Case 10 - Sinofert Holdings Limited

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Problem Statement

- Sinofert Holdings Limited distributes urea to 14 provinces in China
- Out of its 70 suppliers, 13 of them distribute to customers in all 14 provinces. Among the 13 key large capacity suppliers, Sinofert owns 2 of them and needs to produce at maximum capacity for those two plants
- Sinofert made losses or negligible profit from 2007 to 2009, so the company is looking for a new production plan from each supplier to each province.
- All urea produced will be sold at the targeted province at its local average selling price

Assumptions

- All productions are done by the 13 key suppliers and we ignore other supplier since we are not given any data
- Unit for Exhibit 3 is in tonnes while unit for Exhibit 4 is in RMB
- Sales Budget is used as the maximum sales in a province. In sensitivity analysis, this constraint will be relaxed to explore the most and the least profitable province
- Contract Qty is used as the maximum production from a supplier. In sensitivity analysis, this constraint will be relaxed to explore the most and the least costly supplier
- There is no penalty for producing less than contract qty or making less sales than the sales budget

Model Development - Decision and Cost Variables

Let x_{ij} be the number of tons of production at supplier j for province i,

P_i be the average selling prices (RMB/ton) at province i,

M_j be the average manufacturing costs (RMB/ton) at supplier j,

C_{ij} be the average freight (RMB/ton) from supplier j to province i,

S_i^- be the minimum sales quantity (ton/year) at province i,

S_i^+ be the sales budget quantity (ton/year) at province I,

Q_j^- be the minimum qty (ton/year) at supplier j,

Q_j^+ be the contract qty (ton/year) at supplier j

Model Development - LP development

$$\max \sum_{i=1}^{14}\left(\sum_{j=1}^{13} x_{ij}P_i\right) - \sum_{j=1}^{13}\left(\sum_{i=1}^{14} x_{ij}M_j\right) - \sum_{i=1}^{14}\sum_{j=1}^{13} x_{ij}C_{ij}$$

$$s.t. \sum_{j=1}^{13} x_{ij} \geq {S_i}^- \; \forall\, i = 1..14$$

$$\sum_{j=1}^{13} x_{ij} \leq {S_i}^+ \; \forall\, i = 1..14$$

$$\sum_{i=1}^{14} x_{ij} \geq {Q_j}^- \; \forall\, j = 1..13$$

$$\sum_{i=1}^{14} x_{ij} \leq {Q_j}^+ \; \forall\, j = 1..13$$

$$All\ variables \geq 0$$

Base Solution

production	1	2	3	4	5	6	7	8	9	10	11	12	13	Z
1	220000	0	0	0	0	0	0	0	0	0	0	0	0	326750000
2	100000	300000	0	0	0	0	0	0	0	0	0	0	0	
3	180000	0	0	0	0	0	0	0	0	0	0	0	0	
4	0	0	0	0	0	0	0	0	0	120000	80000	0	0	
5	0	0	0	0	0	0	0	0	0	0	0	0	210000	
6	260000	0	0	200000	0	0	0	0	0	0	40000	0	0	
7	220000	0	0	0	110000	120000	0	0	0	0	0	0	0	
8	0	0	0	0	190000	0	0	0	0	0	0	40000	0	
9	0	0	100000	0	0	0	0	100000	0	0	0	0	0	
10	0	0	70000	0	0	0	0	0	0	0	0	0	130000	
11	0	0	0	0	0	0	0	0	220000	0	0	40000	10000	
12	0	0	0	0	0	0	0	0	180000	0	0	0	0	
13	0	0	30000	0	0	0	200000	0	0	0	0	0	0	
14	0	0	100000	0	0	0	0	0	0	0	0	0	0	

The horizontal 1-13 stands for supplier 1-13, the vertical 1-14 stands for province 1-14, and each yellow box represents the values of our decision variables.
Z stands for our optimal profit, 326,750,000 RMB.

Game Plan - Shadow Price

- For each 1 unit of relaxation in contract qty/sales budget, the final profit will increase by the amount in each bracket. For example, an increase of 1 ton of sales budget at Fujian province would increase the profit by 144 RMB.
- It would be more profitable if we have higher sales budget in all provinces, but an increase in contract qty is only more profitable in 7 out of the 13 suppliers, since both Sinofert-owned plants are already producing at their maximum capacities.
- We didn't consider lowering minimum sales/production since we need to maintain strong relationships with the suppliers and establish solid brand images in each province.

Rank of potential market

1	Fujian (144)
2	Jiangxi (99)
3	Liaoning (85)
4	Jiangsu (85)
5	Hunan (85)
6	Heilongjiang (84)
7	Guangxi (78)
8	Guangdong (74)
9	Anhui (61)
10	Hubei (51)
11	Jilin (49)
12	Hebei (40)
13	Shandong (40)
14	Henan (22)

Rank of potential production

1	Shanxi Fengxi (80)
2	Neimeng Erduosi (56)
3	Shandong Lunan (50)
4	Henan Pingdingshan (47)
5	Hebei Jinghua (26)
6	Sinofert Changshan (25)*
7	Hebei Zhengyuan (18)
8	Shandong Ruixing (16)
9	Sinofert Pingyuan (14)*
10	x
11	x
12	x
13	x

Sensitivity Analysis - Relaxed Sales Budget

- Since the shadow prices for all provinces are positive, we increased the sales budget for each province by 10/20/30% due to concerns of marketing and sales capabilities.

	Profit	Increase from original Profit
10%	348,940,000	6.79%
20%	359,232,000	9.94%
30%	367,742,000	12.5%

- The increase from original profit gradually decreases, because the cheaper suppliers ran out of capacities and we need to manufacture from the more expensive suppliers.

Sensitivity Analysis - Relaxed Contract Qty

- We increased the contract qty from the 7 non-Sinofert-owned suppliers with positive shadow prices by 10/20/30%.

	Profit	Increase from original
10%	332,532,000	1.77%
20%	336,650,000	3.06%
30%	340,143,000	4.10%

- Compared to relaxation in sales budget, this is not as profitable. Similarly, the increase gradually decreases because of saturation in sales budgets.

Sensitivity Analysis - Relaxed Sales Budget & Contract Qty

- We relaxed both the sales budget constraint and the contract qty constraint by 10/20/30%

	Profit	Increase from original
10% in both	357,317,000	9.35%
20% in both	387,596,000	18.6%
30% in both	416,861,000	27.6%

- The increase is quite linear, which means the increments in contract quantity can cover the increments in sales budget.

Conclusion

- If the market and production behaves the same way as described, the optimal solution would give a 326,750,000 RMB profit, which is not ideal given the investment of 6,336,270,000 RMB (5.14% increase).
- If we are able to increase sales budget in all provinces, it would be more profitable than increasing contract quantities among suppliers. Of course, If we can relax both constraints, there would be a significant increase in profit.
- The freight cost of the base solution is 256,770,000, which only makes up 4% of the total cost. So it is inefficient to put effort into saving freight cost, compared with putting effort into negotiation with suppliers or increasing sales ability.