A Proposal for Forecasting Highly Seasonal Products: The Unifrigo Gadus S.P.A Case Study

Andrea Eminente, Mosè Gallo, Teresa Murino and Giuseppe Naviglio

***Abstract*—**The aim of this paper is to identify the key products for the Unifrigo Gadus SpA turnover and to optimize the stock level in order to reduce costs and enhance efficiency. Unifrigo Gadus SpA is an Italian importer company of salted codfish which trades more than 60 different items. The output of the conducted Cross Analysis allowed to focus only on 17 products. The time series of the salted codfish sales shows a high seasonality. This makes hard the use of classic statistical methods of time series analysis. Hence, it was necessary to develop a new sales forecasting process combining a mathematical analysis and a subjective evaluation. The new sales forecasting process was tested with the 2011 data, and then utilized to forecast sales for 2012. In the end, fixed the required service level, it was possible to plan the supply orders for the whole year 2012.

***Keywords*—**food supply chain, inventory management, logistics, demand planning modeling.

I. Introduction

THE hard global economic environment the firms have to deal with, addresses an optimization study to the waste reduction. Stocks from being an important competitive weapon became rapidly a "problem" to get rid of. The food importers are a supply chain link embedded between two fires. On one side, the competition is based on the capacity to supply quickly the customers with the goods they need, on the other side, it is necessary a reduction of costs and immobilized capital in order to be competitive with the prices. The global logistic evolution and the possibility for every dealer to buy the goods directly from the producer with the new web tools, makes even more important for importers to be competitive with prices and with the market's requirements, otherwise they could be excluded from the market. In this work, the attention is focused on the key products for the Unifrigo Gadus SpA turnover. It is an historic company in the salted codfish market. The aim of the paper is to identify the costs of the stock management and develop a demand-planning model, as it is not possible to use an already existing one. The target is combining a high service level with a cost reduction in order to enhance the efficiency and the competitive edge.

Teresa Murino, Mosè Gallo, Giuseppe Naviglio are with Department of Materials Engineering and Operations Management University of Naples "Federico II" P.le Tecchio – 80125 Napoli(ITALY)murino@unina.it,mose.gallo@unina.it, www.impianti.unina.it (phone: +390817682629; fax: +390817682388; giuseppe.naviglio@unina.it)

II. Supply Chain and Inventory Management

The stocks management is a basic activity for the supply chain efficiency and it is controlled with attention in big companies with the adoption of logistic management strategies and operative tools that best fit the specific case. The adoption of a particular strategy in goods management is usually determined on:

- Specific characteristics of the management model;
- Specific characteristics of the product, sector, firm;
- Results of the different strategies in the times series;

The strategy is monitored analyzing the results with performance index in order to verify whether it is suitable to the specific context or not.

The development of an effective performance measurement system has a double effect, on one side the evaluation of the current logistic strategy, on the other the measurement of the logistic process efficiency related to the stocks management.

The performances of the goods management system are evaluated with a number of logistics index that permit to size properly the performance and to having knowledge of possible improving margins reachable by refining the management process. Although stocks play an important role in boosting the process performance, they generate costs and so it is necessary to balance the supplies and supplying orders. The importance of these costs can be summarized into three main points:

Costs related to the warehouse are often the main part of logistics costs;

The stocks levels are tightly connected to the service level the company intends to guarantee;

The logistic network configuration is determined on warehouse costs;

A. The stocks management in uncertain context

All the productive sectors have to deal with uncertainty. This is related to a number of factors. There is uncertainty on the customers demand, when and what they will buy. This problem is faced using sales forecasting methods but, anyway, they leave margins of uncertainty and accuracy about the valuation made.

Meanwhile, procurement process cannot be

deterministically due to the variables related to quantities, quality and products lead-time. The uncertainty is generated by deliver and transports inefficiency and supplier reliability in terms of product characteristics and planning ability. The production is also affected by hardly controllable factors such as machine failures, staff shortage, planning and balancing errors. In order to deal with this uncertainty, firms are look for strategies that can reduce the randomness such as information technology tools, partnership, and hardware solution for the goods flow management. Anyway, these solutions cannot remove completely the process natural randomness and so it is necessary to store goods in order to face different scenarios. In figure 1 is shown a typical warehouse scenario. It is noticeable that the decumulation is not constant and the accumulation is not made on regular basis. In the figure, the theoretical stocks trend is increased with a quantity called SS, safety stock, which permits to satisfy the demand in the period following the first supply. Despite of the SS a stock-out was not avoided as noticeable in figure 1.

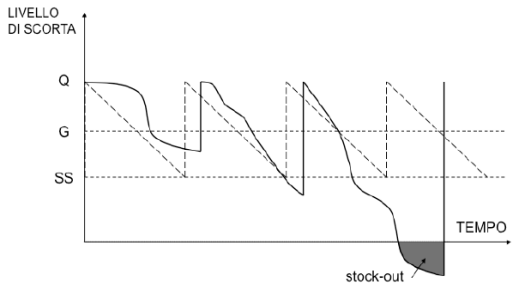

Fig.1: stocks level decreasing and leading to stock-out

III. Demand planning in the Supply Chain

In the current competitive context, all the firms should develop the information flow management along the supply chain as a core competence. In order to acquire this control, integration among all the players of the supply chain is required. This would allow a proper management of the demand evolution, day by day less forecastable. Furthermore, in order to work successfully in the same supply chain, each player should have a good forecasting process organization, which represents the first step of all activity planning process.

A correct management of this process makes the firm more awareness about the market characteristics, its opportunities and evolutions and permits to know the customers' requirements in advance.

The development of a reliable forecasting process is the first step for the whole planning process optimization. The improvements are mainly noticed by the logistic department with reference to cost reduction due to stocks reduction, service level enhancing and, especially, to the possibility of telling in advance the future requirements.

The forecasting process should involve as many departments as possible. This makes available many data representing the whole context.

Hence, it is necessary to be aware of the importance of the forecasting process organization, addressing the efforts to the improvement of three main aspects: communication, coordination and cooperation, the so-called 3 c:

There is communication if there is an information exchange among the forecasting process players

There is coordination if there are recurrent meetings, planned or informal

There is cooperation if there is an interaction at a higher level among the departments through a team development of forecasts with a consensual approach

A. Forecasts importance

The main issue of the planning activity is represented by the necessity of balancing the market requirements, known through already received orders and sales forecasts, and the productive system capacity, considering, meanwhile, the constraints. These are the production mix, the demand rate, the delivery requirements, with reference to the market; and equipment utilization rate, immobilized capital, stocks, suppliers requirements, with reference to the provisions. A company can be considered as a complex system working in a context characterized by various external factors that may affect sensibly the demand rate. In this context there are many operative process working together: the market, the competitive context, the other players actions into the supply chain, etc. The forecasting process is the tool utilized to understand and evaluate all those factors development through the time, and the real impact they have on sales. Indeed, the capacity of having a proactive approach to the market was, in the past years, an important competitive edge and a success factor. Knowing what is going to happen, addresses crucially the company planning activity. This behavior is encouraged by a proper awareness of the company internal and external process and by their correct and quick reading. Forecasts are fundamental anytime it is necessary to make a decision about future strategic or planning activities in a Supply Chain, such as:

- Planning the stocks investments
- Forecasting potential additional productive capacity needs
- Choose among different management strategies

Forecasts, usually, are based on a combination of what was observed in the past, called statistical forecasting, and informed judgments on next events. The informed judgments can result from future customers orders knowledge, macroeconomic context, but also from marketing information such as promotional campaigns, in one word from a proper application of the business intelligence.

IV. Difficulties in Sales Forecasting for Highly Seasonal Items

There are many difficulties in approaching the problem of forecasting the sales for a highly seasonal product with the typical statistical forecasting methods. First of all, the sales

cleaning may delete points which seem out of control that, indeed, represent the main part of the company annual turnover as they represent sales peaks in a short time. Moreover, those peaks are not recorded due to promotional campaigns, on the contrary, usually, prices are higher in the high season and are noticeably lower in the low season when, in spite of this, consumptions is under the average level. This makes difficult the detection of outliers generated by promotional campaigns or spot sales that, often, represent the main part of the turnover of companies that sell highly seasonal items. The evaluation of the average sales level is not expressive as the variance has high values. In addition, it is hard to size properly the forecasts time buckets and how to subdivide the forecasting horizon into them. Choosing short time buckets, even a little forecast errors in a low season period may have an important percentage relevance, on the contrary, aggregating more time buckets together makes the forecast too rough for the high season and inadequate for the company requirements.

A. Seasonality as a forecasting problem

A desasonalization of the time series before the outliers' detection is not suitable in the case of highly seasonal items sales forecasting. Actually, both using

the additive model: $D_t = T_t + S_t + C_t + \varepsilon_t$ (1)

Or

the multiplicative model: $D_t = T_t \cdot S_t \cdot C_t \cdot \varepsilon_t$ (2)

Deleting the seasonal component means removing the main component and leaving an insignificant trace. Indeed, the demand is exclusively related to the season of consumption. The seasonal component is the demand itself. It is not possible to make sales forecast analyzing the time series without the seasonal component. The time series about the sales of a highly seasonal item cannot be considered as a process disturbed by seasonality, on the contrary it is its main part. Hence it is suggested to remove the seasonal component just to evaluate the trend, used to inform the sales department about the context and to help them to evaluate properly the future sales. Seasonality makes also difficult to use a time bucket data to evaluate the sales for the immediately next one. Actually close time buckets can have an autocorrelation index next to 0 while time buckets distant the seasonal cycle my have an autocorrelation index next to 1. Hence the best decision is to use each time bucket to evaluate the same one distant the seasonal cycle. It is noticeable that removing a time buckets classifying it as outlier in the sales cleaning step, removes an important data for the evaluation of the same time bucket in the future. If the seasonal cycle is sensibly long, in order to collect a consistent amount of data, it would be necessary to take into account very old time buckets, risking to compare periods and macroeconomic situations very different one from other. It represents a further problem in the application of a traditional model at this kind of time series.

4.2 Subjective factor integration

The basic element to make deduction on an item already on the market sales is constituted by analytic data about previous sales, similar or substitutive items trend. Those data should, first of all, be filtered and sorted by known elements noticed by experience and supplied in a usable way to the forecast operators. The sales department is for sure the best company division in giving the required information. It is very close to the market and gets continuously feedback from customers about their attitudes and needs. Hence, if properly interviewed, the sales department can provide market data and evaluate the future sales in the different market areas. These data can easily be collected by the company management sending to the sales department and brokers a questionnaire and if needed a file with trend and statistical sales data that may back the operator in filling the questionnaire. There are various topics that the sales department has to investigate but, mainly, those depends on the specific product and sector in which the company is involved.

V. NEW FORECASTING PROCESS ELABORATION

Being the written preliminary remarks about the sales forecasting for highly seasonal items, the following proposed model is based on statistical fundaments but, meanwhile, includes an important subjective factor. The utilization of subjective evaluation are already widespread in the companies but in an informal manner. Here, the aim is to put them in a logical context and quantify the different assessments in order to limit the possibility that they could influence out of control the supply strategy. In figure 2 is shown the suggested model flow chart and subsequently its application is explained step by step.

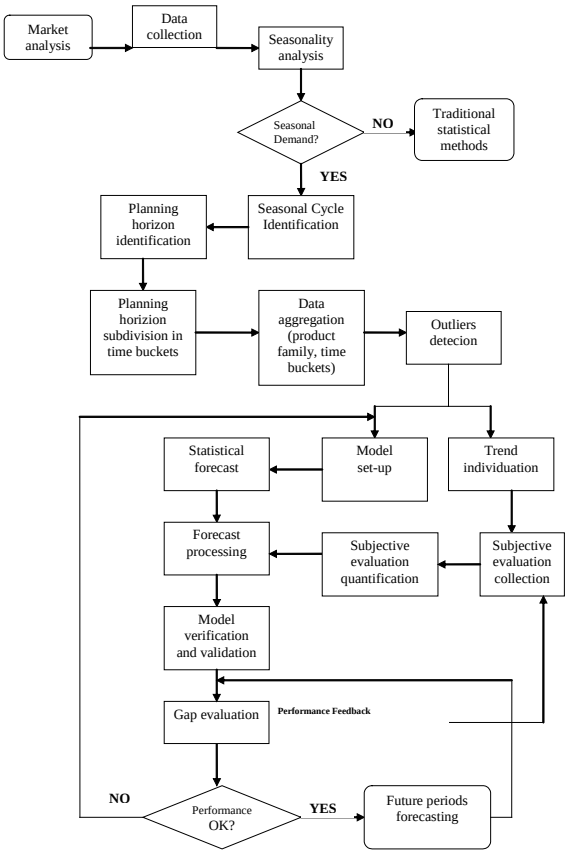

Fig. 2: planning process flow-chart

A. Data collection

As it is noticeable by the flow chart, the first step in the model implementation is represented by the market data collection and time series analysis, in order to get statistical information. Hence, data about the sales of all the items traded by the company and about the current stocks management strategy are collected. So, it is suggested the an ABC analysis and a following cross analysis in order to identify the key products and focus on them the efforts for improving the procurements strategy by an accurate demand planning. In order to accomplish properly the ABC analysis, items are sorted by consumption cumulate percentage and are divided into three categories as shown by Pareto principle with the utilization of a Microsoft Excel formula: IF(%cumulative <= 0,8;"A"; IF(%cumulative <=0,95;"B";"C")), is so defined:

- A items: items representing the 80% of company turnover;
- B items: items representing the 15% of company turnover;
- C items: items representing the 5% of company turnover;

In addition, items are classified by stocks level categories. First of all it is necessary to calculate the average stocks for each week. The result multiplied for each different item value represents the average stocks value. Items are sorted by average stocks value form the higher to the lower, then is calculated the relative value percentage as the single item average stock value out of whole average stocks value and items are classified into three categories as follows using a Microsoft excel formula: IF(%cumulative <= 0,8;"A"; IF(%cumulative <=0,95;"B";"C")), is so defined:

A items: items representing the 80% of stocks average value;

B items: items representing the 15% of stocks average value;

C items: items representing the 5% of stocks average value;

Results are compared using a pivot table. It is suggested to focus the attention on articles belonging to Aa class.

5.1 Seasonality analysis

Having data about previous campaigns sales, it is possible to carry out an autocorrelation analysis (ACF), evaluating the autocorrelation coefficient rk for each value of "k".

$$r_k = \frac{\sum_{i=0}^{N-k-1} (D_{t-1} - \overline{M}) \cdot (D_{t-i-k} - \overline{M})}{\sum_{i=0}^{N-1} (D_{t-i} - \overline{M})^2} \qquad (3)$$

Where $\overline{M} = \frac{1}{N} \sum_{i=0}^{N-1} D_{t-i}$ (k=1,2,3…12)

This analysis permits to compare, in pairs, data distant k months one from the other with the average value of the series $(\overline{M})$. Once calculated the rk for each k, it is possible to analyse the trend of rk using a correlogram. This shows the values of rk for each k for the observed item. If there is a peak in the autocorrelation function $(r_k \geq N)$ for $k > 2$, it is possible to confirm that the time series is affected by seasonality. The value of k that maximizes rk is called seasonality cycle. Then, for each product family or item are calculated L seasonal factors (Si), defined as the demand in a time bucket out of the average demand.

$$S_i = \frac{D_i}{M} \qquad (4)$$

Putting the result into a bar graph is obtained the so-called seasonality pattern.

Hence it is possible to determine whether there is a seasonal component in the demand or not. In the first case, aware of the shown difficulties, it is suggested to apply the model explained in this paper, while, in the latter, it is possible to utilize one of the model present in the statistical literature. In the following paragraphs, it is supposed the presence of a relevant seasonality.

B. Planning horizon and data aggregation

As widespreadly written in statistical literature, sales analysis is carried out with reference to a specific time horizon. Even without specifying exactly the time horizons, it is possible to distinguish among short, medium and long period forecasts. The decision of what horizon has to be analyzed is up to the company management but it depends

also on the market stability. It is unadvisable to make forecasts on a long horizon if the markets is affected by relevant floatation that might make vane them.

Furthermore, in presence of a highly seasonal consumption, it is important to determine the right time buckets into which subdividing the whole forecast horizons and maybe make differences among them. For instance, if the minimum lot size is big, especially compared to the consumption in the low season, it might be unuseful a daily or weekly forecast as it, anyway, could not be applied with a proper supplying. In addition, potential spot sales in months characterized by very low demand, could alter the forecast of that specific time bucket in the future. Aggregating more time buckets permits to make an average forecast and to spread the forecast errors generated by unscheduled sales on more time buckets. Valid criterions for determine the importance of a time bucket was found in an ABC analysis related to year periods. Following the algorithm already explained for the consumption and stocks ABC analysis, time buckets are classified as:

- A periods: periods representing the 80% of sales
- B periods: periods representing the 15% of sales
- C periods: periods representing the 5% of sales

Once it is completed the periods classification, it is possible to aggregate A, B e C periods as considered more convenient, but, anyway, considering short time buckets for a period and longer for B and even longer for C. Afterwards, it is necessary to revise the collected data in the first stage subdividing or aggregating them in order to make them adequate to the new identified time buckets. Furthermore, items belonging to the same product family are aggregated in order to make forecasts for product family on not for each different item, if this is adequate to the company's needs. For instance, may happen that a minimum lot size cannot be referred to just one item and so, even if the forecasts are made for each different item, they cannot be bought individually and consequently the supplying strategy cannot be carried out as supposed theoretically.

C. Outliers' detection and trend individuation

The first step in time series analysis is the outliers' detection. In the case of highly seasonal items, the detection of those points is not easy. Aside from the specific consumption a certain period, some items may have a sales trend among the years. The presence of a relevant seasonal component in the demand makes difficult to identify this trend. Consequently, this component has to be removed in order to point out the sales trend. Actually, often those trends do not follow a mathematical function and it is difficult to calculate them with the linear regression. In this case, it is possible to utilize the moving average method. In the following suggested model, the moving average time horizon depends on the seasonality cycle. Indeed, it is suggested to use a whole seasonal cycle as time horizon. Notice that it is not possible to calculate the average for the first n periods. As an alternative, it is possible to utilize a moving average considering m1 periods before the value and m2 periods subsequent to it. In this case it is impossible to calculate the moving average for the first m1 periods and the lasts m2. If m1= m2 the moving average is defined centered. Anyway, the moving average method makes the original time series smoother. By calculating the moving average on n periods, using n=whole seasonal cycle, it is possible to notice the sales trends as the seasonal component is removed. However, a forecast based only on sales trends and subsequently corrected with the seasonal factor is not reliable in markets characterized by a continuously developing context. An alternative for the sales trends analysis is represented by taking into account the same tame buckets distant a seasonal cycle. Anyway, problems of this approach were previously explained in this paper. The regression analysis permits to identify and quantify the kind of the trend. Considering what was written introducing the suggested method, it is advisable to use the trends only as a backing for human input.

At this stage, it is possible to calculate the statistical sales forecasts and, meanwhile, collect the subjective evaluations to add consequently to the mathematical data in order to get the final forecasts data.

D. Statistical forecasting

Considering what was previously written about seasonality and trend, it is supposed that

The best method to obtain a statistical sales forecast must take into account the same time buckets of different seasonal cycles It is not advisable a consistent quantity of data as this would imply considering data far in time and not comparable. It is also suggested to weight more the recent data. The exponential smoothing is a method which takes into consideration those factors: the forecast comes out from a weighted average of all available data which influence the forecast itself as more as they are more recent:

$$F_{t+1} = \alpha \cdot D_t + (1-\alpha) \cdot F_t, \quad (5)$$

With:

D_t Demand at t;

F_t Last forecast made at t-1, for t;

α Smoothing coefficient; as higher is α higher is the relevance given to the last known demand value.

In alternative to the exponential smoothing, it is possible to use a simple weighted moving average on τ periods. The weighted moving average weights the lasts τ periods in a non-uniform way using ω_t weights previously established.

$$F_{t+1} = WMA_{t+1}(\tau) = \frac{1}{\tau} \sum_{s=t-\tau+1}^{t} \omega_s D_s = \frac{\omega_t D_t + \omega_{t-1} D_{t-1} + \omega_{t-2} D_{t-2} + \ldots + \omega_{t-\tau+1} D_{t-\tau+1}}{\tau} \quad (6)$$

Weights of the different periods are arbitrarily assigned by the management and depend on the market characteristics. The choice about weights represents the viscosity of the system. Sales department or management can assign the weights in order to give more importance to time buckets considered the most explicative ones. The moving average method is simple and applicable to different contexts. Contrary to the exponential smoothing does not take into account every

available data and does not need information about previous forecasts not always available. Apart of the results should be provided some indexes of dispersion, such as range and variance. As it is suggested a small amount of data collection, variance is not significant, so it is suggested to utilize the range as main dispersion index.

E. Human Input

Once the mathematical model is structured and the statistical forecast is carried out, the human input corrects and revises the weighted average with subjective evaluations. These are collected by surveys and questionnaires provided to the sales department. The questionnaire can be filled anonymously or with the operator's name, but, anyway, the importance assigned to all results of all the departments in the company should be the same in order to make evaluations not based on few opinions. All the questions have multiple-choice answers and should not be too much in order to keep the operator concentrated and not confused while giving its opinions. Every single question can have same weight or contrary have different influence on forecasts. The answer for each question should be even in order to avoid neutral answers obtaining non-significant results. Is suggested to prepare the questionnaire with questions about macroeconomic context, company competitive edge, etc. Furthermore it is possible to focus the attention on specific issues such as the company competitive edge about a certain product, substitutive items on the market, etc cc. Once all the results are collected it is possible to analyze data. Combining statistical forecasts with human input sales forecasts are obtained.

VI. Model Validation

It is suggested, in the stage of elaboration and test of the model, to simulate sales forecasts for past time buckets in order to check results with already existing and real data. It permits to set up properly the model. It is possible to compare the forecast with the real data and give a feedback to the sales department. Hence, it is necessary to have real demand data in order to test the model. The gap analysis may be carried out with the utilization of different tools such as: Mean Error e Mean Percentage error.

$$ME = \frac{1}{T - T_A} \cdot \sum_{t=T_A+1}^{T} (D_C - F_t) \quad (7)$$

$$MPE = \frac{100}{T - T_A} \cdot \sum_{t=T_A+1}^{T} \frac{(D_t - F_t)}{D_t} \quad (8)$$

Both, actually, have the limit of balancing positive gap with negative one. So the use of other tools such as

Mean absolute percentage error and Mean absolute deviation is suggested.

$$MAPE = \frac{100}{T - T_A} \cdot \sum_{t=T_A+1}^{T} \frac{|D_t - F_t|}{D_t} \quad (9)$$

$$MAD = \frac{1}{T - T_A} \cdot \sum_{t=T_A+1}^{T} |D_t - F_t| \quad (10)$$

The stage of validation and model setting up may require time but it can represent a crucial point for improving all the forecast process. If the model performances in terms of forecasting accuracy are considered adequate, it is possible to carry out the forecast for future time buckets. Then forecasts are always checked with real data in order to improve continuously the forecasting process and the model. If performances are considered too weak, an immediate set up is required. The proposed model is flexible by modifying the different parameters it has.

VII. Case study: Unifrigo Gadus SpA

Unifrigo Gadus Spa is a firm operating in the field of salted codfish and stockfish supply since the beginning of the last century. It represents a key link in the supply chain for these products in the Italian market. The business of Unifrigo Gadus consists in the importation and distribution of salt cod and stockfish on the Italian territory through a network of food wholesalers, supermarkets, markets, large retailers, etc. The imported merchandise is stored, for the markets of the north Italy, into a refrigerated warehouse owned by the company in Novi Ligure (Alessandria). Conversely, goods for customers located in the south and in the centre of Italy, are stored in a cold store situated in a large industrial complex in Campania. The merchandise stored in Campania is managed and sold by the Naples sales department. All the data of this paper are referred to the merchandise stored in Campania and it will be called just Unifrigo Gadus spa in the following paragraphs. Salt cod has highly seasonal sales trend, as it is noticeable in figure 3, as it is mainly consumed during Christmas festivities. This issue involves every link of the supply chain, causing several difficulties in getting into proportions properly the work force and warehouses. As it was impossible for Unifrigo Gadus Spa o enlarge its products range, the management decided to invest in the core business building two laboratories for packaging the fish.

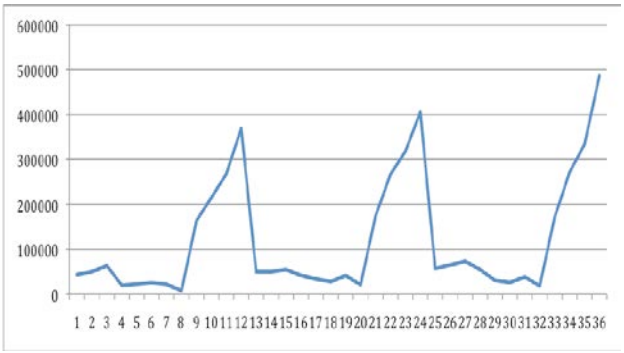

Fig. 3: salted codfish ad stockfish are seasonal items

A. ABC analysis

The high number of items traded by Unifrigo Gadus Spa, even if similar, obliges to a selective stocks management. The aim is the adoption of a more complex management strategy for the most important items and simpler management process for the others, in order to optimize the critical performances

and focusing attention and efforts on relevant elements, rationalizing the resources utilization. The tool chosen for evaluating stocks is the cross analysis as it provides a criterion to classify the stocks, sorting them for costs and turnover importance. For each class the most adequate management strategy will be adopted, with particular attention to class AA items.

Table 1: *Cross Analysis*

		FATTURATO		
		A	B	C
SCORTE	A	BCI28,BCI17,BCI41,FC04,FC07,FLA10,FC10,FLA07,FBA04,FLA15,GAC40,FBA07,DRN16B,SL40,WCP, SLN02	DRN10B,GAC12,GAC20,DRN13B,FLA20	BCI60
	B	BCI12,SLN05,SLN07	BCN13,BCN16,SLN03, BCN07,SLN08,FBA02, SL20	BFM40,BFM27,DRN31B,SLN25
	C		DRN21B,SLN27,FLA04	FC02,DRN07B,BCN21, SLN22,FLA00,SBI12,GAC70,BFM17,DRN41B, SLN28,BFM00,BCN10, SBI17,DRN41N,DRN51N,DRN31N,BCI08,FLA1,FBA01,BCN04,FBA00

B. ABC Analysis Output

The cross analysis shows that the 73% of items, located in boxes 1-5-9, has the same turnover and average stocks value class. 36% of those belongs to AA class and represent the items on which we will focus our attention for two reasons. Actually a potential lack of just one of them may cause an important turnover reduction with recoils on company's brand image, but, meantime, a reduction of their stocks would immediately be reflected into a cost reduction and less immobilized capital. Those items should, theoretically, be managed with a just in time strategy. So it should ask the suppliers for small lot size and frequent delivers. The 35%of Unifrigo Gadus traded items composes the cc class. Those have not a relevant impact on turnover or stocks value and so they do not need a particular attention. BCI60 is the unique item located in class Ca. So it seems that it was not properly managed in the year 2011. There are not items in class Ac and so risking stock-out.

In conclusion, it is possible to state that an ABC analysis is the prerequisite for every rational stocks management strategy. Furthermore a periodic review of the cross analysis table can highlight the evolution of different categories and the potential migration of one or more items from one class to another one. This may lead to a review of supplying strategies for different items in order to obtain a cost reduction and enhance the logistic performances.

C. The current stocks management strategy and its constraints

The current procurement strategy of Unifrigo Gadus SpA is closely bound to the few number of suppliers that it has. Actually, even if there are about 20 suppliers, most of them trade different products or same products but with different brands. Hence, the same item is available only by 2-3 producers. This makes the procurement strategy not flexible and hard to be changed. In addition, some explanations about the goods peculiarities are necessary. Actually there are fishing quotas that rule the market. For some species, for instance Molva Molva, the fishing period is concentred at the beginning of the year but the production period does not coincide with the consumption period. This means that producers have to face important financial and logistic problems. The solution can be found in spreading the sales during the year promoting the product with lower price. Importers, such as Unifrigo Gadus SpA, are ready to buy goods in advance if the price is considered interesting. In other cases, the power of suppliers oblige importers to buy goods all around the year in order to keep the possibility to trade that specific item or brand or to avoid that other competitors could deal with the same supplier. Those factors explain why it is hard to use a Just in time strategy. Anyway, the high stocks value and the current difficulties in getting credit from banks, encourages the optimization of the stocks management process even in a non-flexible context like the one previously explained.

At the moment, Unifrigo Gadus SpA plans its procurements basing on the previous year sales and the current year sales trend. The attention is mainly focused on comparing prices of different items. Indeed, non-linear price variations among different products, may lead to a consumption shift from an item to another one. Even though some items traded by Unifrigo Gadus SpA may seem marginal for the company's turnover, they are necessary to enter in some markets where they are particularly desirable. In addition, wholesalers and retail dealers use to buy all the family product range from one supplier in order to minimize the price, so, even the lack of just one product would mean for a food importer the loss of many items sale or the customer loss.

D. Minimum lot size

Goods are delivered to Unifrigo Gadus SpA in cartons of 20 or 25 Kg, placed on pallet. Each pallet holds as many as 26, 30, 32, 36 or 40 cartons, depending the product and the supplier. The minimum lot size of any product traded by Unifrigo Gadus Spa depends on the means of transporting adopted by suppliers: the truck. Depending on the kind of the pallet, its volume and weight, the truck can be loaded with a quantity of goods between 17000 and 21750 kg but, anyway, they are never referred to just one item. Few suppliers and just in some periods of the year agree to ship part of the minimum lot combining shipping. As Stockfish has high value, it can be shipped in lower quantities combining the shipping with other importers.

VIII. The Highlighted Problem

In light of the data collected and analyzes performed, is noticeable the importance of a careful stocks management and

supplies strategy by the Unifrigo Gadus Spa. Anyway, aspects to be considered are many and not easy to interpret. On one hand, the high value of stocks, the cost of maintenance and their perishability call for a low average stock level. That is why food importers want to get rid of the problem passing it to the suppliers and trying to force them to store and delivering often small lots. On the other hand, importers are forced to have always available the entire range of products and as much quantity as required by customers because of the absence of brands and the high number of competitors. Oppositely, the risk of losing a sale, or even a customer, is near, as customers are not inclined to wait for new goods coming from producing countries. Therefore, here are discussed and analyzed the methods to optimize procurements and keep a lower stock level but, meantime, providing the traditional high level service that Unifrigo Gadus SpA has always maintained during years.

A. Inapplicability of theoretical methods of demand planning at case study Unifrigo Gadus SpA

Every classic method of demand planning would take into consideration a time series to be analyzed. Doing this, it is noticeable how product traded by Unifrigo Gadus SpA are highly seasonal. Last 3 years sales time series with reference to "A items" is an example of this characteristic. So, it would be necessary to attend to a sales cleaning, using a moving average algorithm calculated on 12 months to appreciate salted codfish sales trend in this kind of seasonal market. However, a model that considers sales trend (so a projection in the future of what happened in the past) is not enough adoptable to Unifrigo Gadus SpA. In particular, food market is now characterized by a globalization trading and so by the possibility for the final consumer to replace products with similar ones. Then, money market floatation and political governance are able to affect prices and consequently the convenience of a product comparing to the others. In the forecast of the demand in a dynamic market it is very important to consider such kind of factors that is not possible to read in the trend models and time series. In order to detect cyclical floating it would be necessary to collect data of at least 20 years of sales. However, it is impossible to compare such different periods as many factors change: market, customers' habits and requirements. In point of fact, it is possible to state that food market, and in particular the one related to traditional food, is characterized by a low consumption reactivity to the macroeconomic context. This is true especially in Italy, where people are inclined to invest in everyday consumption a relevant percentage of their wage (80%) and mainly in food. The difficulty in using the classic models of demand forecasting, has lead to put in practice the model above explained and to test its performance in the case study.

IX. Suggested process application

As specified in the proposed model and shown in the flowchart in Figure 2, it is useful to investigate the peculiarities of the commercial items divided by product family, aggregating, where possible, data. Are considered of same family, similar items that differ only by size of fish or supplier. Furthermore, within the same family, the company is partially able to shift consumption from one size to another as needed, satisfying the customers request as well. The need to make a forecast of demand by product family, and not for specific product, is also evident by considering the mode of operation of the producers of salt cod and dried cod. In fact, the minimum lot size is always referred to the entire family and it is not possible to have a minimum lot size made of just one item. Within the minimum lot, the importing company, can only partially determine the set of items, according to the degree of flexibility of the supplier, but in any case it is hard to get a truck (minimum lot) as specifically requested. The families considered are BCI, DRN, FBA, FC, FLA, GAC, SL, SLN, and only with reference to the AA products of the cross analysis.

A. Data analysis

The analysis of data emphasizes that all products traded by Unifrigo Gadus Spa are mainly sold during the last four months of the year, while, during the first 8 months, the consumptions is under the average. Correlogram shows that the seasonality cycle is 12 months. This is explained by the fact that, as told before, codfish is traditionally consumed during Christmas. Those peculiarities mean that typical statistical methods are not applicable to this kind of problems and the choice of taking into consideration the same time bucket of previous years for each time bucket sales forecast is a good choice. In addition it is necessary to size the forecast horizon and to subdivide it properly into time buckets. As the fish market is volatile and there is price flotation, the horizon should be not longer than one year. With reference to forecast time buckets size, it is necessary to make a difference among them. Actually, as the minimum lot size is relevant, especially compared to the consumption during the first 8 month of the year, considering a week as planning time bucket is not suitable as previously explained during the theoretic model introduction. Following the steps explained in the flow chart in figure 2 was carried out an ABC analysis of the weeks of the year. In particular were taken into account the sales of years 2009 2010 and 2011 in order to sort the weeks for average sales recorded in each one. Are so classified as A the weeks, 18, representing the 80% of sales, as B the weeks representing 15% and as C the weeks representing the last 5%. Therefore it is suggested a different approach for the three classes. So, it is suggested to make weekly forecasts for A weeks and to aggregate B and C weeks in order to make two-weeks forecasts for B and monthly forecasts for C periods.

B. Demand planning for Unifrigo Gadus SpA

The planning process currently adopted by Unifrigo Gadus SpA, even if not properly formalized, provides good results.

Therefore, a new process has to be based on the current one which uses the well known sales department ability in forecasting. However, there is the need for a statistical method in order to minimize risks of procurements errors due to wrong subjective evaluations. Hence, were collected data about ever week of years 2008 2009 2010 and 2011 for each different family product, with reference to "AA" items. The sales forecast is made for each family product and for each planning horizon time bucket, for the year 2012 and 2011 making a weighted moving average of the three years preceding the one forecasted using 0,7 0,2 and 0,1 as weight coefficient. This makes the most recent data the most relevant one in the forecast. Once obtained the wanted statistical component of the forecast, the attention was focused on the subjective component. A questionnaire was sent to the sales department and was asked to fill it making inferences about the 2012 consumption and about the 2011 one. Notice that the questionnaire was filled up when 2011 data were already known but it was asked to simulate forecasts for it. In table 2 there are the questionnaire results, quantified by the management.

Table 2*: subjective correction for statistical output*

fam.	2011	I quad 2012
BCI	+15%	+14%
FBA	-3%	0%
FC	+17%	+16%
DRN	+9%	+8%
FLA	+17%	+12%
GAC	-3%	-2%
SL	+15%	+14%
SLN	-3%	+4%

X. The New Model Validation

Once collected both statistical and subjective data, it is possible to test the model comparing 2011 forecasts with 2011 real data, already know. First of all it is necessary to identify a criterion to evaluate the forecast process accuracy. It is necessary to underline that underforecasting does not always lead to stock-out, as the company should have a safety stock. This is sized proportionally to the specific item's market stability, as explained later in this paper. The first index evaluated is the forecast error, which is the gap among real demand and forecast for each time bucket. In addition, is evaluated the forecast global error on the whole planning horizon and both are evaluated also as percentage. Global forecast errors are then distinguished between distortion and dispersion error. The first estimates the gap and its sign in order to make a difference between underforecasts and overforecasts. The latter estimates the forecast error with absolute value avoiding balance between different sign errors.

In addition, it is suggested to consider the ratio among the forecast error and the minimum lot size. It is noticeable, indeed, how even errors of few kg, irrelevant for the company, may be relevant if analyzed in percentage. This makes MPE and MAPE not suitable for this study. Furthermore, as salted cod and stockfish are long-life products, it is possible to balance the overforecasts of a period with following underforecasts, this makes absolute error and MAD less significant than errors balancing positive and negative gap. In the following paragraph there are the new planning process performances with reference to family product BCI (salted cod from Iceland), used as example of the model application, as it represents the Unifrigo Gadus SpA core business.

10.1 BCI planning process performance

The forecast accuracy for BCI is good. The global error is just a few more than one truck of goods, which is the minimum lot size. Furthermore, 18000kg were sold during the 50th week of 2011 after being procured to satisfy a specific request of a customer. Hence, this can be considered as a spot sale. Without this case, the performance the forecast would be even more accurate.

Table 3: *BCI forecast accuracy*

BCI	
sales '11 (kg)	633525
forecasts'11 (kg)	607711
E tot. (kg)	-25814
E tot. %	-4,07%
E abs. (kg)	185712
E abs. %	29,31%
Average err. (kg)	-860,46
MPE	22,09%
MAD (kg)	6190,40
MAPE	56,55%
E/ min.lot averag	-4,78%

XI. Performance Analysis

It is possible to state that the model has generally performed well. This can be seen from global errors data analysis. Significant absolute errors is noticeable, due to the difficulty for the model in predicting the exact time bucket in which the consumption would be recorded. This unfortunately is not a easily-solving problem as the consumption is closely correlated, within the seasonal period of consumption, to the weather conditions; cool days and rain induce an increase in demand. Those weather conditions are not forecastable months in advance. In addition, the long preservation of the product, allows that the overforecast of a period can balance, even if increasing costs for the stock maintenance, the underforecast of a subsequent period. Anyway, it is necessary to consider the storage capacity, with reference to the space in the cold store, but also the company's desire to avoid stock-outs. According to this, and considering the aim of the company, which makes storage and delivery to the customer

capacity its core business, the stock management strategy has to be based on sales forecast but adding to it a safety stock.

XII. Stocks Optimization

The first step in the optimum stock level identification, is the evaluation of maintenance and stock-out costs. Hence, it is necessary to find an objective function to minimize. Stock-out cost is not easy to calculate; in fact, in addition to the gain failure due to the loss of the sale, and loss of clients, there are many implications to take into consideration about the firm image damage. The aim of Unifrigo Gadus SpA is to give the best product at the right price, trying to avoid difficulties in the supplies of the goods. But, if there is a lack of one kind of product maybe it will cause the loss of a customer even for other product families. That is why it is absolutely to avoid a situation of stock-out, especially for the most important products of the company such as the ones located in the AA box of the Cross Analysis. The next analysis will take just this kind of products as example. The purpose is to trying to prevent stock-out and to calculate costs and benefits basing on stock maintenance costs analysis.

A. Optimum stocks' level identification

In order to identify the optimal stocks' level (So) it is taken in consideration, for each time bucket, the sales forecast (P), adding to it the range (R) multiplied by a C parameter.

$$So=P+R*C \quad (11)$$

The C parameter depends on each different family product, and it represents the market stability for that family product. In order to find the optimum C parameter, a cost-benefits analysis is carried out. However, it is necessary to consider that the company does not want stock-out risk. The company considers as "stock-out" every situation in which a goods' lack is not balanced by goods surplus during the following two periods. Once the So is determined for each time bucket, it is possible to plan the procurements for the whole year. Anyway it is necessary to consider the minimum lot size of 18000 kg for BCI and in the following example, it is assumed an empty store at the first time bucket G0=0. As in the time bucket 1-2 the sales forecast P 1-2 >0 and 0<So 1-2 <18000, a minimum lot is supplied. The stock level G1-2 at the beginning of time bucket 1-2 is calculated as the difference between the procurement and the sales forecast in the time bucket 1-2 P1-2. For the following time bucket (3-4) G34 is calculated as G1-2 – P3-4. If this quantity is > So 3-4 there is no order, contrary, if it is < So 3-4 there is a new order of one or more minimum lots App 3-4 and it is calculated the new G 3-4 = G1-2 – P3-4 + App 3-4 verifying that G 3-4 is > So 3-4 . The algorithm is repeated for all the time buckets.

XIII. Costs-Benefits Analysis

The cost function for BCI without considering stock-out is:

$$CsBCI:(Cf+Cm+Camm)xGM+Cc+Cp+Ci \quad (11)$$

Where:

CsBCI = annual storage cost BCI

Cf = annual financial cost for each average kg stored

Cm = annual workforce cost for each average kg stored

Camm= annual equipment amortization cost for each average kg stored

GM = average stock level

Cc = store rental

Cp = weight loss cost

Ci = perishability cost

It is possible now to calculate costs considering the stock level obtained from the new model application:

CsBCI = (0,04 €/kg + 0,04079 €/kg + 0,00603 €/kg * 70344 kg + 35119 € + 6007 €+ 0 € = 62399 €

In the same way, it is possible to estimate the real incur cost during 2011, in order to compare real data with the theoretically ones that it are possible to obtain with the new process. Coefficients regarding financial interests, amortization and workforce costs are considered stable. The cost function is changed considering the real 2011 average stock level that was 198216 kg for A items of BCI and the real weight loss cost of 47.697 €. The total result is 137840 €. It is necessary to underline that this cost does not include two further cold store rooms that, contrary, are considered in the new model cost function, as the company would like to have more space to store goods in the future. This means that, not only there is a cost reduction of 47872 €, more than 50%, (55,73%) but this cost reduction is indeed worked out using even two more rooms which would permit a better storing strategy in order to pursue always FIFO strategy.

A. Sensitivity analysis

Known the suggested output, resulting from the calculation of the optimal stock level as the demand forecast adding 3 times the range, are now evaluated changes in the cost related to parameter C changes. The analysis is again performed in relation to sales forecasts prepared for 2011 and real sales record for the same period. Below, in Table 4, are reported indexes of rotation and duration and the relative costs of weight loss and aging.

Table 4*: costs and index for different C*

C	sales 11	GM 11	C medio	Aver.stocks value	Rot.index	Dur.index	Cp	Ci
0	639429	30144	€ 6,39	€ 192.519	21,21	17,21	1.103	0
1	639429	45744	€ 6,39	€ 292.149	13,98	26,11	2.540	0
2	639429	57144	€ 6,39	€ 364.955	11,19	32,62	3.964	0
3	639429	70344	€ 6,39	€ 449.255	9,09	40,15	6.007	0
4	639429	87744	€ 6,39	€ 560.383	7,29	50,09	9.347	0
5	639429	94944	€ 6,39	€ 606.366	6,73	54,20	10.943	0
6	639429	110544	€ 6,39	€ 705.996	5,78	63,10	14.835	0

Att	639429	198216	€ 6,39	€ 1.265.914	3,23	113,15	47.697	0

Table 4 summarizes the costs for each different value of C. It is noticeable that the solution with C=3 is the optimum, as with C> 3, there are problems of store saturation (overstock OS) and then the solution would not be feasible or would present logistical difficulties apart being characterized by higher costs. For C <3 there is indeed a cost saving but stock out episodes occur and so these situations are not taken into account. For C <3 company does not require additional storage cells and consequently it cost is saved.

Table 5: *costs and indexes for different C*

calcolo costi	Costo celle	Cp	Ci	kg medi	Costo TOT	Freq.S-O	Fr.O-S
C=0	30199	1.103	0	30144	€ 40.418	33,33%	0
C=1	30199	2.540	0	45744	€ 46.573	10%	0
C=2	30199	3.964	0	57144	€ 51.445	6,67%	0
C=3	35119	6.007	0	70344	€ 62.400	0	0
C=4	35119	9.347	0	87744	€ 71.001	0	6,67%
C=5	35119	10.943	0	94944	€ 74.775	0	13,33%
C=6	35119	14.835	0	110544	€ 83.385	0	16,67%
GEST.ATT	30199	47.697	0	198216	€ 137.840		

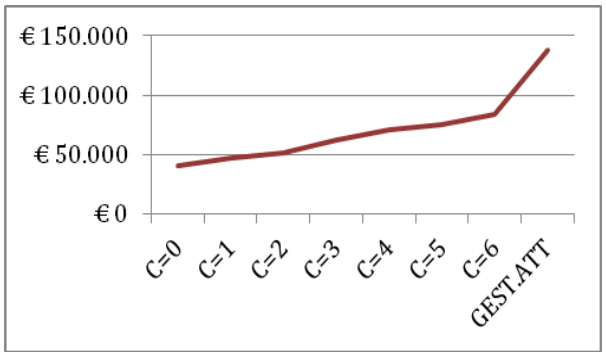

Fig. 4: *Costs increase as C is higher*

XIV. Results Analysis

Unifrigo Gadus SpA is for sure an efficient and effective company. As a matter of fact, it is in the salted fish market since 1878. Even though the salted fish market is very stable with reference to the total turnover, Unifrigo Gadus SpA grew in the last four years, managing today the 40% more of goods than four years ago. Anyway, its logistic and forecasting strategies and the planning process were not updated. Consequently, the immobilized capital and financial costs became bigger. In addition, the bigger amount of stocks in the warehouse, leaded to a worse rotation index and logistic problems. Even if the company makes contracts with its customers, and it could potentially work on forecasts, spot sales still represent the biggest part of the turnover, making important the existence of the safety stock, in order to guarantee a high service level. The new sales forecasting process suggested, properly adapted and implemented to the case study Unifrigo Gadus SpA, showed encouraging and reliable results, especially with reference to "key products". The global forecasting errors are not relevant while are easy to solve. The use of a good forecasting process allows the company to reduce the stocks, keeping the wanted service level. The optimal stocks level is calculated adding to the sales forecast C times the range among the max and min sales volume of the previous three years, with reference to the same time bucket. Considering that the company does want to avoid stocks out, it is noticeable that, with reference to family product BCI, the optimal solution is represented by C=3. Lower values, actually, could lead to stock out, while C>3 values are not suitable due to the store size (see overstock frequency). Data analysis emphasizes the existence of relevant improvement margins. Indeed, the new forecasting process leads to average stocks level reduction of 64,65%, with reference to BCI and consequently to a stocks management cost reduction of 55,73%. Furthermore, a lower stocks level improves the index level and all the logistic process, as there is more free space in the store.

XV. Conclusions

In a drop in consumption moment, like the one the market is now in, the aim of modern companies is to reach a compromise between cost reduction and a good service guarantee. Companies are trying to pursue best quality levels of management in order to obtain better results with fewer resources trying to remove all the inefficiencies. In spite of this, there are many aspects of the industries that could be improved and supply chain management is not diffused enough at the moment. The main supply chain's problem is the lack of synergy among players, in fact there are not effective technology tools, and companies are not so helpful to communicate and share information. However, in this competitive context, the basic core competence that should be improved is the control of information flows through the company of the supply chain. This in order to encourage the integration among the companies and all the players of the supply chain to reach the correct forecast of the demand that now is more and more unpredictable. The success of the supply chain depends on a good forecast process, so every player should pursue it. The aim is knowing the market and the final customers requests, that is why the supply chain players have to manage this process as best as they can, understanding opportunities and improvement perspectives. The starting point to obtain the optimization of the whole industry organization is to improve and expand the planning process. Consequence of this process should be a lower stocks level and a costs reduction enhancing the logistic performance of the companies. Now, this kind of planning process optimization is very hard for high seasonal items. Actually, those products' time series, characterized by irregular flows, makes difficult to use the typical methods of sales forecasting. Then this dynamic market, more and more global, including many demand factors, such as floatation of financial and money markets, forces the players to the need of a reactivity

unknown until this moment. This reactivity, necessary to face the demand, could be reached only with integration between a statistical, mathematic and objective model and a subjective evaluation of the planning process and the market demand by the sales department. The elaboration of this kind of model leads to the creation of a reliable, repeatable, accurate and reactive tool.

REFERENCES:

[1] Bruzzone A.G. "Supply Chain Management", Simulation, Volume 78, No.5, May, 2002 pp 283-337 ISSN 0037-5497

[2] Chase, Jr., Charles W., "Getting People to Use Your Forecasts," The Journal of Business Forecasting: Methods & Systems, Spring 1998.

[3] Dallari F., Marchet G., Noè C., "Benchmarking Sales Forecasting Processes", Logistics Research Network, Plymouth, 2005

[4] Ghobbar A., C.H.Friend, Evaluation of forecasting methods for intermittent parts demand in the field of aviation : a predictive model, Computers & Operations Research, 2003,pp.2097-2114

[5] Kenneth B. Kahn and John T. Mentzer, "Forecasting in Consumer and Business Markets," .Journal of Business Forecasting, Summer 1995, pp. 21-28.

[6] Marien E. J, "Demand Planning and Sales Forecasting: A Supply Chain Essential", Supply Chain Management Review, Winter, 1999.

[7] Mentzer, John T., Mark A. Moon, John L. Kent, and Carlo D. Smith, "The Need for a Forecasting Champion," The Journal of Business Forecasting: Methods & Systems, Fall 1997.

[8] Holimchayachotikul, P., Leksakul, K., Guizzi, G., Robust design for etching process parameters of hard disk drive slider fabrication using data mining and multi response optimization, WSEAS Transactions on Systems and Control, 6 (1), 2011, pp. 15-24.

[9] Holimchayachotikul, P., Derrouiche, R., Leksakul, K., Guizzi, G., B2B supply chain performance enhancement road map using data mining techniques, International conference on System Science and Simulation in Engineering - Proceedings, 2010, pp. 336- 341.

[10] Holimchayachotikul, P., Limcharoen, A.,

[11] Leksakul, K., Guizzi, G., Multi-objective optimization based on robust design for etching process parameters of hard disk drive slider fabrication Proceedings of the 11th WSEAS International Conference on Automation and Information, ICAI '10, 2010 pp. 166-170.

[12] Guizzi, G., Gallo, M., Zoppoli, P., Condition based maintenance: Simulation and optimization, Proceedings of the 8th WSEAS International Conference on System Science and Simulation in Engineering, ICOSSSE '09, 2009, pp. 319-325.

[13] Gallo, M., Grisi, R., Guizzi, G., Romano, E., A comparison of production policies in remanufacturing systems, Proceedings of the 8th WSEAS International Conference on System Science and Simulation in Engineering, ICOSSSE '09, 2009, pp. 334-339.

[14] Caputo, G., Gallo, M., Guizzi, G., Optimization of production plan through simulation techniques WSEAS Transactions on Information Science and Applications, 6 (3), 2009, pp. 352-362.

[15] Gallo, M., Guerra, L., Guizzi, G., Hybrid remanufacturing/manufacturing systems: Secondary markets issues and opportunities. WSEAS Transactions on Business and Economics, 6 (1), 2009, pp. 31-41.

[16] Murino, T., Naviglio, G., Romano, E., Cost estimation in an aeronautical supply chain SKIMA 2011 - 5th International Conference on Software, Knowledge Information, Industrial Management and Applications, 2011, pp. 126- 132.

[17] Murino, T., Romano, E., Santillo, L.C., Supply chain performance sustainability through resilience function Proceedings – Winter Simulation Conference, 2011, pp. 1600-1611.

[18] Gallo, M., Romano, E., Santillo, L.C., A methodological approach to manage WEEE recovery systems in a push/pull logic Proceedings - Winter Simulation Conference, art. no. 6147827, 2011, pp. 1035-1047.

[19] Gallo, M., Murino, T., Romano, E. The simulation of hybrid logic in reverse logistic network, International conference on System Science and Simulation in Engineering - Proceedings, 2010, pp. 378-384.

[20] Murino, T., Naviglio, G., Romano, E. Optimal size of kanban board in a single stage multi product system. WSEAS Transactions on Systems and Control, 5 (6), 2010, pp. 464-473.

[21] Murino, T., Naviglio, G., Romano, E., Zoppoli, P. Single stage multi product kanban system. Optimization and parametric analysis, Proceedings of the 8th WSEAS International Conference on System Science and Simulation in Engineering, ICOSSSE '09, 2009, pp. 313-318.

[22] Romano, E., Santillo, L.C., Zoppoli, P., Transformation of a production/assembly washing machine lines into a lean manufacturing system WSEAS Transactions on Systems and Control, 4 (2), 2009, pp. 65-76.

[23] Romano, E., Santillo, L.C., Zoppoli, P. A static algorithm to solve the air traffic sequencing problem WSEAS Transactions on Systems, 7 (6), 2008, pp. 682-695.

[24] Bruzzone A, Giribone P, Revetria R Operative requirements and advances for the new generation simulators in multimodal container terminals, Winter Simulation Conference Proceedings, 2, 1999, pp. 1243-1252.

[25] Bianchi, N.P., Evans, S., Revetria, R., Tonelli, F. Influencing factors of successful transitions towards product-service systems: A simulation approach International Journal of Mathematics and Computers in Simulation, 3 (1), 2009, pp. 30-43

[26] Mosca, R., Cassettari, L., Revetria, R., Magro, G. Simulation as support for production planning in small and medium enterprise: A case study Proceedings -Winter Simulation Conference, 2005, art. no. 1574537, pp. 2443- 2448

MOSÈ GALLO has a PhD in "Production Systems and Technologies" (Department of Materials Engineering and Operations Management of the University of Naples "Federico II"). He also has a master degree in mechanical engineering from the same university. At the moment he is a contract researcher at the Department of Materials Engineering and Operations Management of the University of Naples "Federico II." He has several research interests related to the design and management problems of production systems. In particular he has studied issues concerning quality, maintenance, production planning, environmental sustainability, and soft computing techniques applied to industrial fields. He has authored several papers presented at international conferences and published in international journals of industrial engineering. His email address is mose.gallo@unina.it.

T. Murino graduated in Mechanical Engineering, is assistant professor in the ING-IND 17, Industrial Plant System disciplinary group, in the Faculty of Engineering at University of Naples Federico II. She teaches Manufacturing System Management, Goods and Services Production System, and Industrial Logistics at Engineering Faculty. She is also Professor at "Consorzio Nettuno". She is also peer-reviewer for Elsevier Editorials, and other journal ISI indexed.
The research activities is mainly concerned about the following topics: Simulation modelling; Maintenance strategies; Supply Chain Management models; Quick Response Manufacturing; Sustainable production processes; Location-Routing and vehicle routing Problem, Lean Service and Lean production implementation. Her email address is murino@unina.it

G. Naviglio is a PhD in "Production Systems and Technologies" at the Department of Materials Engineering and Operations Management of the University of Naples "Federico II". He has a master degree in management engineering from the University of Naples "Federico II". The research activities is mainly concerned about the following topics: Simulation modelling; Maintenance strategies; Supply Chain Management models; Manufacturing systems; Health and Safety problems; Lean Service and Lean production implementation. He is author of several works presented at international conferences and issued on international journals of industrial engineering . His e-mail address is giuseppe.naviglio@unina.it.

A. Eminente is graduated in Management Engineering at University of Naples Federico II and has a master degree in productive process management. He is currently operations manager at Unifrigo Gadus SpA. In particular, he supervises the optimization of the goods supply chain. His e-mail address is: andrea.eminente@unifrigo.it