Case 3 - DD Traders

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DD Traders allocate product manufacturing in China

- 20 Products (with different SKU ID)
- 3 Suppliers
- Planning for October, November, and December of 2010
- Supplier 2 cannot produce Product 4&11
- DD Traders would like to minimize cost while producing enough products to meet demand for each month and product.

Assumptions

- Demand for each product in each month is fixed and must be met.
- There is no inventory or warehouse. Products produced in each month can only be used in that month.
- For each supplier, the total production in November cannot be more than 115% or less than 85% of the total production in October. Similarly, the total production in December cannot be more than 115% or less than 85% of the total production in November.
- Individual product order for each supplier in each month cannot be less than 300 units. Of course, DD Trader can choose to not order that product from a certain supplier in any month.

Model Development

We developed an IP with

- Decision variable X_{ijk} where i = SKU ID, j = month (1=October, 2=November, 3=December), k=supplier#.
- Cost index C_{ijk}
- Demand index D_{ij}
- Capacity index P_{jk}
- Demand constraint
- Capacity constraint
- 115% and 85% supplier monthly cost constraint
- Non-negativity constraint (we omit the >300 unit constraint in order for simplicity, turns out in all our models there is no order that has <300 units)

Model Development

$$min. \sum_{i=1}^{20} \sum_{j=1}^{3} \sum_{k=1}^{3} c_{ijk} \times x_{ijk}$$

$$s.t. \sum_{k=1}^{3} x_{ijk} = D_{ij} \quad for\ i = 1..20,\ j = 1..3$$

$$\sum_{i=1}^{20} c_{ijk} \times x_{ijk} \leq P_{jk} \quad for\ j = 1..3,\ k = 1..3$$

$$\sum_{i=1}^{20} c_{i1k} \times x_{i1k} \leq 1.15 \times \sum_{i=1}^{20} c_{i2k} \times x_{i2k} \quad for\ k = 1..3$$

$$\sum_{i=1}^{20} c_{i1k} \times x_{i1k} \geq 0.85 \times \sum_{i=1}^{20} c_{i2k} \times x_{i2k} \quad for\ k = 1..3$$

$$\sum_{i=1}^{20} c_{i2k} \times x_{i2k} \leq 1.15 \times \sum_{i=1}^{20} c_{i3k} \times x_{i3k} \quad for\ k = 1..3$$

$$\sum_{i=1}^{20} c_{i2k} \times x_{i2k} \geq 0.85 \times \sum_{i=1}^{20} c_{i3k} \times x_{i3k} \quad for\ k = 1..3$$

$$x_{ijk} \geq 0 \quad for\ i = 1..20,\ j = 1..3,\ k = 1..3$$

Base Solution

- INFEASIBLE
- After a brief review, we found out that it's impossible to meet the +/-15% supplier monthly cost variation constraint
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Monthly Total Production (in units)		
October	November	December
382,140	702,184	276,744

- No matter how we allocate the production plan, the 115% and 85% constraint cannot be satisfied. Therefore, we discarded this constraint and reran the model.

New model

- Without the +/- 15% constraint, the new model can be divided into three sub-models, each dealing with the production allocation in each month.
- For each month, the model is:

$$min. \sum_{i=1}^{20} \sum_{j=1}^{3} c_{ij} \times x_{ij}$$

$$s.t. \sum_{j=1}^{3} x_{ij} = D_i \quad for\ i = 1..20$$

$$\sum_{i=1}^{20} c_{ij} \times x_{ij} \leq P_j \quad for\ j = 1..3$$

$$x_{ij} \geq 0 \quad for\ i = 1..20,\ j = 1..3$$

Base Solution

- Total Cost:

  $4,066,017.71

- Original Cost:

  $4,231,114.98

	2010 October			2010 November			2010 December		
SKU ID	Supplier 1	Supplier 2	Supplier 3	Supplier 1	Supplier 2	Supplier 3	Supplier 1	Supplier 2	Supplier 3
1	6082	0	37038	3795	0	37469	0	0	500
2	0	0	13320	0	0	20844	0	0	20448
3	11592	0	0	22176	0	0	0	0	35784
4	30224	0	0	31024	0	0	0	0	1280
5	0	0	11832	0	0	16080	0	0	18528
6	16032	0	0	23280	0	0	0	0	37296
7	0	0	12480	0	0	27792	0	0	6048
8	11848	0	0	38504	0	0	0	0	0
9	0	0	10040	0	0	28280	0	0	22880
10	0	0	26352	0	0	60624	0	0	13032
11	6696	0	0	35424	0	0	9324	0	0
12	2160	0	0	26244	0	0	5040	0	0
13	0	12168	0	0	24444	0	0	3420	0
14	23904	0	0	30816	0	0	13152	0	0
15	31572	0	0	15552	0	0	0	0	4932
16	29556	0	0	34632	0	0	0	0	6912
17	0	19908	0	0	36756	0	0	9936	0
18	0	0	18144	0	0	57504	0	0	18816
19	0	0	40032	0	0	90624	0	0	31776
20	0	0	11160	0	0	40320	0	0	17640

Sensitivity Analysis - Supplier 2 price change

- After November, the unit price for each product from Supplier 2 is increased by 5%
- Same constraints with the new model
- Ordering pattern is almost the same, except when SKU ID = 17, where the order is given to Supplier 1 instead.

	2010 October			2010 November			2010 December		
SKU ID	Supplier 1	Supplier 2	Supplier 3	Supplier 1	Supplier 2	Supplier 3	Supplier 1	Supplier 2	Supplier 3
1	6082	0	37038	3794	0	37470	0	0	500
2	1	0	13319	1	0	20843	0	0	20448
3	11592	0	0	22176	0	0	0	0	35784
4	30224	0	0	31024	0	0	0	0	1280
5	0	0	11832	0	0	16080	0	0	18528
6	16031	0	1	23280	0	0	0	0	37296
7	0	0	12480	0	0	27792	0	0	6048
8	11848	0	0	38504	0	0	0	0	0
9	0	0	10040	0	0	28280	0	0	22880
10	0	0	26352	0	0	60624	0	0	13032
11	6696	0	0	35424	0	0	9324	0	0
12	2160	0	0	26244	0	0	5040	0	0
13	0	12168	0	0	24444	0	0	3420	0
14	23904	0	0	30816	0	0	13152	0	0
15	31572	0	0	15552	0	0	0	0	4932
16	29556	0	0	34632	0	0	0	0	6912
17	0	19908	0	36756	0	0	9936	0	0
18	0	0	18144	0	0	57504	0	0	18816
19	0	0	40032	0	0	90624	0	0	31776
20	0	0	11160	0	0	40320	0	0	17640

Sensitivity Analysis - Supplier monthly cost floatation

- While we can’t accommodate the +/- 15% supplier monthly cost variation constraint, we would like to find out the minimum variation percentage that would generate a feasible solution
- Turns out that from somewhere between +/- 65% and +/-70% month-to-month variation, the IP would become feasible (work shown in stability 1.xlsx and stability 2.xlsx)
- Since that under the current demand, the month-to-month cost variation is so high, it would be reasonable to disregard the plan of stabilizing volume from each supplier

Sensitivity Analysis - Total price increase effects

- Due to the possible CHY appreciation and labour shortage, we would like to evaluate the change in purchasing allocations in response to the increase in unit prices from all suppliers.
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	+2%	+4%	+6%	+8%	+10%
Total Cost	$4,147,918	$4,229,819	$4,311,720	$4,393,621	$4,475,521

- In October and November, where supplier 3 monthly capacities are already at maximum, the extra work is shifted to supplier 1. Other than that, the purchasing allocations remain the same.

Conclusion

- According to our analysis, each unit type at each month is produced by one supplier, except for SKU ID #1 in October & November which is produced by both supplier 1 and 3.

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Oct	1+3	3	1	1	3	1	3	1	3	3	1	1	2	1	1	1	2	3	3	3
Nov	1+3	3	1	1	3	1	3	1	3	3	1	1	2	1	1	1	2	3	3	3
Dec	3	3	3	3	3	3	3	0	3	3	1	1	2	1	3	3	2	3	3	3

- The total cost is $4,066,017.71, which is about 4% less than the original purchase allocation plan of $4,231,114.98.