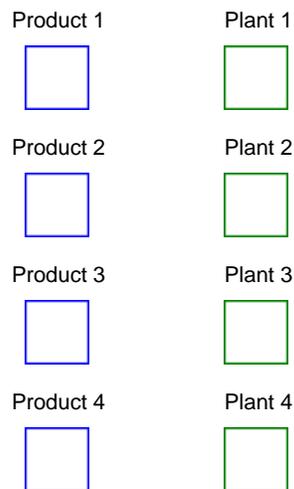


## Capacity Planning and Flexibility

Download Flexcap Software

When you open the FlexCap application you will see a four-plant, four-product system:



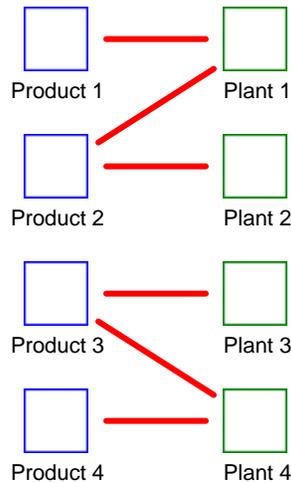
From the Model menu, under Model Parameters, you can change the number of plants and the number of products.

By double-clicking on a product you will see the parameters associated with each product: the demand mean and standard deviation, as well as a maximum and minimum demand (i.e. demand can vary but it will always fall within the min and max). That is, for each product, we are given a characterization or forecast of what demand will be over some time period, say next year. There are also selling price and stockout cost parameters but these can be ignored for this assignment.

By double-clicking on a plant you will see the parameters associated with each plant: namely its average capacity in terms of the number of units that can be produced, the standard deviation of capacity, as well as a minimum and maximum capacity. Total production in a plant is limited by its capacity. The capacity and demand numbers are expressed for the same time period, for example one year.

To "link" plants with products, you use the palette on the screen. Pick up the blue arrow in the palette, click on a product and then click on a plant - this will create a link between the product and the plant. Links can be deleted by selecting the red circle from the palette

and clicking on the link to be deleted. A link signifies that the product can be produced in the plant. For instance:



In this system plant 1 can make products 1 and 2; plant 2 can make product 2, plant 3 can make product 3 and plant 4 can make products 3 and 4. Note that the sum of production of products 1 and 2 by plant 1 cannot exceed the capacity of plant 1.

There can also be capacity limits associated with each link - to set these limits, you need to click on the link. You also need to turn on the ENFORCE LINK CAPACITIES command from the OPTIONS menu; the default is to ignore the link capacities. The link capacities determine the upper limit on production of a specific product in a specific plant. Links also have production and transportation costs associated with them. These can be ignored for this assignment.

Note that if all products, plants, or links are going to have the same parameters, the parameters can be changed together by selecting Change all Products from the Model menu.

The software allows you to simulate such systems (Simulate in Model menu). The simulation has two possible options, Minimize Lost Demand and Minimize Costs.

On each run of the simulation, the software samples a demand for each product and a capacity for each plant (i.e., a random draw from a normal distribution with the given mean standard deviation, truncated to the range specified by the min and max). Then the software solves an optimization problem to determine how best to meet the demand (or minimize costs) with the given plant capacity and the given product-plant configuration, denoted by the links that indicate which plants can produce which products. If Minimize Lost Demand is selected, the objective of the optimization is to maximize the amount of demand that can be met, or equivalently to minimize the shortfall - amount of demand not

satisfied. If Minimize Costs is selected, the objective is to determine the production so as to minimize total costs (production, transportation, stockout etc.). The software reports the sales, the average shortfall, the average plant utilization, the average total cost and average gross revenue. The individual plant average utilizations are displayed in the plant icons. Individual product shortfalls are displayed in the product icons. The sales, cost and gross revenue numbers are only meaningful if you actually put the relevant costs into the model. The Minimize Lost Demand option does not consider cost so this option can be used without worrying about the various costs. The software also reports what the shortfall would be if you had "total flexibility:" that is, each plant can produce all of the products.

### Assignment

A. Suppose you have 6 plants each with capacity of 100 and no variability. Suppose you have 6 products, each with mean demand of 100 and standard deviation of 30.

Using the Minimize Lost Demand option, evaluate the system with dedicated production: that is, plant 1 can only produce product 1, plant 2 can only make product 2 etc.

Now consider adding flexibility to the system; that is, make the plants capable of producing more than 1 product. What is the best way to add flexibility? What are the benefits? How much do you need to add?

Now consider the dedicated system again. Suppose you could increase the capacity at the plants. What are the benefits? How does increasing capacity compare with adding flexibility?

B. Suppose you have the opportunity to plan the manufacturing system at a green-field site for a family of printers. You currently offer 8 printers; the expected annual demand and standard deviations for the 8 printers are given in the following table (units are 000's).

Printer Type	Expected annual demand	Standard deviation for annual demand
A	80	10
B	80	30
C	60	10
D	60	30
E	40	20
F	40	5
G	20	10
H	20	5

The manufacturing system will entail a set of parallel lines. Each line will assemble and test printers. A line can be dedicated to a printer type, or can have some amount of flexibility; a line can be designed to assemble and test any subset of the printer types.

Assume that each line will have a production capacity of 100,000 units per year, regardless of whether it is dedicated or flexible.

The annualized cost for building and operating a dedicated line for any printer type is estimated to be \$1,200,000. Suppose that the annualized cost to build and operate a flexible line is the cost for a dedicated line, \$1,200,000, plus an estimate of \$100,000 to \$150,000 for each additional product that the line can make (Thus, a line that can manufacture printers A, F and G will cost somewhere between \$1,400,000 and \$1,500,000 annually.)

The net margin on each printer is \$25; this is the difference between the revenue and the cost of material and distribution.

Use FlexCap (the Minimize Lost Demand option) to find a good capacity plan for this facility.