THEORY OF INVENTORY MANAGEMENT BASED ON DEMAND FORECASTING

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Abstract: Efficient management of supply chains consists in particular in ensuring possibly highest quality of customer service and striving for minimization of the costs generated by flow between the links. Typical cause of constantly increasing costs is excessive inventory levels throughout the chain. The reason for this situation is maladjustment of the level of supply to the level of demand in the market, which results in surplus stock. The starting point for reduction in inventory levels is forecasting of demand in the market through market prognoses in cooperation with all the links in the supply chain. Therefore, in the aspect of demand forecasting, the character of data flow and the type of cooperation between the links is essential.

Keywords: dependent and independent inventory, demand forecasting

Introduction

Management of logistics chains plays a key role in the process of demand forecasting. The whole supply chain is subject to flow of both materials and information. Contemporary concept of supply chain management strives for cooperation in order to reduce inventory throughout the chain, whereas planning is carried out using the principle of continuity, dividing all the information required in order to control the processes of flow [5,9,12]. Fig. 1 presents one of the models of inventory management where the components of the chain work independently and information is transferred only at the level of adjacent links.
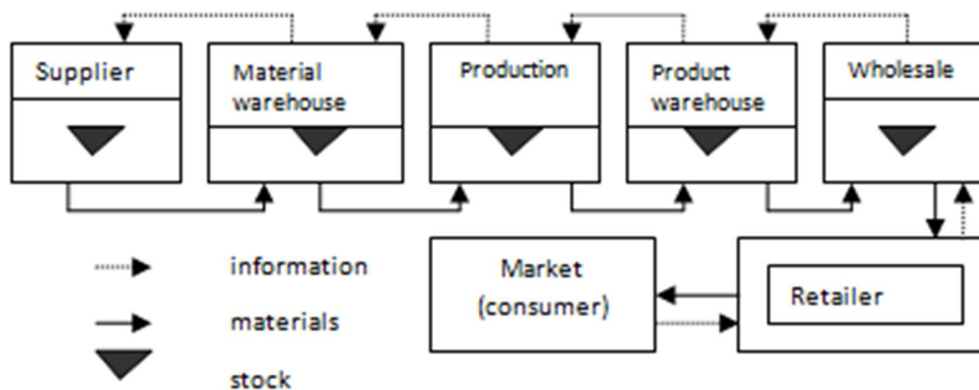

Figure 1. Streams in inventory management
Source: [10]

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The arrows in Fig. 1 point clearly to communication between individual chain links, which causes that information about the demand expressed in order size is subject to verification at the level of retailers. Then, the same level of demand is repeated, which is expressed in orders from other entities in the chain. Each link cares only for their own interests, being in close relationship with suppliers and customers. This behaviour leads to maintaining a particular level of inventory in each link, which is kept in a 'ready state' in order to satisfy customer needs at any moment [14]. Thus, a task of safety stock is to maintain a suitable level of customer service, whereas its independent building in each unit of the chain causes generation of surplus inventory throughout the logistics chain. Aiming at ensuring the highest standard of customer service, the companies must bear the costs of [17]:

- 'physical flow,
- warehousing,
- maintaining the stock,
- depletion of the stock.
- other costs.'

Accumulation of these costs causes considerable expenses to the company, particularly in the cases of 'artificially' high level of safety stock.

Each link in supply chain, starting from manufacturers, distributors, wholesalers or retailers strives for taking suitable measures at their levels towards forecasting of demand for their products. At the same time, each of the entities is guided by achievement of main goals of their activity, aimed at ensuring possibly highest customer service. At this stage, the questions arise of the limits of demand and chances to analyse the demand. The answer to these questions would allow for adjustment of companies' operation to actual demand.

Early demand forecasting allows for limitation of costs generated as a result of storage of excessive amount of unsold products [1]. It should be emphasized that the selected techniques of prediction are contained in the implemented advanced IT systems used for warehouse management. The enterprises which do not use these systems or use them only for limited areas, incur considerably higher costs of building inventory.

Types of Stock Essential to Demand Size According to their Origins

It seems proper during analysis of each stage of flow of materials and information and in consideration of maintaining safety stock in each link to define a limit within a logistics chain which signals key level of satisfying the demand with the stock. The location of maintaining main stock in the chain depends on a number of factors, including in particular [14]:

- 'sector,
- character the product,
- market environment (competitors, customers)'.

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One of the places where main inventory is collected is warehouse at retailer's place, which concerns especially the products of high demand that are sold on regular basis. Another example of these places is manufacturer's assembly warehouse, where the products are assembled only to order: main inventory will be generated in this place of the chain. This shows that key inventory might appear at any stage of the chain, depending on the above listed conditions. The point which separates links in the chain from those which collect main inventory is termed a separation point: it also demarcates the areas of independent and dependent demand [4, 15]

The former of the abovementioned areas is connected with ordering of materials which occurs as a result of demand for another products, processed by the same manufacturer (e.g. fuel pump being a part of a car which is manufactured by the given company). Independent demand does not concern the internal flow of materials, but it results from the demand in consumer market (e.g. the same pump targeted to external market as a spare part).

The required dependent demand is estimated based on constant calculations used in the given company, whereas independent demand is an effect of conducted market prognoses. This study focuses on this very demand. The division of the demand is graphically represented in Fig. 2.
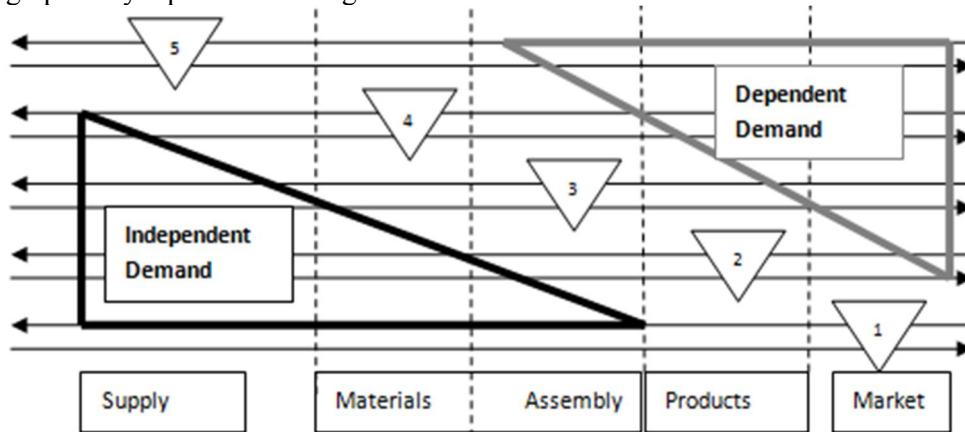

Figure 2. Dependent and independent demand
Source: [10]

Fig. 2 presents five opportunities of location of main inventory depending on the type of agreement between the entities in the chain and on manufactured products. Each case shows both advantages and disadvantages of these supply chains. [10]

Main inventory at first level is located in the area of consumer market (retail shops, wholesalers). The advantage of this configuration is immediate response to consumer needs, minimal lead times through easy access to stock. Main disadvantage of this system is high costs of collecting the stock.

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The second level contains key inventory in the end product warehouse at the manufacturer's or main warehouse in sales company. The disadvantage of this solution is that reduction in costs of storage and handling stock means elongated lead times, which, in consequence, results in deterioration of the quality of customer service.

Third level represents assembly warehouse as a point of storage of main inventory. This location is used for storage of only parts and subassemblies which are assembled to order. Compared to previous levels, the level of inventory is considerably reduced, which is also conducive to reduction in the cost of collecting and transport of stock. The drawback of this solution is elongated time of customer service.

Main stock at the fourth level is collected in the materials and raw materials warehouses. Analogically, the level and the costs of inventory are reduced, with elongated lead times.

The last, fifth level shifts the 'load' of collecting stock to suppliers of materials and raw materials, which is moved towards manufacturer only in the case of the demand signalled by distributors. Time of waiting for execution of orders is the longest in this case.

In terms of independent inventory management, its fundamental part is safety stock, which occurs at each stage of company's operation and plays a role of a buffer in case of unexpected change in order size. Its task is to ensure a suitable customer service level.

The most important factors in managing independent inventory include [10]:

− optimisation of fast-moving stock,

− proper definition of safety stock,

− reduction in excessive inventory.

Furthermore, in order to ensure proper customer service it is essential in the case of independent demand to point to 'ordering point' which determines a safe deadline for collecting the order without the risk of premature depletion of the inventory [16].

Suitable inventory management under conditions of demand forecasting should focus on proper customer service, control of current and future demand and minimization of costs connected with maintaining and replenishment of stock [12].

Process of Forecasting

Frequent changes and new events which occur in the market cause that current methods of prediction used individually or separately by each link in the supply chain are becoming insufficient due to huge deviations from the prepared forecast.

This method makes the entrepreneurs who plan production not totally sure that the prepared prognoses will come true at 100%. Eventually, entrepreneurs typically order from suppliers bigger amounts of goods than necessary, putting themselves at risk of building inventory and increased costs of storage.

The method for limitation of this phenomenon is not only to prepare a forecast but also to develop it so that it is possibly most precise. Moreover, not only deviation from average forecast is important but also use of different number and types of forecasts which, combined together, might ensure the demanded effect of elimination of excessive inventory.

Several traditional forecasting methods based on statistical series and developing techniques of prediction based on common forecast are currently in use. They will be discussed further in the study.

Commonly used combined statistical and mathematical techniques combined with innovative IT have opportunities to predict changing market phenomena with minimal error. These methods range from the simplest techniques for selected repeated phenomena to advanced methods which take into consideration a variety of market parameters.

Before characterization of the selected forecasting methods, one should emphasize the concept of forecast and the process of preparation of forecasts.

According to B. Guzik and other authors, forecast is 'a judgement which informs about occurrence of a certain phenomenon in a particular moment in the future (...) which is unknown at the moment of its formulation'[6]. M. Cieślak characterized forecast as a 'rational and scientific forecasting of future events'[3].

Forecasts are prepared according to the following scheme[2]:

- definition of the forecast phenomenon,
- collecting information,
- selection of suitable prognostic tools,
- preparation of forecast,
- assessment of the forecast.

Considerable importance during demand forecasting is from the level of the phenomenon in previous periods. Each delay, fluctuation or change will have effect on accuracy of the forecast prepared for the incoming period. Precise record of data concerning sales and taking into consideration the phenomena which occur in the environment decides about the quality of forecast.

Forecasts built on statistical series can take into consideration a uniformity of the series and changes which occur and their direction. Depending on the types of data, one can, in the case of constant level of data, emphasize naive models, moving average or exponential smoothing or, in the case of fluctuations and tendencies, models of time series containing a trend [3]. These methods are numbered among quantitative methods, commonly known and used in practice. However, in the case of demand forecasting they might turn out to be insufficient.

Another problem with inaccuracy of forecasts is approach of logistic managers to the issues of forecasting which is frequently treated as a necessity, exclusively as a transfer of information from a retailer to manufacturer rather than from the standpoint of costs in logistics chain. Thus it sometimes occurs that the forecasts do not match the reality, whereas striving for improvement of forecasts occurs slowly and ineffectively.

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In order to obtain possibly most precise forecast and to avoid excessive inventory, one should make use of advanced methods of forecasting, such as 'Collaborative Forecast, which satisfies the demand from the customer and the availability of raw material supply at the manufacturers' end' [18]. This forecast is prepared based on subjective assessment of supplier and customer and has the character of qualitative forecast. It takes into consideration use of typical statistical forecasts which are prepared based on historical data concerning sales by means of statistical methods from manufacturer. Conventional forecasts combined with Collaborative Forecast might ensure the highest level of accuracy of the forecast demand and reduce costs throughout supply chain. Utilization of a number of statistical methods at the same time might bring considerably better effects than in the case of a single forecast prepared by means of a selected method.

As a result of combination of several types of forecasts a composite forecasting is obtained [12]. Main goal of preparation of this forecast is using advantages of each of the solutions in order to obtain one, possibly best and the most accurate forecast. Therefore, this activities require taking into consideration at least two methods of preparation of forecasts and then calculation of weighted average so that the higher weights are assigned to more accurate types of forecasts. The generated weighted average of the prepared statistical forecasts and qualitative forecasts is termed a hybrid forecast [8].
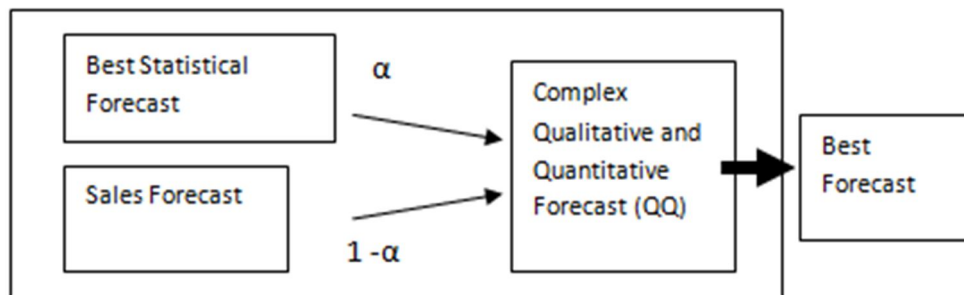

Figure 3. Process of selection of the best forecast
Source: [12]

Figure 3 presents last of the three stages in the process of preparation of hybrid forecast, which consists in calculating of weighted average for quantitative and qualitative forecast (QQ), which is a result of the most accurate statistical forecast and sales forecast selected at the first stage based on their errors.

In order for combined forecast to be credible for entrepreneurs, each component forecast must meet the following criteria [18]:

− each forecast must have a predefined time horizon and should concern possibly highest amount of resources for which future demand is calculated,

− each forecast must be prepared based on all the available methods,

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−use of the methods for preparation of forecasts does not have to impact on improvement in accuracy of forecast, but combining these methods increases the opportunities to obtain a more precise calculations.

The Essence of Assessment of Forecast Errors

The forecasts should be unconditionally subject to error measurement: firstly, due to the necessity to inform contractors within the supply chain about actual demand; secondly, in order to ensure improved management of risk connected with variable demand. Z. Hellwig takes into consideration forecast error and argues that it is 'a judgement whose reality of an event is a random event, whereas probability of this event is known and sufficiently high for practical applications' [7].

Error assessment is performed in order to assess and identify the areas for which they are untypical. This is aimed at focusing on only these resources which call for higher accuracy.

The following methods can be employed for assessment of the effects of forecasting [11]:

−comparison of the error of indirect forecast to the error of final forecast. Indirect forecast results from baseline forecast corrected with market analysis concerning changes in demand, marketing activities or strategies of competitive enterprises,

−comparison of the error of final forecast to the error of Naive forecast prepared by means of naive average method. The forecasts prepared by means of simple methods might turn out to be more efficient that final forecasts which resulted from a complex process of selection of a number of forecasting methods.

−separation of errors of final forecast depending on the locations in which they are exceptionally high or low. This procedure allows for separation of those areas of demand which call for preparation of even more accurate forecast. Moreover, this method forces comparison of errors of different forecasting methods, both quantitative and qualitative ones. As a result of high errors of forecasting, wrong calculations of future demand are made, although this level can be lower than in the case of not using the methods at all. The more advanced forecasting techniques, the lower probability of 'stock pile-up', i.e. better adjustment of production size to the needs of final customers. Measurement of deviation of forecast to its average has been the most reliable method for assessment of the quality of forecasting.

Summary

Poor communication between the links in supply chain and neglecting high errors of forecast is a frequent cause of growing costs throughout the chain, resulting from increasing inventory levels. In the environment of companies with global scope, collecting and synchronization of information distributed between suppliers and customers is frequently disturbed by communicational noise. This leads to obtaining incomplete or inaccurate data about future demand without taking into account current economic situation in the selected market.

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In order to optimize operation of supply chain, it seems essential to forecast the demand at the level of each link in the logistics chain. There are a variety of techniques and methods of quantitative and qualitative forecasting today. However, due to measurability and objective character of statistical methods, they are more frequently used in many companies which are natural participants of logistics chains. Subjective qualitative methods still bring up the rear of the methodologies of sales forecasting.

Apart from preparation of forecasts using a selected method, another problem is the quality of flow of information about the demand size. This information is transfer only between direct links in supply chain. This means that actual demand size for final customer will be known only to retailers and the adjacent links, e.g. wholesalers. Other participants obtain information about the demand indirectly. These two factors impact on inaccurate demand forecasting and prospective rise in the costs of inventory.

The solution can be combination of several methods of forecasting at the same time, using both quantitative and qualitative methods prepared at the level of cooperation between the links. Based on assessment of the errors of forecasts, one can assess possibly best forecasts in the studied logistics chain, whereas the effect of combination of the methods depends on the character of the chain.

Proper and cyclic assessment of consumer market and consumers' expectations is a key factor in planning of production size in companies. This assessment is typically made based on forecasts for final products. The more accurate demand forecasting, the more efficient decisions for the planned production, lower inventory levels and costs of maintaining inventory. Therefore, utilization of forecasting techniques in company's operation is economically justified and rational.

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TEORIA ZARZĄDZANIA ZAPASAMI BAZUJĄCA NA PROGNOZOWANIU POPYTU

Streszczenie: Efektywne zarządzanie łańcuchami dostaw polega przede wszystkim na zapewnieniu możliwie najwyższej jakości obsługi klienta oraz dążenie do minimalizacji kosztów generowanych przez przepływ pomiędzy jego ogniwami. Typowymi przyczynami stale rosnących kosztów jest nadmierny poziom zapasów w całym łańcuchu. Powodem takiej sytuacji jest niedostosowanie poziomu dostaw do poziomu popytu na rynku, co prowadzi do gromadzenia nadmiernych zapasów. Punktem wyjścia do obniżenia poziomu zapasów jest prognozowanie popytu na rynku poprzez prognozy rynku we współpracy z wszystkimi ogniwami łańcucha dostaw. Dlatego też w aspekcie prognozowania popytu istotne są, charakter przepływu danych jak i rodzaj współpracy między poszczególnymi ogniwami.

依据需求预测的库存管理理论

摘要：高效的供应链管理包括高质量的客户服务，努力减小流通成本。成本增加的典型原因是整个产业链库存水平提高。造成剩余库存的原因是供应水平与需求水平的失调。我们可以将根据市场供应链预测市场需求作为削减库存水平的起点。因此，在需求预测方面，数据流的特性及其相互之间的联系合作的类型是至关重要的。