



MIDDLE EAST TECHNICAL UNIVERSITY

Term Project Report
IE407

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1 Introduction

Intro...

2 Project Body

Body intro...

2.1 Proposed Model

Parameters:

I : Set of products

I^1 : Set of product pairs (i_1, i_2) that cannot be placed on the same shelf.

I^2 : Set of product pairs (i_1, i_2) that will be included together in the assortment.

K : Set of shelves

π_i : Profit made by selling one unit of product i

w_k : Width of shelf k

γ_k : Shelf k 's effect on demand

ds_k : Depth of shelf k

dp_i : Depth of unit product i

b_i : Width of a facing for product i

d_i : Coefficient for demand rate for product i per unit width and one facing

β_i : Space elasticity factor for product i

s_i^l : Lower bound on the shelf inventory of product, if i is selected in the assortment

s_i^u : Upper bound on the shelf inventory of product, if i is selected in the assortment

Notation:

$|I|$: Size of the set of products

$|K|$: Size of the set of shelves

Calculated Data Sets:

N_{ik} : number of product i in shelf k per allocation:

$$N_{ik} = (ds_k/dp_i) - ((ds_k/dp_i)\%1)$$

Decision Variables:

X_{ijk} : Will the product i have j allocations on shelf k . Such that,

$$X_{ik} = \begin{cases} 1, & \text{if } i \text{ is allocated } j \text{ times in } k \\ 0, & \text{otherwise} \end{cases}$$

Objective function:

$$\max \sum_{i=1}^{|I|} \sum_{k=1}^{|K|} \sum_{j=1}^4 \gamma_k * \pi_i * d_i * (b_i)^{\beta_i} * (j)^{\beta_i} * x_{ijk}$$

Subjected To:

$$\sum_{k=1}^{|K|} \sum_{j=1}^4 X_{ijk} \leq 1 \quad \forall i \in I \quad (\text{Rule 1})$$

$$\sum_{k=1}^{|K|} (N_{ik} * (\sum_{j=1}^4 X_{ijk} * (j)^{\beta_i}) - s_i^u * (\sum_{j=1}^4 X_{ijk})) \leq 0 \quad \forall i \in I \quad (1)$$

$$\sum_{k=1}^{|K|} (N_{ik} * (\sum_{j=1}^4 X_{ijk} * (j)^{\beta_i}) - s_i^l * (\sum_{j=1}^4 X_{ijk})) \geq 0 \quad \forall i \in I \quad (2)$$

Constraint (1) and (2) come from Rule 3 and 4.

$$-w_k + \sum_{i=1}^{|I|} (b_i * (\sum_{j=1}^4 X_{ijk} * (j)^{\beta_i})) \leq 0 \quad \forall k \in K \quad (\text{Rule 6})$$

$$(\sum_{k=1}^{|K|} \sum_{j=1}^4 X_{i_1jk}) - (\sum_{k=1}^{|K|} \sum_{j=1}^4 X_{i_2jk}) = 0 \quad \forall (i_1, i_2) \in I^2 \quad (\text{Rule 7})$$

$$(\sum_{j=1}^4 X_{i_1jk}) + (\sum_{j=1}^4 X_{i_2jk}) \leq 1 \quad \forall k \in K \quad \forall (i_1, i_2) \in I^1 \quad (\text{Rule 8})$$

Restrictions:

$$X_{ijk} \in \{0, 1\} \quad \forall i \in I \quad \forall j \in \{1, 2, 3, 4\} \quad \forall k \in K$$

2.1.1 Q2

Q2

2.1.2 Q3

Q3

2.1.3 Q4

Q4

2.1.4 Q5

Q5

2.1.5 Q6

Q6

2.1.6 Q7

Q7

2.2 Discussion

Discussion...

3 Conclusion

Conclusion

4 Appendix

4.1 Sub1: Data Set for Q1,Q2

Table 1: Sets of product pairs
 $I^1 : (2, 5), (3, 8), (16, 20)$
 $I^2 : (1, 12), (3, 8), (9, 15), (16, 20)$

Product number	π_i	b_i	dp_i	d_i	β_i	s_i^l	s_i^U
1	15	10	7	4	0.5	2	15
2	8	9	6	10	0.2	1	19
3	12	5	10	10	0.3	1	23
4	6	7	7	7	0.2	1	9
5	11	9	9	5	0.9	1	16
6	14	6	8	2	0.4	1	21
7	14	9	6	1	0.5	1	11
8	6	5	9	6	0.3	1	18
9	5	9	9	7	0.8	2	11
10	11	10	9	3	0.8	1	11
11	12	7	5	4	0.1	2	17
12	8	5	6	7	0.8	2	22
13	11	7	6	2	0.1	1	12
14	13	8	9	9	0.8	3	12
15	7	9	8	11	0.8	3	19
16	14	23	5	2	0.1	2	16
17	9	25	6	9	0.1	1	10
18	10	17	8	1	0.8	2	16
19	13	15	9	4	0.2	2	20
20	5	23	6	2	0.6	3	19
21	11	19	8	6	0.6	2	24
22	11	19	9	6	0.4	1	16
23	7	16	7	8	0.5	2	13
24	10	14	5	2	0.8	1	16
25	13	16	10	4	0.9	2	14

Shelf number	w_k	ds_k	γ_k
1	50	34	0.25
2	65	30	0.60
3	80	26	1
4	95	27	0.60
5	110	29	0.25

4.2 Sub2: Rules

- 1- If a product is selected in the assortment, than all facings for the product must be placed on the same shelf. ✓
- 2- The manager does not want to allocate more than four facings for a product. ✓
- 3- If a product is selected in the assortment, then a minimum shelf inventory amount must be placed on the shelves. Similarly, for each product there is an upper bound on the shelf-inventory. ✓
- 4- If a product is selected in the assortment, lower and upper bounds on its facing number are calculated by using shelf depth, product depth and lower and upper bounds on the shelf-inventory. ✓
- 5- *Each product provides a certain profit per unit sold.*
- 6- Each shelf has a certain width and the total width of the facings placed in the shelf cannot exceed its width. ✓
- 7- For some pairs of products, there is a restriction that if one is included in the assortment, the other product must also be included. ✓
- 8- For some pairs of products, there is a restriction that they cannot be on the same shelf. ✓

References