Applied Electronics

Jeffrey L. Rummel

Applied Electronics provides semiconductor chips for a variety of customers all over the world. The chips are produced at six fabrication plants and packaged into boxes of 100 chips.

The plants were originally designed to produce the quantity of chips required for the country where they were located, but as demand changes, there is the potential to produce chips in one country and ship them to another.

You have been asked to construct a model that will find the most effcient production schedule for next year. This would set the production levels at each plant, and then determine how many boxes will be used locally and how many will be shipped to other regions.

Production Details

There are six plants around the world: Austin, Frankfort, Canada, Mexico, Chile and Japan. The original plant was in Japan so it has much higher costs than the newer plants. The second plant was built in the US (in Austin, Texas), then came the Frankfort plant (built to supply demand in Europe). The next plant was built in Chile to meet demand in Latin America. The last two plants were designed to meet local demand, a plant first in Canada, and then the newest plant in Mexico.

Each plant has designed capacity, but each plant should only be planned to produce around 80-90% of that capacity. Here are the plant capacities, in millions of boxes, and how many boxes are planned to be produced this year:

	Mexico	Canada	Chile	Frankfurt	Austin	Japan
Capacity	22.0	3.7	4.5	47.0	18.5	5.0
Production Plan	17.2	2.6	4.1	38.0	14.0	4.0

The demand in each area has changed over time due to competition and the customers who still use the chips that Applied Electronics produces:

	Mexico	Canada	Chile	Frankfurt	Austin	Japan
Demand	3.0	2.6	16.0	20.0	26.4	11.9

The cost of supplying demand first consists of the production costs per box in that plant (all figures are converted to US dollars). These costs are a function of the plant design, but are also affected by local costs (labor, material, energy, for example). Any boxes shipped to the region from a plant located in another region are subject to an import duty (a percentage of the cost). Here are the production costs and import duties:

	Mexico	Canada	Chile	Frankfurt	Austin	Japan
Production Cost	92.63	93.25	112.31	73.34	89.15	149.24
Import Duties	60.0%	0.0%	50.0%	9.5%	4.5%	6.0%

For example, a box of chips produced in Canada and sent to Mexico would have an effective cost of $93.25 times 1.6, or $149.20.

Finally Applied Electronics has determined the additional shipping costs from one region to another (so the shipping cost within a region is zero). Here are the costs to ship a box from one region to another. These costs include air shipment rates and the costs of packaging to protect the boxes while in transit:

	Mexico	Canada	Chile	Frankfurt	Austin	Japan
Mexico	–	11.40	7.00	11.00	11.00	14.00
Canada	11.00	–	9.00	11.50	6.00	13.00
Chile	7.00	10.00	–	13.00	10.40	14.30
Frankfort	10.00	11.50	12.50	–	11.20	13.30
Austin	10.00	6.00	11.00	10.00	–	12.50
Japan	14.00	13.00	12.50	14.20	13.00	–

The objective is to create a plan that has the lowest total cost: production cost plus duties (if shipped to another region) plus shipping costs (if shipped to another region).

A team has created a production plan by trying to maximize the quantity that can be produced at each plant for local demand, in order to minimize duties and shipping. Then the team identified additional capacity from other plants to meet the total demand in the region. They have also tried to keep production quantities within reasonable bounds to allow for downtime and to keep some buffer capacity. Here is the plan:

	Mexico	Canada	Chile	Frankfurt	Austin	Japan
Mexico	3.0	–	–	–	12.4	1.8
Canada	–	2.6	–	–	–	–
Chile	–	–	4.1	–	–	–
Frankfort	–	–	11.9	20.0	–	6.1
Austin	–	–	–	–	14.0	–
Japan	–	–	–	–	–	4.0

Assignment

1. Create an implementation of Vogel's approximation method (VAM) to find a good production plan for Applied Electronics. How much does this save versus the team's plan? You can use all of the capacity at each of the locations.

2. Since running production at 100% is not usually feasible, solve the production plan using at most 85% of the plant's capacity. How much more costly is this plan?

3. Since Chile is the plant that is the most difficult for Applied Electronics to support, create two plans (one at 100% and one at 85% of designed capacity) that do not use Chile at all. How do these costs compare with the solution using Chile?

4. Create a short deck that describes your algorithm implementation, and the solutions to the three questions.

There is a spreadsheet that contains all of this data if your team would like to utilize that for your algorithm: `Applied Electronics Data.xlsx`. Each of the tables above is identified as a `Named Range`. You can also save the file as a CSV file and use that.

Important Restriction

This assignment is a way for me to understand the programming skills of the class. You **should not** search the web for algorithms that implement VAM – this is not an assignment to see how good you are at searching for code. If you feel you are having difficulty with the algorithm, please contact me.