Supply Chain Inventory Control Model for Nestle India Ltd.

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Abstract— Nestle India manufactures and sells food products which are associated with a shelf-life. On the other hand there are different points of sales through the distribution network of the company such as distribution centres, distributors and retail outlets. If at any point, the stock fails to move on to the next point beyond its shelf-life, it results in expiry of the goods which is a loss to the company in monetory terms since the company directly or indirectly has to compensate the affected parties in the distribution system and ultimately incur the loss itself. Nestle refers to the expired stock as Bad Goods, though the term also includes stocks damaged in transit, which forms a very nominal part of total bad goods.There has been an increasing trend of Bad Goods value over the past few years. As a result, there is a growing concern among the various stakeholders, especially the Demand and Supply Planning, Supply Chain Department and also the sales team to some extent, regarding controlling and then reversing the trend of Bad Goods. This is because a factor for the occurrence of Bad Goods which has been identified is the mismatch, mainly the excess between the planned sales forecasted by the Demand Planning team of the SCM division, and the actual sales, resulting in unsold stocks and ultimately expired stocks or Bad Goods.This paper presents an Inventory Control model for perishable items in three-level supply chains using just-in-time logistics. The goal is to minimize the total cost of the whole supply chain. This includes cost of production, cost of freight and cost of inventory holding perished goods. The model, for the purpose of simplification, has been developed with the assumption that all goods are delivered to the customers prior to their expiry date and hence there are no perished items. To develop a more realistic model, a scenario analysis can be carried out by considering different inventory capacities of the warehouses, as different multiples of the sums of the capacities of the customers they cater to. A sensitivity analysis can also be carried out by making changes to the demand plans. Premium Solver Pro of MS Excel is the software tool used to solve and validate the model.

Index Terms— demand and supply planning, inventory, just-in-time logistics, Nestle, perishable items, sensitivity analysis, supply chain

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1 INTRODUCTION

There has been an increasing trend of Bad Goods value over the past few years. As a result, there is a growing concern among the various stakeholders, especially the Demand and Supply Planning, Supply Chain Department and also the sales team to some extent, regarding controlling and then reversing the trend of Bad Goods.

The globalized and competitive market in twenty first century requires appropriate supply chain management. In supply chain management all of the processes (such as planning, supply, delivery, operating and assessment) present in the network of organizations have to be considered. The interactions among different economic institutions (such as supplier, wholesaler, final retailer, etc.) have to be analyzed as well. One major difficulty in supply chain is when dealing with perishable goods (e.g., food). These goods, if not delivered prior to their expiry date, are considered as lost sale. On the other hand, designing inventory control mechanisms to determine the optimal size of orders, the frequency and time of orders, and total cost of inventory for perishable products is very complex. Therefore, organizations dealing with these kinds of products try to use modern ways to preserve them as much as possible and also employ ways to minimize the cost of the decaying items while trying to meet the customer's expectation.

PROCEDURE FOR MODEL DEVELOPMENT

2.1 Literature Review

A detailed and extensive literature review was carried out. Research papers in the relevant fields of supply chain management, inventory control and perishable goods among others were referred to.

2.2 Field Study and Data Collection

A two-month field study was conducted at the company Nestle India Ltd. for the purpose of data collection. The scope of the study comprised the organization's corporate head office in Gurgaon, the Western India regional office in Mumbai and site visits and surveys at warehouses, distributors and varied types of retail outlets at selected urban and rural localities of Maharashtra and Gujarat. However, the base data used for the development of the Model has not been shared in this paper for confidentiality purposes.

2.3 Model Development

After extensive studying and understanding of the concepts from the literature review, followed by the field study, the model development has been carried out. The mathematical model has been described in the following sections. The list of assumptions is mentioned in the beginning. The mathematical equation is presented along with the constraint equations and the list of notations. The software of Premium Solver Pro has been used for the purpose of Optimization. The same software

has also been used to carry out the Sensitivity Analysis for the Model.

2.4 Conclusion and future work

The paper concludes by presenting the scope of future development of the model in this paper.

3 LITERATURE REVIEW

The literature review carried out for this paper has been summarized and presented in the following paragraphs. One can find here the authors, their paper referred to and the methodology which each of the papers uses for developing their respective models.

Ghasimi and Ghodsi in their paper "*Inventory Optimization for Perishable Items*" use the concepts of Mixed Integer Linear Programming with tools like Genetic Algorithm and CPLEX. Tyagi in his paper,"*Inventory Optimization of ageing stock by declining market demand and variable holding cost*"deploys Optimization considering Weibull distributed deterioration and using tools like Mathematica.

Van Elzakker, Zondervan, Raikar, Hoogland, Grossmanin their publication,"*Tactical Planning Optimization for FMCG items considering shelf-life restrictions*" implements Mixed Integer Linear Programming using CPLEX. Simatupang, Wright, Sridharan in"*Theory of Constraints in Supply Chain Collaboration*" performs survey, performance metric, theoretic discussion.

Adebanjo and Mann in their paper,"*Identifying problems in demand forecasting in FMCG industry*" executes the Integrated Definition (IDEF) model. Abernathy, Dunlop, Hammond, Weil in their "*Information age of retail supply chains*" makes us of Surveys, simulation, theoretical discussion

Waller, Johnson, Davis develops their publication, "*Vendor-managed Inventory in retail supply chain*" based on Surveys, simulation, theoretical discussion. Forslund and Jonsson discuss in their paper,"*Impact of forecast information quality on supply chain performance*"the tools of FIQ definition, devising metrics, survey of Swedish companies

Reichhart and Holweg in "*Creating a customer-responsive supply chain*" talk about the Synthesis of existing literature on manufacturing and supply chain responsivuness. Webby and O'Connor in "*Judgmental and statistical time series forecasting*" elaborates on theLiterature review of empirical studies on comparison between and comparison of judgmental and statistical forecast methods

4 PROJECT MODELLING

The following assumptions have been considered at the beginning of the project modelling:
- The three levels of supply chain consist of multiple producers (also called factories or suppliers), multiple intermediate warehouses and multiple distributors (also called customers). Several customers are grouped together into zones, and are allocated to each of the warehouses
- Road is the only type (mode) of transportation
- Multiple products

- The demand in each period is constant and deterministic.
- Shortage of goods is permissible.
- The time when goods are sent from factories is considered the beginning of the expiration period
- Consumption of goods from warehouses (removed to deliver to customers) is in first-in-first-out (FIFO) order.
- The transportation time is neglected as it is a short time compared to the total time.
- The capacity of each supplier is limited.
- The customer's demand in each period has been estimated.
- Warehouses have limited capacity.
- Each warehouse allocates only a certain space to each type of good.
- There is an inventory limit at the end of each period
- Production cost worked backwards, using sales price and profit-margins at various echelons
- Milk-runs considered for transportation from warehouse to customers, circular path assumed
- Identical storage capacity of all distributors
- Inventory holding costs, transportation costs according to industry standards
- Production plan for considered zones divided according to contribution of zones to total sales
- Production capacities for considered zones divided according to contribution of zones to total sales
- Inventory holding capacities identical for all considered products
- Inventory holding capacities identical for all considered products
- Back-order and expiry before final sales not considered

The notations used are as follows:
- Factory index i = 1, …, I
- Warehouses index j =1, …, J
- Retailer index k =1, …, K
- Period index t =1, …, T
- Product (Goods) index l = 1, …, L

A two-month field study was conducted at the company Nestle India Ltd. for the purpose of data collection. The scope of the study comprised the organization's corporate head office in Gurgaon, the Western India regional office in Mumbai and site visits and surveys at warehouses, distributors and varied types of retail outlets at selected urban and rural localities of Maharashtra and Gujarat. The inventory levels data at the 3 different levels of the supply chain has been collected in terms of Indian Rupee (INR) vale. The variables are used in the calculation are the different product categories and the different geographical regions.

The final equation which has been developed as the result of this study is as follows, subject to all the constraints equations mentioned subsequently.

(1) Minimize $Z = \sum_t\sum_l\sum_i\sum_j (X_{ijl}^t \cdot a_{ijl}^t) + \sum_t\sum_l\sum_i (p_{il}^t \cdot \sum_j X_{ijl}^t) + \sum_t\sum_l\sum_i\sum_j (b_{jkl}^t \cdot Y_{jkl}^t) + \sum_t\sum_l\sum_j h_{jl}^t \cdot (\sum_i X_{ijl}^t - \sum_k Y_{jkl}^t)$

Subject to:

$$(2) \quad \sum_i X_{ijl}^t >= d_{kl}^t \qquad \text{for all } k, l, t$$
$$(3) \quad \sum_j Y_{jkl}^t >= d_{kl}^t \qquad \text{for all } k, l, t$$
$$(4) \quad \sum_i X_{ijl}^t - \sum_k Y_{jkl}^t >=0 \qquad \text{for all } j, l, t$$
$$(5) \quad \sum_i X_{ijl}^t - \sum_k Y_{jkl}^t <= s_{jl}^t \qquad \text{for all } j, l, t$$
$$(6) \quad \sum_j Y_{jkl}^t - d_{kl}^t <= r_{kl}^t \qquad \text{for all } k, l, t$$
$$(7) \quad \sum_j X_{ijl}^t <= p_{il}^t \qquad \text{for all } i, l, t$$
$$(8) \quad X_{ijl}^t <= m_{ijl}^t \qquad \text{for all } i, j, l, t$$
$$(9) \quad Y_{jkl}^t <= n_{jkl}^t \qquad \text{for all } j, k, l, t$$
$$(10) \quad X_{ijl}^t, Y_{jkl}^t, d_{kl}^t >=0 \qquad \text{for all } i, j, k, l, t$$

X_{ijl}^t Quantity of product *l* transported from factory *i* to warehouse *j* in period *t*

Y_{jkl}^t: Quantity of product *l* transported from warehouse j to customer k in period t

p_{il}^t: Production cost of product *l* in factory *i* in period *t*

h_{jl}^t: Holding cost of product *l* in warehouse *j* in period *t*

a_{ijl}^t: Transportation cost of product *l* from factory *i* to warehouse *j* in period *t*

b_{jkl}^t: Transportation cost of product *l* from warehouse *j* to customer *k* in period *t*

d_{kl}^t: Demand of product *l* at customer *k* in period *t*

c_{il}^t: Production capacity of product *l* in factory *i* in period *t*

s_{jl}^t: Holding capacity of product *l* in warehouse *j* in period *t*

r_{kl}^t: Holding capacity of product *l* at customer *k* in period *t*

m_{ijl}^t: Transportation capacity of product *l* from factory *i* to warehouse *j* in period *t*

n_{jkl}^t: Transportation capacity of product *l* from warehouse *j* to customer *k* in period *t*

The purpose of the model is:
- Reduction in the production cost at the factories
- Reduction in the transportation cost of warehouses and customers
- Minimizing inventory holding costs at the warehouses

Equation (1) is objective function of the model, which includes the cost of producing the items at the factories, the transportation cost of items from the factories to the warehouses and from the warehouses to the retailers and the cost of preserving the items in the warehouses.

Equation (2) states that the total demand during the planning period should be secured, in other words, the total delivered items to the customers (distributors) should be greater than or equal to the total received demands during the planning period.

Equation (3) also states that the total demand during the planning period should be secured, in other words, the total produced items at the factories should be greater than or equal to the total received demands at the customers during the planning period.

Equation (5) shows the limitation of warehouse capacities i.e. the difference between received quantity and delivered quantity of the items cannot be more than its capacity.

Equation (6) is the space constraints of the distributors and determines the inventory level in each distributor.

Equations (8) and (9) restrict the capacities for transportation modes in each period. The amount of transported items shouldn't be more than the transportation capacity.

Equation (10) shows that in each period the customer's required quantity for an item per period, the quantity of received items from each supplier for each warehouse, and the items delivered to customers should all have non-negative values.

5 RESULTS

5.1 Sample problem

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I	J	K	L	T
5	2	4	6	8

- I: Number of factories
- J: Number of warehouses
- K: Number of customers
- L: Number of products
- T: Number of time periods (months)

Factories	Warehouses	Customers	Products	Time periods
Samalkha, Haryana	Bhiwandi, Maharashtra	Mumbai Zone 1	Nestum Baby Food	Jan-2013
Moga, Punjab		Mumbai Zone 2	Everyday Whitener	Feb-2013
Ponda, Goa	Aslali, Gujarat	Gujarat Zone 1	Neslac	Mar-2013
Nanjangud, Karnataka		Gujarat Zone 2	Choco Eclairs	Apr-2013
Bicholim, Goa			Maggi Sauce	May-2013
			Nescafe Classic	Jun-2013
				Jul-2013
				Aug-2013

5.2 Premium Solver Pro Results

	Actual	Optimized	Difference
Total Cost	INR 2,18,86,301.7	INR 1,31,14,183	Less INR 87, 72,118.7 (40.08%)

The following scenarios were attempted:
Inventory capacity at the warehouses = 1.5 times the base case
Inventory capacity at the warehouses = 10 times the base case

	Base Case	Scenario	Difference
Case 1 (1.5 times)	INR 1,31,14,183	INR 1,31,31,835	INR 17,652 increase (0.135%)
Case 2 (10 times)	INR 1,31,14,183	INR 1,31,57,496	INR 43,313 increase (0.33%)

The following sensitivity analyses were also attempted
- Demand at customers 5% higher than base case
- Demand at customers 5% lower than base case

Case	Change in demand plan	Change in total costs
3	5% increase	2.03% increase
4	5% decrease	2.29% decrease

The obtained objective function values show a decrease or savings of Rs. 88, 53,415.7 (40.45 percent) as against the actual company data for production and inventory for the similar products, factories, warehouses, customers and time periods. This is because, while at the company the production and logistics plan is carried out according to the demand forecasts; in this model all the production, inventory and transportation costs are also considered alongside demand plans, and the optimum solution is arrived at from the perspective of minimum total cost.

6 CONCLUSION AND SCOPE FOR FUTURE WORK

The report presents production and inventory plans which aims at minimizing the total cost which comprises production, holding and transportation costs. A linear programming problem is modelled and an optimized solution arrived at. The model is built on the dimensions of 3 levels of the supply chain, namely factories, warehouses and customers; and other dimensions of products and time periods. The model makes use of assumptions which have been previously listed, and which probably form the limitations of the model. This model has been created, keeping in mind products of a food and beverages company Nestle India Ltd., and the products are perishable and come with an expiry period. So in order to give the model a more realistic form, the expiry of the goods and the cost of expiry (loss or disposal cost) can also be considered. Moreover, another improvement can be made in which the discounting of near-expiry periods so as to prevent expiry and the cost of doing so is also considered.

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