IMPACT ANALYSIS OF A CROSS-CHANNEL RETAILING SYSTEM IN THE FASHION INDUSTRY BY A SIMULATION APPROACH

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ABSTRACT

In recent years, the wide spread of e-commerce and mobile channel purchasing has deeply changed retailing sector, leading to the unavoidable necessity of integrating them with the physical stores. In this context, main purpose of the present work is to analyse how the introduction of this new integrated strategy, called cross-channel retailing, can impact on the performances of a traditional supply chain. In order to analyze the change in trend of a defined set of KPIs, a simulation model has been developed. It uses, as case study, a Fashion and Apparel Retailing company that manages an extended network of both direct-operated and franchising mono-brand stores. Simulation results show that, despite a decrease in service level, the adoption of a cross-channel strategy may result in a significant cost reduction due to the better management of replenishments to stores.

Keywords: multi-channel retailing, fashion and apparel industry, supply chain management, simulation.

1. INTRODUCTION

In the fast changing environment of the retailing industry, adapting to always increasing customer requirements can make the difference in being a highly successful and profitable market leader. In the recent years, one of the main challenge to meet customers' needs is the integration of traditional stores with mobile channels in a new synchronized operating model called cross-channel retailing (Lanzilotto et al., 2014). It gives to customers the opportunity to have a seamless experience across all company's channels.

The last decades, in fact, have been characterized by the wide spread of e-commerce and mobile channel purchasing that have deeply changed retail business and management strategies leading to the birth and the development of e-commerce companies. Furthermore, the diffusion ICT based tools of retail supply chain has contributed to modify retail operations (Elia and Gnoni, 2013). In this context, traditional brick and mortar companies have attempted to increase sales and improve profitability by adding online retail channels for consumers (Bretthauer et al, 2010). Many small businesses, use platforms like eBay and Amazon Marketplace on one hand, and a self-managed online store on the other hand, as sales channels (Schneider and Klabjan, 2013). On the other side, "pure-play" Internet retailers are also opening physical stores or cooperating with traditional retailers (Agatz et al., 2007).

Nowadays, multi-channel retail systems have experienced increasing interest. The simultaneous and integrated management of all channels is not simple and assumes that the supply chain meets the requirements of visibility, accuracy and control of information, flexibility and efficiency. Furthermore, some processes such as inventory management and logistics become extremely critical by adopting a cross-channel retailing.

In this context, focusing the attention on the particular case of the Fashion and Apparel (F&A) industry, purpose of this paper is to analyze the impact on supply chain performance deriving from the introduction of a cross-channel strategy by a simulation approach. The focus on a real fashion supply chain means considering all its features and peculiarities: short product life cycles; unpredictable and volatile demand; impulsive purchasing behavior; wide product variety; demand-driven and long and complex supply chains (Iannone et al., 2015).

After a brief introduction on advantages due to the adoption of new integrated strategies (section 2), the conceptual framework is presented in section 3, defining all the processes, material and informative flows of a cross-channel fashion supply chain with two sale channels. Next, a set of Key Performance Indicators (KPIs) measuring system performance have been defined taking into account store and supply chain operations, service level, profitability and costs (section 4). The case study is the presented in section 5, while in section 6 we describe the logical process of the simulation model and the different operational scenarios. To conclude, in section 7, simulation results are shown and analyzed.

2. ADVANTAGES AND CRITICALITIES OF A MULTI-CHANNEL RETAILING SYSTEM

The multi-channel retailing can be defined as a synchronized operating model in which all of company's channels, i.e. traditional stores and mobile channels, are aligned and present a single face to the customer, allowing companies to meet customers' requirements and to be more competitive. From customer point of view, main benefit due to cross-channel application is to provide a seamless experience across all channels, translating benefits characterizing the online experience

in physical stores and vice versa. Main advantages of the web channel can be observed in the reduction of buyer's search costs, in providing detailed information to the customer and offering a very large range of products. From traditional channel perspective, the proximity to the customer is considered the key element.
Combining the two sales modalities (in store and online) with delivery options, several channels comes out representing the logistic services offered to customers:

- *"buy in store, pick up in store"*: it is the traditional in store purchase and pick up;
- *"buy in store, home delivery"*: after buying the item in store, an additional home delivery service is provided by the retail firm;
- *"reserve in store, pick up in the same or another store"*: when the item required is not available in the store, the retailer verifies availability in another nearby store. In case of success, the product is booked and the customer can pick it up in the store where it is available or wait for the delivery to the first visited store;
- *"buy online, home delivery"*: it is the traditional e-commerce. The user buys the product online and it is delivered to its home.
- *"buy online, pick up in store"*: the customer buys the product online and then picks it up in a physical store or in a pick-up point, thus cancelling home delivery costs;
- *"reserve online, pick up in store"*: customer books product online, then pays and picks it up in the physical store; this model differs from the previous one just in the purchasing process which is not performed online in advance but in the physical store at the moment of the pick-up.

The analysis of different logistic paths highlights the processes that could become critical by adopting multi-channel retailing and several capabilities are required for a successful implementation (Mercier et al., 2014): (i) accurate and real-time inventory management; (ii) lean warehouse operations; (iii) reliable and quick distribution network; (iv) efficient return flows.
Information sharing and synchronization among channels is the distinctive element of the management strategies. Elia et al. (2014) proposed two management models of retailing systems with several sales channels:

- *multi-channel model*: the management of channels is separate, i.e. each channel manages independently information on its products, customers and distribution network;
- *cross-channel model*: the management of the channels is integrated and coordinated. This means a high level of integration in operations which implies the adoption of a single and shared information system containing real-time updated information on purchases and stock levels in each warehouse or store.

3. CROSS-CHANNEL IMPACT ON THE TRADITIONAL FASHION SUPPLY CHAIN

The conceptual framework developed by Lanzilotto et al. (2014), defines all the processes, material and informative flows of a cross-channel fashion supply chain with two sale channels: the physical channel (with the traditional sale in the physical stores) and the "buy online, pick up in store" channel (where the customer can buy the product online and pick it up in the preferred store). This framework is the starting point in this paper for the definition of the simulation model. We describe the particular case of a company that manages an extensive network of direct-operated and franchising mono-brand stores. Below the detailed description of the traditional supply chain and then the additional processes and flows due to the adoption of the cross-channel.

3.1 Traditional channel

Framework shown in Figure 1 with black colour represents processes, material and informative flows that underlie the complex SC in the F&A industry in case of adoption of the traditional channel strategy only (Iannone et al., 2013). Blocks and arrows coloured in red, instead, represent the additional processes and flow required for the adoption of a cross-channel strategy and will be better described in the following paragraph.
The process starts from the development of the *New Collection* by the styling office and the definition of the *Demand Forecasts*. While the *New Collection* is considered as a simple input for our framework, forecasting is one of the pillars on which all further planning activities are based. In the F&A industry this process is crucial and particularly complex due to high volatility and unpredictability of demand and is based on historical sales data and characteristics of the new collection and stores. Next step is the drafting of *Merchandise Orders* (*MO*), which define purchasing quantities for each item, and *Delivery Orders* (*DO*), which define time and place for products deliveries from suppliers. For simplicity, we suppose that the k-th supplier produces the k-th item and delivers it all to the area warehouses in quantity Q_{kj}. The supply process ends with the delivery of goods to the Area Warehouses according to the DOs. At this point, warehouse staff has the task of preparing personalized kits of items to send to the *Stores* (*S*) according to the *Replenishment Orders* (*RO*). The j-th warehouse supplies only a specific set of n_j stores pertaining to its area. The process described so far defines the material and informative flow that characterizes the PRE-SEASON phase that, as the name implies, is performed before the beginning of the selling season. The IN SEASON phase, instead, starts with the first sales recorded in the stores. We suppose that both deliveries form the suppliers and replenishments to the stores are also performed during the selling season even if they are scheduled before it.

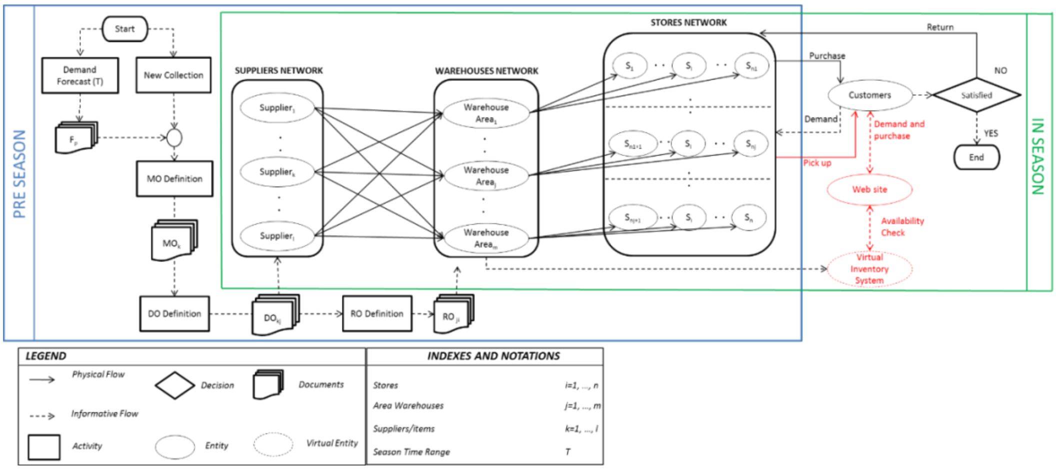

Figure 1: Supply Chain Of F&A Industry – Traditional And "Buy On Line, Pick Up In Store" Channels

3.2 Channel "buy online, pick up in store"

With the modality "buy online, pick up in store", also called "Click and Collect" strategy, the customer chooses products online and then picks them up in the physical store or dedicated facility. Management approach of this channel changes according to the retailing model applied. If a *multi-channel* model is implemented, the product bought online is shipped from a central warehouse to the store selected by the customer; no control is carried out at the store level to verify the product availability. On the contrary, if *cross-channel* model is implemented, central warehouses and stores' inventories are synchronized as a centralized inventory works. Thus, the customer chooses a product on the web site and if it is available in the selected store, he can buy it online and pick it up in short time (e.g. less than one hour). Otherwise, the information system verifies in which warehouses the product is available and plans a shipment from the nearest location to a specific store. The cornerstone of the system is the *Virtual Inventory System*: it contains data of all central warehouses and stores' inventories updated in real time.

4. KPIs

The set of KPIs used for our analysis were selected after a careful study. After a literature study we were able to find and analyse the indicators already used in retail field for the evaluation of supply chain performance. Some KPIs are focused on inventory management, particularly on inventory inaccuracy, i.e. the discrepancy in information between the real inventory and the information system, and the costs directly related to it (Fleisch et al., 2005). On the other hand, considering the order fulfilment process, the main parameters to be estimated concern the service level in store and the indicators express the accuracy of delivery in terms of lead time, quality and quantity of delivered goods (Amer et al., 2010). Mattila (1999) have analysed retail performance with special regard to product sourcing strategies, while, with reference to financial dimension, extensively investigated in literature, the standard financial indicators, e.g. Return On Investment, Return On Assets, Net Cash Flow, etc., have been applied also to retail supply chain (De Felice and Petrillo, 2013; Byoungho, 2006; Moore and Fairhurst, 2003). Therefore, the processes to be taken into account are several; a useful tool to monitor all of them is the SCOR Model. It is a reference model applied for performance measurement of supply chain processes (Caricato et al., 2014). Vlachos (2014) has chosen eight areas for the performance evaluation of retail supply chains: plan, forecasting, source, replenishment, ordering, distribution and delivery, store operations, sales and returns. Taking into account SCOR areas of interest and indicators, together with parameters deriving from business practices, a set of KPIs are defined for a traditional retail supply chain.

Their definition is reported in table 1.

5. INTRODUCTION TO THE CASE STUDY

As already mentioned, main purpose of this research work is to analyse the impact of the introduction of a new integrated strategy on Supply Chain performances through the definition of a simulation model. As case study we used an Italian Fashion Company which works in the national territory with hundreds of franchising and direct operated mono-brand stores and just a single central warehouse. The data collected from the abovementioned company concern characteristics of 10 selected clothing items and 10 selected point of sales (POS) and the related historical data on sales.

5.1 Characteristics of the Clothing Items

Clothing items can be grouped into:

- *Clothing:* products, such as jackets or coats, that can be quickly purchased without trying them on in the dressing room;
- *Clothing to Try on:* all the items that require the use of the dressing room;
- *Accessories:* handbags, scarves, jewelry, etc.;

And three price ranges: (i) *Cheap:* from 0 a 50 Euro; (ii) *Intermediate:* from 51 to 100 Euro; (iii) *Expensive:* more than 100 Euro.

Table 1: KPIs assessment after the introduction of the "buy online, pick up in store" channel

Category	KPI	Definition	Notes
Service Level	**Forecasting Error (*FE*)**	Percentage of errors in *sales forecasting* (*f*) compared to *actual sales* (*s*). $FE_{ik} = \frac{f_{ik} - s_{ik}}{f_{ik}} * 100$	FE has to be calculated for each sales channel since forecasts are estimated for each of them and not for the whole retail system. For forecasting purpose, in fact, the mobile channel could be treated as an additional store with its defined characteristics.
	Backlog Time	Time range during which the stock level is null.	Together with FE it can help assessing how much the demand was underestimated and it can be used to estimate the amount of possible lost sales.
	Sales Percentage (*%S*)	Ratio between sales and quantities delivered to the stores (*R*). $\%S_{ik} = {s_{ik}}/{R_{ik}}$	In this sector, it is meaningless to evaluate the pure data on actual sales since, given the impulsive purchasing behaviour of customers, sales will increase with the availability of product in stores.
	Service Level	Ratio between actual sales and demand (*d*): $SL_{ki} = {s_{ki}}/{d_{ki}}$	It is usually defined as the ratio between orders fulfilled and total orders received; which in this context are respectively represented by actuals sales and demand.
Profitability	**Inventory Turnover (*IT*)**	It measures how many times inventory is sold or used over a period. It is defined for centrale warehouse and POS by the ratio between *quantity outgoing* the warehouse and *average inventory*: $IT_{W,j} = {R_j}/{\overline{IW_j}}$; $IT_{POS,i} = {s_i}/{\overline{IS_i}}$	For the warehouses, quantities outgoing are defined by the items delivered to the stores (*R*) and $\overline{IW}$ represents the average inventory level. For the stores, quantities outgoing are defined by the actual sales (*s*) and $\overline{IS}$ represents the average inventory level.
	Store profitability (*SP*)	Ratio between turnover and store area. $SP_i = \frac{\sum_{k=1}^{l} s_{ik} * Pr_k}{dim_i}$.	Pr_k represents the price of the k-th item and dim_i is the dimension of the i-th store expressed in m^2.
Supply Chain Costs	**Warehouse management costs (*CW*)**	Fixed and variable costs for management of warehouse and for holding stocks. $CW_j = cfw_j + \sum_{k=1}^{n} (\overline{IW_{k,j}} * cu_k * cH_j)$	- cfw_j : fixed warehouse management cost; - cu_k: unitary purchase cost of the k-th item; - cH_j: unitary holding cost in the warehouse expressed as a percentage of cu_k.
	Store Management Cost (CPOS)	Fixed and variable costs for management of stores and for holding products in stores. $CPOS_i = cfpos_i + \sum_{k=1}^{l} (\overline{IS_{ik}} * cu_k * ch)$	- $cfpos_i$: fixed POS management cost; - ch: unitary holding cost in the store internal warehouse expressed as a percentage of the unitary purchase cost – it is higher than equivalent cost for the central warehouse.
	Primary transport cost (CTP)	Fixed and variable costs of transport from suppliers to central warehouses. $CTP = \sum_{k=1}^{l} \sum_{j=1}^{m} (DIST_{kj} * QD_{kj} * CV_{kj} + CF_k)$	For the k-th supplier and the j-th warehouse: - $DIST_{kj}$: distance expressed in Km; - QD_{kj}: quantity delivered; - CF_k and CV_{kj}: fixed and variable unitary transport cost.
	Secondary transport cost (CTS)	Fixed and variable costs of transport from central warehouses to stores. $CTS = \sum_{i=1}^{n} \sum_{j=1}^{m} [dist_{ij} * R_{ij} * cv_{ij} + cf_{ij}]$	For the i-th store and the j-th central warehouse: - $dist_{ij}$ is the distance expressed in Km; - cf_{ij} and cv_{ij} are fixed and unitary variable transport cost.

The selected items include all the product categories and all the price ranges and they are listed in Table 2.

Table 2 Clothing Items characteristics

	Category	Description	Price Range
1	Clothing to try on	Trousers	Cheap
2	Clothing to try on	Shirt	Cheap
3	Clothing to try on	Dress	Exp.
4	Clothing to try on	Denim Trousers	Interm.
5	Clothing to try on	Denim Trousers	Cheap
6	Clothing	Cotton Cardigan	Cheap
7	Clothing	Jacket	Interm.
8	Accessories	Necklace	Interm.
9	Accessories	Handbag	Interm.
10	Accessories	Foulard	Cheap

5.2 Characteristics of the Point of Sales (POS)

The 10 selected Stores represent a good mix of the whole store network and they are identified by:

- *Dimension* [m^2], including exhibition area and internal warehouse. Stores are "Small" if they are smaller than 100 m^2, "Large" if are larger than 200 m^2 and "Medium" in other cases;
- *Location:* it can be on the Street, in a Shopping Mall or in Airport. Depending on the store location, the three product categories record different sales levels. Accessories, for example, are highly sold in airports because customers are passing and purchases must be very quick, while in shopping malls and on the street, accessories have very little success. Opposite behaviour is showed for clothing to try on;
- *Geographical Area*, in which POS are located. Since we are referring to a company that works nationwide in Italy, we consider three different areas: North, Centre and South.

The 10 stores selected for the simulation represent a good mix of the whole company's network and their characteristics are shown in Table 3.

Table 3 POS characteristics

	Geographical Area	Location	Dimension	
			M^2	category
1	South	Airport	66	Small
2	South	Shopping Mall	113	Medium
3	South	Street	180	Medium
4	South	Street	58	Small
5	South	Shopping Mall	62	Small
6	Centre	Shopping Mall	343	Large
7	Centre	Street	82	Small
8	North	Shopping Mall	100	Small
9	North	Street	84	Small
10	North	Street	41	Small

5.3 Historical Data on Sales

Historical sales data were collected over a time range of 5 months (140 days) corresponding to the whole Fall/Winter season (from October to February), divided into four different periods:

I. Early Season (from day 0 to day 42)
II. Christmas Time (from day 43 to day 85)
III. Early Sales (from day 86 to day 114)
IV. Late Sales (from day 115 to day140)

The following table shows, for each of the 10 selected POS, the historical sales data (hs_i) and in particular the mean number of items sold per day. These numbers represents an aggregate value for all the 10 selected items. To obtain the number of pieces sold for each k-th item, this value must be multiplied for the “mix” value (m_k) which represents how the total value of the sales, reported in Table 4, is shared between the items. This mix is different for stores located in the South, Center or North of Italy and is reported in Table 5.

Table 4 Historical Salesa Data (hs_i)

Period / POS	I	II	III	IV
1	3,08	3,96	2,71	3,08
2	1,89	1,72	8,84	1,895
3	3,68	4,33	4,28	3,68
4	1,57	1,01	0,83	1,57
5	3,13	1,73	2,31	3,13
6	1,95	1,68	1,32	1,95
7	1,05	0,42	0,53	1,054
8	1,14	1,68	1,56	1,14
9	1,01	1,19	0,59	1,01
10	0,96	0,94	0,88	0,96

Then the number of pieces sold, for each of the four analysed periods, for each store and for each item is given by:

$$hs_{ki} = hs_i * m_k$$

6. DEFINITION OF THE SIMULATION MODEL

Main purpose of the developed simulation model was to analyse how performances of a fashion retail supply chain can change when introducing an integrated strategy between traditional physical stores and online sales.

Table 5 Mix Value (m) for the different Areas

Area / item	South	Center	North
1	8 %	22,2 %	6,9 %
2	19,6%	10,9 %	15,3 %
3	7 %	11,5 %	10 %
4	12,3 %	8,4 %	11,7 %
5	11 %	11,6 %	13,3 %
6	9,9 %	10,1 %	8,4 %
7	7,9 %	8 %	9,2 %
8	6 %	2,4 %	1,6 %
9	6,2%	6 %	8,9 %
10	12,2 %	8,9 %	14,7 %

The model developed with Rockwell Software Arena has the main purpose of simulating the supply, delivery and sales process and its general diagram is represented in Figure 3. It uses as input data:

1. *Sales Forecasts* for each item and for each POS (f_{ki}). This value is equal to historical sales data (hs_{ki}) recorded during previous selling seasons as defined in previous section;
2. *Merchandise Order*, which defines the total quantity to be purchased from suppliers for each item (Q_k);
3. *Delivery Order,* which defines quantity and time for deliveries from suppliers to the central warehouse ($D_k(t)$);
4. *Replenishment Order*, which defines quantity and time for deliveries from the central warehouse to the stores ($R_{ki}(t)$).

The model starts with the casual generation of the daily demand for each item and for each store both for the traditional channel ($d_{ki}(t)$) and for the online channel ($do_{ki}(t)$). Even though in current practice not always shop assistants record real demand (which means also recording missed sales) through Electronic Point of Sales (EPOS) devices, this information is highly important for always improving sales forecasts. Given demand, the model checks availability of the requested product by verifying that demand is lower or equal to the inventory level. While for the traditional channel we check availability in the store internal warehouses ($IS_{ki}(t)$), for the online purchases we have to distinguish the two logistics strategies:

- *Multi-channel:* the two channels – traditional and online – are separate, then purchases and deliveries are independently managed. The retailer does not satisfy on line purchases with stores’ on-hand inventory, but always ships the requested items from the warehouse, previously performing a check for availability in central warehouse stock ($IW_k(t)$).

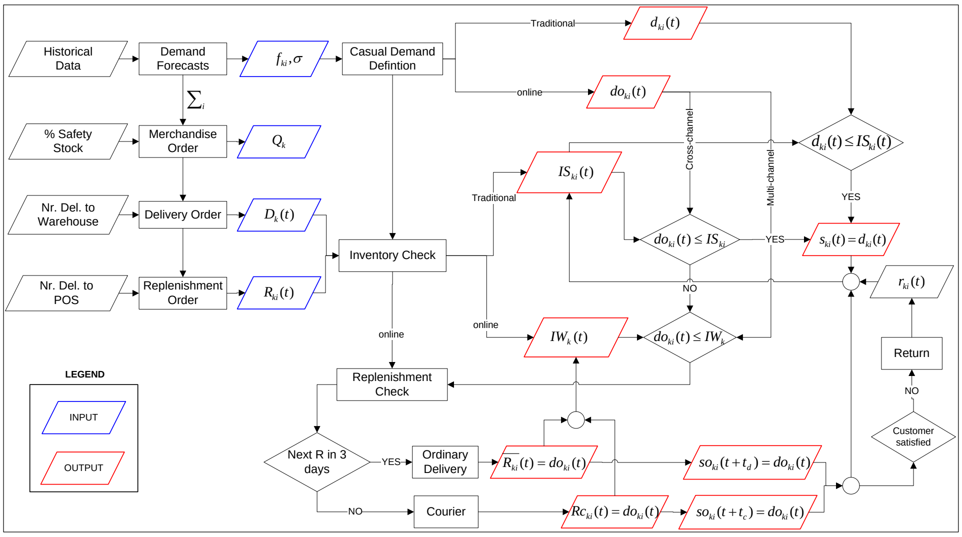

Figure 2 General Diagram of the Simulation model

- *Cross-channel:* in this actually integrated strategy the company has a single and shared information system containing real-time updated information on all stock levels. In this case, the model first performs an availability check in the store internal warehouse ($IS_{ki}(t)$), and then, only in case of unavailability, delivers the requested product from the central warehouse.

For online purchases which are shipped from the central warehouse, we need to perform a further check for replenishment schedule: if there is an ordinary shipment to store already scheduled in the next three days the requested item will be unified with the pre-defined shipment ($\overline{R_{ki}}(t)$) otherwise it will delivered through a dedicated courier ($Rc_{ki}(t)$).
Another crucial variable that has to be considered when dealing with online purchases are returns ($r_{ki}(t)$). While this phenomenon can be disregarded for physical stores, it becomes important in integrated strategies since customers do not physically see or try the item and may simply do not like or fit it. In our model the returned goods will stay in the store increasing stock level and will not be shipped back to warehouse for recovery since we disregard defective products return. The return rate is fixed as the 15% of the online total demand.
Then, output data given by the model are:

1. *Demand*, for the physical stores ($d_{ki}(t)$) and for the online market ($do_{ki}(t)$);
2. *Sales*, for the physical stores ($s_{ki}(t)$) and for the online market ($so_{ki}(t)$);
3. *Inventory levels*, for the stores internal warehouses ($IS_{ki}(t)$) and for the central warehouse ($IW_k(t)$);
4. *Ordinary additional shipments* for online purchases ($\overline{R_{ki}}(t)$);
5. *Courier shipments* ($Rc_{ki}(t)$).

All those outputs will be used to calculate KPIs reported in Table 1.
In the following sections we will better describe all the steps of the simulation model.

6.1 Merchandise and Delivery Order

This plan defines, for each clothing item, the quantities to be purchased from the suppliers. We suppose, for simplicity, that the k-th item is supplied entirely by the k-th supplier.
The purchase quantity is defined by:

$$Q_k = \sum_{i=1}^{n} f_{ki} * (1 + SS)$$

Where f_{ki} is sales forecast for both traditional and online channel and SS is the Safety Stock fixed as 40%.
This total quantity (Q_k) is delivered from the suppliers to the central warehouse in 3 different periods: (i) 80% at time 0 (Dk,0); (ii) 20% at time 50 (Dk,50); (iii) The remaining 10% at time 86 (Dk,86).
It is important to underline that the last deliver to the warehouse (at period 86) coincides with the beginning of the sales period.

6.2 Replenishment Order

Replenishments to the stores are weekly performed, for a total of 17 deliveries from day 1 to day 115 when the late sales period starts. In this last phase, in fact, from day 116 to day 140, the stores try and sell all the remaining goods out in order to reduce costs for the withdrawal of unsold goods. In addition, we suppose to deliver to the stores only the 80% of the total quantity purchased in order to absorb possible fluctuations in demand.
Then the quantity to be delivered to the i-th store is weighted in respect to the sales forecasts f_i and is defined as:

$$R_i = \frac{\frac{f_i}{f} * D_{k,t}}{n_{weeks}}$$

Where n_{weeks} is the number of weeks between two consecutive deliveries to the central warehouse.

The quantity supposed to be sold through mobile channel are not delivered to the stores but stays at the central warehouse waiting for the actual request.

6.3 Simulation scenarios

In order to assess the impact of the introduction of an online strategy on the performances of a traditional supply chain, we simulated 11 different scenarios, by keeping fixed the sales forecasts for the traditional channel (as per Table 4) and increasing the sales forecasts for the online channel.
Given the mean sales forecast for the traditional channel equal to 20.130 item/day, for each scenario we progressively increase the online forecasts of this quantity, except for scenario 0 that simply represents a traditional retailer without online market (Table 6).

Table 6 Simulated scenarios

Scenario	Online forecast [item/day]	Traditional mean forecast [item/day]
0	0	
1	2.013	
2	4.026	
3	6.039	
4	8.052	
5	10.065	20.130
6	12.078	
7	14.091	
8	16.104	
9	18.117	
10	20.130	

It is clear that, according to the sales forecasts, the quantity purchased from the suppliers and delivered to the central warehouse will increase while the replenishment plan remains unchanged. As already mentioned, in fact, items sold online will be shipped to stores with ordinary deliveries when possible; in this case the replenishment plan will be updated accordingly, otherwise they will be delivered by courier.
Each scenario is simulated both with a multi-channel and a cross channel strategy, for a total of 22 simulation.
The simulation time range covers 140 days, i.e. an entire selling season.

7. ANALYSIS OF RESULTS

In this section we show and analyse the trend of the selected KPIs in all the simulated scenarios.

7.1 Forecasting Error

As shown in Figure 3, the mean forecasting error grows with the online purchasing both for the items and POS.
This is clear since we have a return rate which contributes to increase deviation between forecasts and actual sales.
In addition, when introducing a cross-channel strategy, this deviation will further increase since all the items supposed to be purchased online are not delivered to the stores but stocked in the central warehouse and shipped only when requested. It implies that all stores on-hand stock are quickly consumed thus increasing the possibility of stock outs.

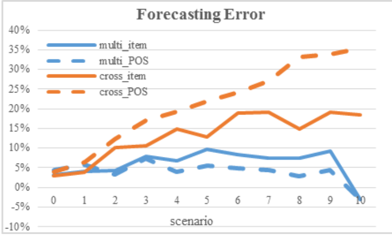

Figure 3 Forecasting Error for items and for POS

7.2 Backlog time

As shown in Figure 4, the backlog time increases when introducing the cross-channel strategy. This indicator is obviously strictly connected to the previous one (forecasting error) since it measures for how long the store is unable to satisfy customer request due to products unavailability.

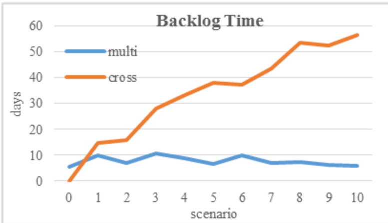

Figure 4 Backlog time

On the contrary, with the multi-channel strategy, online purchases are always satisfied with dedicated shipments from central warehouse.

7.3 Sales Percentage

As shown in Figure 5, in the multi-channel strategy the mean value is almost constant at more than 85% despite the increasing rate in returned goods.

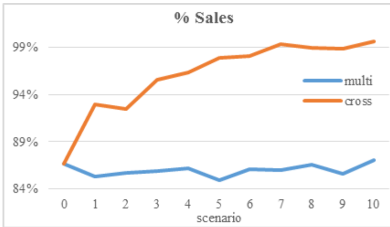

Figure 5 Sales Percentage

Whit this approach, in fact, both sales and deliveries to stores will increase. When introducing a cross-channel approach, additional items will be delivered only if necessary then this ratio will obviously increase.

7.4 Service Level

As shown in Figure 6, for both retailing strategies, service level of the online market does not significantly change. For the traditional POS, instead, this KPI drastically decreases when adopting a cross-channel approach. In this case, in fact, stores stocks are consumed by online purchases as well, then backlog time increases (ref. section 7.2) since scheduled delivered items are not able to satisfy traditional demand. This trend is due to a not optimized replenishment strategy, since quantity supposed to be sold online are not delivered to the stores but stays at the central warehouse waiting for the actual request.

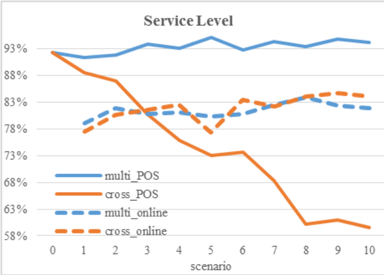

Figure 6 Service Level

7.5 Inventory Turnover

Figure 7 and 8 show an opposite trend of the inventory turnover in central warehouse and stores for the cross-channel strategy. This is due to the fact that, with this approach, before delivering an item from the central warehouse all stores stocks must be consumed. This obviously leads to an increase in inventory turnover for the stores and a decrease for the warehouse.

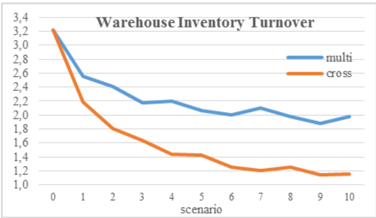

Figure 7 Warehouse Inventory Turnover

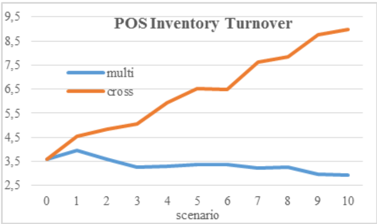

Figure 8 POS Inventory Turnover

7.6 Store profitability

As already mentioned in previous sections, in the 11 different simulated scenarios, sales forecasts and consequently demand, purchase quantity and items delivered to stores. Then, in order to appropriately compare these different conditions, Figure 9 shows the value of the store profitability compared to quantities delivered to stores.

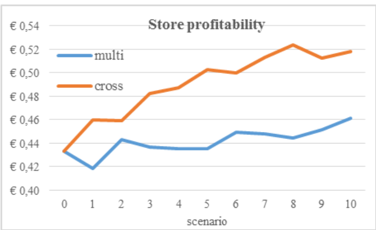

Figure 9 Store Profitability

When introducing a cross-channel approach, this KPI records an increasing trend slightly higher that the multi-channel case since quantities shipped to POS are reduced and, as shown in section 7.3, sales percentage increases.

7.7 Warehouse Management Cost

As for previous sections, in order to appropriately compare the different scenarios, Figure 10 shows the value of the warehouse management cost compared to quantities delivered to it, i.e. the total purchased quantity. It is clear that in the cross-channel strategy, items are delivered to stores only when they are actually requested resulting in a higher average level of stocks (ref. section 7.5); this implies a higher cost for their holding.

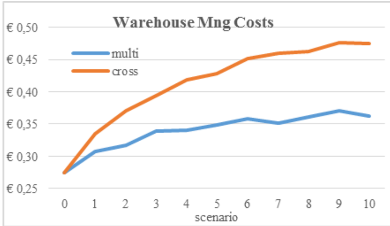

Figure 10 Warehouse Management Cost

7.8 Store Management Cost

Figure 11 shows the value of the store management cost compared to quantities delivered to them. This cost has an opposite trend than the previous one, since in the cross-channel strategy, replenishments to stores, considering both ordinary deliveries and courier shipments, increase and, at the same time, the average stock level in the stores' internal warehouses decreases. This results into a lower holding cost.

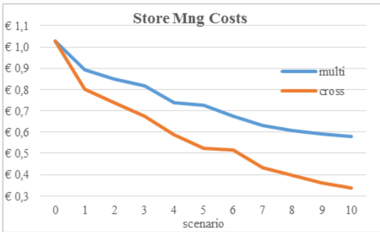

Figure 11 Store Management Cost

7.9 Primary Transport Cost

Parameters used to calculate the primary transport cost are reported in Table 7. These values are estimated according to real transports. Since we use same values for both logistics strategy, their actual value is not influencing global cost trend.

For the fixed transport cost (*CF*) cost we supposed to have a step function which reflects the need of using bigger or more than one means of transport, and is defined as:

$$\begin{cases} CF_k = CF_k & if\ Q_{D,k} < 50 \\ CF_k = CF_k * (1 + 25\%) & if\ 50 < Q_{D,k} < 100 \\ CF_k = CF_k * (1 + 50\%) & if\ 100 < Q_{D,k} < 200 \\ CF_k = CF_k * (1 + 70\%) & if\ Q_{D,ki} > 200 \end{cases}$$

Figure 12 shows the values of the unitary primary transport cost, i.e. the total transport cost compared to the quantities delivered to the central warehouse. This value is equal for multi- and cross-channel since we suppose that purchasing and delivery plans do not change for the two strategies. The slightly decreasing trends reflects the higher saturation of the transport means when quantities increase.

Table 7 Primary Transport parameters

Supplier	*DIST* [Km]	*CF* [€/trip]	*CV* [€/Km]
1	400	30	0,04
2	1600	50	0,015
3	4500	130	0,005
4	2300	110	0,01
5	600	30	0,04
6	850	30	0,035
7	1200	50	0,015
8	1700	80	0,005
9	4700	130	0,002
10	800	30	0,03

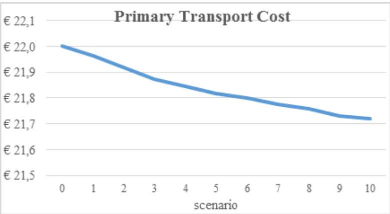

Figure 12 Primary Transport Cost.

7.10 Secondary Transport Cost

Parameters used to calculate the secondary transport cost are reported in Table 8. As per primary transport (section 7.9) these values are estimated according to real transports. For the fixed transport cost (*cf*) we suppose to have a step function which reflects the need of using bigger or more than one means of transport, and is:

$$\begin{cases} cf_i = cf_i & if\ R_i + \bar{R_i} < 50 \\ cf_i = cf_i * (1 + 50\%) & if\ R_i + \bar{R_i} > 50 \end{cases}$$

Table 8 Secondary Transport parameters

POS	*dist* [Km]	*cf* [€/trip]	*cv* [€/Km]
1	50	23	0,1
2	90	22	0,1
3	70	24	0,1
4	30	20	0,1
5	60	25	0,1
6	120	44	0,1
7	150	45	0,1
8	400	52	0,1
9	450	50	0,1
10	500	55	0,1

Figure 13 shows the values of the unitary secondary transport cost, i.e. the total transport cost compared to the quantities delivered to the POS through ordinary weekly deliveries. This value decreases when online purchases increase, demonstrating a higher saturation of transport means.

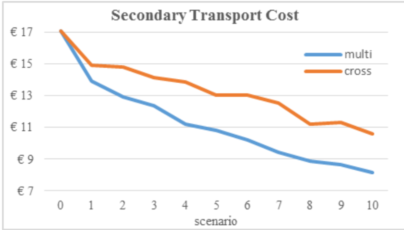

Figure 13 Secondary Transport Cost

On the other hand, this unitary costs remains higher in the cross-channel strategy since on average we deliver lower volumes. It is important to underline that, for online purchases, we need also to evaluate courier costs (Figure 14) since we need to guarantee deliveries within three days even if there I no scheduled ordinary delivery in this time range.

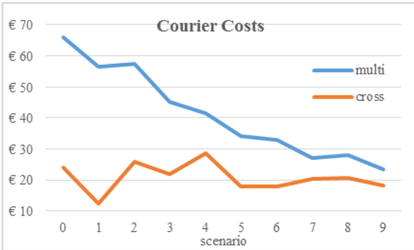

Figure 14 Courier Cost

We are supposing that the courier cost is independent from the quantity delivered in a single solution but it is only proportional to the number of deliveries. For this reason, this cost is decreasing when online purchases increase; in fact, only the quantity delivered through courier increases but not the number of deliveries.
In the cross-channel strategy this value always remains lower since courier deliveries are requested only in very few cases.

7.11 Total Cost

Figure 15 shows unitary total cost (including purchase cost), i.e. the total cost compared to total purchase quantity. It is clear that cross-channel strategy seems to be the most economically viable given that total costs always remains lower.

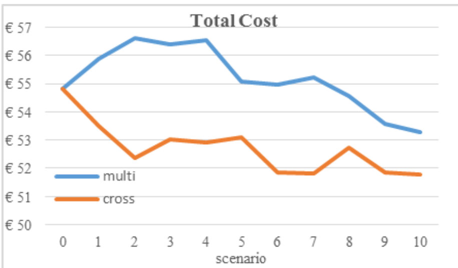

Figure 15 Total Cost

8. CONCLUSIONS AND PERSPECTIVES

The integration between physical stores and mobile channel is the new frontier for retail: customer expectations are always increasing, then operational requirements and supply chain configuration must be considered in the design and management of a cross-channel system.

This paper shows how the introduction of another fulfilment path, in addition to the traditional one, impacts on the SC of F&A industry. The first requirement for the implementation of this integrated strategy is coordination and proper management of the information flow which becomes an enabling factor. The role of the virtual inventory system is, in fact, crucial for the access to data on availability and location of products. In addition, the analysis of a defined set of KPIs which considers aspects connected to service level, profitability and costs, highlights that despite an increase in backlog, the cross-channel strategy can guarantee a significant cost reduction due to the better management of replenishments to stores. It is also important to underline that the replenishment policy is not optimized for the cross-channel approach, then by varying replenishment plans, in terms of frequencies and quantities, we may experience a further improvement both in cost and backlog reduction due to a better fulfillment of customers expectations.

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