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From a traditional replenishment system to vendor-managed inventory: A case study from the household electrical appliances sector

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Abstract

This paper shows that vendor-managed inventory is also used fine in household electrical appliances sector. Taking Electrolux Italia as an example, the implementation of this technique is presented and analysed, highlighting the various processes involved (sales forecasting, capacity need forecasting, master planning, replenishment need calculation, dispatch planning, shipping), parameters (target stock, replenishment need, dispatch plan, assigned stock, etc.) needed to regulate vendor managed inventory. The paper points out the benefits obtained following the implementation of this technique and presents based on the case the variables that define and characterize the conditions under which it can be applied.

Keywords: Continuous replenishment; Inventory management; Supply chain management

1. Introduction

The evolution of present-day market and the change in roles and power within the channel have transformed competition between firms into competition between whole supply chains. Focusing strategy on improving the performances of channel (Clark and Hammond, 1997) is the one and only road the firm can take to reach a greater competitive advantage (Towill, 1997).

The concept of *Supply Chain Management* was first applied to the grocery sector through the spread of *Efficient Consumer Response* (ECR) around the beginning of the 1980s and then to the apparel industry as *Quick Response*. This innovative approach was then adopted in. The theory proposes a re-planning of supply chain, acting on the various production-points of interface between and distribution (Fig. 1), that is, the area of promotions (efficient promotion), assortments (efficient assortment), development and introduction of new products (efficient new product introduction), and logistics that considers replenishment processes (efficient replenishment) (Kurnia et al., 1998).

Focusing the attention on the last area, it would be a significant lever to surmount the trade-off between costs and service level and so increase the

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performances of the whole channel. One of the main solutions proposed in this field is Continuous Replenishment (CR). It facilitates the implementation of other support techniques, the foremost of which is clearly EDI, then bar code, scanner, computer-assisted ordering (CAO), cross-docking, multi-drop/multi-pick, Electronic Forecasting System, Billing System, Automated Receivable-Payment System, Electronic Warehouse Receiving System, Vehicle Fill Optimisation, Truck Scheduling etc. (for greater detail see De Toni and Zamolo, 2002).

CR reorganizes the traditional system of ordering and replenishment characterized by the transfer of purchase orders from the distributor to the supplier. CR is a process of restocking where the producer sends to the distribution centre full loads whose composition varies according to sales and in conformity with a prearranged level of stock (Fig. 2). Particularly if the responsibility for replenishment passes into the hands of manufacturer, CR is more properly called Vendor-Managed Inventory (VMI) (Caputo, 1998). The manufacturer himself indeed decides the quantity to be delivered on the basis of information about sales and the stock level in the distribution centre, taking into account the orders already acquired by outlets and following a pre-established programme of replenishment. The distributor, on the other hand, has to guarantee a continuous flow of information to enable the manufacturer to formulate realistic order proposals and make reliable provisions. The key characteristics of VMI are thus short replenishment lead times, and frequent and punctual deliveries that optimize production and transport planning.

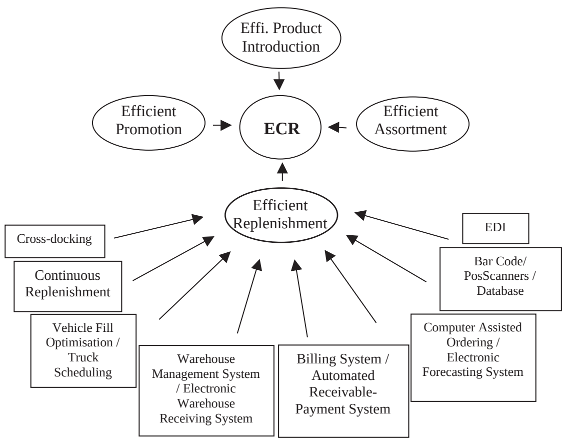

Fig. 1. Efficient consumer response.

There are not many studies to be found in literature that analyse in detail a real application of this technique, while those that do exist mostly regard the apparel, food and grocery sector (Cottrill, 1997; Holmström, 1998). The main results obtained in the literature are indicated in the paragraph where the VMI application fields are analysed.

Several obstacles hinder the spread of VMI. The obstacles are linked on one hand to investments needed achieve integration between partners, and on the other to reaching a critical trading volume, and long distances between parties.

This technique has strong potential to be applied in sectors other than grocery, where it was first developed, and could even be extended to the upstream nodes of the supply chain. The evolution of household electrical appliance (Cardinali, 1999; Carpaneto, 1999) has seen a increase of distribution concentration and a simplification of purchases. This develops in part mirrors the

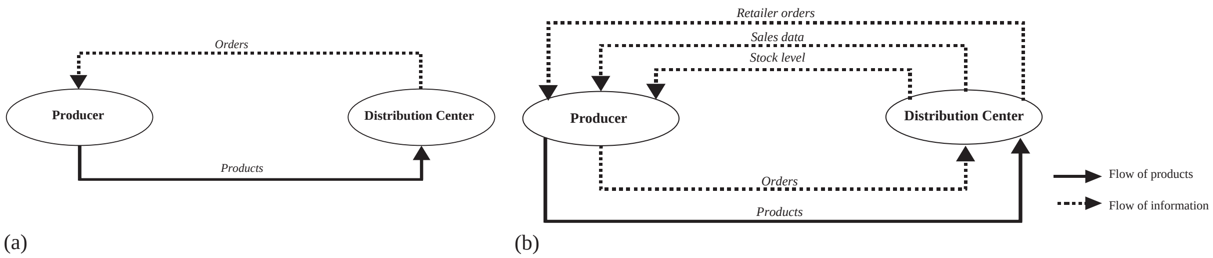

Fig. 2. (a) Traditional replenishment system; (b) continuous replenishment.

evolution in the grocery sector (Schiavoni, 1988; Spranzi, 1994; Zaninotto, 1988) and indicates that VMI could also be useful in the household electrical appliance supply chain. The case proposed is such an attempt. It points out how these ECR principles have been received in the home appliance sector, too. Among the actions taken by the Electrolux group to improve efficiency and internal performance in supply chain the substitution of traditional supply system with VMI had special relevance and success. The system was first implemented to manage replenishments to sales companies, then the same logic was extended upstream to manage replenishments with suppliers. After presenting the mechanisms, algorithms and parameters that regulate the VMI between factory and sales companies it is shown how its adoption-enabled Electrolux–Zanussi group to extend the principles upstream, involving the producing plant and suppliers. The analysis and comparison of the results obtained before and after the implementation of VMI, particularly in the Porcia plant, allow to confirm the validity of the technique and achievement of the theoretical objectives proposed by ECR (Roland and Partner, 1996). Finally this paper extrapolates from the case all the variables that define and characterize the conditions for the application of this technique.

2. Application of VMI in the Electrolux group

Electrolux group's reaction to the aforementioned market changing turns into a search for a revision of the whole logistical and managerial process, migrating from a "push" flow, characterized by erroneous forecasts and high fluctuation of the demand, to a "pull" flow, based direct on the demand of final customers. The key element of this improved process is the exchange and sharing of data and information throughout the whole supply chain, involving suppliers upstream and "sales companies" (SC) downstream. The main logistical device in the improved process is that of VMI, implemented in the majority of SC and extended over the main suppliers (Electrolux Zanussi, 1999).

2.1. Application of VMI towards sales companies

The idea behind the use of VMI method towards sales companies is to implement "pull" control concept: manufacturing and production is to be controlled by market demand, its trends, and seasonal nature, in other words by the actual sales of SC. The sales companies latter share with the factory information relating to their orders portfolio, level of stock, and sales forecasts, and the factory guarantees to cover a determinate safety stock level (target stock-TAS). The same logic is the basis of the replenishment process adopted between the factory and the supplier: the latter tries to restore an agreed stock level of components (TAS) calculated on actual market demand. Here, the analysis of the VMI process within the wider control of the SC is highlighted.

As can be seen from Fig. 3 the actual orders placed by the SC with producers disappear. Moreover planning the quantity to be shipped to sales companies is the responsibility of the producer. Thanks to Target Stock enables the peaks of replenishments to be levelled out, which in turn permit a levelling of production. At the same time market demands are still covered out efficiently and with a high service level.

The Electrolux group has numerous plants and sales companies all over the world. This justifies the group's decision to equip itself with a reliable information system that can transmit world-wide data. The system used is called the Electrolux Forecasting and Supply System (EFS-95), functioning on the IBM AS/400 hardware package. Using this system, sales companies and plants share master data containing information on part number, prices and general characteristics of products. These data are gathered in a common database which is updated by production plants. Inside the replenishment system it is possible to individuate the following processes, outlined in Fig. 4.

Sales Forecasting process is carried out by the sales company. It supplies a forecast on future sales based on past data including past sales, commercial advertising campaigns and customer orders. There are two levels of forecasting: one for the management of long periods and the other for

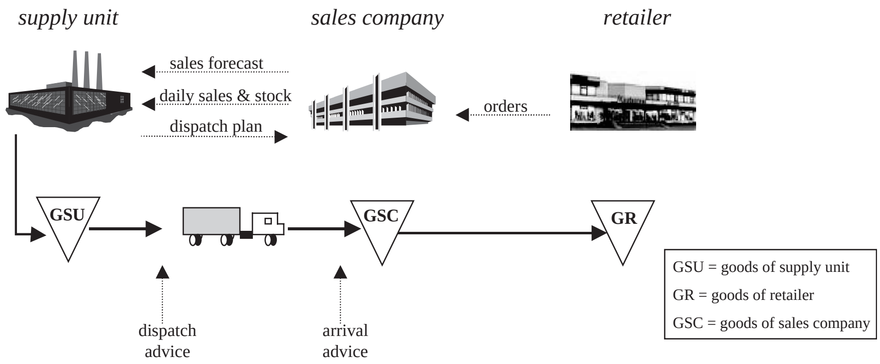

Fig. 3. VMI process towards sales companies.

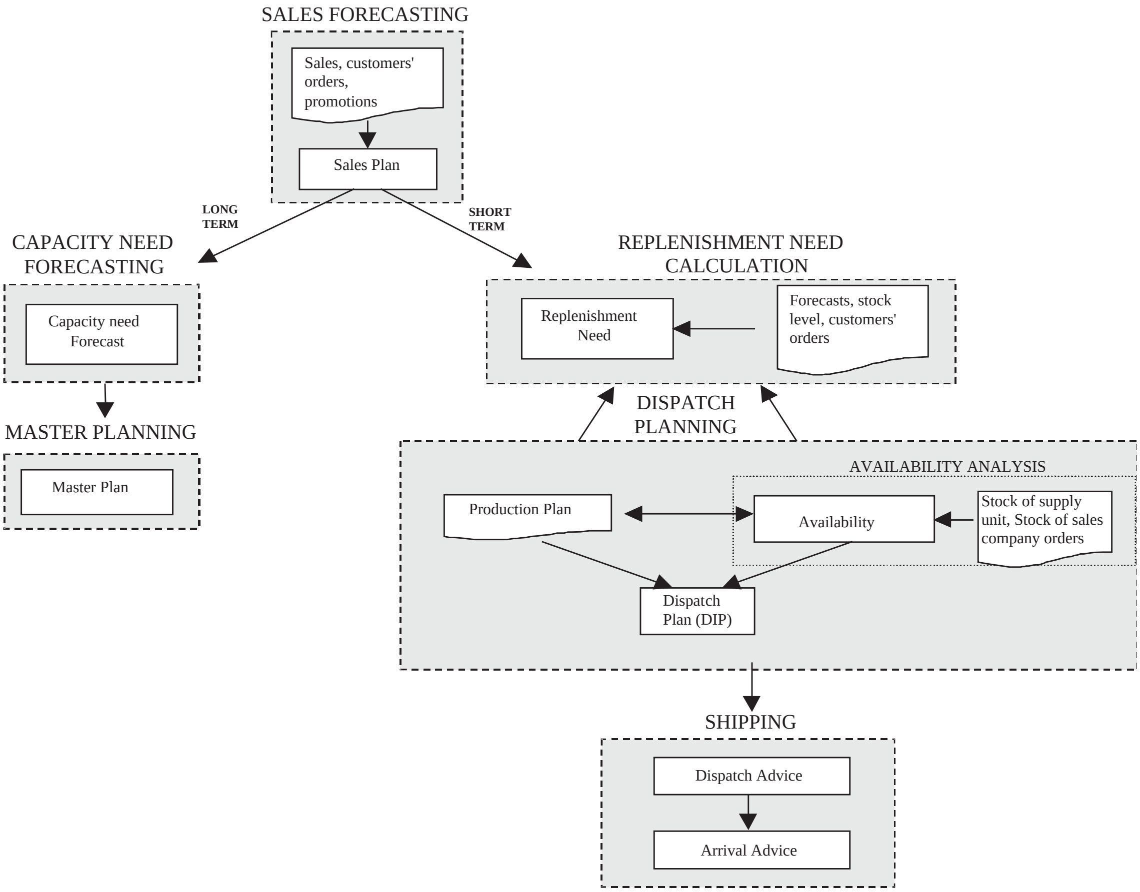

Fig. 4. Processes involved in VMI.

the management of short periods. The former defines the monthly needs of SC in terms of macro aggregates covering a rolling period of 1 year. These forecasts represent the input of Capacity Need Forecasting process where medium-long-term production is defined and the required production capacity is evaluated. Data are shared with the SC and used in the successive Master Planning process. Here the production capacity of plants, the possible maintenance required, the human and material resources needed are defined and programmed in greater detail. Data about the latter are sent to suppliers who are then able to plan their own production capacity. This process, like the former one, does not consider any data related to stock, as it provides for an advance projection of future sales and the relative adjustment of production capacity without any reference to warehouse availability.

Short-term forecasts are made on a weekly basis for each code and cover a period of 12 weeks. They represent the input for Replenishment Need Calculation process in which, for each code, the quantity of goods that must be consigned to a sales company on a certain day is calculated, so that stock is restored to a prefixed level and can cover a specified sales period. The inputs for calculation originate from the sales plan, stock level in sales company, customers' orders, which are dispatched daily, and from the sales forecast, which are dispatched weekly. The first step is the definition of Target Stock (TAS), which is the device used to absorb any unexpected fluctuation in sales until the next arrival of goods. The factory then has to plan supplies so that the SC warehouse contains a level that can meet the forecasted needs. The factory and SC agree on the value of TAS in days (TASdd), that is, the number of days covered by the supplies in warehouse. That value is determined according to the level of reliability of the forecasts on each code (in fact, once a certain service level has been decided a lowering in the reliability of forecasting increases the level of safety stock), and the trust and reliability of supplier and the frequency of replenishment.

To determine the level of stock in the SC that the factory has to guarantee, a calculation is made starting from the TASdd, its equivalent in pieces depending on the customer's needs calculated by evaluating a predetermined horizon of visibility:

$$\text{TASpc} = \frac{\sum_{i=1}^{n} \text{forecast}(i)}{nd}\,\text{TASdd}, \qquad (1)$$

where TASpc is the Target Stock in pieces, TASdd is the Target Stock in days, forecast (i) is the forecast of sales in the ith period, n is the number of weeks of the temporal horizon (generally fixed at 4), d is the number of sales' days (fixed at 7), $\sum_{i=1}^{n}$ forecast$(i)/nd$ is the forecast of average sales per day during the period considered.

The system calculates the TASpc for 12 rolling weeks, therefore, the plant have to know input data for the needs relative to the following 16 weeks (in the hypothesis of $n = 4$).

Once TAS value has been fixed, Replenishment Need (RN) is calculated; RN is the quantity the factory has to dispatch to the sales company so that the SC's stock level at the moment of arrival of goods is equal to the level of TAS calculated for that period (Fig. 5).

$$\text{RN}_i = \text{TAS}_i + \text{Requirement}_i - (\text{GSC} + \text{GIT})_{\text{current}}, \qquad (2)$$

where $\text{GSC}_{\text{current}}$ is the current level of stock in sales company, $\text{GIT}_{\text{current}}$ is the goods in transit which will arrive in SC, Requirement is the need relative to the period considered, that is, the maximum value between sales forecast and the sum of back orders and customer orders:

$$\text{Requirement}_i = \max[\text{forecast}_i, (\text{CustomerOrders}_i + \text{BackOrders}_i)], \qquad (3)$$

where BackOrders are the quantity of goods not yet delivered.

Starting from the value of RN the factory determines the quantity of each single good to be consigned to SC using a calculation of finite

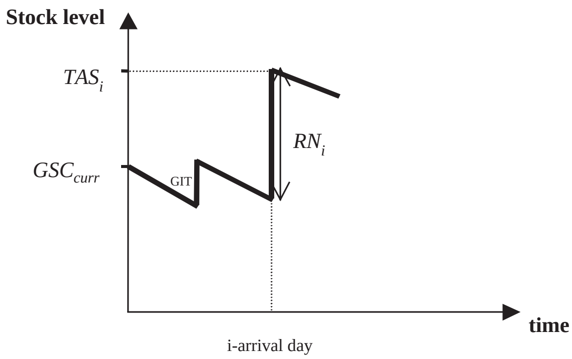

Fig. 5. The tendency of the stock.

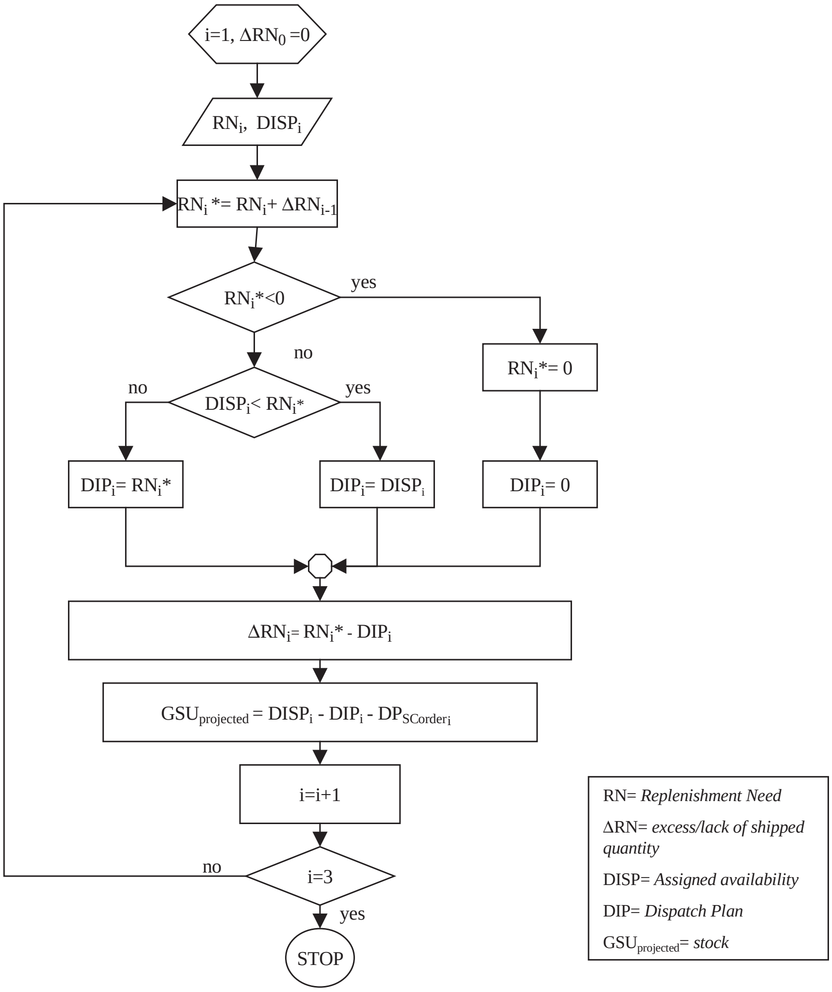

Fig. 6. Dispatch Planning.

capacity, (Dispatch Planning, Fig. 6), that is, warehouse availability and production plan are considered. It is considered if does exist or not the availability to cover Replenishment Need, considering on one hand production plan and on the other the availability of products in a fixed period deduced using the sub process of Analysis of Availability.

The availability assigned to SC during a fixed period is thus equal to:

$$\mathrm{DISP}_{i,k} = \mathrm{GSU}_{\mathrm{assigned}_{i,k}} + \mathrm{AP}_{\mathrm{assigned}_{i,k}}, \tag{4}$$

where $\mathrm{DISP}_{i,k}$ is the availability assigned in the ith week to the kth SC, where $\mathrm{GSU}_{\mathrm{assigned}_{i,k}} = \mathrm{GSU}_i * \sum_{j=i-3}^{i-1} \frac{\mathrm{RN}_{j,k}}{4} / \sum_{k=1}^{n} \sum_{j=i-3}^{i-1} \frac{\mathrm{RN}_{j,k}}{4}$ is the quantity of goods in a determinate code assigned in the ith week to the kth SC, GSU_i is the quantity of goods available in the ith week for the SC managed by VMI, $\mathrm{RN}_{j,k}$ is the value of the Replenishment Need in the ith week of the kth SC, and $\mathrm{AP}_{\mathrm{assigned}_{i,k}}$ is the assembly plan assigned in ith week to the kth SC.

If this availability is not sufficient to cover all the demands, the system assigned the quantity of good ($\mathrm{GSU}_{\mathrm{assigned}}$) on the basis of the quantity required by the sales company in a fixed period compared to the total requirements in the same period. The model is characterized with a two-weeks frozen production period, that is a temporal horizon in which the production plans cannot undergo further modifications. In the first week of frozen production ($i=1$) (Fig. 6) the calculation begins from the value of the RN for that week (RN_1) determined beforehand by the RN Calculation. If the value is negative the system automatically cancels it so that no goods are dispatched to the SC. Conversely, the system considers the availability assigned to the SC (DISP1). If it is higher than RN_1 then the quantity that will be dispatched to the (DIP1) is equal to the value of RN_1, otherwise a quantity equal to the availability assigned will be dispatched to SC. After this calculation the quantity dispatched, either in excess or deficit (ΔRN), and the quantity of stock at the end of the first week of the frozen production period ($GSU_{projected_1}$), are determined, also considering the dispatch plan for those SC not managed by Replenishment ($DP_{SCorder}$). This calculation is repeated for the second week of frozen production quantities and for the first week not frozen. This sets an assembly plan that will satisfy the forecasted Replenishment Need. For the third week then DISP = RN = DIP and consequently $\Delta RN = 0$. If for a certain code the $GSU_{projected_3} > 0$ it means that the assigned availability is greater than demands and therefore it is re-assigned within the frozen production period to those SC whose code has a $\Delta RN > 0$ (delayed consignment), thus increasing assigned availability for that period and consequently the DIP.

Let us now see how, in the Porcia plant, the temporal organization of those phases of Replenishment that lead to planning restocking and productive lines in short time are organized. As the model provides, every day sales companies send the factory, by EFS95, data regarding sales, Stock Levels (GSC), Arrival Advice and order portfolio. On Monday mornings the sales forecasting for the 16 rolling weeks is sent. Thus on Mondays (Fig. 7) TAS and RN are calculated for the 12 rolling weeks. These data are integrated by the level 4 local system with those relative to factory stocks and transferred to the level 3 system that plans production lines at weekly intervals. In

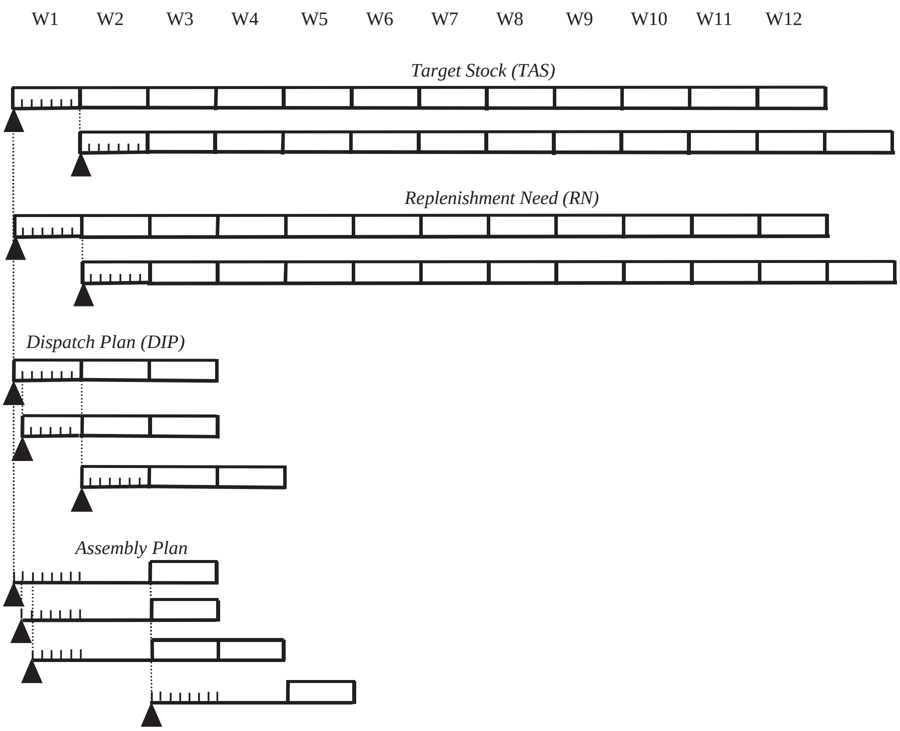

Fig. 7. Phases of replenishment planning.

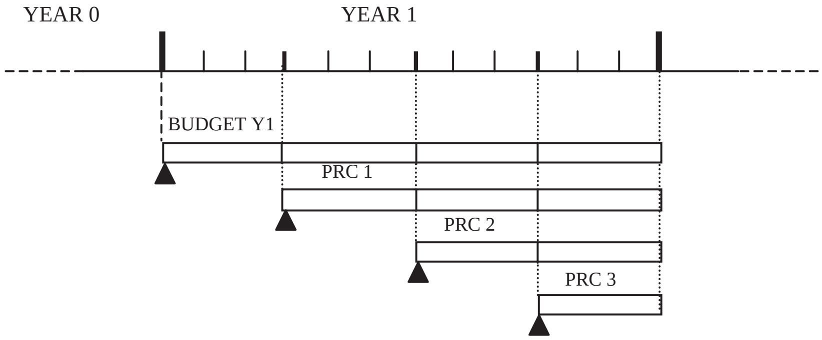

Fig. 8. Exchanged information and phases in replenishment process.

particular the Dispatch Plan for the current week (W1) and the following two weeks (W2, W3), and the expected assembly plan for the following second week (W3) are determined.

If necessary on tuesdays the Dispatch Plan and consequently the assembly plan for W3, which therefore is frozen and distributed on the several assembling lines, are manually modified, while on Wednesdays a provisional one is created for week W4, to be delivered to suppliers.

Finally in the Shipping process, DIP quantities being produced or withdrawn, they are consigned to sales companies. As soon as consignment has been done, a *Dispatch Advice* is delivered, that on one hand allows to update the value of good in transit from the factory to the SC (GIT—Goods in Transit), and on the other hand allows sales companies to prepare receiving the goods. Once the goods have been received the sales company sends an *Arrival Advice* that allows to update GIT again and inform the factory of the receipt of goods delivered.

3. Application of VMI towards suppliers

The Electrolux Group has extended the Replenishment process upstream in the supply chain, involving the majority of the suppliers. In particular for the Porcia plant the process involved more than 50% of the total number of suppliers and they account for more than the 80% of the components needed in production.

As in the relation between the SC and the factory, where the production plant replenishes the warehouse of the SC according to a pre-fixed level of supply of finished products, also suppliers are made responsible for the stock level of components or subsets based on actual demands.

Different from what happens in the replenishment process between the factory and the SC, in this case the process of calculation of various parameters isn't carried out by the supplier but by the production plant. All the data that contribute to determine these parameters (sales orders, supply level, forecasts, etc.) are however transmitted and shared with suppliers. The mostly used transmission device is EDI that, together with Extranet, carries out the 75% of the communications between the production plant and the suppliers.

The exchanged information (Fig. 8) can be divided on the base of the temporal horizon.

3.1. Long-term information

This is the historical data and sales forecasts of representative SC selected on the basis of the seasonal nature of the market, the production capacity of the plant and the bill of materials. The most important document is the *Budget*, created and placed at the suppliers' disposal every year. The Budget contains forecasting data about supply for each component with relation to the whole following year. This document is updated quarterly as far as codes and volumes, and changes its names to Preaccount (PRCi) to indicate that the data of the former *i*th quarter are fixed (Fig. 9). These data allow the supplier to univocally manage the quantities of components with relation both to appliances and spare parts, kits and

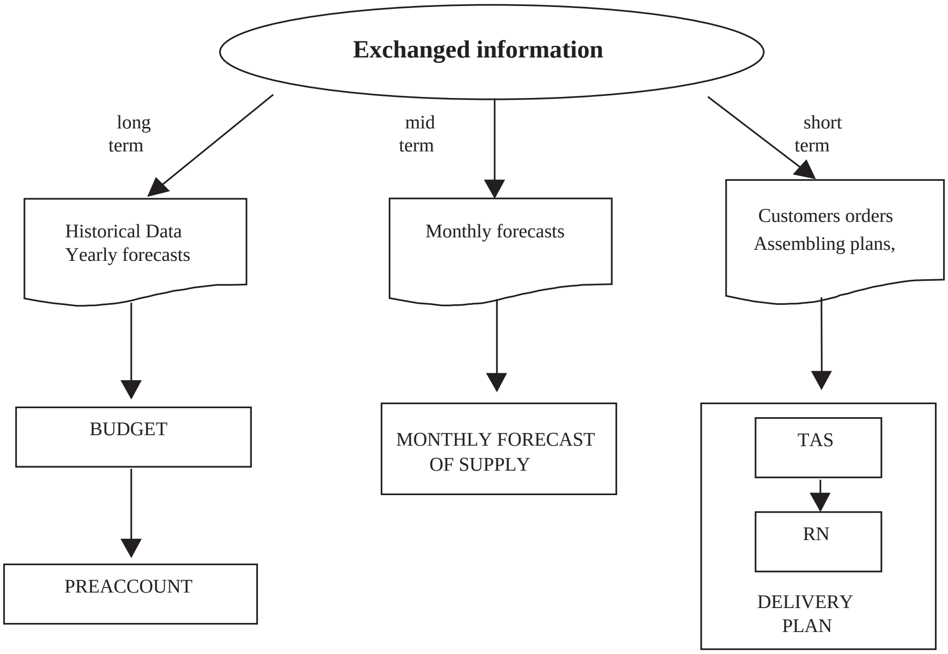

Fig. 9. Schematization of long-term information.

substitutes, and to forecast incidental critical states that could occur during the year. These data are often passed by fax or EDI.

In this way many advantages can be obtained: the supplier knows the productive seasonal nature of factory and is able to single out the incidental critical states. On the other hand the supplier has to compare the data of required production with his own production capacity, in order to decide about possible investments, probable preproductions or the renunciation to a certain part of production.

3.2. Mid-term information

They concern the re-setting of forecasts on the base of the actual market trend given by SC. Long-term yearly data pass month by month to the short-term management. Every first week of a month (W0) it is created the forecast of supplies of the second following month (M2) and the supplies for the current month (M0) are frozen. The data related to M1 and M2 months are updated week by week (Fig. 10). Also this information is used by suppliers to adjust their own production capacity on the base of requests.

3.3. Short-term information

This is actual data that originate from the real quantities of produced and sold appliances, the orders received by the SC, the bills of materials updated week by week that therefore contribute to determine the needs of components, calculated on the basis of the planned assembly schedule. Even if there is the will to spread the use of Extranet in future, this data, mainly transmitted by EDI, are used for the daily check of Target Stock, Replenishment Need and therefore updating of the Delivery Plan (DIP).

As explained in Fig. 11, the replenishment system for the short-term assumes that the delivery plan has a frozen period of 1 week (five working days). The DIP's forecast, which is daily updated, covers the second week and, starting from Wednesday, also covers the third week, too, resulting in a planning window of variable length.

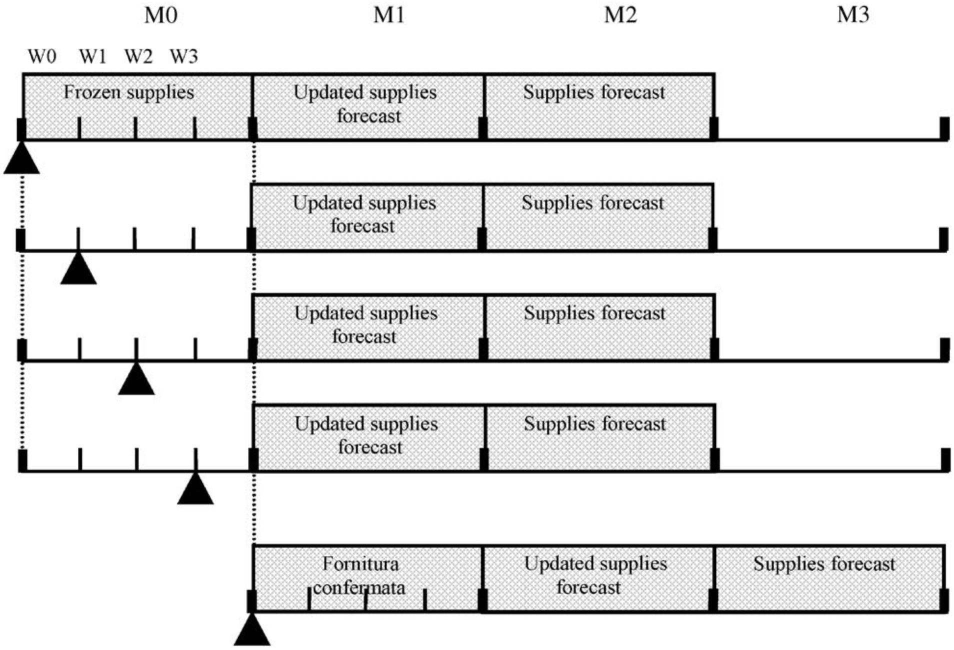

Fig. 10. Mid-term information and usage.

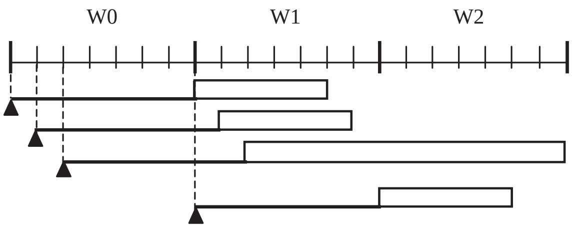

Fig. 11. Dispatch plan (DIP).

As is the case between sales company and factory, the checking of replenishment requirements consists in determining, for each code, the quantity of goods that the supplier has to consign to the production plant to restore the agreed stock level. The inputs for calculation come from production requirements, that is, the quantity of components required by the lines on the base of the planned assembly schedule and the stock level in the factory.

The calculation starts from the setting of TAS, which has to absorb incidental delivery fluctuations during the frozen period. Even in this case there is a TAS expressed in days (TASdd) and settled with the supplier according to delivery frequency, the distance of the supplier, type and critical state of code. There is also a TASpc that, taking into account the need of the planned period, converts the days of coverage into pieces:

$$\text{TASpc} = \frac{\sum_{i=1}^{n} \text{forecast}(i)}{nd}\,\text{TASdd}, \tag{5}$$

where n is the number of days of covered by the forecast (fixed 5 by the Porcia Plant).

Forecast is the quantity of components required in the lines for the assembling of the ith day. Before determining the Replenishment Need, that is the quantity of goods that the supplier has to consign to restore TAS, the available quantity of stock in warehouse (Stock_i) is calculated,

$$\text{Stock}_i = \text{Stock}_{i-l} - \Delta\text{TAS}_{i-l} - \text{Anticipated Requirement}_{i-l}. \tag{6}$$

The quantity of available supplies is calculated considering the former period (Stock_{i-l}), the variation of TAS related to the former period $\Delta\text{TAS}_i = \text{TAS}_i - \text{TAS}_{i-l}$, and the Anticipated Requirement_{i-l}. Anticipated Requirements are

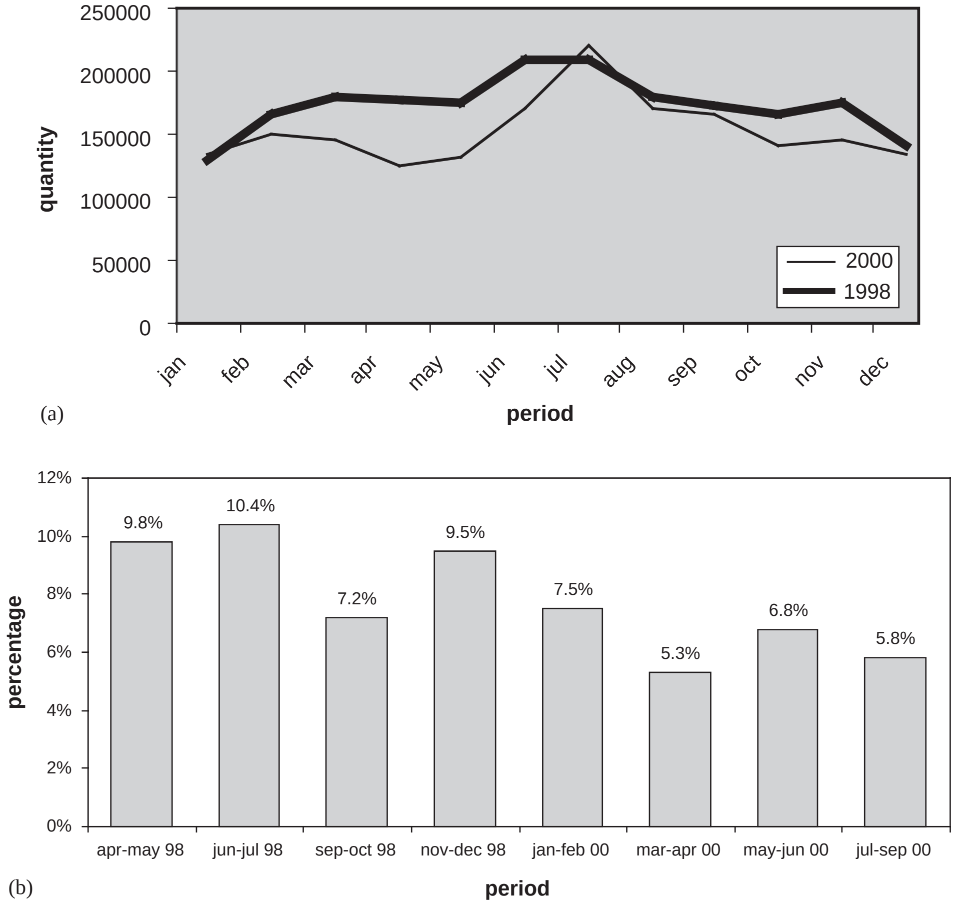

Fig. 12. (a) Integrated supply trend; (b) percentage of order lines not filled due to the production system.

the requirements for the components that, before being used at the final assembling of the line, need to undergo one or more preassembly phases, and therefore their delivery has to be made earlier than indicated by the final assembly plan by a certain number of days (generally 2). This parameter is generally the requirement related to the second following period.

4. Results

The adoption of VMI has proved a great success for the Electrolux group. The change from the logic of traditional replenishment to VMI approach has provided significant advantages for all involved in distribution and supply chain. In particular for the factory these include: (a) immediate response to customer's various requirements, (b) higher level of customer service, (c) fewer errors thanks to the elimination of paper documents, (d) increased market visibility, (e) improved planning and reduced re-planning, (f) significant stock reduction both inside the factory and in the upstream and downstream chain, (g) better management of risks and opportunities, (h) greater sales.

Examining the Electrolux plant in Porcia, and comparing the years 1998 (the year when the VMI process directed towards SC was installed) and 2000 (the year in which the process can be considered routine), the results achieved can be demonstrated by comparing the main performance indicators of the supply chain:

the total inventory and of Order Fill Rate towards retailers.

As can be seen from Fig. 12(a) the volume of total inventory has been notably reduced (in certain periods the reduction has reached 30%), with a consequent significant decrease in the cost of storage to the advantage of the whole chain. This reduction in costs can be transformed into a reduction in the price of product leading potentially to an increase in sales.

Another important result is that obtained from the analysis of the Order Fill Rate, that is firm's ability to satisfy in terms of time and volume the requirements of the final customer, estimating the orders not correctly filled. In particular the number of orders not settled by the firm on the agreed date or in the agreed quantity due to stock-out, and so directly due to the productive system, have been evaluated.

Passing from 1998 to 2000 (Fig. 12(b)) it can be seen from the analysis of the Order Fill Rate, that there has been an increase in the number of correct shipments and a decrease in the number of orders not correctly fulfilled, due to errors imputable to productive system.

5. A comparison between traditional system and VMI

As it has been mentioned in the introduction, VMI transforms the traditional replenishment system. Starting from the theoretical analysis of these two processes and this case study, six main characteristics can be pointed out, which define and differentiate the two proposed models (see Table 2): order generation, exchanged data, used devices, the management and planning of production by supplier, performances and application contexts.

5.1. Order generation

On the base of the analysis carried out the order generation process proves to be extremely different and modified in the passage from traditional system to VMI: the responsibility of replenishment passes in the hands of supplier who does not receive orders to fill, but plans the quantities and times for replenishment so to guarantee a dynamic stock level according to market flows (TAS—Target Stock), and to optimize not only his own stock, but the whole integrated stock.

5.2. Exchanged data

Therefore, the mere transfer of purchasing orders to fill between customer and supplier gives space to an intense exchange of data and information about selling forecasts, the stock level of customer's warehouse, the orders and consumes of the nodes of chain more downstream, the promotional actions undertaken by customer.

5.3. Used devices

The greater intensity and timeliness demanded by VMI to the flow of materials and information require the use of such devices different from those that support the traditional model. Therefore on one hand traditional devices are used based on paper supports (fax, etc.), on the other hand, paperless electronic instruments, standardized systems for transmission and coding, automated systems for the generation and management of replenishments, are used.

5.4. Planning

Moreover, in VMI the sharing of sales data and marketing activities between the two parts allows first of all to carry out a notable decrease of demand amplification along chain (Forrester effect). This is due to reducing the increase in dispatch volumes caused by decisions taken by single members of the chain, to secure promotions or safety stock levels. Secondly VMI allows the levelling of the supplier's forecasts and therefore an improvement of production planning at the suppliers. The greater reliability of sales forecasts (SF), the definition of a dynamic stock level (TAS) to guarantee service to the end customer and the continuous stock monitoring of the SC allow the supplier to obtain, unlike in the traditional production planning mainly based on distorted sales forecasts, a more stable production plan

(Master Production Schedule—MPS). Having the freedom to plan replenishments, the supplier is able, requirements being equal, to achieve a greater levelling and optimize the production capacity, as well as a better use of transportation capacity in dispatched loads.

5.5. Performances

The greater logistical, and most of all informative, integration guarantees an improvement in efficiency not only inside every single unit, as happens in a traditional replenishment system, but inside the whole supply chain. The continuous monitoring of customer demand indeed allows the supplier to select, in case of an unavailability of products, new criteria for the allocation of capacity or materials according to the actual market requirement and not to rely, without a clear vision, on criteria like the ordered quantity, frequency, the importance of customer, etc.

5.6. Application fields

The application field of the process based on the logic of VMI is not unlimited. In fact even inside an Electrolux production plant, it is the primary but not the only management system of replenishments. Both for upstream re-replenishment process and downstream replenishment traditional order is needed for doing business with many suppliers and customers.

One of the main hindrances to the spreading of VMI is the reluctancy of certain companies in considering the benefits offered by cooperation.

There still persists, most of all in distributors, a strong distrust in transferring replenishment responsibility towards producers and sharing data related to consumers, sales plans and forecasts. This fear originates form the strong belief that in this way their power of channel would be reduced, allowing producers to approach and better know the demands of final consumers (Saiper and Geiger, 1996). Many distributors do not understand that only through cooperation a chain can reply more efficiently to the market's demands and therefore be a more competitive channel. These problems surfaced also in the Electrolux case, that has been discussed. Particularly the fear of loosing control, most of all in sales companies, was present at the beginning and proved to be a restraining element for the implementation of this replenishment system in practice.

Moreover it is important to notice that the implementation of a VMI process requires organization changes in the production plan, too. These changes do not involve only the logistical function but all the functions (Maggiali, 1997), particularly sales (that allow the reduction of customers' stocks), production planning (that focuses on an increase of flexibility), marketing (that together with distributors selects the product range to focus on), purchasing (that try to apply towards suppliers the same concepts of VMI used downstream). A decentralized organizational structure therefore proves to be preferable to an accentrated structure (Sabath et al., 2001).

To these requirements have to be added the elements that affect the reached performances and consequently the application fields (Table 1). On the one hand are considerations linked to the characteristics of the demand for a product, particularly its variability and predictability. On the other is considerations linked to the volume of a product. Conflicting results have been achieved in the evaluation of the impact of demand variability on VMI system performances. While Gavirneni (2001) and Xu (1996) assert that together with the increase of variability, the

Table 1
Variables which affect performances and application field of VMI compared with traditional system

Variables	(Value of variable)	
	Low	High
Exchange volume		■
Distance between the parts	■	
Reliability of dispatched information		■
Predictability of demand		■
Variability of demand		■
Reliability of supplier		■
Computerization level		■
Flexibility	■	
Productive capacity	■	
Criticality of code		■
Bulk of the code	■	

benefits obtained by greater cooperation given by VMI increase too. Waller et al. (1999) and Cochen Kulp (2002) contradict these outcomes demonstrating how an increase of demand variability does not basically modify the performances gained by VMI system and therefore this variable does not affect its application field.

In our opinion the study of the influence of this variable on VMI performances cannot be analysed without considering the ‘‘flexibility’’ variable, which has not been taken into account in Waller et al. and Cochen Kulp's studies. With highly flexible own production systems, and with suppliers that have also flexible production systems, VMI allows a substantial reduction in the time to respond to the changes in the market or to the overproduction (Gavirneni, 2001; Waller et al., 1999). The benefits of VMI determined by better predictability and production planning could therefore be reduced.

Moreover VMI performances turns out to be deeply affected by the predictability and accuracy level of demand (Cochen Kulp, 2002), indeed with a highly unpredictable demand and most of all with low reliability and information accuracy transmitted between customer and supplier VMI benefits prove to be fruitless if compared with a traditional system. Indeed it requires an actual ‘‘infopartnership’’.

Vergin and Barr (1999) and other experiences concerning ECR have highlighted the need to reach a critical mass that justifies the technological investments supporting VMI; moreover Waller et al. (1999) demonstrate how together with the increase of volume the performances of chain increase too, and particularly the level of stoks, and therefore the costs related to these decrease. In Electrolux case, this is one of the main variables that affected the choice between the use of VMI and the traditional system upstream and downstream. Volume and geographical distance between the partners are related also to the IT and automation level required and therefore to the need of supporting technological investments (Helm, 2000), that could be justified only against high volumes and reduced distances. In the Electrolux case this led to the maintenance of a traditional system for some partners, even if only for non-European sales companies and smaller customers at a great distance and with a low penetration in the market. The influence of IT capability downstream has not been as important as it has been for suppliers. This is because sales companies, though being independent entities, have previously already had a level of data-processing and logistical integration with the production plants. Much different is the upstream situation characterized both by a more heterogeneous suppliers base as far as technological and data-processing capabilities are considered, and by a great variety of production and part codes. Towards the suppliers with low IT capabilities, delivery reliability and non-standard product codes, the group maintained a traditional replenishment system.

Many people regard VMI as a mere automation of replenishment process and therefore assert that its usage is justified only for standard products, characterized by steady demand, long life cycle but reduced margins, i.e., those that Fisher (1997) call ‘‘functional products’’. According to Fisher, these products require indeed an effective supply chain, where the main focus is the optimization of the physical flow of products, that is the reduction of costs through the standardization and automation of processes. ‘‘Innovative products’’ on the other hand require a reactive supply chain, characterized with elevated flexibility and careful marketing activity, because the elevated uncertainty of market and low life cycle increment the risk of obsolescence and therefore the costs related to excessive supplies. Actually the potentialities and benefits offered by VMI are closely related to and have to be connected with the strategical collaboration with partners. If it is the production unit who manages the supplies of his own customer in accordance with shared sales forecasts, incidental but without information about actions, like promotional campaigns carried on by the customer or the introduction of new products by marketing, VMI would generate great inefficiencies and losses for both the partners. Moreover the benefits of VMI, coming from the use of a more efficient allocation of resources, based on actual needs, could be greater for ‘‘innovative products’’ rather than ‘‘functional products’’. Therefore,

Table 2
Comparison between traditional replenishment system and VMI

<table>
<tr><th></th><th>Traditional system</th><th>Vendor Managed Inventory</th></tr>
<tr><td rowspan="6">Order generation</td><td>Customer's responsibility vs</td><td>Supplier's responsibility</td></tr>
<tr><td>♦ Order issue by customer</td><td>♦ No order issue</td></tr>
<tr><td>Dispatch vs</td><td>Planning</td></tr>
<tr><td>♦ Supplier carries out the quantity to supply at the delivery date demanded by customer</td><td>♦ Planning of replenishments by supplier, according to an agreed stock level (TAS) dynamical with market flows</td></tr>
<tr><td>Unrelated supply vs</td><td>Integrated supply</td></tr>
<tr><td>♦ Unrelated responsibility of customer's and supplier's supplies</td><td>♦ Supplier's responsibility of integrated supply</td></tr>
<tr><td rowspan="2">Exchanged data</td><td>Transmission vs</td><td>Sharing</td></tr>
<tr><td>♦ Purchase orders</td><td>♦ Sales forecasts
♦ Stock level
♦ Orders received from sales points
♦ Marketing actions</td></tr>
<tr><td rowspan="2">Devices</td><td>Unrelated devices vs</td><td>Common, standard and integrated devices</td></tr>
<tr><td>♦ Informative transfers generally carried out by paper devices (fax,…)
♦ Manual systems of replenishment generation and management
♦ Unrelated encode, identification, transmission and transport systems</td><td>♦ Paperless systems for informative transfer, carried out electronically (therefore more timely and accurate)
♦ Electronical devices for the automation of replenishment processes
♦ Standard and integrated encode, identification, transmission and transport systems</td></tr>
<tr><td rowspan="6">Production management and planning by supplier</td><td>Warped forecasts vs</td><td>Reliable forecasts</td></tr>
<tr><td>♦ Forecasts defined on the base of own sales distortd by the undocumented promotions and overpurchases</td><td>♦ Forecasts defined on the base of own customers' sales and shared actions</td></tr>
<tr><td>Unsteady planning vs</td><td>More steady and levelled planning as far as capacity</td></tr>
<tr><td>♦ Definition of MPS on the base of forecasts (SF), back orders (BO) and the availability in warehouse (DISP)
<table><tr><th></th><th>1</th><th>2</th><th>3</th><th>4</th></tr><tr><td>SF</td><td></td><td></td><td></td><td></td></tr><tr><td>BO</td><td></td><td></td><td></td><td></td></tr><tr><td>DISP</td><td></td><td></td><td></td><td></td></tr><tr><td>MPS</td><td></td><td></td><td></td><td></td></tr></table></td><td>♦ The definition of a dynamic stock level to grant (TAS) and monitoring of supplies of customer (GSC) allow moreover a levelling of production (MPS) and an optimization of productive capacity
<table><tr><th></th><th>1</th><th>2</th><th>3</th><th>4</th></tr><tr><td>SF</td><td></td><td></td><td></td><td></td></tr><tr><td>TAS</td><td></td><td></td><td></td><td></td></tr><tr><td>GSC</td><td></td><td></td><td></td><td></td></tr><tr><td>BO</td><td></td><td></td><td></td><td></td></tr><tr><td>DISP</td><td></td><td></td><td></td><td></td></tr><tr><td>RN (MPS)</td><td></td><td></td><td></td><td></td></tr></table></td></tr>
<tr><td>Assignment of priorities
Not according to actual criticality vs</td><td>Assignment of priorities
according to actual ctitical status</td></tr>
<tr><td>♦ Assignment of priorities not according to actual needs, but on the base of ordered quantity, order frequency, customer's dimension…</td><td>♦ Assignment of priorities according to actual criticality</td></tr>
<tr><td rowspan="2">Performances</td><td>Efficiency of internal processes vs</td><td>Efficiency of both internal and external processes</td></tr>
<tr><td>♦ High lead times of interface processes
♦ Untimely consignments
♦ Loads generally non optimized
♦ High elevated stock</td><td>♦ Short lead times of interface processes
♦ Timely and frequent consignments
♦ Loads optimization
♦ Short integrated stock</td></tr>
<tr><td rowspan="2">Applicability conditions</td><td>Low volumes, high distances,
low integration vs</td><td>High volumes, short distances,
high integration</td></tr>
<tr><td>♦ Even small exchange volumes
♦ Even high distances between supplier and customer
♦ Low reliability and forecast of demand
♦ Low informatization
♦ High flexibility and reply time to market
♦ Low criticality of code</td><td>♦ High exchange levels
♦ Short supplier-customer distances
♦ Reliability and forecast of demand
♦ High informatization
♦ Low flexibility and reply time to market
♦ High criticality of code</td></tr>
</table>

VMI can offer great potentialities to both the types of products. In the Electrolux case, the innovativeness of products has not affected the choice of the replenishment system, but it has influenced the setting of some parameters that define the VMI process, such as the service level required, the target stock, and the replenishment frequence. The characteristics of code that determined the choice of upstream adoption of VMI were specificity, criticality and volume space of code. Those codes provided with high specificity (therefore with a low volume of yearly use), low criticality and elevated volume space are managed with replenishment policies different from VMI; those codes where variables "volume space" and "specificity" proved more important compared with others are managed with a traditional replenishment policy with reorder quantities at needs and hourly timeliness of replenishment. But those codes characterized essentially with a very low criticality are managed with a traditional replenishment system with reorder point (ROP).

Therefore, this presence of both traditional replenishment systems and the VMI, on the one hand highlights the application limit of this technique, but on the other confirm the outcomes achieved by Waller et al. (1999) and by Småros et al. (2003). Referring to a supply chain in which there are, at the same time, both customers managed by a traditional replenishment system and clients managed by the VMI, they prove how, even in this case, it is possible to achieve an improvement of performances for all the customers involved as well as for supplier (Table 2) (Towill, 1997; Fisher, 1997).

6. Conclusions

Thus the data show how the implementation of VMI model that follows the innovative logic of Continuous Replenishment proposed by ECR, has enabled the Electrolux group to obtain important results, confirming the realization of the benefits proposed theoretically. In general the group's appointed goals were reached, and Electrolux's future plans are even more ambitious looking forward to an improvement of replenishment process by strengthening of communications with suppliers and sales companies so that the state of dispatches and market trend can be monitored daily. The main objective is to reduce the greatest source of errors and inefficiency in the process, that is, uncertainties linked to sales forecasts, which is a variable that strongly influences the settlement of TAS and so stock level.

Moreover empirical evidence shows that VMI logic, created for the grocery sector, can be extended with success to other sectors, including that of household electrical appliances. Without doubt the importance of the group considered, together with its upstream and downstream partners who all use the process of VMI, confirms the inherent values that render it suitable for implementation. High sales volume, criticality of supply and product shipments, short distance between firm and sales company, high level of know-how, and the state of advance of IT are favourable conditions for the adoption of VMI.

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