Supply chain optimization

1. Capacitated Plant Location Model (Chopra and Meindl, 2004)

SC consulting, a supply chain consulting firm, has to decide on the location of its home offices. Their clients are primarily located in the 16 states in Table 1 below. There are four potential sites for home offices: Los Angeles, Tulsa, Denver, and Seattle. The annual fixed cost of locating an office in Los Angeles is $165,428, Tulsa is $131,230, Denver is $140,000 and Seattle is $145,000. The expected numbers of trips to each state and the travel costs from each potential site are also shown in Table 1.

Table 1. Travel costs and number of trips

State	Travel costs ($)				Number of trips
	Los Angeles	Tulsa	Denver	Seattle	
Washington	150	250	200	25	40
Oregon	150	250	200	75	35
California	75	200	150	125	100
Idaho	150	200	125	125	25
Nevada	100	200	125	150	40
Montana	175	175	125	125	25
Wyoming	150	175	100	150	50
Utah	150	150	100	200	30
Arizona	75	200	100	250	50
Colorado	150	125	25	250	65
New Mexico	125	125	75	300	40
North Dakota	300	200	150	200	30
South Dakota	300	175	125	200	20
Nebraska	250	100	125	250	30
Kansas	250	75	75	300	40
Oklahoma	250	25	125	300	55

Each consultant is expected to take at most 25 trips each year.

(a) If there are no restrictions on the number of consultants at a site and the goal is to minimize costs, where should the home offices be located and how many consultants should be assigned to each office? What is the annual cost in terms in terms of the facility and travel?

(b) If at most 10 consultants are to be assigned to a home office, where should the offices be set up? How many consultants should be assigned to each office? What is the annual cost of this network?

(c) What do you think of a rule where all consulting projects out of a given state should be assigned to one home office? How much is this policy likely to add to cost compared to allowing multiple offices to handle a single state?

2.

Sunchem, a manufacturer of printing inks, has five manufacturing plants worldwide. Their locations and capacities are shown in Table 2 along with the cost of producing one ton of ink at each facility. The production costs are in the local currency of the country where the plant is located. The major markets are North America, South America, Europe, Japan, and the Rest of Asia. Demand at each market is shown in Table 2. Transportation costs from each plant to each market in US dollars are shown in Table 2. Management has to come up with a plan for 2006.

(a) If exchange rates are expected as in Table 3, and no plant can run below 50% capacity, how much should each plant produce and which markets should each plant supply?
(b) If there are no limits on the amount produced in each plant, how much should each plant produce?
(c) Can adding 10 tons of capacity in any plants reduce costs?
(d) How should Sunchem account for the fact that exchange rates fluctuate over time?

Table 2.

	North America	South America	Europe	Japan	Asia	Capacity (tons/year)	Production cost/ ton
USA	600	1,200	1,300	2,000	1,700	185	$10,000
Germany	1,300	1,400	600	1,400	1,300	475	6,400 Euros
Japan	2,000	2,100	1,400	300	900	50	1,800,000 Yen
Brazil	1,200	800	1,400	2,100	2,100	200	14,000 Real
India	2,200	2,300	1,300	1,000	800	80	400,000 rupees
Demand (tons/year)	270	190	200	120	100		

Table 3. Exchange rates

	US$	Euro	Yen	Real	Rupee
US $	1.000	0.840	111.6	2.366	43.53
Euro	1.190	1	132.9	2.815	51.82
Yen	0.00896	0.00750	1	0.0212	0.390
Real	0.42267	0.35510	47.1747	1	18.40
Rupee	0.02297	0.01930	2.56368	0.0543	1

3. Managing Growth at SportStuff.com

In December 2000, Sanjay Gupta and his management team were busy evaluating the performance at SportStuff.com over the last year. Demand had grown by 80 percent over the year. This growth, however, was a mixed blessing. The venture capitalists supporting the company were very pleased with the growth in sales and the resulting increase in revenue. Sanjay and his team, however, could clearly see that costs would grow faster than revenues if demand continued to grow and the supply chain network was not redesigned. They decided to analyze the performance of the current network to see how it could be redesigned to best cope with the rapid growth anticipated over the next three years.

SPORTSTUFF.COM

Sanjay Gupta founded SportStuff.com in 1996 with a mission of supplying parents with more affordable sports equipment for their children. Parents complained about having to discard expensive skates, skis, jackets, and shoes because children outgrew them rapidly. Sanjay's initial plan was for the company to purchase used equipment and jackets from families and any surplus equipment from manufacturers and retailers and sell

these over the Internet. The idea was very well received in the marketplace, demand grew rapidly, and by the end of 1996 the company had sales of $0.8 million. By this time a variety of new and used products were sold and the company received significant venture capital support.

In June 1996, Sanjay leased part of a warehouse in the outskirts of St. Louis to manage the large amount of product being sold. Suppliers sent their product to the warehouse. Customer orders were packed and shipped by UPS from there. As demand grew, SportStuff.com leased more space within the warehouse. By 1999, Sportstuff.com leased the entire warehouse and shipped to customers all over the United Sates. Management divided the United States into 6 customer zones for planning purposes. Demand for each customer zone in 1999 was as shown in Table 4. Sanjay estimated that the next three years would see a growth rate of about 80 percent per year, after which demand would level off.

THE NETWORK OPTIONS
Sanjay and his management team could see that they needed more warehouse space to cope with the anticipated growth. One option was to lease more warehouse space in St. Louis itself. Other options included leasing warehouses all over the country. Leasing a warehouse involved fixed costs based on the size of the warehouse and variable costs that varied with the quantity shipped through the warehouse. Four potential locations for warehouses were identified in Denver, Seattle, Atlanta, and Philadelphia. Warehouses leased could be either small (about 100,000 sq. ft.) or large (200,000 sq. ft.). Small warehouses could handle a flow of up to 2 million units per year whereas large warehouses could handle a flow of up to 4 million units per year. The current warehouse in St. Louis was small. The fixed and variable costs of small and large warehouses in different locations are shown in Table 5.

Sanjay estimated that the inventory holding costs at a warehouse (excluding warehouse expense) was about $600 \sqrt{F}$ where F is the number of units flowing through the warehouse per year. Thus, a warehouse handling 1,000,000 units per year incurred an inventory holding cost of $600,000 in the course of the year. Use the following inventory costs:

Range of F	Inventory Cost
0-2 million	$250,000 + 0.310F$
2-4 million	$530,000 + 0.170F$
4-6 million	$678,000 + 0.133F$
Over 6 million	$798,000 + 0.113F$

SportStuff.com charged a flat fee of $3 per shipment sent to a customer. An average customer order contained four units. SportStuff.com in turn contracted with UPS to handle all its outbound shipments. UPS charges were based on both the origin and the destination of the shipment and are shown in Table 6. Management estimated that unbound transportation costs for shipments from suppliers were likely to remain unchanged, no matter what the warehouse configuration selected.

QUESTIONS
1. What is the cost SportStuff.com incurs if all warehouses leased are in St. Louis?
2. What supply chain network configuration do you recommend for SportStuff.com?

Table 4.

Zone	Demand in 1999	Zone	Demand in 1999
Northwest	320,000	Lower Midwest	220,000
Southwest	200,000	Northeast	350,000
Upper Midwest	260,000	Southeast	175,000

Table 5.

Location	Small Warehouse		Large Warehouse	
	Fixed cost ($/year)	Variable cost ($/unit flow)	Fixed cost ($/year)	Variable cost ($/unit flow)
Seattle	300,000	0.20	500,000	0.20
Denver	250,000	0.20	420,000	0.20
St. Louis	220,000	0.20	375,000	0.20
Atlanta	220,000	0.20	375,000	0.20
Philly	240,000	0.20	400,000	0.20

Table 6.

	Northwest	Southwest	Upper Midwest	Lower Midwest	Northeast	Southeast
Seattle	$2.00	$2.50	$3.50	$4.00	$5.00	$5.50
Denver	$2.50	$2.50	$2.50	$3.00	$4.00	$4.50
St. Louis	$3.50	$3.50	$2.50	$2.50	$3.00	$3.50
Atlanta	$4.00	$4.00	$3.00	$2.50	$3.00	$2.50
Philly	$4.50	$5.00	$3.00	$3.50	$2.50	$4.00

4.
Moon Micro is a small manufacturer of servers that currently builds all of its product in Santa Clara, California. As the market for servers has grown dramatically, the Santa Clara plant has reached capacity of 10,000 servers per year. Moon is considering two options to increase its capacity. The first option is to add 10,000 units of capacity to the Santa Clara plant at an annualized fixed cost of $10,000,000 plus $500 labor per server. The second option is to have Molectron, an independent assembler, manufacture servers for Moon at a cost of $2,000 for each server (excluding raw materials cost). Moon sells each server for $15,000 and raw materials cost $8,000 per server.

Moon must make this decision for a two-year time horizon. During each year, demand for Moon servers has an 80 percent chance of increasing 50 percent from the year before and a 20 percent chance of remaining the same as the year before. Molectron's prices may change as well. They are fixed for the first year but have a 50 percent chance of increasing 20 percent in the second year and a 50 percent chance of remaining where they are.

Use a decision tree to determine whether Moon should add capacity to its Santa Clara plant or if it should outsource to Molectron. What are some other factors that would affect this decision that we have not discussed?

5.

Steel Appliances (SA) manufactures high-quality refrigerators and cooking ranges. SA has one assembly factory located near Denver from which it has supplied the entire US. Demand has grown rapidly and the CEO of SA has decided to set up another factory to serve eastern markets. The supply chain manager is asked to find a suitable location for the new factory, which will serve markets in Atlanta, Boston, Jacksonville, Philadelphia and New York. The coordinate location, the demand in each market, the required supply from each parts plant, and the shipping cost for each supply source is shown in Table 7.

Table 7.

Sources/Markets	Transportation cost $/(ton.mile)	Quantity in tons	Coordinates	
			x	y
Supply sources				
Buffalo	0.90	500	700	1200
Memphis	0.95	300	250	600
St. Louis	0.85	700	225	825
Markets				
Atlanta	1.50	225	600	500
Boston	1.50	150	1050	1200
Jacksonville	1.50	250	800	300
Philadelphia	1.50	175	925	975
New York	1.50	300	1000	1090

Determine the optimal location of the new site.