, and Martin in the Proceeding of the American Institute for Decision Sciences (1979). Since that time, it has been used in several textbooks as an illustrative example.

The case study asks students to determine the minimum number of the bank locations to “cover” 20 northeast Ohio counties. Coverage refers to a county with a location or a county adjacent to a location. Inspection of a map (below) provides students with an intuitive entrée into the solution. However, this gives rise to a binary integer programming model. The formulation includes 20 binary decision variables, one for each county, and 20 constraints, representing the coverage with adjacency.



adjacency

For example, if X1 represents the yes-no decision to place a bank in Ashtabula County (1 above), then the corresponding constraint would be: X1 + X2 + X12 +X16 $\geq$ 1. This requirement demonstrates that for Ashtabula to be covered, a bank must be located in at least one of Ashtabula, Lake, Geauga, or Trumbull counties.

Solving this formulation is easily handled by Excel's Solver, setting the decision variable to be binary. Students can visually identify this solution as feasible.

Extension1: An obvious extension to the problem is to determine the minimum number of bank locations needed to cover all 88 counties of the state of Ohio. This challenge does not easily permit a solution-by-inspection approach as with the 20-county example.

Determining the adjacency constraints may be a challenge to students, but an Internet search will provide resources with an adjacency matrix with is easily converted into the required constraints. Some data wrangling is expected to be necessary. Once such resource is https://www.census.gov/geographies/reference-files/time-series/geo/county-adjacency.html.

Extension 2: Reformulating the problem with the addition of county-level data is a path toward challenging the appropriateness of a model. Perhaps an alternative objective may be formulated. If county population were considered, one might set an objective to maximize the population reached for two, three, four, etc. banks located across the state. Where would those then be located? Graphing the results of this analysis by plotting the population reached versus number of banks allowed may offer insights into diminishing returns. Alternative formulations might focus on per capita GDP, banking data variables, etc. Census data, Ohio state data resources, FDIC data, etc. may be useful. Wrangling data from various sources can be a useful exercise.

Extension 3: Visualizing the model and solution with tools such as Tableau and ARCGIS may be a very useful way to visualize the problem and any extensions. Note that these platforms are useful tools in accessing data and in any required data cleaning.

Extension 4: Once students have mastered the basics of the problem and any extensions, instructors may wish to challenge students to take on another state and prepare a presentation with an overview of the modeling effort and results.

Extension 5: Having compiled a clean dataset relative to Ohio counties, an interesting and accessible exercise is to create clusters of similar counties. Varying the number of clusters may help students deepen a sense of the variation among counties.

https://www.indexmundi.com/facts/united-states/quick-facts/ohio may be a useful resource. R-Studio has tools to ease this effort; the k-means approach is relatively easy to incorporate into a course.

Some resources:

"Management Science: The Art of Modeling with Spreadsheets" by Stephen G. Powell and Kenneth R. Baker, 2010.

“Management Science and Decision Technology” by Jeffrey D. Camm and James R. Evans, 2000.

Nobile, J. (2021). Crunching the data on the largest banks in Ohio and Northeast Ohio in 2021. *Crain's Cleveland Business, 42*(35), 7.