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A Study of Goal Programming Model for Sales Planning of Multi-Product Garment Production Corporate Unit

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ABSTRACT
This paper addresses the problem of precise sales planning in a male garments manufacturing corporate unit. Researching real life situations is quite demanding as every case has its own set of complexities. Before building a model for such situations, we must take into consideration the accurate parameters so that the solution derived is practical and possible. We have applied a GP model to solve the problem of selecting profitable regions for a garments manufacturing corporate unit with different category of products, operating in different regions and selling through a team of sales executives. The solutions provided addresses the problem quite precisely.

Key Words: Product Category, Region, Sales planning.

INTRODUCTION

Every corporate manufacturing unit is engaged in either sales or service sector, with a motive to maximise returns and minimise costs with an ultimate goal of satisfying customers. A corporate manufacturing unit engaged in sales of certain products needs to plan all its sales and marketing strategies in advance. A sales plan is a broad strategy that outlines and forecasts all the plans and strategies through which the desired sales figures would be achieved in a given period, in a given territory. It states the sales objectives, strategies to fulfil those objectives and available resources to achieve that plan. But before a product reaches the stage when it is ready for sale it passes through the complex process of being manufactured.

In a corporate manufacturing unit, with powerful planning, the business and production operation can go smoothly. Enterprise Resource Planning which is also known as ERP, is the most popular resource management system at present, adopted by manufacturing firms worldwide. ERP is an extension of Material Requirements Planning (MRP), which was developed in 1960s. It is a management and control system with planning as the critical function, covering overall resources of enterprises, which has become the leading system of production planning arrangements and resource management for many manufacturing enterprises. However, with decades of developments in the management thoughts and philosophies of ERP, the traditional calculation methods of MRP are the implementation foundation for ERP.
Under ERP planning system, a comprehensive business plan is executed first of all. It includes guidelines for sales and operations planning. A sale planning assesses demand and operations planning assesses capacity planning depending on the feedback of demand forecasting. Based on the inputs, master production planning is done. Materials requirement and capacity planning is finalised along with workshop production planning and purchase order planning.

Wallace (2006) conducted a study on demand forecasting, Sales & Operations Planning in a corporate manufacturing unit. It highlighted how synergy between them can fulfil the corporate manufacturing unit's objectives. Chen (2005) shed light on various incentives given to motivate sales force, analysing market information and thus do effective production and inventory planning for success of overall strategy of a corporate manufacturing unit. Bower (2005) analysed 12 most common threats to sales and operations planning process. It

highlighted various shortcomings and lacunas that can affect the effective implementation of planning in the absence of proper coordination and communication among different departments. Kahn (1996, 1998) researched and stressed on the proper Interdepartmental integration for effective product development performance and sales. Lapide (2004, 2005) and Feng et al. (2008) researched on the various aspects of sales and operations planning in a corporate manufacturing unit. Grimson (2007) developed a sales and operations model to integrate the various functions of different departments. Wiers (2009), Genin et. al. (2007) highlighted the importance of APS system. While citing examples of companies, he stressed on shop floor autonomy for better implementation of APS system. Zhang et. al. (2005) conducted an empirical study on successful implementation of ERP systems planning in China in corporate manufacturing units. They concluded that Enterprise resource planning not only helps in putting all the available resource to optimum use, it saves lots of costs as well. Kanet (2010) also did extensive study on the implementation of ERP systems. Feng et. al. (2008) did study on the value of sales and operations planning in oriented stand board industry with make to order manufacturing system. Their study considered cross functional integration under deterministic demand and spot market resource.

Wang and Fang (2001) developed a model for Aggregate production planning with multiple objectives in a fuzzy environment in a corporate manufacturing unit. In their studies they used fuzzy variables to prove their point. Wang et. al. (2012) developed a Production scheduling model based on the finite capacity of discrete manufacturers. Xiao et. al. (2010) created an enterprise planning model based on bill of manufacturing. All the variables were taken into consideration that are used in manufacturing. Kopanos et. al. (2010, 2011) did a study on optimal production scheduling and lot-sizing in dairy Plants. They did their study in a yogurt production Line plant in a corporate manufacturing unit. Tenhiala (2011) presented a contingency theory of capacity planning. It focussed on the link between process types and planning methods used in multi-objective and multi-product manufacturing company.

In the present study, we have taken the example of a gents garments manufacturing company, Richlook, N.Delhi. This is a multi-objective and multi-product manufacturing company which requires advanced sales planning for its various products as demand and sales vary round the year. The firm has latest state of the art imported stitching machines imported from Italy. The work force is also skilled with 70% of the work force are females. The company operates in two shifts of 8 hours each. The cloth used is procured from local sources. The company has its own brand under which it sells locally. The company also does job work for others. Like every company, the company has to allocate its limited resources to the best use so that profit could be maximised. The company has to do meticulous sales planning with an objective to promote profitable regions and discourage investments and promotion in regions with low sales.
This study presents a goal programming model for sales planning of multi-objective multi-product production unit. By applying this GP model, the firm can make precise strategies with regard to promotion of particular product in particular regions that could result in maximizing profits and minimizing costs.

PROBLEM DATA

The Rich look Company has employed 32 salesmen to market its garments, mainly in North India. But the bulk annual sale comes from the main seven regions which are operated by seven senior sales executives. The firm has nine product categories consisting of various gents garments. These are Caps, Ties, T-Shirts, Belts, Trousers, Jeans, Casual Shirts, Formal Shirts and Sox.

Information given in Table 1 shows that in each column, how a rupee of sale is distributed in each of the seven regions among the various product categories as in fourth quarter 2010-11. For example, the .07 coefficient for the first product (Caps) indicates that on an average in 7 regions, out of one rupee, 7 paise of sale comes from caps in region 1.

Table 1: Rupee Value of Sales for a Product in Seven Regions (Fourth Quarter 2010-11)

Product Category	No.1	No.2	No.3	No.4	No.5	No.6	No.7
Caps	.07	.02	.01	.15	.15	.15	0.00
Ties	.05	0.00	0.00	.10	.10	.07	0.00
T-Shirts	.20	.35	.30	.25	.25	.25	.50
Belts	.07	.07	.07	.10	.15	.10	.03
Trousers	.15	.15	.15	.15	.15	.15	.15
Jeans	.10	.20	.10	.10	.10	.10	.05
Casual Shirts	.18	.10	.17	.10	.05	.05	.12
Formal Shirts	.15	.08	.17	.02	.02	.10	.12
Sox	.03	.03	.03	03	0.00	.03	.03
Total	1.00	1.00	1.00	1.00	1.00	1.00	1.00

Sales potential of all seven regions is given below in Table 2 for the next quarter.

Table 2: Market Potential of each of the Seven Regions (First Quarter 2011-12):

Region	Market Potential (MPi) (₹)
1	**2,25,000.00**
2	**1,35,000.00**
3	**1,50,000.00**
4	**1,00,000.00**
5	**2,10,000.00**
6	**80,000.00**
7	**2,50,000.00**
Total	**11,50,000.00**

In Table 3, among the nine product categories, the Yi represents the maximum amount of product line capacity that is available to the firm at the given price and cost structure. We assume that the firm can generate sufficient working capital to handle ₹ 11, 50,000 of sales for the planning period, first quarter 2011-12.

Table 3: Maximum Capacity of Different Category of Products in ₹ (First Quarter 2011-12)

Product Category	Capacity in ₹ (Y_i)
1	70,000.00
2	20,000.00
3	210,000.00
4	70,000.00
5	150,000.00
6	100,000.00
7	150,000.00
8	150,000.00
9	30,000.00

Goal Programming Model

The general GP model can be expressed as:

$$\text{Minimize } Z = \sum_{i=1}^{m} (d_i^+ + d_i^-)$$

$$\text{subject to } \mathbf{Ax} - \mathbf{I}\, d_i^+ + \mathbf{I}\, d_i^- = b$$

$$x, d^+, d^- \geq 0,$$

where m goals are expressed by an m component column vector **b** (b_1 b_2 …….b_m). **A** is an m × n matrix which expresses the relationship between goals and sub goals, **x** represents variables involved in the sub goals (x_1 x_2 …….. x_n), d^+, d^- are m component vectors for the variable representing deviations from goals and **I** is an identity matrix in m dimensions. Now, each one of the m goals must be analyzed in terms of whether over or under-achievement of the goal is satisfactory. If over-achievement is acceptable di^+ can be eliminated from the objective function. On the other hand, if under-achievement is satisfactory, di^- should be left out of the objective function. If the goal must be achieved exactly as defined, both di^+ and di^- must be in the objective function.

The deviational variables di^+ and di^- must be ranked according to their priorities, from the most important to the least important. If the goals are classified in k ranks, the priority factor (j = 1, 2,…….k) should be assigned to the deviational variables. The priority factors have the following relationship:

$$P_j > > > nP_{j+1} (j = 1, 2 \ldots . k-1)$$

Which implies that the multiplication of n, however large it may be, cannot make P_{j+1} greater than or equal to P_j. Mathematically, the GP model developed here is as follows:

Objective Function:

$$\text{Minimize } Z = \sum_{i=1}^{9} P_i\, d_i^+ + \sum_{i=10}^{16} P_i\, d_i^+$$

subject to the constraints:

Capacity of Caps:

$$.07\, x_1 + .02\, x_2 + 0.01\, x_3 + 0.15\, x_4 + 0.15\, x_5 + 0.15\, x_6 + 0\, x_7 + d_1^- - d_1^+ = 70{,}000$$

Capacity of Ties:

$0.05\ x_1 + 0x_2 + 0x_3 + 0.10x_4 + 0.10x_5 + 0.07x_6 + 0x_7 + d_2^- - d_2^+ = 20,000$

Capacity of T-Shirts:

$0.20x_1 + 0.35x_2 + 0.30x_3 + 0.25x_4 + 0.25x_5 + 0.25x_6 + 0.50x_7 + d_3^- - d_3^+ = 2,10,000$

Capacity of Belts:

$0.07x_1 + 0.07x_2 + 0.07x_3 + 0.10x_4 + 0.15x_5 + 0.10x_6 + 0.03x_7 + d_4^- - d_4^+ = 70,000$

Capacity of Trousers:

$0.15x_1 + 0.15x_2 + 0.15x_3 + 0.15x_4 + 0.15x_5 + 0.15x_6 + 0.15x_7 + d_5^- - d_5^+ = 1,50,000$

Capacity of Jeans:

$0.10x_1 + 0.20x_2 + 0.10x_3 + 0.10x_4 + 0.10x_5 + 0.10x_6 + 0.05x_7 + d_6^- - d_6^+ = 100,000$

Capacity of Casual Shirts:

$0.18x_1 + 0.10x_2 + 0.17x_3 + 0.10x_4 + 0.05x_5 + 0.05x_6 + 0.12x_7 + d_7^- - d_7^+ = 150,000$

Capacity of Formal Shirts:

$0.15x_1 + 0.08x_2 + 0.17x_3 + 0.02x_4 + 0.02x_5 + 0.10x_6 + 0.12x_7 + d_8^- - d_8^+ = 150,000$

Capacity of Sox:

$0.03x_1 + 0.03x_2 + 0.03x_3 + 0.03x_4 + 0.03x_5 + 0.03x_6 + 0.03x_7 + d_9^- - d_9^+ = 30,000$

Market Potential Goals for Territory 1 – 7:

$x_1 + d_{10}^- - d_{10}^+ = 2,25,000$

$x_2 + d_{11}^- - d_{11}^+ = 1,35,000$

$x_3 + d_{12}^- - d_{12}^+ = 1,50,000$

$x_4 + d_{13}^- - d_{13}^+ = 1,00,000$

$x_5 + d_{14}^- - d_{14}^+ = 2,10,000$

$x_6 + d_{15}^- - d_{15}^+ = 80,000$

$x_7 + d_{16}^- - d_{16}^+ = 2,50,000$

SOLUTION

The solution values of x_i's and deviational variables d_i's obtained by using the modified simplex method of goal programming is stated as follows:

$x_1 = 0$	$x_2 = 1,35,000$	$x_3 = 1,50,000$	$x_4 = 0$
$x_5 = 1,44,000$	$x_6 = 80,000$	$x_7 = 1,23,500$	
$d_1^+ = 27,800$	$d_1^- = 0$	$d_2^+ = 0$	$d_2^- = 0$
$d_3^+ = 0$	$d_3^- = 0$	$d_4^+ = 16,745$	$d_4^- = 0$
$d_5^+ = 16,745$	$d_5^- = 0$	$d_6^+ = 14,425$	$d_6^- = 0$
$d_7^+ = 84,980$	$d_7^- = 0$	$d_8^+ = 88,000$	$d_8^- = 0$
$d_9^+ = 0$	$d_9^- = 0$	$d_{10}^+ = 0$	$d_{10}^- = 0$
$d_{11}^+ = 1,00,000$	$d_{11}^- = 0$	$d_{12}^+ = 66,000$	$d_{12}^- = 0$
$d_{13}^+ = 0$	$d_{13}^- = 0$	$d_{14}^+ = 6,15,500$	$d_{14}^- = 0$
$d_{15}^+ = 0$	$d_{15}^- = 0$	$d_{16}^+ = 0$	$d_{16}^- = 0$

CONCLUSION

After going through the model, it is well evident that to maximize net returns and minimize costs, it would be better to drop regions 1 and 4 as the optimal solution excludes these regions. Selling in these regions will result in decline in net revenue.

If we consider economic opportunity cost to the firm, additional market potential in other sales regions will contribute nothing. Since different products have different potential in different regions, these costs should be compared with the estimated sales and marketing cost of acquiring additional units of these resources. For example, if additional demand in sales region no.3 can be created for less than 12 cities on the rupee, then clearly it will be beneficial for the firm to expand its market potential in this sales region, until its value to the firm falls

or its cost of acquisition increases.

This model will help firms having multiple product categories with Pan India presence in various regions. By applying this GP model, firms can make exact strategies with regard to promotion of particular product in particular regions that could result in maximum revenue at minimum cost.

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