Pfizer, Inc. is one of the world's largest pharmaceutical companies. It was founded in 1849, and aims to discover, develop, and manufacture breakthrough medicines. These medicines are marketed and sold in more than 150 countries. In this problem, we'll focus on the branch of Pfizer in Turkey. Pfizer's immediate customers in Turkey are medical doctors (MDs) because the majority of its products are prescription drugs.

Pfizer pharmaceutical sales representatives (SRs) provide MDs with supply samples and information on indications for drugs and potential adverse effects. To do this, they maintain close relationships with MDs through regular visits. Each SR is assigned a territory, which is a list of MDs to be visited by that SR. Territories are formed by combining smaller regions, called bricks. For each brick, we have information on the sales data, number of MDs, and MD profiles. This information is then used to compute an index value for each brick, which captures various factors to show the workload of the brick in terms of the number of SRs required for it. For example, if the index value is 0.5, then the workload is estimated to be half of a full time workload.

Because of the dynamic structure of the market (MDs leave or move to the area, products become more or less popular, etc.), these index values change over time. Hence, the territories assigned to each SR should be periodically reconstructed to balance the workload between the SRs. We'll solve this re-assignment problem using integer optimization.

Problem 1 - Formulating the Problem

We'll solve the problem for a single geographical district that has 22 bricks and 4 SRs.

Since we want to assign each brick to an SR, we define a binary variable for each brick and SR pair. So we have binary decision variables xi,j, where xi,j is equal to 1 if brick j is assigned to SR i, and equal to 0 otherwise.

How many decision variables are in our optimization problem?

Answer: 22\*4 = 88

Since the SRs have to visit the MDs in their offices, it is important to minimize the total distance traveled by the SRs. This is our objective. Each SR has an office in a certain brick, called their "center brick". We will compute the total distance traveled by an SR as the sum of the distances between the center brick and every other brick in that SR's territory.

Let di,j denote the distance between the center brick for SR i and the (center of the) brick j.

Given our decision variables xi,j, what best describes our objective?

Answer: Minimize the sum of di,j times the decision variables, summed over all i and j.

We have three main types of constraints. The first is that each brick must be assigned to exactly one SR.

Which of the following constraints models this restriction for brick 1?

Answer: x1,1 + x2,1 + x3,1 + x4,1 = 1

The second main type of constraint tries to balance the workload between the SRs. The sum of the index values of the bricks of an SR correspond to his/her total workload and should be approximately 1. To model this, we'll constrain the workload of each SR to range between 0.8 and 1.2. Denote the index value of brick j by Ij.

Which of the following constraints do we want to add to our model for SR 1?

Answer:



The final set of constraints in our model constrains what we call "disruption", which is defined as the inclusion of new bricks in the territories of SRs. Suppose we have data Ni,j, which equals 1 if brick j is not currently assigned to SR i, and is equal to 0 if brick j is currently assigned to SR i. What the constraint would force no more than 2 new bricks assigned to SR 1?

Answer:



Problem 2 - Solving the Problem

Solve the problem as formulated in Part 1 using Excel.

What is the optimal objective value?

Answer: 160.22

In the solution, brick 10 is assigned to which SR?

Answer: SR 3

In the solution, how many new bricks does SR 2 have in her territory?

Answer: 1, looking at the output in the Disruption constraint.

In the solution, what is the total workload of SR 1?

Answer: 0.9206, looking at the output in the Workload constraint.

Problem 3 - Changing the Restrictions

Change the constraints so that the workload for each SR must be between 0.9 and 1.1, and then resolve the problem.

What is the new objective value?

Answer: 171.68

Is this smaller or larger than the objective value in the original problem, and why?

Answer: It is larger, because this is a minimization problem with more restrictive constraints.

Increase the disruption bounds to 3.

What is the new objective value?

Answer: 162.43

Suppose the head of logistics at Pfizer would like to find a solution with an objective value very similar to that of the original solution (the very first solution we found in this problem), but would like to decrease the disruption bounds to 1. What could he do to keep the objective value close to the original value (the very first objective function value we found)?

Answer: Decreasing the disruption bounds (making them more restrictive) will increase the objective, as this is a minimization problem, so to balance this we need to make the work load bounds less restrictive, for example by changing them from [0.8,1.2] to [0.7,1.3].

Which restrictions or assumptions made in this problem could actually be relaxed to get a better solution.

Answer:

* The center brick of each SR could also be re-assigned to try and better center an SR in their territory.
* We could solve for a larger geographical area at once (more bricks and more SRs) so there are more possible assignments.
* We could assign a brick to more than one SR so they could share the workload.