Non-Linear Programming. Based on Kolesar and Blum (1973). Suppose that a company must service customers lying in an area of A square miles with n warehouses. Kolesar and Blum showed that when the warehouse(s) are located properly, the average distance between a warehouse and a customer $(A/n)^{1/2}$ Assume that it costs the company \$90,000 per year to maintain a warehouse and \$400,000 to build a warehouse. Also, assume that a \$5,000,000 building cost is equivalent to incurring a cost of \$500,000 per year indefinitely. The company fills 180,000 orders per year, and the shipping cost per order is \$1.25 per mile. If the company serves an area of 120 square miles, how many warehouses should it have?

Discussion.

This is an example of a non-linear programming model to minimize cost. The model is non-linear because the objective function is an algebraic equation of degree greater than 1, making the boundary of the feasible region non-linear. The rest of the mathematical model remains similar to that of a linear model. The constraints ensure that the decision variable (warehouses built) is an integer. The decision is how many warehouses need to be built in the area being served by the company.

Model.

Parameters:

M: Annual maintenance cost

C: *Building cost*

Q: Annual order quantity

S: Shipping cost per mile

A: Area served by company

Decisions:

n : *Number of warehouses to build in area A*

Calculated Parameters:

B: *Annual Building cost* $= C/10$

$(A/n)^{1/2}$*: Average distance between warehouse and customer*

Decisions:

n : *Number of warehouse to build in area A*

Objective: *Minimize cost*

$$min\ (M + B) * n + Q * S * \ (A/n)^{1/2}$$

Constraints:

$n \in Integer$ (2) Integer number of warehouses

Optimal Solution. The following is the solution obtained from Excel Solver.

51(AP).xlsx

A minimum cost of $1752270.38 be attained by building 5 warehouses in the area.

Number of warehouses	5	
Area served (square miles)	120	
Annual Maintanace cost	90000	
Building cost	400000	
Annual building cost	40000	
Orders	180000	
shipping cost/mile	1.25	
Average distance shipped	4.89897949	
annual Shipping cost	1102270.38	
Total cost	1752270.38	