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Trade-Off Between Keeping Finished Product Storage and Programming Make-To-Order Production

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1. Introduction

The problems of storage management of raw material, processing material and finished product are well-known (Meredith and Shafer, 2007; Nahmias, 2004). In this environment, the storage of finished product ends up being highlighted with an interface between two conflicting logics: the production logics and the sales logics. In the production area the aspects of the use optimization of production means are a key factor, since for the sales area the demand compliance in time and quantity by the customer is an important feature.

Krajewski and Ritzman (2006) explain that the challenge of foreseeing the customer demand is found in the root of most business decisions. All over the organization there are forecasts of many distinct variables of future demand like competitor strategy, regulation changes, technological changes, processing times, suppliers' delivery deadlines and quality losses. The tools to accomplish these forecasts are basically the ones used for sales demand: judgement, knowledgeable people's opinions, averages of past experiences, regression and techniques of time series. Using them, the forecasting performance may be improved, but they are hardly ever perfect. The recognition of this reality and the search for ways of updating them, when the unavoidable forecasting mistake or unexpected event happens, are the managers' role.

This text presents a situation studied in a chemical company, where the problem reported was the high level of finished product storage and the frequent lack of product to meet the order. In the study done at the company we evidenced that the short term compliance policy, together with the wide product portfolio and their variable demands generated a number of conflicts between the production and the sales areas which drove to the situation found.

2. Methodology

In spite of the wide set of techniques and models developed to deal with the aspects of demand versus production, we see in certain cases that the forecasting process hardly ever meets the characteristics of real demand behavior (HESTON and SADKA, 2006). This creates an intense communication between the production and the sales areas to produce what is being sold and minimize the production of what does not have demand. This process ends up reducing the efficiency of demand forecasting methods a lot. This process of communication must exist as a growing way in the solution of unavoidable demand forecasting failures, but in many cases it becomes a conflicting point according to different logics of the areas involved (Gopal and Mcmillian, 2005).

Slack and Lewis (2003), when they analyze the operations strategy, define it as a strategic reconcilement of market requirements with the operations resources. This definition already signals the need of a continuous process of negotiation between the production and the sales areas, even if in a long term view. Besides these aspects, the authors point out this negotiation is complicated by several "*trade-offs*" between the operations resources, the market requirements and themselves (figure 1).

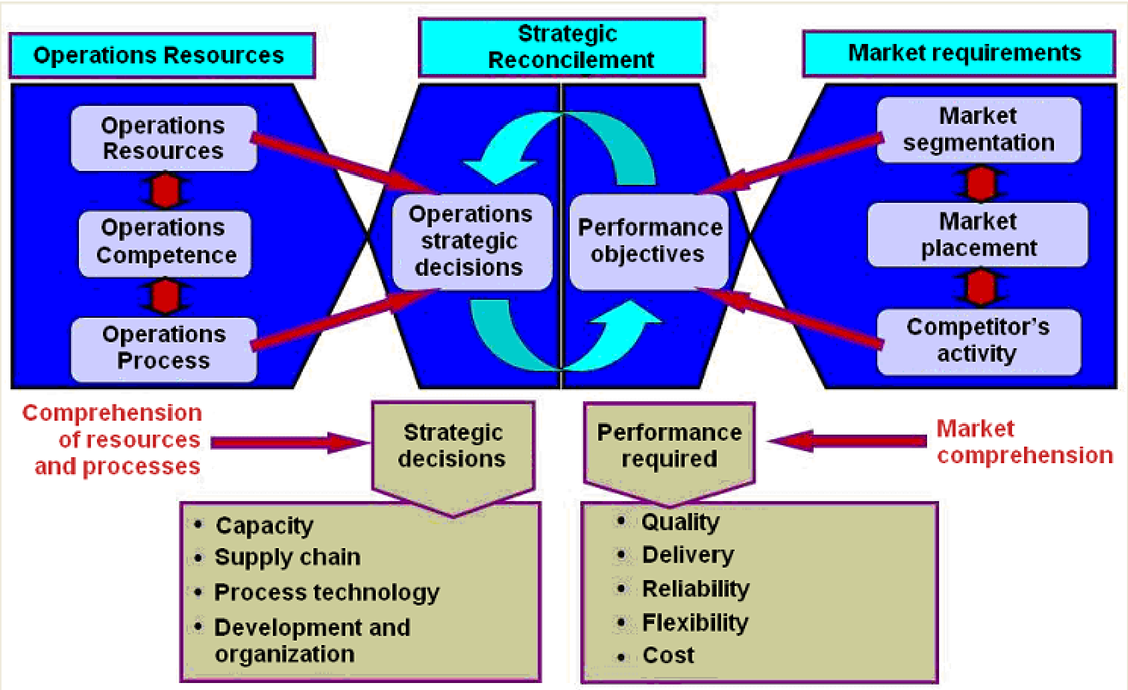


Figure 1: Chart of factors related to the operations strategy (SLACK and LEWIS, 2003).

In the search to deal with the aspects of demand versus production to work which storage strategy to be adopted, Ballou (2006) lists 27 forecasting techniques and classifies them in three categories: quantitative, of historical projection and causal ones. Despite the large quantity, the author states that unless there is need to develop specific long term forecasts, the logistics professional is limited to the short term forecasts which help in the storage control, shipment programming, warehouse load planning and similar. This short term characteristic, still according to the author, limits the techniques which can be used, since studies demonstrate that simpler techniques of the time variety make as good or better forecasts than more sophisticated and complex versions.

For irregular, highly uncertain and dynamic demands, arisen from factors like promotions, few buyers getting large sums, seasonal or cyclic purchases, among others, they represent a very special problem. In this context the collaborative forecasting, done with multiple participants, tends to produce closer forecasts than just one alone or only by one of the former techniques. This method is a complex process and inherently unsteady, since the forecasting always tends to come back to the situation in which one of the members makes individual forecasts. However, this process, being well conducted, brings, besides the benefits of the best forecast, the ones of the improvement of inter-functional and inter-organizational communications which can justify the additional effort required (Ballou, 2006).

The analysis done by Zan and Sellitto (2007) of three demand forecasting techniques shows how the adequacy of a technique is strongly influenced by the product sale behavior and unexpected factors, what ends up making this relationship complex in which the product portfolio is high as the case of the company studied in this article.

In another work, Lemos (2006) makes out a methodology of demand forecasting method selection in different situations, but the method was illustrated in two case studies. A study investigated the case of products with regular demand and the other the scenery of a new product launching.

3. Case study

The company studied produces a variety of products for use in the construction work in finishing processes like aggregating for setting coating and impermeables or seals. The customers are mainly hardware stores. It has a product portfolio grouped in 12 families, with a mix of products of 250 different items, assorted by purpose (aggregating or impermeables), by trademark (fancy name of the products) and appearance way (kinds of containers from small packages of 1 kg for some products up to 200 kg for others).

Being an industry of the chemical sector, the production is driven mainly to batches, but it can be discrete according to the product family. The production is stored in pallets, but some products are stored in bulk. There are also products which may be used as inputs for the production of other products. The sales are done at whole, retail and can be fractionated. The products are sent from two distribution places. One located at the plant and another distribution center located in a large urban center 500 km far.

The history of sales dispatch from 2006 and 2007 was analyzed. The analysis was done taking into account logistic performance indicators and demand forecasting methods.

From the set of logistic performance indicators listed by TigerLog (2008) and based in the works of Bowersox et al (2002), Hijjar et al (2005) and Julianelli (2006), the analysis was guided by some external indicators of logistic performance. The profile of the sales orders was analyzed as to the delivery time, service deadline and service completeness.

Table1 shows the results of the historical survey performed in an aggregated way and with side view at orders complied completely in one dispatch date. This side view was due to its representativeness (97% of the orders complied) and for the fact that the orders complied in a fractionated way occurred according to specific products. In the analyses done by family and by product the side view happened in a similar way, but analyzing the orders crossing off the information which did not belong to the analysis, that is to say, disregarding the order records which belonged to product family or analyzed product.

An analysis of compliance profile makes us notice the policy of short term compliance which, combined with the product portfolio and the variable demand, had generated conflicts between the sales and production areas.

Table 1: Profile of sale orders compliance – period 2006/2007.

Performance Indicator	Description
Compliance completeness	•97% of the orders were complied in only one dispatch date.
Deadline (*)	•83% of the orders had between 0 and 4 days of deadline. •49% of the orders had between 0 and 1 day of deadline.
Delay in the delivery (*)	•89% of the orders had delay between 0 and 4 days. •73% of the orders had delay between 0 and 1 day.

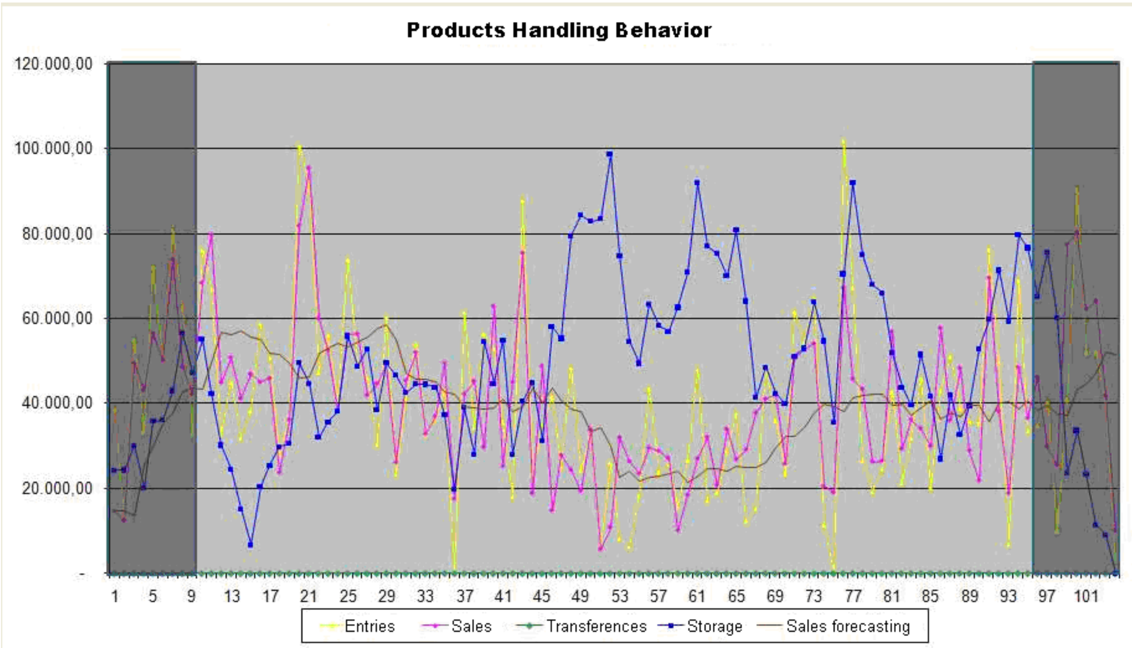
(*) Calculated over the the total of orders complied in only one dispatch date.

The solution adopted by the production area to minimize the conflict was the raise of storage level of finished products. Fact which ended up creating another problem, that was the lack of storing room and discontinued products.

The occupation of lot storing room was estimated from the production lots identified in all sale dispatches. With this information the lot size was estimated as being the sum of all sale dispatches of the same lot and the date of its availability in the storage as being the same as the date of the first dispatch of that lot identification.

In Figures 2 and 3 we can notice the behavior of weekly handling of two product families, identifying the entries (production), sales (dispatch), storage (balance) and sales forecasting used (moving average n=9). These two families correspond to 60% of the billing among the 12 families analyzed. The storage curve, the way it was gotten, represents a condition when the storage was least for the production accomplished. If the lot production date happens before the dispatch of its first fraction, the volume in storage tends to be larger than it is observed in the graph.

The handlings represented here show how the demands of these families are irregular and without significant trends. This way, as reported by Ballou (2006), the collaborative forecasting methodology started to be considered as the most appropriate for the company environment.



Weeks of production

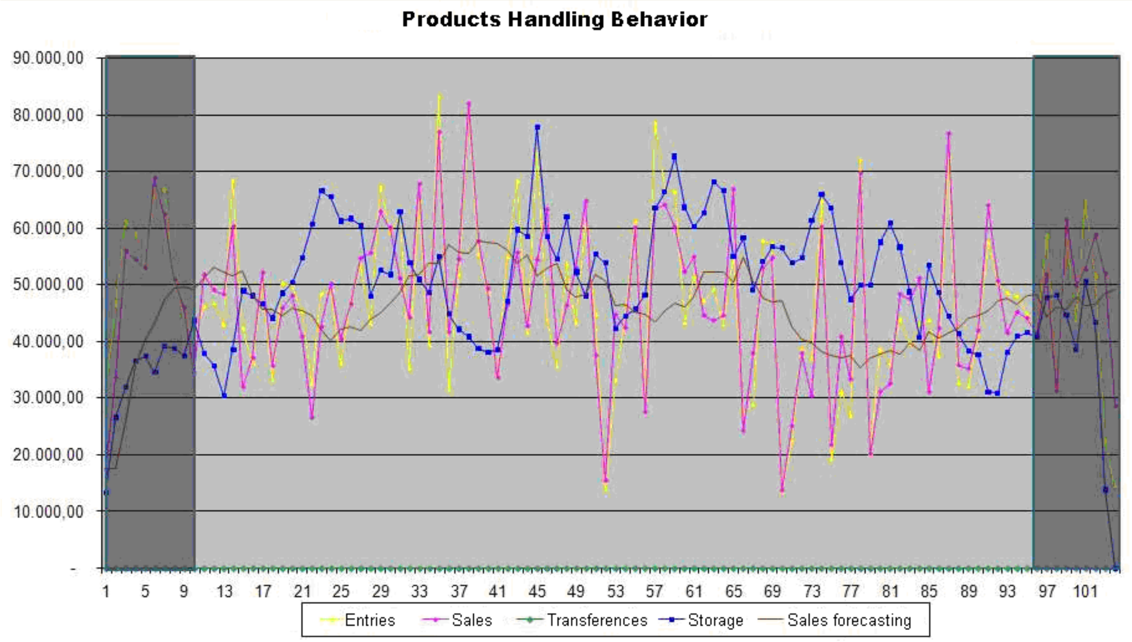
Figure 2: Behavior of product handling of family B.

To support this collaborative forecasting process, from the meetings between the areas involved, they implemented an information system which facilitated the determination of the forecasted demand. This instrument was a panel where, for a certain product selected, historical data and future demand already programmed are presented.

Like historical data, information of former weeks is presented about: the week sales, order portfolio with delivery in the week, week demand forecasting, relationship among order portfolio / accomplished sale and demand forecasting / accomplished sale.

Like future demand, the volume of order portfolio for a week +1, the week +2 and over or equal to 3 weeks is presented. This information brings to light the demand already committed for the next two weeks and the one already confirmed for further.

Besides this information the instrument requests two parameters: security storage level and collaborative factor. The security storage level was established according to the production capacity for scheduling all the products of the portfolio for production within the weekly period, allowing with this a gap for the production to set production orders within the most appropriate sequence.



Picture 3: Behavior of product handling of family H.

The collaborative factor (Cf) is indeed an adjusting factor of the forecasting according to the information and discussion together with the areas involved about the sales forecasting for the following week. The instrument presents the forecasting based in the established rule (P1) and this value is discussed together with the areas involved to check its closeness to the sales area reality (perspective of sales deal), with the existing storage level and with the production area reality (capacity of scheduling the production orders). This factor generates a forecasting displacement, in normal situations, for a value closer than it will be accomplished (P2) (Figure 4).

$$P2 = Cf * P1 \tag{1}$$

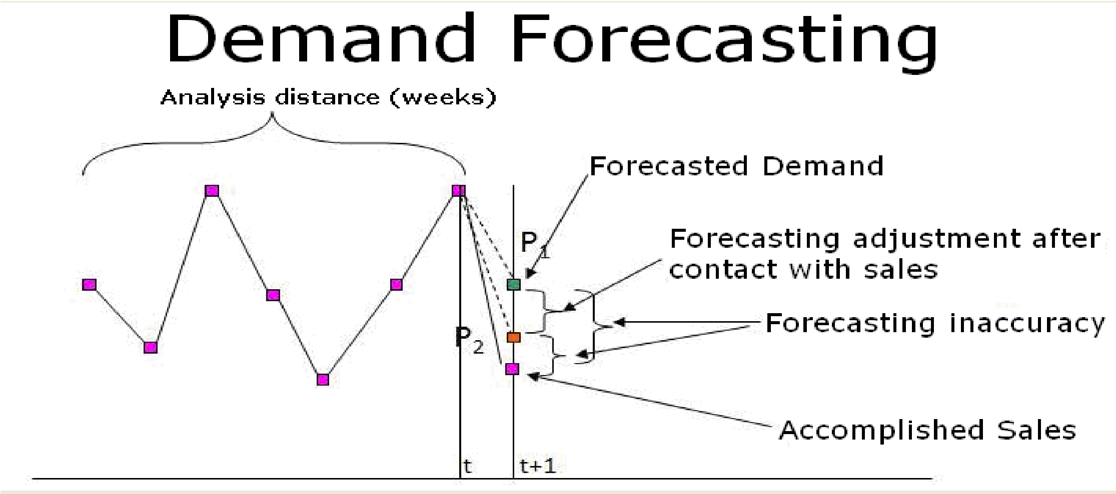


Figure 4: Influence of the collaborative factor of forecasting adjustment.

The question of scheduling the production orders was a problem evidenced due to the size of the product portfolio of the company. Figure 5 shows the distribution of the number of items traded monthly per family within the period of 2 years. This representation shows the dimension of the product portfolio which, combined with the profile of sales performed, enables to glimpse the trouble found by the production area in meeting the delivery policy at short term.

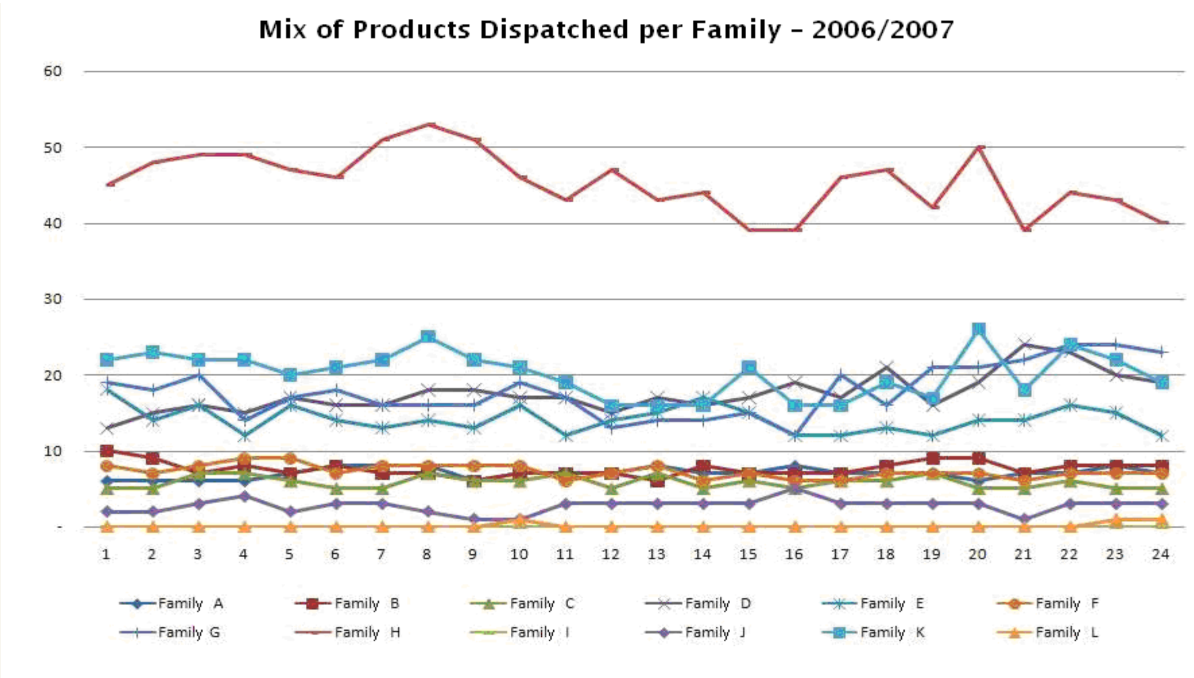


Figure 5: Quantity of products dispatched per family in the period 2006/2007.

The creation of the demand forecasting collaborative space also enabled the identification of aspects which appeared among the participants during the debates, as being the ones which created storage failures. To focus the discussions essencially in the demand forecasting, these aspects were identified as storage performance inhibiting factors, that is to say, factors that drive to the lack or generation of finished product storage. In this discussion these factors and their variables were characterized as internal-external and natural-controllable. Internal-external concerns the condition of this factor being dependent only or not on the company's decision. Natural-controllable concerns the condition of this factor being characteristic of the process or having possibility of being controlled.

The discussion about these factors was to establish the search for the ideal condition, i.e. to be considered internal and controllable. This way, each of the factors identified was firstly classified according to the participants' feeling of the areas involved and a commitment was established to search for the ways of conducting those factors which were found in the natural and/or external situation for the internal and/or controllable situation (Table 2).

Table 2: Classification of inhibiting factors of storage performance.

FACTOR	VARIABLES	Internal External	Natural Controlable
Least production lot	-Lot size – costs -Lot size – process		
Mix of products per group	-Quantity of SKUs (variety in graph ABC) -Discontinuity of SKU		
Transference Lençóis – Tamboré	-Freight use – Load composition (variety, volume) -Sales service (frequency x variety) -Loading and Unloading times		
Order Compliance at zero deadline	-Quantity of products (variety) -Sales forecasting (demand)		
Procedures of Production programming	-Calculus model .comply Sales .batch .lot .work team .shifts .process balancing		
Capacity of Installed Production	-Flexibility -Batch size		

Conclusions

Some of these factors were discussed and presented to the group composed by members of production and sales in a way to identify in which area this factor had its origin and its condition of mitigation. The building of simulations of sceneries of demand compliance levels and the history of storage levels showed the work complexity of each area and their limitations in dealing with these factors, enabling a better understanding by the areas involved in the whole process and not only in their part.

Based in a reduced set of inhibiting factors of the finished product storage performance, a set of tools and procedures was instrumentalized for the communication improvement and integration between the production and sales areas which enabled forecasting closer to the real short term demand, special treatment of product leftovers according to the production lot sizes, an integration room and a joined decision about what and how much to produce.

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