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Space Optimization & Association Analysis in Retail Sector

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Abstract: In this paper detailed analysis is shown on how to make best use of space in the retail sector. How to increase sales of related products is also shown. A scenario is presented for the retail sector, where the space available in the shelf, for the merchandise to be placed, is limited and, it has to be put to best use. Also there could be products which are associated with each other, in other words, a product's sales could increase if it's placed next to an associated product. There are four products Bread, Butter, Jam and Cheese. We determine the ideal mix of quantities of the products in the shelf in order to maximize the sales. Also, the layout for placing the products (in one-dimensional space) based on the association amongst them is designed.

Keywords: Space, Optimization, Retail.

1. Scenario

In the retail sector, the space available in the shelf for the merchandise to be placed is limited and it has to be put to best use. Also there could be products which are associated with each other, in other words, a product's sales could increase if it's placed next to an associated product.

2. Business Problem

There are four products Bread, Butter, Jam and Cheese. Determine the ideal mix of quantities of the products in the shelf in order to maximize sales? Also, design the layout for placing the products (in one-dimensional space) based on the association amongst them.

3. Data Available

1. The total space available in the shelf for placing the products = 40 feet

2. The minimum and maximum space that could be given for each product
Min_Space(Bread) = 6 feet Max_Space(Bread) = 14 feet
Min_Space(Butter) = 8 feet Max_Space(Butter) = 12 feet
Min_Space(Jam) = 6 feet Max_Space(Jam) = 16 feet
Min_Space(Cheese) = 8 feet Max_Space(Cheese) = 14 feet

3. Space-Sales historical data for each product. Space in feet, Sales in units

Space(Br)	Sales(Br)
2	5
4	8
6	11
8	14
10	16
12	18
14	19
16	20
18	20
20	20

Space(Bu)	Sales(Bu)
2	6
4	10
6	14
8	15
10	16
12	17
14	18
16	19
18	19
20	19

Space(J)	Sales(J)
2	5
4	6
6	7
8	10
10	13
12	14
14	15
16	16
18	17
20	17

Space(C)	Sales(C)
2	7
4	9
6	11
8	13
10	15
12	16
14	17
16	18
18	18
20	18

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4. The transaction information involving the products in the analysis

Transaction Number	Item	Transaction Number	Item
1001	Bread	1006	Cheese
1001	Jam	1007	Bread
1002	Jam	1007	Butter
1002	Bread	1008	Jam
1003	Bread	1008	Cheese
1003	Jam	1009	Bread
1004	Jam	1009	Butter
1004	Bread	1010	Bread
1005	Butter	1010	Cheese

5. The Selling Price of Bread, Butter, Jam and Cheese.

Selling Price(Bread) = $1.5
Selling Price(Butter) = $2.5
Selling Price(Jam) = $2
Selling Price (Cheese) = $2

4. Methodology

Space Optimization

Objective Function

Maximize Total Sales Dollar = Sales Dollar(Bread) + Sales Dollar(Butter) + Sales Dollar(Jam) + Sales Dollar(Cheese)
(i.e.) Maximize Total Sales Dollar = 1.5*Sales Units(Bread) + 2.5* Sales Units(Butter) + 2* Sales Units(Jam) + 2*Sales Units(Cheese)

Constraints

Total Space= Space(Bread) + Space(Butter) + Space(Jam) + Space(Cheese)
(i.e.) 40 feet = Space(Bread) + Space(Butter) + Space(Jam) + Space(Cheese)

Min_Space(Bread) <= Space(Bread) <= Max_Space(Bread)
(i.e.) 6 feet <= Space(Bread) <= 14 feet

Min_Space(Butter) <= Space(Butter) <= Max_Space(Butter)
(i.e.) 8 feet <= Space(Butter) <= 12 feet

Min_Space(Jam) <= Space(Jam) <= Max_Space(Jam)
(i.e.) 6 feet <= Space(Jam) <= 16 feet

Min_Space(Cheese) <= Space(Cheese) <= Max_Space(Cheese)
(i.e.) 8 feet <= Space(Cheese) <= 14 feet

With Space-Sales historical data for each product, the following relationships can be obtained using simple non-linear regression as the logarithmic curve came out as the best fit.

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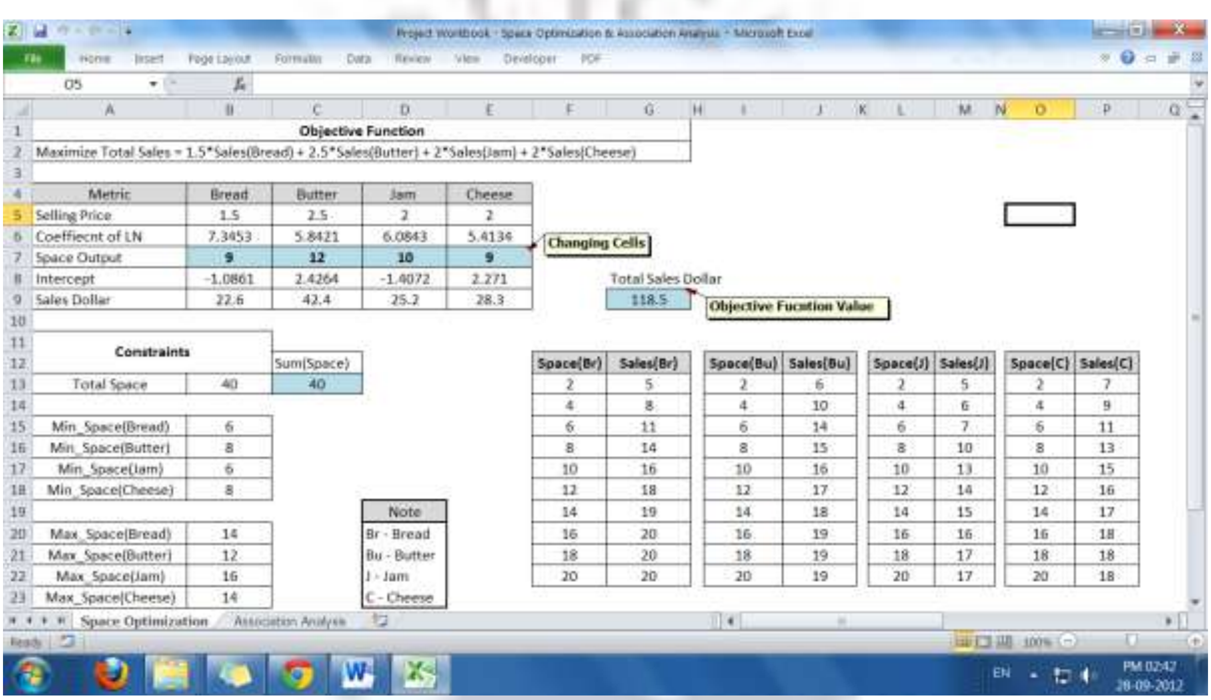
Sales(Bread) = Function (Space(Bread))
(i.e.) Sales(Bread) = 7.3453*ln(Space(Bread)) - 1.0861

Sales(Butter) = Function (Space(Butter))
(i.e.)Sales(Butter) = 5.8421*ln(Space(Butter)) + 2.4264

Sales(Jam) = Function (Space(Jam))
(i.e.)Sales(Jam) = 6.0843*ln(Space(Jam)) - 1.4072

Sales(Cheese) = Function (Space(Cheese))
(i.e.)Sales(Cheese) = 5.4134*ln(Space(Cheese)) + 2.271

When the above inputs are fed into Excel Solver, it iterates for the different combinations of product space in order to maximize sales and freezes on the best possible combination.



Output

Maximum Sales Dollar = $ 118.5
Space(Bread) = 9 feet
Space(Butter) = 12 feet
Space(Jam) = 10 feet
Space(Cheese) = 9 feet

5. Association Analysis (Market Basket Analysis)

With the transaction information involving the products in the analysis, the following metrics can be calculated.
The association of two products A➔ B is measured by the following:

- Support: % of transactions where A and B are purchased
- Expected Confidence: % of transactions where a product B is purchased
- Confidence: % of transactions where a product B is purchased given A is purchased
- Lift: Confidence / Expected Confidence - gives the measure of strength of Association of A➔ B

This gives the chance of how likely that a customer buys product B when he has bought product A as compared to any customer at random.

The above mentioned metrics can be calculated for the following combinations:
A➔ B, A➔C, A➔D, B➔C, B➔D, C➔D

Note: A➔ B might not be same as B➔A in business but it means the same from implementation perspective. So, A➔ B is considered equivalent to B➔A. Also in terms of calculation using the formula, A➔ B is same as B➔ A

Bread and Jam	
Support	
P(Bread n Jam)	40%
Expected Confidence	
P(Jam)	50%
Confidence	
P(Jam/Bread)	57%
Lift	
Confidence/Expected Confidence	1.14

Bread and Butter	
Support	
P(Bread and Butter)	20%
Expected Confidence	
P(Butter)	30%
Confidence	
P(Butter/Bread)	29%
Lift	
Confidence/Expected Confidence	0.95

Bread and Cheese	
Support	
P(Bread and Cheese)	10%
Expected Confidence	
P(Cheese)	30%
Confidence	
P(Cheese/Bread)	14%
Lift	
Confidence/Expected Confidence	0.48

Jam and Butter	
Support	
P(Jam and Butter)	0%
Expected Confidence	
P(Butter)	30%
Confidence	
P(Butter/Jam)	0%
Lift	
Confidence/Expected Confidence	0

Jam and Cheese	
Support	
P(Jam and Cheese)	10%
Expected Confidence	
P(Cheese)	30%
Confidence	
P(Cheese/Jam)	20%
Lift	
Confidence/Expected Confidence	0.67

Butter and Cheese	
Support	
P(Butter and Cheese)	0%
Expected Confidence	
P(Cheese)	30%
Confidence	
P(Cheese / Butter)	0%
Lift	
Confidence/Expected Confidence	0

Based on the lift values, it can be concluded that the following products are closely associated in the following order.

1. Bread and Jam
2. Bread and Butter
3. Jam and Cheese
4. Bread and Cheese

Based on the association between the products, the layout can be designed this way to broaden the purchase basket of customers.

Butter	**Bread**	**Jam**	**Cheese**

6. Solution

Combining the results from Space Optimization and Association Analysis, we can design the planogram (shelf) this way.

Butter	**Bread**	**Jam**	**Cheese**
12 feet	9 feet	10 feet	9 feet

Thus, the retail space available can be put to best use.

7. References

[1]. [Online]. Available: http:// www-users.cs.umn.edu/~kumar/dmbook/ch6.pdf [2012, October/16].