Quantifying shelf-out-of-stock in fashion & apparel retail stores

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Abstract: Failures occurring in each logistic chain node inevitably affect products availability in storage and distribution points, leading to stock-outs and subsequent customer dissatisfaction. Dealing with retailers which sell to final consumers, the economic estimation of the Shelf Out-of-Stock (OOS) loss is notoriously challenging. Moreover, in fashion and apparel stores, it is even difficult to estimate the size of OOS: due to the fickleness of the shopper, a OOS condition may even not lead to a lost sale. This paper focuses on the verification of the occurrence of out-of-stock events in fashion stores, aiming to get a quantitative evaluation of the potential lost sales through the analysis of the number of days of products unavailability. The number of OOS events due to early stock depletion will be consequently calculated, along with their consequences. The proposed procedure has been validated on real data of an important Italian fashion company.

Keywords: Shelf-out-of-stock; Lost sales; Inventory Management

1. Introduction

The theme of the shelf out-of-stock is increasingly topical among companies that consider customer satisfaction the main objective of their business and are oriented to offer the consumer "the right product in the right place and at the right time".

Out-of-stock (OOS) events have a significantly negative effect on company's revenues, therefore, to increase business profitability, it is crucial to quantify this phenomenon and the relative lost sales.

Many authors have stressed that OOS phenomenon in retail stores is the direct symptom of the failures of some supply processes, such as incorrect estimation of demand, inefficient distribution of products between different stores, incorrect replenishment criteria, etc.

In the greatest part of retail business, the only available information on customer demand derives from sales data: when a product is out-of-stock then, there is usually no awareness of the entity of the potential lost sales. This generates a problem in demand forecasting, which should be the starting point for all operations planning, and plays a key role in supporting the achievement of company's strategic targets (Moon, Mentzer, Smith, & Garver, 1998).

Several literature examples, referring to shelf out-of-stock events, mainly focus on illustrating the consumers' reactions and behavior (Campo, Gijsbrechts, & Nisol, 2000; Emmelhainz, Emmelhainz, & Stock, 1991; Papakiriakopoulos et al. 2008). Indeed, customer satisfaction is a key parameter to increase consumer loyalty towards the brand, specifically in fashion and apparel industry: Campo, Gijsbrechts, & Nisol (2003) estimated the costs incurred by the retailer and the supplier according to the various reactions that consumers may have when facing an out-of-stock situation. Surveys in international large-scale retail trade have estimated that the impact of OOS phenomenon averages 8.3% as a percentage of the total number of sold items (Gruen, Corsten, & Bharadwaj, 2002). Emmelhainz et al. (1991); moreover, it has been shown that retailers lose up to 14% of customers due to product out-of-stock when, in turn, a brand manufacturer may lose more than 50%.

To approach the above mentioned issues, this paper aims to quantify customer service level in a fashion & apparel retail store and to estimate the entity of out-of-stock events, trying to quantitatively evaluate the related potential lost revenues.

Following an inventory management theory approach, sales data of selected products in selected stores have been analysed to point out the stock-out-periods; lost revenues for each product in each store have then been computed using sales average and standard deviation.

The discussion will primarily focus on the major causes and consequences of out-of-stock events in retail stores, and will then concentrate on implementing an effective method for OOS quantification. It is thus described the procedure to identify and select appropriate products and stores to be analysed together with the criterion to compute shelf out-of-stock days and the out-of-stock items number due to an early depletion of the refurbishment lot: the proposed approach has been validated on an important Italian fashion company with 160+ stores in Italy.

2. The Shelf Out-Of-Stock problem

The expression *shelf out-of-stock* describes the situation where a consumer cannot buy the desired product from stores shelves because it is sold out. The major variables that can affect product availability in the stores and that

can be the cause of out-of-stock have been pointed out by several authors in literature (see Papakiriakopoulos, Pramatari, & Doukidis, 2008):

Variables related to OOS	References
Sales velocity	(Anupindi, Dada, & Gupta, 1998)
Inventory level	(Clark & Lee, 2000; Downs, Metters, & Semple, 2001)
Promotional product	(Gruen, Corsten, & Bharadwaj, 2002)
Store size	(Gruen, Corsten, & Bharadwaj, 2002)
Seasonality	(Metters, 1998)
Stock centralization	(Cetinkaya & Lee, 2000; Nahmias & Smith, 1994)

Table 1: Variables related to the OOS problem

2.1 The major causes of out-of-stock

The above variables can bring, together with other issues linked to supply chain management, the depletion of on-shelf-product, hence customer dissatisfaction and an increasing probability of incurring into lost sales.

Many companies in recent years are giving increasing importance to consumers and to their level of satisfaction; this derives, with no doubt, from the availability of products that want to buy in the stores.

Products on-shelf-availability depends on several factors, among which we can identify:

- assortment: the necessary quantities should be available for sale, directly on the shelf, at the right time, i.e. when the customer wants to buy them;
- products display: the exhibition space dedicated to the product should be congruent with the desired sales volume;
- stock list accuracy: the stock list recorded in the information systems or in accountancy should correspond to the physical products availability;
- sales forecasts: forecasts of sales should be accurate, reliable and related to the promotional process;
- order process: the amount of product needed in a certain period in a given store (sales forecast or refurbishment requirements) should be promptly reported in order to guarantee a timely delivery to that store;
- availability at the supplier premises: product to be refurbished in the stores should be available in the supplier warehouse or, eventually, in the upstream supply chain;
- delivery process: the ordered quantities should be delivered to the store at the appropriate time, not before (store warehouses may be too small) nor after (which cause OOS).

Unfortunately, inefficiencies and lack of coordination between supply chain actors are often present, generating delayed deliveries and shelf-out-of-stock problem in the stores.

2.2 The consumers answer to an OOS

In literature, up to 15 possible solutions for a consumer forced to face an out-of-stock situation have been classified; however, usually only the top five are considered (Gruen, Corsten, & Bharadwaj, 2002):

- purchase the item in another store;
- delay the purchase (from the same shop);
- replace the item with another one of the same brand;
- replace the item with another item belonging to a different brand;
- not purchase the item at all.

Possible different behaviors adopted by consumers dealing with an out-of-stock situation were also studied by Fitzsimons (2000), who shows the response in terms of consumer satisfaction and also in terms of choice behavior. Results suggest that consumers response to an out-of-stock situation is driven mainly by two factors: the difficulty of making an alternative choice and how important that particular out-of-stock item is for the customer: the more consumers are tied to the product, the more difficult it will be for them to make an alternative choice.

Moreover, many studies show that an out-of-stock event is the most frequent cause of frustration for customers. The importance of ensuring a high availability of a product on the shelf is also underlined by researches (Drèze, Hoch, & Purk, 1994): they show that the total amount of money spent per visitor in a selling point is flexible and strongly depends on the number, on the presence and on the quantity of products available on the shelf.

2.3. Measuring an OOS

The simplest method to register OOS is pointing out any empty space on stores shelves: these empty spaces are clear indicators of un-replaced products. Obviously, such procedure should be periodically carried out in order to obtain more precise information about the OOS phenomenon. The more frequently the shelf is checked, the higher the measurement accuracy will be. Thus, many resources - in terms of personnel – should be involved to continuously inspect and check the shelves.

A second approach (European OOS Index - EOI) has been proposed by ECR Europe, after a joint effort of retailers and suppliers in the European grocery retail sector. ECR Europe is a joint trade and industry body, launched in 1994 to make the grocery and fast moving consumer goods sector as a whole more responsive to consumer demand and promote the removal of unnecessary costs from the supply chain. Considering only fast moving items with low sales volatility, the defined Index monitors daily sales of the corresponding products: if in a given day a product sells no items (or less than a predefined threshold), then it is considered an OOS.

A technology-based approach for automatic-detection of OOS is through the use of Radio-Frequency Identification (RFID) technology (Ngai, Cheng, Au, & Kee-Hung Lai, 2005). Using item-level RFID tags and multiple readers within the store, it would be possible to monitor every item's position, thus determining its availability. However, due to complex issues in item-tagging procedure, costs and responsibilities, it is expected that it will take many more years before item-level tagging is widely used by industry. Thus, this method won't be further analyzed in this paper.

3. The proposed approach

The paper proposes a new procedure to quantify the number of OOS days, and, consequently, to estimate lost sales for each product in the stores of fashion companies, operating in the clothing and women accessories industry.

To this extent, a *shelf out-of-stock condition* (OOS) occurs when a product is no longer available in a store (thus it is neither in the store warehouse nor on the shelves) and cannot be sold. Besides, a *lost-sale* arises when it is reasonable to expect a product sale (e.g. it is probable that a certain customer could ask for the specific product) while the product is OOS.

As a consequence, we do not consider a lost-sale if the product is OOS and, at the same time, it is not reasonable to expect a customer demand (i.e. the product is out-of-style or it has different seasonal characteristics). In order to determine if a product is requested from customers during a certain period of time, the following hypothesis was introduced: a lost sale for OOS may just occur between two successive replenishments so the quantification of OOS events occurred after the last assortment of a product has been ignored (see Figure 1).

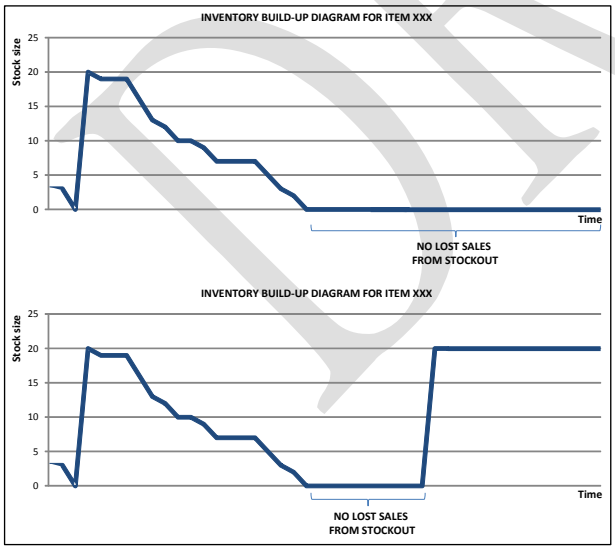

Figure 1: Example of not-OOS condition

This choice derives from the awareness that the distribution of products in retail may stick to marketing strategies which can be unrelated to logistic management; considering just the OOS occurred between two successive reorders, the depletion of a product before the next replenishment cannot be regarded as a strategic choice, but as a mere logistics inefficiency (see Figure 2).

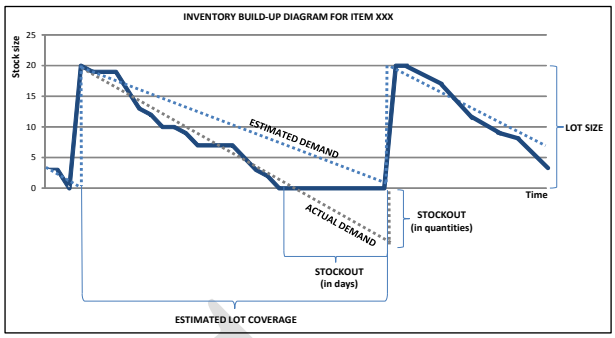

Figure 2: Example of an OOS condition

Figure 2 shows the recorded (actual) demand is steeper than the one estimated, causing the product depletion before the next replenishment; considering that the product was sold again after the replenishment, we assume that the OOS condition generated lost sales.

The procedure consists of analyzing the inventory build-up diagram per each product in each store, determining those products which inventory level reached zero and which, after the next replenishment, were sold again. Among these, only products with statistically significant data (in terms of sold quantities) were taken into account. Product by product, comparing the estimated lot coverage with the actual demand – recorded by the information system – the number of OOS days and quantities were computed multiplying the number of OOS days with the average sales in the same period (i.e. assuming the same demand pattern recorded in the days immediately before and after the OOS event).

It should be pointed out that using the average sale to estimate the OOS entity may not be appropriate when dealing with certain products with intermittent or lumpy demand pattern. Reliable results may be obtained with the proposed method when dealing with large-scale sales products while findings may not be considered surely reliable with high-cost slow movers items. Thus, two key factors need to be analyzed and compared per each product: mean (μ) and standard deviation (σ) of sales rate. The proposed procedure should only be applied with products with low coefficient of variation $c_v = \sigma / |\mu|$.

3.1. The procedure

The procedure is summarized in the following steps:

1) gather the data related to each replenishment policy for each item in each store, i.e. the replenishment lot, the expected demand per period, the replenishment frequency;

2) analyze the sales data for each product in each store (it would be preferable to collect the data in an information system) and filter those product which show a coefficient of variation of the sales in each store over a certain threshold. The threshold should be determined by the analyst according to the needs of the Company and the characteristics of the

assorted products: the higher the threshold, the higher the accuracy; the lower the threshold, the larger the number of analyzed products.

3) compute the inventory level for each product in each store;

4) determine the number of out-of-stock events and the number of out-of-stock days per each item in each store (referring to OOS event only if a customer demand is recorded after the next replenishment, as it has been previously explained);

5) compute the sales average in the period in which the OOS is recorded;

6) estimate the entity of lost sales by multiplying the number of days of out-of-stock computed at step 4) by the sales average computed at step 5);

7) eventually, proceed with the economical evaluation of the lost sales using the preferred accounting method (e.g. per each OOS unit, considering a loss equal to the marginal profit per product).

With regards to step n.4), the number of out-of-stock days for each code was computed considering the number of days when no stock was available between two successive replenishments. It is noticeable that this methodology was tested on stores assorted with apparel and women accessories, which generally follow specific rules of distribution depending on the type of product, on the season and on the fashion trend: thus, it was necessary to be careful not to consider situations in which the product was absent in the store because of strategic decisions coming from distribution planning level. For instance, at the beginning of the season, a certain product may not be present in the stores because its distribution has been specifically postponed; in this case, obviously no OOS should be recorded despite the product inventory level is zero. For this reason, in order to find out the number of OOS days occurred in a given period, the date of arrival and the date of the last sale for each product have been necessarily considered.

However, this approach leads to an underestimation of the actual number of out-of-stocks, both at the beginning of the product distribution period (a certain store may have experienced a delay in the first assortment delivery while other neighboring stores were already supplied, and this could have locally generated an unsatisfied customer demand) and at the end of the season (being no successive replenishment planned, the sudden stock depletion for a certain product was not considered as OOS).

4. Results from the validation on a industrial case

The analyzed fashion company manages 200+ stores selling an assortment of 50'000+ product of women apparel and accessories in Italy, with a total revenue of more than 60M€/Y. The sales in 137 stores were analyzed from 01/09/2009 to 31/12/2009 and 877 different products were selected (1,7%) among those which registered out-of-stocks and were characterized by a coefficient of variation less than 6. The total sales of these products were 7'227 units in the analyzed period, and the proposed procedure estimated lost sales for 2'075 units. Considering each OOS product sale's price, an overall amount of more than 200k€ sales revenues was detected, but a total revenue loss of more than 60k€ has also been estimated: this resulted in a potential revenue growth rate of 28,7%.

ITEMS IN STOCK OUT AND LOST SALES	
Number of days of the analyzed period	120
Total analyzed stores	137
Total analyzed items	51554
Total analyzed items with OOS	877
Total sales of analyzed OOS items	7227
Lost sales of analyzed OOS items	2075
Potential revenue growth rate (%)	28,7%

Table 2: Summary chart of lost sales

5. Conclusions and future research

The shelf out-of-stock phenomenon reflects all failures occurred in the supply chain, such as an incorrect prediction of the demand, an inefficient allocation of products between different stores of the same company or an incorrect replenishment system of stores caused by a non-logical distribution.

A good demand forecasting is the starting point through which all operations can be planned, and plays a key role in achieving the strategic objectives of a company and of the supply chain logistics as a whole (Moon, Mentzer, Smith, & Garver, 1998).

Despite this fact, the most common inventory management practice relies in predicting the demand for specific items just by studying past sales. If these items were always in stock and available for sale, then past sales and past demand would be the same thing: this event though, actually never happens, because items go out of stock from time to time, therefore causing the amount sold to be less than the amount demanded (Wecker, 1978).

As emphasized by Conrad (Conrad, 1977), it is important to distinguish between the number of sales and the demand of the market. Sales figures substantially reflect the quantity of a specific product sold in a particular period of time: the quantity sold is usually assimilated by most companies to the products demand. Nevertheless, the number of product sales is not equivalent to the products actual demand at all. To perform an accurate demand forecasting, with the aim of reducing out-of-stocks and consequently of increasing the customer service level, it is not enough to simply use historical data: what really matters is not just the amount of sold products, but also the actual amount of products demanded, because it automatically incorporates out-of-stock events. Analyzing only the number of sales, we would tend to underestimate the demand for products

gone out-of-stock, and we would also risk to have an overestimation of in-stock products demand, since customers would therefore tend to substitute the sold-out product with another in-store item (Conrad, 1977).

For these reasons, trying to overcome usual incorrect demand forecasting practices, this paper focused the attention both on the identification of the OOS days number and on the quantification of each product's lost sales in any store it was sold.

The test of the implemented methodology on a real fashion company case confirmed that OOS events have a negative effect on the volume of sales; therefore, the quantification of these events, and of their respective lost sales generated, is both crucial to increase the business profitability and to raise the quality of customer service.

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