



MIDDLE EAST TECHNICAL UNIVERSITY

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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

$\pi_i$ : Profit made by selling one unit of product  $i$

$w_k$  : Width of shelf  $k$

$\gamma_k$  : 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

$\beta_i$ : 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:**

$X_{ik}$  : Will the product i be on shelf k. Such that,

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

$f_{ik}$ : Number of allocated facings for product i on shelf k.

**Objective function:**

$$\max \sum_{i=1}^{|I|} \sum_{k=1}^{|K|} \pi_i \gamma_k d_i (f_{ik} * b_i)^{\beta_i}$$

**Subjected To:**

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

$$f_{ik} \leq 4 \quad \forall i \in I \quad \forall k \in K \quad (\text{Rule 2})$$

$$\sum_{k=1}^{|K|} f_{ik} * N_{ik} \leq s_i^u * X_{ik} \quad \forall i \in I \quad (1)$$

$$\sum_{k=1}^{|K|} f_{ik} * N_{ik} \geq s_i^l * X_{ik} \quad \forall i \in I \quad (2)$$

Constraint (1) and (2) come from Rule 3 and 4 and enforces  $f_{ik}$  to be 0 when  $X_{ik}$  is 0.

$$\sum_{i=1}^{|I|} f_{ik} * b_i \leq w_k \quad \forall k \in K \quad (\text{Rule 6})$$

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

$$X_{i_1 k} + X_{i_2 k} \leq 1 \quad \forall k \in K \quad \forall (i_1, i_2) \in I^1 \quad (\text{Rule 8})$$

**Restrictions:**

$$X_{ik} \in \{0, 1\} \quad \forall i \in I \quad \forall k \in K$$

$$f_{ik} \geq 0 \quad \text{and} \quad f \text{ is integer} \quad \forall i \in I \quad \forall k \in K$$

### **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	$\pi_i$	$b_i$	$dp_i$	$d_i$	$\beta_i$	$s_i^l$	$s_i^U$
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	$w_k$	$ds_k$	$\gamma_k$
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