A SOLUTION FOR MULTI-ITEM DEMAND

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Abstract: Forecasting the demand is one of the most important challenges for every organization. A good forecast of demand can help companies to know how to assign their resources to satisfy the future demand. It also helps companies with multi products in inventory management and production planning regarding to the demand of each item. This paper is trying to forecast the annual detailed demand for a list of items when the aggregated demand of all of them together is fairly constant and known, but the demand of the items is unknown. It analyzes the customer behaviors in order to find a pattern to make the companies able to forecast the detailed demand for all the items with aggregated known demand.

Keywords: Multi-Item, Demand, Pattern, Inventory.

Introduction: Demand forecasting provides critical input to support the decisions of capacity planning and the associated capital investments for capacity expansion that require long lead-time [1]. This paper proposes a simple numerical method applicable for determining the demand for different products which is easy to understand and effective in practice and may match so many cases.

Considering forecasting methods proposed in a lot of papers, we can surely express that there is no best forecasting method. There are cases when a company or a service producer is producing a list of products, such as cheese, bread, milk, food (restaurants), journals (publications), and so on, and the customers might choose at each time one of the products of the company. We are trying to find the detailed demand of company's product list when the demand for all of the products, aggregately, is known and the company has its specific customers.

The reminder of this paper is organized as follows; Literature review, and then we study the methodology which is confirmed by a numeric example. It ends with conclusion.

Literature review: We can forecast the demand or wait for the demand; in the make-to-order scenario, a manufacturer sets the production quantity after observing the actual demand; in the make-to-stock scenario, a manufacturer sets the production quantity before the demand is realized [2]. Pure waiting for the demand is just applicable for very specific cases and mostly a level of demand forecasting is prerequisite for any business. Demand might follow a seasonal pattern. If the demandis seasonal, and if we can estimate the total demand, it is not a difficult process to compute the demand for the seasons separately (see [3], and also [4]) however in this paper we do not deal with that situation and simply we assume it constant. Forecasting the demand in previous researches are usually done by various ways from simple forecasting approaches such as Naïve approach or moving averages approach (see [5], and specially [6]) to exponential smoothing [7] and associative models [8]. There have been so many efforts to forecast the multi item future sales by applying different methods (such as [7])

Methodology: This methodology can be used by vendors or sales department. Sometimes we can estimate the total demand forecast, but disaggregating that demand to find the detailed demand of multi items could be difficult. This paper deals with this situation. It can be applied when the customers are distinctive, products don't have a short life time, and the list of the products is not changing.

Knowing the demand is perquisite for most of inventory models and capacity planning. For managing any businesses successfully, we need to have the demand or forecast the demand with a good level of accuracy. We assume the customers are buying the products regularly. Every company (or vendor) has a list of products which can include one or more products. For making it more general let's say the company has changed its list of products by entering some new products or removing some of its previous products and next day (or next period) is the first period with the new list. In this method we need initial customers' orders or demands. If it were not possible to have it, we would have to wait for it and then we can start. This methodology is able to forecast the part of demand which is for those customers who are buying the products regularly.

First thing that we need to do is doing a survey in finding out how customers will move from one product to another product. This can be referenced to comprehensive studies on customer behaviors. There is a probability that a customer who buys product A,next time again buys product A as well as they may prefer to buy one of the other products. There are a lot of factors in customers' mind which make them decide about their next purchases, and just some of them are known. It is quite difficult to find out about all of the factors and even customers may not be able to define. In fact it is an outcome of some known and unknown factors. Therefore we prefer to concentrate on the outcome of those factors. Based on historical data, making some interviews, doing a survey or some other ways perhaps we will be able to realize that a customer who buys product B, next time will buy again product B with probability of P_{BB} or will change his/her next purchase to product A, C, or D with probability of P_{BA}, P_{BC}, P_{BD}. We assume that the initial demands for the products of the company which are A, B, C… are determined and presented as d_A, d_B, d_C …. We can present this information in two matrices.

$$d_1 = [d_A \quad d_B \quad d_C \quad .. \quad ..] \quad Matrix\ I$$

$$D_P = \begin{bmatrix} P_{AA} & P_{AB} & P_{AC} & .. & .. \\ P_{BA} & P_{BB} & P_{BC} & .. & .. \\ P_{CA} & P_{CA} & P_{CA} & .. & .. \\ \vdots & \vdots & \vdots & & .. \\ \vdots & \vdots & \vdots & & .. \end{bmatrix} \quad Matrix\ II$$

That is expectable that if we multiply d_1 by the probabilities matrix (D_P), we will have the demand for d_2 which will be the next period demand and we can continue:

$d_2 = d_1 \times D_P$,

$d_3 = d_2 \times D_P$Equation I

$d_n = d_{n-1} \times D_P$,$d_3 = (d_1 \times D_P) \times D_P$,

d_3 =$d_1 \times D_P^2$$\boldsymbol{d_n}$=$\boldsymbol{d_1} \times \boldsymbol{D_P^{n-1}}$Equation II

By this process, as we will see in the illustrative example, we can compute the demand of each product for next periods until a new product enters or a product removes from the products list. There might be some cases in which we need to move needed inventories for some production lines periodically from main warehouse to their own warehouses near to their production lines. In those cases, we can do as below; considering the demand for each product, we can find the needed quantity or amount for the inventories. When we have d_i computed, we have the demand for products A, B, C… in period i. Since we can find how much of each inventory is used in making one unit of A, B, C and so on, we can find the needed inventory for period i to match the d_i . Then by a simple summation, we can have weekly, monthly (or any limited period) needed amount of inventories which could be placed in small warehouses near to each A, B, C… production lines for meeting the d_is for that period. (D_P , after a few times multiplying by itself, usually gets convergence to specific matrix which we can take numerous advantages from this obtained pattern. It is obvious that even when the matrix has reached the convergence and demand pattern is known (products are ordered proportional), the customers are still changing their selected products in each time purchasing, but what we see is the pattern of consumption which is very beneficial.

An Illustrative Example: Our company has changed some of its product and now the product list includes product A, B, C, D, E, and F. It has been forecasted that the sales for the products aggregately will be 2000 units daily. The customers will be ordering or buying daily. The aim is finding the detailed demand of each product. Imagine the result of a survey shows that a customer who buys product A will again buy product A in the next purchase with 55.3 percent, but they might change from A to B, C, D, E, or F with 8.4, 12.5, 0.0, 8.8, and 15. So there is always a chance, that the customers buywho buys A, buy any other product except E in their next time. We can find these percentages for all the other products, considering what customer will buy next time after buying each product. These probabilities are presented in table I. We need to start from somewhere (the initial point). Let say that our customers first set of orders is a mixture of demands for the products (presented at table II). We can say if we multiply a matrix created from the initial demand of the products (table II) by a matrix formed fromfirst column of table I and compute their summation, we will have the probable demand for product A in next period. Therefore, when we do this for all of its six columns, we will have the demand for all of them. For that purpose, we can define two matrices. One row matrix is acquired from table II (Matrix III) and a 6 by 6 matrix from table I (Matrix IV) and multiplication of these two matrices which is the presented Matrix V.

$$d_1 = [886 \quad 53 \quad 667 \quad 259 \quad 113 \quad 22]$$
$$Matrix\ III$$

$$D_P = \begin{bmatrix} 0.533 & 0.084 & 0.125 & 0 & 0.088 & 0.15 \\ 0.132 & 0.701 & 0.032 & 0.023 & 0.095 & 0.017 \\ 0.002 & 0.045 & 0.65 & 0.082 & 0.149 & 0.072 \\ 0.017 & 0.103 & 0.028 & 0.732 & 0.021 & 0.099 \\ 0.031 & 0.015 & 0.028 & 0.164 & 0.48 & 0.282 \\ 0.095 & 0.027 & 0.004 & 0.043 & 0.007 & 0.824 \end{bmatrix}$$
$$Matrix\ IV$$

$$d_2 = d_1 \times D_P$$
$$= [509 \quad 171 \quad 557 \quad 265 \quad 243 \quad 258]$$
$$Matrix\ V$$

Every step in this method is built on the previous step, so for finding next demand, we need to multiply the resulted matrix (d_2) by the probabilities matrix(D_P). If we continue this for 7 steps, the demand will be as Table IIIfor next 7 periods. Now, if we compare the demands for these periods, we can see that the differences between the demands in different periods reduce gradually. This is what we expected; by passing the time, we have to multiply the D_p matrix by itself, again and again, which after a while the tendency of the matrix in forming a specific patternwill be observed. Purchasing finds its pattern and makes a new matrix. We can see that the products are ordered with a determined proportion in compare to each other while the customers are still changing from one product to another product based on D_p.

There might be some factories which change their products weekly or monthly! For those cases, it is difficult to implement this methodology, but if the company keeps on producing the same products, we will be able to compute the annual demand for all the items provided that the aggregate demand is determined. As it is observed in the above data, soon the customer demand will find its pattern. That pattern is presented in table IV.

Conclusion: Although there have been so many researches on determining the demand, this paper deals with finding the detailed demand for multi-item sales when the total demand is acquired from other methods in other researches or it is known. The proposed approach works properly when the products are not in growth or decline part of their life and the customers are mostly the same. The accuracy of this methodology is directly related to the accuracy of the results of our customer behaviors study entered into demand pattern matrix (D_P).

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Table 1:

	Product A	Product B	Product C	Product D	Product E	Product F
A	0.553	0.084	0.125	0	0.088	0.15
B	0.132	0.701	0.032	0.023	0.095	0.017
C	0.002	0.045	0.65	0.082	0.149	0.072
D	0.017	0.103	0.028	0.732	0.021	0.099
E	0.031	0.015	0.028	0.164	0.48	0.282
F	0.095	0.027	0.004	0.043	0.007	0.824

Table II; orders for the first day

	A	B	C	D	E	F
Demand	886	53	667	259	113	22

Table III; demands for each product in next 7 periods						
	Product A	Product B	Product C	Product D	Product E	Product F
Period 1	886	53	667	259	113	22
Period 2	508	171	557	265	242	257
Period 3	341	225	446	294	267	426
Period 4	273	252	357	319	255	543
Period 5	250	267	293	334	234	622
Period 6	246	276	248	340	215	675
Period 7	250	282	219	340	200	710

Table IV						
	Product A	Product B	Product C	Product D	Product E	Product F
Daily demand	276.0466	288.9653	172.3618	308.2639	171.8782	782.4842
Yearly demand	100758	105473	62913	112517	62736	285607

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