POLITECNICO DI MILANO

Inventory Replenishment in Luxury Fashion Industry: An Advancement Strategy

Master's Thesis

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EXECUTIVE SUMMARY

The main purpose of this study is to introduce an advancement of the inventory replenishment strategies developed for the luxury fashion goods. For this purpose, a model is composed and different scenarios are evaluated by using the model. Findings of this study are providing promising insights and contribute to not only the business practices but also the academic communities' for future researches.

1. Literature Review and Encountered Open Issues

The current reports released have shown that the industry of luxury goods is growing day by day so as the interest on the industry. Bain and Company's 2014 Annual Global Luxury Study claims that the luxury market is experiencing a slow but a stable growth. There are number of factors which trigger the success of the companies and the growth of the industry such as design, marketing and communication but undoubtedly these factors are not solely enough for the companies to achieve a sustainable success within the industry. Recent studies on the topic have demonstrated that the whole supply chain and its management strategies are relevant on enhancing companies' competitive advantage within the market. This applies also to the luxury fashion industry and to the companies operating within the industry. The supply chain models and management choices represent a high coherence with the critical success factors of luxury firms, so as the performances of them (Brun et al. 2008). However, the topic of supply chain is a wide area to study and involves a high level of complexity for a number of reasons. Number of players and the number of possible actions can be taken by this players are one of the most important factors that increase the level of the complexity in the supply chains. Moreover, the dynamic nature of the supply chains, which is a result of involving too many non-constant variables, makes the management of them even more complicated. The Brand Owner and the Store which are the two main players in the supply chains of luxury fashion industry, have to make numerous decisions throughout the whole chain. One of these decisions which affects not only the internal performance of the company but also external one, is about the management of inventory levels on stocks, which leads us to think more about the replenishment policies of these inventories.

Replenishment strategy of the inventories is one of the most critical fields of the supply chain topic and it plays an important role at the all stages of the chain. The right inventory replenishment strategy can significantly improve supply chain costs and performances by having a high customer service level while maintaining a low inventory level and replenishment costs. For this reason, a lot of studies have been performed on the topic and the literature on inventory replenishment policies shows a variety of approaches. The existing strategies on the literature define different approaches depending on the review period and ordering quantity parameters. However, it has been observed that almost none of these approaches are applicable to the luxury fashion goods since the market and the product characteristics of the luxury fashion goods represent quite different features. The luxury fashion goods retailing is highly complex and competitive. As it is mentioned before number of players and their possible actions plays an important role on this complexity. The Brand Owner perspective and Store's point of view are so different than each other when we have a look at the inventory replenishment problem from their sides separately, we might end up with different solutions. It is also highly likely that none of these solutions are the one which is best for the sake of the whole supply chain. Moreover, industry includes different companies that have different strategies and target customers with different needs. Different levels of luxury would require applying a different strategy or in the same way, within the same company different type products with different characteristics requires some distinct approaches. Unfortunately, there is almost no academic source that deals with all this complexity directly and tries to define an inventory replenishment model specific for luxury fashion goods. Not only in the literature but also in real life business methods are not structured and the best practices are also not well defined. Therefore, an elaboration on the inventory replenishment strategies of luxury fashion goods by considering specific characteristics of the industry is needed. This need is mainly driven by the key issues listed below:

- The lack of focus on the replenishment strategies in luxury fashion industry, both, in academia and companies
- The complexity of the market and the nonexistent framework of employing replenishment models
- The easily identifiable benefits from having a clearly defined replenishment model

The drivers presented above provide the basis for the study. Research questions are targeting those key drivers and driven by the goal of this study which is to introduce an advancement of the inventory replenishment strategies developed for the luxury fashion goods.

When all these considerations are taken into account, four main questions are formulated:

1. How could re-ordering policies affect inventory levels of stores?
2. How could re-ordering policies affect the performance of different players of the supply chain?
3. How could replenishment strategies' performance change for different product types?
4. How to improve replenishment strategies trough a comprehensive framework, considering lead time and selling period?

With the aim of answering these questions, a definite number of hypotheses are done in this study. These hypotheses that are presented below are expected to shape the course of the study and help the overall objective to be achieved:

- Hypothesis no. 1: By constructing different re-ordering policies, the profitability of the Store, the Brand Owner and the supply chain as a whole could bring the final outcome of the best practices implemented.
- Hypothesis no. 2: By making an observation of products belonging to the luxury fashion category, which have different characteristics, an image for their behavior would be given. By implementing different replenishment strategies, the results will be compared, which will lead to the most optimal replenishment model for each type of product.
- Hypothesis no. 3: Considering lead time and selling period, observations would be done on current practices, together with the simulation the possible improvements in the replenishment strategies will be implemented.

2. Framework of the Research

The framework of the study follows a flow which starts with a comprehensive literature review. Investigating on what has been done so far on the topic is made the identification of the major key issues more clear. On the other hand, the encountered gaps that are faced during the literature review have brought new issues to the table and these questions compose the basis of this study. For the purpose of answering these research questions a model is developed and different scenarios are evaluated via simulation to obtain a better strategy for the inventory replenishment strategies of the luxury fashion goods.

Fig. 1 presented below, captures an overview of the framework of this study that is going to be presented:

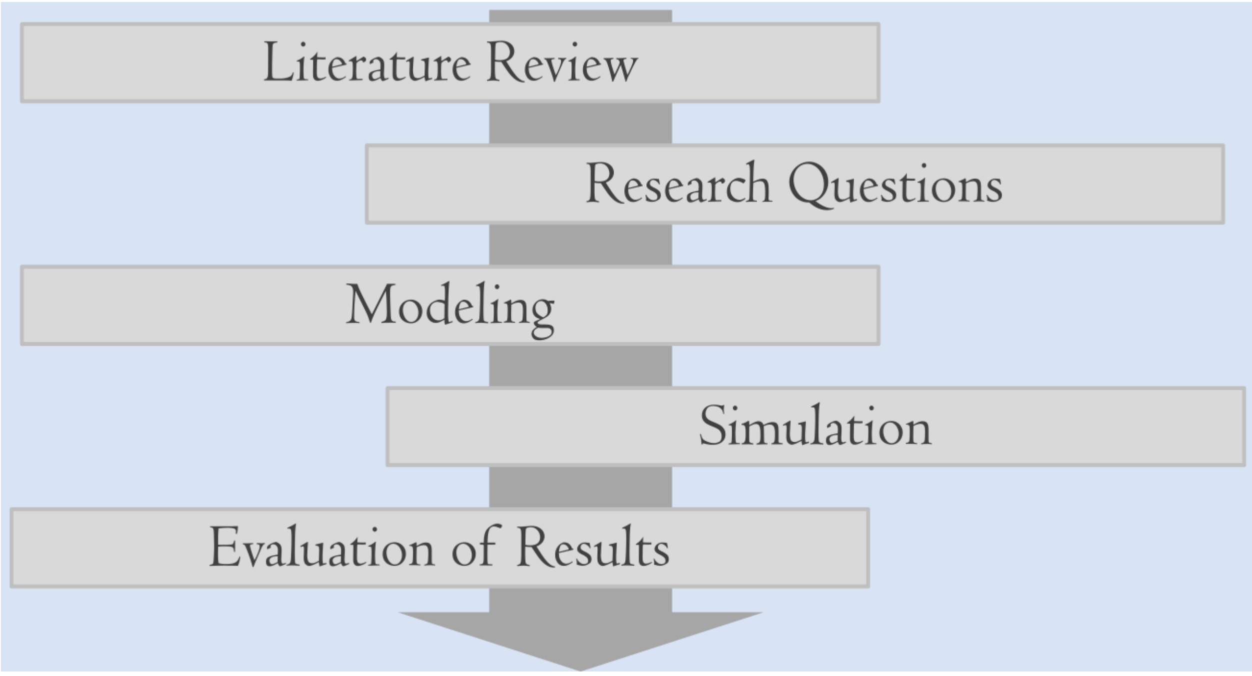


Figure 1: Research Framework

3. Description of the overall Structure and Procedure

Given the above stated goals, it is quite clear that this Master Thesis gives a variety of benefits when implemented in the luxury fashion companies. In order to bring these goals to light, the model structure that has been created has to be elaborated.

When observing the main questions, a clear conception of the framework how the modeling procedure should be conveyed arises. In the initial phase of the modeling act, assumptions based on our research in the field were constructed. By doing so the results from the simulation are represented in a clarified view thus, a picture of the overall system was created.

The below stated assumptions capture the building basis for the model:

- One Echelon Distribution Network - The network applied in the model is composed by two players, the Store and the Brand Owner which are directly connected. This suggests that there are no intermediaries between the two players. Therefore, the network can be summarized as single echelon distribution network.
- Single Item – For the purpose of setting a solid model basis, the model is considering only one stock keeping unit (SKU) when the ordering is done. The assumption can be gradually improved by applying the model for each SKU taken into consideration separately, followed by categorization of the different SKU in a logical manner for obtaining a more complex order.
- Zero Lead Time – The premise is stating that the Brand Owner has an infinite capacity for producing the needed items, on one hand and the Store does not have a lead time applied when making the order, on the other hand. The intention for constructing the model in this way was to obtain a simplified and fundamental model.
- No Returns Policy – In order to justify this proposition, the situation of the unsold inventories has to be elaborated. Unsold inventories are those items that are left when the selling season is finished. In the model, the assumption of no returns policy is applied in a way that the Brand Owner cannot buy back the remained items from that selling season.
- No Order Restrictions –. In this study, the restrictions that are usually present in the luxury fashion industry do not apply. Minimum order quantity and minimum value of ordered items (to justify the costs of order placed) or maximum value of ordered items

(security reasons, tax limitations etc.) are some of these restrictions which are mostly introduced by brand owners to the Stores.

Adjacent to the assumption development phase, the model composition phase follows. This stage represents the core of the model since it incorporates all important elements curtail for the proper model construction.

The model is build by using Excel Visual Basic Application (VBA) for different scenarios generated using specific parameters through VBA's code. In order to be able to comprehend the system as a whole, different aspects taken into account are listed in the following text.

- Demand Generation – The process of generating the customer demand was done specifically for each case, depending on different factors. However, in order to obtain comparable results in each case the demand for the total selling season was expected to be normally distributed with mean 1000 and standard deviation 100.
- Selling Season – With observations of the selling behavior in luxury fashion industry it has been concluded that the most optimal duration of the selling season is 20 weeks.
- Number of Players – The model is taking into account two main players. The Store, representing one of the players, leaning towards profit optimization, on one hand, and cost minimization, on the other hand, through the optimization of the replenishment quantity. The second player is the Brand Owner, again aiming for the same goals. The Brand Owner aiming for maximal profit, which mainly depends on the number of items sold to the Store. The Store, which has the variable costs, and also the cost of overstock and stock-out, should find the most optimal strategy to remain competitive and lower the all these costs while maintaining its revenues on a high level.
- Number of replenishment possibilities – In order to achieve the goals previously stated, the analysis of implementation of different replenishment possibilities was constructed in the following manner. Starting from a basic scenario by not having the option to replenish, the profit was compared to all additionally developed, more detailed cases, incorporating more replenishment options.
- Item Characteristics – With the identification of the significance of the two categories of items, fashionable and evergreen, for the luxury fashion industry, it has been decided that due to their distinctive characteristics it is worth constructing the model

considering them both. The table below depicts the differences between these two categories, giving further insight of why they were chosen for elaboration.

	EVERGREEN ITEM	FASHIONABLE ITEM
Fashion Trends	• Does not affect the demand significantly	• Plays an important role on the demand
Lifecycle	• Several selling season	• One selling season
Selling Price	• Stable over the season	• Different percentages of discounts are applied throughout the season
Over-stock Cost	• Relatively low	• Very high

Table I: Main differences between Evergreen and Fashionable Items

With regard to presentation of the Supply Chain as one entity, the research was conveyed by observing the Store's point of view firstly, followed by the view of the Brand Owner. Lastly, in order to finalize the picture for both players, the supply chain's perspective was observed.

- Store's Perspective

For the purposes of the research the focus was mostly employed towards the analysis of the Store's perspective due to the fact that this player has a variety of different options and decision making process of affected by a lot of factors. In order to grasp the idea for the Store's point of view, more than one scenarios were studied, both, for fashionable and evergreen items. Starting from the analysis of 1-period game, continuing to 2-period and finishing with N-period game, the model incorporated a vast number of cases and increased its significance.

In the following, further explanations of how the Store's perspective was modeled can be seen.

- 1 Period Game – The main question which was given an answer through the analysis of 1 period game was *how much initial inventory is needed*? The initial inventory is the inventory which the Store has in possession at the start of the selling season. By adjusting this number of items, the optimal value, according to the maximal profit was obtained. Beginning with the demand generation, following the assumptions of the model, the profit calculation was done, by taking into consideration the amount of items which are left at the end of the season and the variable costs linked to each owned item in the store.
- 2 Period Game – In the second step of the model construction, 2 period game was analyzed, where the option to make a re-order was introduced. For this case the two main questions were *how much initial inventory is needed?* and *what is the optimal replenishment amount?* For the first question three possibilities were considered. One applied the logic of having independent demand. The rest applied the assumption that the demand is correlated, positively and negatively. However, for the definition of the replenishment amount, after a vast theoretical review, the replenishment amount was taken as a function of the initial inventory and the demand from the first period. The additional assumption made applying to the initial study was the re-ordering time, initially set to week 10 or at half of the selling season. However, due to the *question in which week is the most optimal to replenish?*, this assumption was evoked and by changing the demand structure, the model was shaped for having replenishments in different times. The general flow of the model construction started with generation of the demand, again having the previously stated characteristics for the whole selling period, however applied for the two periods separately. Subsequently, by using the variable End of Period, applied for the two separate periods and introducing the variable Beginning of Period, which is the inventory with which the second period is having on stock, the profit calculation was realized.
- N-Period Game – By applying the stated assumptions, the profit has been calculated for more than one replenishment possibility, giving the suggestions

for achieving optimization for evergreen and fashionable items, from the point of view of the Store.

- Brand Owner’s Perspective

In this phase, the profitability of the second player of the system has been taken into account. The profit level of the Brand Owner differs from the one for the Store, since it is affected by different variables. For the sake of simplicity the profit has been assumed as it is impacted only by the number of items sold to the Store. Differently from the Store’s point of view, the number of periods that the items sold does not make a difference for the Brand Owner’s profitability. What is important for this case is the total number of items sold throughout the season.

- Supply Chain Perspective

As the game theory suggests, in an environment where the outcome depends on the decisions of two or more autonomous players, no single decision maker has full control over the outcomes. The profitability of the system as a whole depends on the profits of both involved players and the decision taken together. Therefore, studying the Store and the Brand Owner’s perspective alone is not enough. The final stages of the study the need for having supply chain perspective came into sight. The actors can be encouraged to act in the interest of the whole supply chain rather than focusing only in their own self interest in return to a gain in the long-term which is bigger than their immediate profits. The model suggests that the optimal value chosen from this perspective maximizes the sum of the profits from both players and alternative joint decision mechanisms can be developed based on this suggestion.

4. Summary of the findings

Through the creation of strong cross boundary connections between study areas, such as luxury fashion industry, supply chain management and replenishment policies, the preset aims for this study were attained. In the following table, the conclusive approach linking the goals, the means used and the results is indicated.

	Key issues	What should be done	How should be done?	Results
1	Discontinuity between replenishment strategies and different product types	The impact level of replenishment strategies for different product types	Observation of products belonging to the luxury fashion category, which have different characteristics. Implementation of different replenishment strategies, the results will be compared, which will lead to the most optimal replenishment model for each type of product.	Pattern related to the product characteristics and replenishment policies was found.
2	Lack of knowledge about the Store performance when implementing different re-ordering policies	The impact of re-ordering policies on inventory levels and the performance of the Stores	Creation of different re-ordering policies, the profitability of the Store, the Brand Owner and the supply chain as a whole could show the final outcome of the best practices implemented.	The optimal replenishment strategies for all player included were defined.
3	Lack of clear guidelines for replenishment strategies improvement	The way to improve replenishment strategies, considering lead time and selling period	Considering lead time and selling period, observations on current practices, together with the simulation the possible improvements in the replenishment strategies will be implemented.	Through the vast literature review and the suggested replenishment model, the guidelines for improvement were defined.

Table II: Conclusive approach linking the research framework and results

By creating a comprehensive framework on the different replenishment strategies, incorporating the most important stakeholders in the system a thorough analysis of the replenishment practices was achieved. Three main groups of results have been presented in this Master Thesis, according to the targeted research questions.

- Impact of replenishment policies on different product types

  In this study, a deep analysis of the products' characteristics is done and differentiation dimensions are defined. From here, the application of separate replenishment strategies arise, leading to the final conclusion about the system performance outcome. It was seen that the supply chain system reacts in a different manner for the two main product categories observed in this Master thesis. For the fashionable items, a behavioral pattern emerged giving the suggestion that by lowering the number of replenishment and also the total number of items replenished throughout the selling season, the performance of the system will be optimized. On the other side of the range, the evergreen items have a contrasting behavior. In order to optimize the overall system performance, it is advised to have more replenishment options along the selling season for this product type with a relatively higher number of items.

- Impact of replenishment policies on inventory levels and the SC players' performance

In the study 2 main players are taken into account and the decision making process is studied by considering those players. After having a deep analysis of the Store's role in this system, the impact of the Brand Owner and the supply chain as a whole were further investigated, leading to specific conclusions. Starting from the Store's point of view, moving to brand owner's point of view, the study led to conflicting interests, both optimizing the profit of the chosen player. However, with regard to the optimization of the system as a whole the results obtained are satisfactory for both sides.

- Further improvement of replenishment strategies, considering lead time and selling period

The topic of the presented Master thesis provides a ground open for improvements. Its findings have a significant value for not only the practitioners in the sector but also to the researchers in academia. The insights gained from the study, support the phases of analysis and re-planning of the replenishment strategies, inventory management policies for the practitioners and comply with the academia and researches done so far on the topic. Yet, it also requires further investigations on the field to be able to obtain more applicable results for the firms who are operating in the luxury fashion industry.

1. INTRODUCTION

With this study, an advancement of the replenishment strategies developed for the luxury fashion industry will be explained. The luxury fashion industry presents different characteristics compared to others, especially regarding the structure of the supply chain and the implemented replenishment strategies. Since the supply chain and replenishment strategies have a great influence in the overall performance of the companies, it is important to investigate the further improvements within this area. In order to develop an effective framework which can be implemented within the companies, obtained results from extensive academic literature together with the current practical applications of several replenishment models are employed.

In the past few years, the topic of supply chain structure in luxury fashion industry has been reviewed by several illustrious academics. However, due to the fact that the industry is composed by companies with a specialized supply chain structure, creating a unified framework has been difficult. Some of the obstacles that researchers and companies face are the significant differences in product characteristics, customers' behavior and market competition.

In order to analyze the product's characteristics, it is essential to elaborate a clear concept of how the term "luxury" will be understood in this study. Even though a variety of definitions on what a luxury product and a luxury brand represent, as articulated by Dubois et al. (2001) and Vickers & Renand (2003), the discussion still continues. Traditionally, luxury is defined as "something which is out of the ordinary in terms of daily living needs" (Vickers & Renand, 2003). However, this definition does not capture the actual meaning of today's luxury goods, and thus the need of a new definition of this term arises. According to Heine (2012), the basic definition of luxury nowadays can be summarized as "anything that is desirable and more than necessary and ordinary". Even if this definition was presented recently, a current unified consensus amongst researches cannot be achieved.

Apart from this issue, the existence of different product categories with different characteristics makes the industry even more complex. In order for a product to be considered as luxury, it should posses the following characteristics: excellent quality, which sometimes is even considered as synonym for luxury; very high price, when comparing same product alternatives;

uniqueness, which is in a close relationship with the very high price and premium quality; aesthetics and polysensuality, considering the product as a piece of art; heritage and personal history, the elaboration process and the consumption should follow tradition and superfluousness (uselessness), these products are not necessary for survival (Dubois et al. 2001). These product traits represent the critical success factors for each luxury company. On one hand, they distinguish the products in this industry from others by making them hard to reach, establishing high margins and obtaining a stable market growth. On the other hand, these product characteristics push companies towards using specific strategies, which are hard to implement in other industries, and therefore, it is hard to standardize the strategies' structure.

Furthermore, the customers' characteristics also differ from one another. Nowadays, customers expect a higher level of satisfaction, better service, better prices, better quality and convenience. Retailers must deliver a smarter customer experience that creates new advocates which increase sales in today's fierce luxury market. Today, most of the retailers are likely to develop a brand as it has high potential as a way to obtain loyal customers. Besides, the brand is one of the many factors that may influence customer's purchasing behavior because of the uniqueness and specialty of the product. As a result of the changes in the market characteristics, companies have to adjust themselves according to the customers' needs, therefore, a noticeable focus switch from the product, which was central in the past, to customer satisfaction, which has the most attention now, can be noted. This is the reason why most of the companies are facing some difficulties in satisfying today's customers.

In any case, this market is constantly growing and moving upwards, making it a very important economic factor (McKinsey 1990). The forecasts done by Bain & Company (2011) show that this industry is going to grow further with growth rates of about ten percent. As a consequence, new companies want to enter this market, making the competition even higher. On the other hand, the demand is becoming more unpredictable, but also growing. Therefore, companies try to face these challenges by increasing the product variability and offering the customers to choose from a customized selection of products. In this state, what is the role of replenishment policies used in this industry? Replenishment policies have a significant impact on the supply chain of every company. This influence is mainly due to its direct relationship between costs and therefore, the profit. Depending on the replenishment model used, the company can shape its' profit structure in the most optimal way, in order to satisfy the customers and also obtain high margins and lower costs. In luxury fashion industry due to the high product variety, the product, customer and market characteristics, the replenishment strategies used in traditional industries cannot be applied. From this statement, the main issue for the topic of this paper is presented. On one side, the importance of the replenishment strategy has to be acknowledged. On the other side, the industry complexity has to be coped with in order for companies to obtain higher profits. The efficiency and effectiveness of the replenishment model have a direct influence on the supply chain performance, and the nonexistent unified model represents a significant setback for luxury fashion companies.

The main objective of this study is to present a guideline model for the replenishment decision making process of luxury fashion companies. Undoubtedly, introducing such a model would open new horizons not only to the companies operating within the industry but also to the researchers studying in the field. By focusing on the replenishment strategies for this industry, the whole supply chain will be improved, also improving the profitability for all the players included in the process of decision making. Moreover, the study will cover some of the existing gaps while bringing along with it new question marks to the academics working on this area.

This paper will present an initial replenishment model for companies belonging to the luxury fashion industry. The structure is presented as follows: Section 2 gives an observation of the industry and market characteristics in order to understand the differences in this industry. Furthermore, by elaborating the existent policies used by companies today, a clear picture of the current state is presented. Section 3 analyzes the methodology used in order to provide a unified replenishment model. In Section 4, the results from the suggested model are going to be clarified. Section 5 will give an overview of the whole study to conclude this one and Section 6 will discuss opportunities for further improvement to the future researches.

2. LITERATURE REVIEW

2.1. Overview of the Luxury Fashion Industry

2.1.1. Defining Luxury

Defining the term “luxury” has been an issue for a long time. Starting from the concepts presented in the past, from Dubois et al. (2001) and Vickers and Renand (2003), which stand for the most basic of all, it has been concluded that a conceptual base for understanding of the meaning of luxury is missing. Furthermore, the definition of luxury besides the lack of clarity of the meaning of the term “luxury”, lack of research in terms of operations management and critical success factors is growing. Thus, authors agree that it is impossible to achieve consensus. Aside from this problem, the complexity of the products considered as luxury represents further obstacle. The products that make this industry vary to a high level, having characteristics totally different when compared to each other and are hard to put in the same category. However, when faced with this kind of complexity, the need of clarification and understanding of the luxury industry for the stakeholders becomes more serious.

The early definitions of the term luxury were explaining that luxury is something more than necessary (Bearden and Etzel 1982, Muhlmann 1975, Sombart 1922). Even though, most of the luxury products are truly something that is not necessary for people’s lives, today the biggest portion of the salaries are spent on products that are also not necessary and still they cannot fall into the category of luxury products. Therefore, this version of the luxury definition can be considered as obsolete, since the living standard has moved upwards after the 19th century, after which, the meaning of luxury was anything that is more than necessary and ordinary (Meyers 1995). It can be noticed right away that even this definition is not fully capturing the significance of luxury, because it is missing the part where it fulfills some human needs and desires. According to Kemp (1998), when comparing necessity and luxury on one hand with the Maslow hierarchy (1970), it can be seen that the peak of the pyramid, which takes the place of self-actualization needs corresponds to luxuries. Accordingly, the definition for luxury can be stated as anything that is desirable and more than necessary and ordinary.

To further define the term luxury, there is the need to observe its' relativity (Heine, 2012). Luxury can be seen differently depending on the person's desires. This relativity can be regional, temporal, economic and situational. The regional relativity considers resources according to their availability in different geographical areas (Merki 2002). With the temporal relativity, the aspect of how the perception of luxury changes over time is observed (Fuerher, 2008). The economic aspect observes how a person's perceptive of luxury changes according to its access to resources (Kepferer 2008). With the cultural relativity, unlike the other types, the desirability for the product is observed, since it differs from culture to culture (Kapferer and Bastien 2009). Finally, the situational relativity refers to the changes in classification of resources depending on the necessity for it (Kemp 1998).

The meaning of luxury can be viewed from many different aspects (Heine, 2012). One of them is according to the area of research. According to the philosophical-sociological understanding of luxury look at the evolution of luxury, the societal benefits that this growth brings and all the changes that happened in the customer preferences (Fuehrer 2008). It can be concluded that this captures the widest scope of the meaning of luxury and includes all resources.

The micro-economic understanding of luxury gives a representation on the relationships between price and demand, and income and demand (Deaton and Muellbauer 1980, Kemp 1998). With this view, the concept of luxury goods was introduced in micro-economic perspective as goods that are more than necessary and ordinary, but are also suitable for exchange. The main difference between necessary or ordinary goods is that the level of luxuriousness is measured according to the market demand and also impacted the demand trends (Poll 1980).

Finally, the managerial understanding of luxury introduces the concept of luxury products. Mainly the focus on the studies is on luxury brands and on the customers. With the studies about luxury brands, cover the brand identity, image brand analysis. On the other hand, when studying the customers, the focus is on their behavior, preferences, customer characteristics that influence their purchasing motives. When the scope of the different understanding is observed, it can be noticed that going from the first one, the philosophic-social understanding to the managerial one, the scope is becoming narrower. The managerial understanding represents the smallest scope taking only branded products, which are more than necessary when compared to others. From here, the term “luxury products” is understandable.

In order to grasp the meaning of this term, in the following section the market characteristics are going to be presented.

2.1.2. Luxury Market Overview

This paper frames its discussion around luxury fashion goods, its market, and the main players. As the global economy steadily recovers, growth in this market can be also noted, since these products are characterized by a high income elasticity of demand. According to Frank (1999), the market is experiencing a spending boom, which occurs when the number of high income groups increases, as well as the middle and lower-income classes. These consumers have a lower saving rate and are used to spend more money in luxury than they used to before.

According to the Bain and Company’s 2014 Annual Global Luxury Study, luxury goods market has a slower, but stable growth. Most of the markets now are supported by touristic spending, with Chinese tourists as the leader spenders. The market growth has been a result of many factors, like globalization in the end of the 20th century, the era of e-Commerce and Social Media marketing, through which a new segment of customers unreachable by then was able to enjoy the goods that luxury fashion industry was offering. McKinsey stated in their study “The glittering power of cities for luxury growth”, that by 2025, luxury goods spending will be highly focused in cities. Around 600 cities will account for 85% of the growth in luxury apparel market. Additionally, they indicate that the more the desired products are considered as unique, the more the growth will be concentrated in the cities.

One of the biggest challenges in the business world of fashion industry is the management of different rates of evolution in each geographic area. The European market is entering its mature phase where customers ask for tradition, reliability, and concepts. On the other hand, the biggest market today, the US, is perceiving luxury as a type of lifestyle, because the market is still growing. In Asia, luxury fashion is used to show wealth and status in the society, which indicates that luxury fashion, is still in an introduction phase. All these different characteristics have to be considered so that companies can be apt to face the presented risks and maintain their future growth.

According to Exane BNP Paribas, currently there are serious risks that luxury industry is facing. In consideration of luxury products sales are generally used as a signal of the rise of private wealth, and with growing difference between the income levels, luxury spending is growing. On the other hand, when these gaps between income levels become fuzzy, through higher marginal tax rates, this might bring to a negative impact on the spending growth. Another risk to consider is the link between luxury spending and customers feeling richer. This proportionality will impact the luxury industry negatively, if the salaries start to decrease, the property prices start to decline or the credit obtaining process gains complexity. The impact will be the highest if these scenarios happen in China, since Chinese account for about 30% of the personal luxury goods consumption. With the recent changes in government's efforts to reduce inequality, application of higher taxes for wealthy people the Chinese market is becoming very mixed. Moreover, due to the high percentage of luxury spending while traveling, any cause that will prevent people from travelling will cause a significant impact on this industry. Another important factor, are the mergers and acquisitions happening in this industry. On one side, these agreements are bringing higher incomes to companies, due to the newly acquired customers. On the other, they may lead to high cost of damaged returns on invested capital.

The question of the different motives for becoming a luxury fashion consumer is very complex and closely related to many values of the customer. The financial part of the value includes the price, discount, interments. Furthermore, the functional part covers the quality, uniqueness, usability, basic functions; the individual part of the luxury value incorporates the personality of the customer, as level of materialism, self identity, and self perception. Finally, the social dimension of luxury has to be mentioned, focusing on customer prestige and identification in the society. These values are appreciated more or less in each customer segment with a different intensity. According to Wiedmann, Hennings, and Siebels, there are 4 main groups of consumers in this industry. The first one is characterized by people who desire self satisfaction rather than making a social statement. The second group is made of customers who are very concerned about quality and differentiation from the rest. The next customer group has the characteristics of perceiving the quality of life and pleasure aspects of luxury consumption to be important, as well as the opinion of the society. Fourthly, the customers who are inclined towards self-directed pleasure and life enrichment to be most important for their perception of luxury value fall into the last group.

Apart from the segmentation according to the luxury value, differences in market behavior can be noticed depending on the geographical area. Hence, the European market, as stated above, is a mature market, where the customers are expecting quality, innovation, exclusivity, customer care and a variety of offered customized services. On the other hand, the emerging markets, such as the Asian one, have tendencies to be satisfied with extravagance, by feeling that they are part of the luxury brand community, by stating a role in the society.

According to these observations, it can be concluded that companies need to make a suitable approach so that they can reach every type of customer. By presenting the companies with a responsive replenishment model, the customer base would be increased, the overall costs would be decreased and most importantly, the profit gained will be maximized. Since the customer variety is wide, some of the researches state that this market cannot be segmented but it should be followed in order to understand customer behavior and needs. Furthermore, as mentioned above different companies have different strategies and target customers with different needs, therefore, with this study we will try to capture the situation for all three types of luxury fashion companies and unify the characteristics that they posses in order to make replenishment more efficient and effective. With the research done on the different types of companies, the focus will be grouping the products into according to their target market, since one company has a variety of products that are addressed to different markets. Therefore, with the differentiation of the products a clearer image of the companies' strategies can be seen.

2.1.3. Overview of Luxury Companies

The term luxury brand has been also hard to define as the term luxury. In academic literature, academics associate the word luxury to describe the prestigious brands (Vigneron & Johnson, 2004). In the research from Brun et al. (2008), has been concluded that luxury goods represent wealth, power and satisfy nonessential wants. Furthermore, researchers agree that luxury brands are associated with a conceptual and symbolic dimension which creates values for the customer. According to Jackson (2004), luxury brands hold the following characteristics: global recognition, core competence, high quality and innovation, powerful advertising, immaculate in-store presentation and superb customer service.

In the luxury brand category, stated by Esteve and Hieu (2005), there are different levels of luxuriousness, therefore different brands. The brands can be split into the types that follow. At the initial place, there are the entry-level luxury brands, which have the lowest luxury level and generally are not recognized as members of the luxury brands group. The medium-level luxury brands, on the other hand, enjoy the recognition of being a part of the luxury brands group, but are again on a lower level than the others. The brands established as leading luxury brands belong to the top-level luxury brands group. Finally, the elite-level luxury brands are a niche group of brands, characterized with highest quality, as well as prices.

Another classification of the luxury companies is recognized as “Three-Tier Approach” which also known as “3-A”. These three tiers are named as accessible, aspirational and absolute and they refer the positioning of the companies within the market. The absolute segment brands are placed in the top of the pyramid and they appeal to customers for whom money is not a consideration who acknowledge brand history and reputation. For example companies like Hermes and Brioni belong to this categorization. On the other hand, aspirational luxury companies are viewed as prestigious but appeal to customers with slightly lower income such as Gucci and Saint Laurent. Lastly, accessible segment composed by companies that attract customers from middle and upper-middle class who strive for luxury goods as symbols of differentiation and status but have budget restrictions. Burberry and Tiffany & Co. can be given as examples of companies from this segment (Clark et al. ,2010).

Another differentiation, according to Nueono and Quelch (1999), depends on the brand awareness. The brands can be divided into connoisseur and star brands. The former type is consisted of brands which have limited awareness, often focused on niche markets. The latter, on the other hand, aim to obtain the highest level of brand awareness. The paradox of being known to everyone by accessible by few can be noticed for this type.

A further distinction is made referring to the business volume. Heine, (2004), in “Concept of Luxury”, provides this distinction. According to this comparison, on the first level there are micro-scale brands, which do not have many employees and gain modest revenue. Secondly, the small-scale brands are the brands specialized in some markets with a small volume. On the third level, there are the medium-scale brands with more than 100 million Euros. Fourthly, the brands that are not many numerous, with revenues of more than 250 million Euros are the large-scale brands. The final two levels belong to the big and giant players. These places are taken by few brands in specialized categories, which enable them to generate revenues even more than 5 billion Euros per year.

Even though, the luxury brands market is considered as complex, diversified, rapid and in constant evolvements (Atwal and Williams, 2009; Christodoulides, Michaelidou, and Li, 2009), researchers have not been studying it for so long. This industry, worth $220 billion (Keller, 2009), is rarely present in the academic world. As it was seen, the definition, measurement and operations are still not agreed upon (Kepferer & Bastien, 2009). Despite the product complexity and high production and marketing costs, luxury companies are one of the most profitable and fastest growing.

As elaborated in the previous part, the luxury market has reached its maturity. Therefore, the demand has been increasing quite fast in emerging markets, such as China. Companies have the opportunity to expand even more. On the other hand, the entry barriers have been lowered. Thus, existing companies cannot rely only on their brand assets and loyal customers. Nowadays, already well established companies have to develop their brand symbol, legacy, quality, esthetic value, relationships with customers in order to maintain their position.

The luxury fashion industry is characterized by three types of companies regarding the size. Firstly, the small local manufacturers, followed by the medium sized industrial firms and large luxury conglomerates. In the past period the conglomerates had a significant rise. These conglomerates often focus on just one product, or they span on multiple categories, such as, fashion, cosmetics, jewelry like LVMH. The leading luxury fashion group is Louis Vuitton Moët Hennessy. LVMH has a wide portfolio of luxury fashion brands including Louis Vuitton, Givenchy, Christian Lacroix, Christian Dior, Emilio Pucci, Kenzo, Celine, Marc Jacobs. The closest competitor of this company is Gucci, followed by Prada which is considerably smaller.

2.1.4. Defining Luxury Products

In order for a product to be considered as luxury, according to the studies made so far, it has to have some distinct critical success factors. They include price, quality aesthetics, rarity, be extraordinary and symbolism. According to Olson and Reynolds (1983), these factors can be divided into three subgroups, including concrete, abstract and manufacturing characteristics. The category of concrete characteristics captures the physical attributes and when more concrete characteristics are combined an abstract one is created. The third part is the characteristics obtained from using a special manufacturing process.

When looking at the 7 major characteristics separately, it can be seen that the price is the one used the most in literature and practice, since it is the easiest one to use for comparison. (McKinsey, 1990). With only using the word luxury, the high price is always the first thing added to the product. Even inside the luxury industry, there is a difference between the level of prices of premium and entry level luxury products. On the other hand, if a new brand, which just entered the market, increases the prices dramatically, according to Kapferer and Bastien (2009), a sudden increase in the demand cannot be noticed.

The second characteristic, which is also associated to luxury immediately, is the high quality level. The quality level is observed with focus on different aspects. The manufacturing characteristics show the level of the expertise of the producer. The producer, according to the customers should have both technical and stylistics competences on the highest level. The first part is shown through the deep knowledge and experience in this industry and the second should come from the manufacturer talent, skills and creativity (Kapferer and Bastien, 2008). The complexity of the product is considered that needs to be on a high level also. The complexity level can be measured by the time that is needed to create the product, the handcraftsmanship level, etc. The components and material of a luxury product are the crucial part of the customer evaluation. Usually, the materials used for luxury products are categorized as luxury themselves. The same principle applies to the construction and function. Both of these characteristics have to be on the top level. When the number of features is observed, in comparison to other products, it can be noted that the luxury products often have more features, when the customer asks for them. Considering the service level, a rich customer experience should be offered always, including the customer advisory, customization options, reparation, etc. (Valtin 2004). The study of the abstract product characteristics, include the level of comfort and usage the product provides, which, as all other characteristics should be on an explicit level. Then the durability and value must be guaranteed. These characteristics rely on the type of material, manufacturing efforts and the function principles. Furthermore, the functionality and performance have to be superior when compared to other products, which, most of the times is not needed.

In all the studies made, almost all have the same conclusion, that aesthetics is the distinctive characteristic for luxury products. In order for a product to be considered as luxury, this trait has to be fulfilled, since the majority of customers are expecting this from a luxury product.

Another trait is the uniqueness of the product, meaning that the product is hard to obtain. The companies have to ensure this rarity by making their products in limited editions (Catry 2003).

Additionally, most of the customers, name the extraordinarity as one of the most important characteristics. These characteristics can be resulted by making different design, construction principle or even by having innovative functional attributes (Valtin, 2004).

Finally, the symbolism behind the product has to be to a large extent. Luxury companies give a very important role to human values and lifestyles, hence, the products have to comply with the taste of the upper class. This symbolism can be achieved through the product design or by spreading specific information for the product which is going to associate it with someone or something important.

This critical success factors mix is generally high for all luxury products, but variability between the levels of luxuriousness can be seen. If only one characteristic has a higher value, then the whole luxuriousness level is higher for that product (Esteve and Hieu, 2005). Based on this, the products are divided into subcategories. According to these subcategories, companies structure their approach towards the customers. This includes the marketing strategies and the channels through which the companies communicate to the customers.

A brief study on the different types of products is conveyed in order to differentiate the marketing strategies and better understand the products which fall into the luxury group.

The first range according to which the products can be divided is the level of personal vs. impersonal. According to McKinsey (1990), some categories of products such as apparel, glasses, and watches are more suitable luxury products than the others like furniture, garden furnishing etc. Therefore, companies based upon their product define the most optimal marketing strategy to reach the customers and present their product in the proper way.

Another differentiation is by the way the product is consumed: in a group or individually. When it comes to studies about purchasing motives, this observation is very important, since some products are seen most of the time by many others, but some products are rarely seen apart from the owner of the product (Bearden and Etzel, 1982).

Dubois and Duquesne (1993), differentiate the products according to their accessibility and exceptionality by following the changes in their prices. In the category of accessible products most of the people can afford to buy them at least once. On the other hand, the exceptional ones are those which are affordable to a very few people.

The next type category is made according to the uniqueness of the product. According to the uniqueness level a product can be unique, which is the top level of products that are not replicable. On the second level on the uniqueness scale there are the limited edition products, which are still similar to the unique ones. In the limited-diffusion, products have a high rarity which is mainly based on the manufacturing complexity, because of the need of handwork. The last subgroup is consisted of expanded-diffusion products. These products are made in serial production, and are easier to reach by the customers.

With the last division, between carryover and fashionable products, considers the product development, manufacturing, marketing and selling phases. In the study of Caniato et al. (2009), it is elaborated that the supply chain structure depends on the product attributes. Companies usually have more than one product lines, which make the product variety high and complex.. The main difference between the carryover and fashionable items is the lifecycle duration. The evergreen products are marked with a long life on the market. On the other hand, fashionable items last only one selling season.

Depending on the above stated product categories the replenishment model in use differs. According to the characteristics of the product the reordering policies should be shaped in a manner that would bring a lower level of costs, reaching high number of customers, and maximizing the profit.

2.2. Supply Chain Management

The concept of Supply Chain Management (SCM) has been revised and evolved a lot since it has been first introduced. Today the Council of Supply Chain Management Professionals (CSCMP) which is a worldwide professional association for individuals involved in SCM defines it as a profession which integrates supply and demand management within and across companies. According to CSCMP, SCM encompasses the planning and management of all activities involved in sourcing and procurement, conversion, and all logistics management activities. Moreover, CSCMP highlights the coordination and collaboration with channel partners, which can be suppliers, intermediaries, third party service providers, and customers as an important aspect of the SCM. Another definition of SCM is addressed as the integration of key business processes from end user through original suppliers that provides products, services, and information that add value for customers and other stakeholders, by Dr. Dugles M. Gambert who is the director of Global Supply Chain Forum (GSCF). The SCM framework developed by GSCF emphasizes the fact that all activities that are involved in the production of a product or the delivery of a service must be studied together.

Similar to the ones that are mentioned above there are several SCM definitions and frameworks in the literature which also imply that there is a growing interest in SCM studies. The number of SCM articles is continuously growing on a yearly basis starting from the middle of the 1990s (Stock et al., 2009). The interest on the subject is increasing day by day not only in the world of academia but also practitioners' side on which several companies continue to analyze and attempt to improve their supply chains constantly. A research done by Accenture (in co-operation with Stanford and Insead) reveals that SCM is critically important or very important to

89% of the surveyed executives (Naslund et al., 2010). Naslund and Williamson (2010) state two main reasons for the increased interest in SCM on their paper called *What is Management in Supply Chain Management?* The first one is the competitive global environment which requires an efficient and effective management of the organization itself as well as its relationships with other organizations through the supply chain. The second one is the potential benefits of SCM that includes improvement in returns on investments (ROI) and returns on assets (ROA). Both of these reasons are strong motivations for organizations not only to evaluate their supply chain continuously but also to assess the techniques to manage it effectively.

Previous studies indicate that product features influences supply chain model and management choices. Several authors agree on the fact that supply chain strategies should be carefully investigated and evaluated by taking into consideration the features of the product and drivers for competing in the specific industry. Fisher (1997) has suggested a classification of products as functional and innovative to better define supply chain configurations of the products as their nature requires. He has suggested that functional products that have rather predictable demand, long life cycle and low contribution margin requires a physically efficient SCM. On the other hand, innovative products that have an uncertain and moderately price sensitive demand, calls for a market responsive strategy. Following these findings much research is done in the area. Lamming et al. (2000) in their paper *An Initial Classification of Supply Networks* stated that supply networks differ substantially according to the type of the product being supplied. They discuss that product type classification may be more useful than sectoral distinctions as supply networks frequently transcend the bounds of one industry. Supporting Fisher's argument, they propose two more dimensions, which are product complexity and product uniqueness, as important product features which determines the appropriate type of supply network. The other research on the area has shown that the uncertainty is not only arising from the demand side but also from the side of suppliers (Lee, 2002). Lee agrees that not all supply chain strategies are appropriate for all firms but a classification is necessary with an understanding of the uncertainties faced by the firms from the demand side and the supply side. He suggests four different types of supply chain strategies for different kind of products by considering the different nature of demand and supply uncertainties of different products:

<table>
<tr><td colspan="2"></td><td colspan="2">Demand Uncertainty</td></tr>
<tr><td colspan="2"></td><td>Low (Functional Products)</td><td>High (Innovative Products)</td></tr>
<tr><td rowspan="2">Supply Uncertainty</td><td>Low (Stable Process)</td><td>Efficient Supply Chain</td><td>Responsive Supply Chain</td></tr>
<tr><td>High (Evolving Process)</td><td>Risk-hedging Supply Chain</td><td>Agile Supply Chain</td></tr>
</table>

Table 1: The Right Supply Chain Strategy to Match with Product Uncertainty proposed by Lee (2002)

A different approach to choice of an appropriate supply chain model is described in the paper called *Analysis and Design of Focused Demand Chains*, based on the product life cycle, time window for delivery, volume, variety and variability. There is no one demand chain strategy can best service to all the diverse requirements for alternative products and services. Therefore, demand chains should be engineered in order to match customer requirements which can be achieved via segmentation on the basis of each product's characteristics (Childerhouse et al., 2002). The authors suggest four different supply chain models which are MRP, kanban, packing center, design and build. They claim that the supply chain performances of the systems are significantly improved by applying the right strategy to the right demand chain via increased sales volume, decreased costs, and increased customer service levels in relation to order cycle times, product development lead times and variety.

Volume/Variability dimension is another factor which should be taken into account when choosing the right SC strategy. Product manufacturing and distribution must be aligned with the demand volume-variability profile through a mix of build-to-stock, build-to-order, and make-to order strategies. Selecting appropriate manufacturing and distribution strategies based on volume and variability, significantly improves operational efficiencies by optimizing service levels while keeping inventories in the low levels. Moreover, statistical analyses can be used to combine both volume and variability to set safety-stocks levels that are most efficient to meet customer service levels (Vitasek et al. , 2003).

An interesting approach on the topic is proposed in the paper called *A new framework for SC management: Conceptual model and empirical test.* Cigolini and Perona (2004) classified the products in order to find the best matching SCM model, depending on the three factors: the dominant phase of the product life cycle, the complexity of the product and the type of the supply chain. The authors present three different SC models which are efficient, lean and quick supply chain, which are summarized in the table below:

	Type of Supply Chain		
	Efficient	**Lean**	**Quick**
Variable vs. fixed cost ratio	Low	Medium	High
Manufacturing flexibility	Low	Medium	High
Elasticity of demand to price	High	Medium	Low
Main competitive weapon	Price	Product, Price, Time, Service	Product, Time

Table 2: Main differences among SC types proposed by Cigolini et al. (2004)

Apart from the theories suggests an appropriate SC strategy according to the products' characteristics, there are other studies which suggest that the demand of the product, so as the supply chain configuration of it, depends on factors such as accessibility, the number of substitute products offered by competitors, brand appeal (Byrnes, 2004).

The triple-A which stands for agility, alignment and adaptability is another SC model suggested by Lee (2004) again. He claims that being fast and cost effective is not enough for a supply chain to have a sustainable competitive advantage over competitors. The supply chains must be also agile in order to respond to short term changes in demand or supply rapidly. They should align the interest of all supply chain partners to improve the performance of the entire chain. Last but not the least they should be adoptable to adjust the SC design to accommodate market changes such as political shifts, economic progress and technological advances. According to Lee, firms need fresh attitude and a new culture to carry their supply chains into a triple-A performance level. Companies must give up efficiency mind set, which is counter-productive; be prepared to keep changing networks; and, instead of looking out for their interests alone; take responsibility for the entire chain (Lee, 2004).

2.3. Supply Chain Management in Luxury Fashion Industry

For several years great effort has been devoted to the study of branding and marketing of luxury fashion goods. However, in recent years supply chain operations of these goods also started to attract researchers' attention with the dynamic and complex nature of the industry. One of these recent studies has shown the importance of operational issues for luxury fashion firms in order to build and support their brands by demonstrating how supply chain configuration and management decision impacts the critical success factors of luxury fashion firms (Brun et al. 2008). The common findings of the researches done so far, suggest that supply chain models and management choices represent a high coherence with the critical success factors of luxury firms such as product quality, style and design, country of origin, emotional appeal, brand reputation, creation of life style. For example, for a company where the superior product quality is a critical success factor, it is necessary to select the material suppliers and outsources carefully and to create long term partnerships in order to ensure a reliable quality over time. Whereas, if the style and design is the key point, the activities related to design should keep in house while having a good collaboration with experienced externals (Brun et al., 2008).

The researches on this area also show that SCM models in the literature do not apply to the luxury context and further investigation dedicated to the supply chain operations of the luxury specific industry is needed. When the consolidated supply chain strategy models found in the literature have been compared with the reality of luxury firms from various industrial sectors, it has been seen that not all the contingent variables extracted from the models proved to be applicable to companies operating in the luxury segment. Although some of the considered models provide useful contingent variables for identifying and classifying the products (uniqueness, high variety, low volumes, product complexity, market characteristics etc.) this is not yet enough in order to provide a complete description of the segment and of its requirements in terms of SC strategy (Caniato et al. , 2008).

In order to operate in the luxury industry, specific requirements of the market, as well as the current trends, should be taken into consideration carefully. Danziger (2004), consider the 'luxury' as more than a savvy business strategy or brand management tool. He describes the luxury with a new level of enhanced experience, deeper meaning, richer enjoyment and more profound feelings. He also highlights the matter of *everyone everywhere ants more luxury*: "The luxury market is no longer something out there, circumscribed by income levels, personal wealth, or spending budgets. Today everyone is part of the luxury market. Luxury is for you, for me, for people living in trailer parks, inner-city projects, 1,500 sq. ft. tract homes, suburban 'Mc Mansions,' gated enclaves, mansions, and everywhere in between" (Danziger, 2004). A more detailed research regarding to market dynamics are given in the previous sections. Yet, it is important to notice that the appropriate managerial choices can be defined through the whole supply chain only if a strong commitment is advocated to idea of luxury and necessities come along with it. Even within the industry itself, different clusters can be identifies to better apply the SC strategies. Caniato et al. (2011) defined four clusters from a sample of 15 Italian companies and studies has shown that these clusters present differences in terms of SC strategy, as well as in terms of practices for managing manufacturing, sourcing and distribution processes. The classification is done on the basis of five variables which are company size, selling volume, product complexity, product fashionableness and brand reputation. These variables enable them to compose the clusters based on factors that are considered exogenous to the SC process. The results obtained from the studied case studies led the authors organize three clusters, which are internally homogenous with respect to many SC practices, depending on their positioning relative to selling volume and product complexity : *Fashion Goliaths*, *Quality Davids* and, *Techstige*. Some of the variables that are considered are shared by every cluster, as they refer to quality, uniqueness and variety characteristics that are common across the entire luxury industry. Yet, some of them led cluster-specific SC strategy implications that are related to the different CSFs.

Figure 1 represents a summary of the values considered in the study, assumed by product fashionableness, company size and brand reputation for each area:

Selling volumes		Low complexity	High complexity
	High volume	Large firms Fashionable products Symbolic brand reputation	
	Low volume	Small firms Fashionable products Technical brand reputation	Large firms Non fashionable products Technical/Symbolic brand reputation
		Product complexity	

Figure 1: Cluster characteristics in terms of variables (Caniato et al. , 2011)

The study has proven that within each cluster similar SC configurations and practices are exist. For all the clusters, main features of the observed manufacturing, sourcing and distribution processes are common and they are consisting with demand features and CSFs. The main features of each cluster are shown in Figure 2.

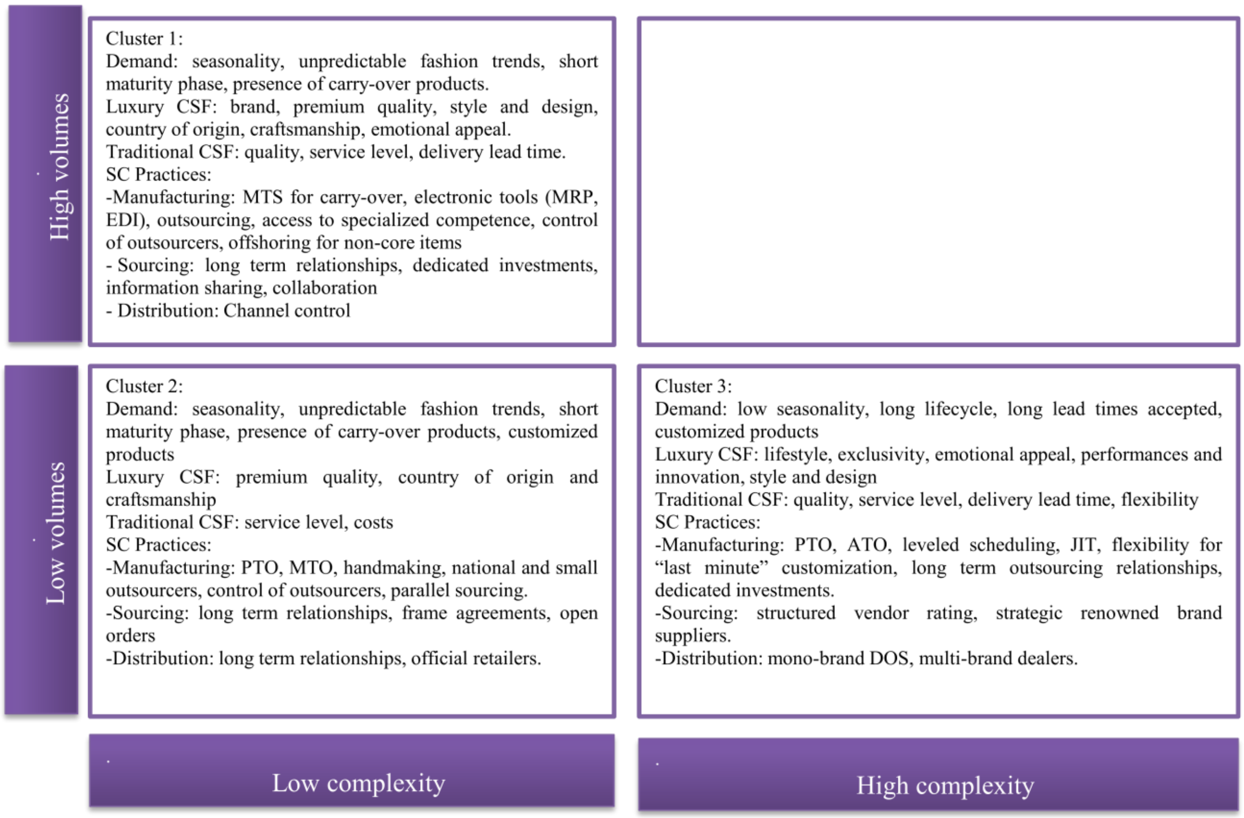


Figure 2: Demand features, CSF and supply chain practices observed in the case studies (Caniato et al. , 2011)

Caniato et al. (2011) highlighted that the SC approaches of the studied companies are not well-structured, partly because of the lack of specific contributions that link the specific requirements of the luxury industry to knowledge about SC management. The results of the study show that there is the possibility of applying at least a few drivers from traditional SC strategy literature to luxury segments which can be a starting point to introduce more structured SC approaches to the firms operating in the sector. Moreover it also shows that the luxury industry is not internally homogeneous. There are different clusters as far as such drivers are concerned and these clusters have specific SC implications and CSFs that are matched by a set of similar SC configurations and practices.

In another related paper not specifically working on the luxury segment but fashion in general, by Iannone et al. (2013), a replenishment model is suggested in order to support coordinated strategic choices continually made by SC actors. The push-pull model proposed in the paper aims to achieve the full optimization of replenishment planning phases, identifying the right ordering quantities and periods for fashion retails. Application of the model to an important Italian fashion company shows that the passage from a total push strategy, currently used by the company, to a push-pull one, suggested by the model, allowed not only a reduction in the estimation of goods quantities to purchase at the beginning of a sales period (with considerable economic savings), but also elaboration on a focused replenishment plan that permits reduction and optimization of departures from network warehouses to Points of Sale (POS).

In the following section the importance of replenishment strategies as a part of the supply chain will be explained. After providing an overview of the state of the supply chain in luxury fashion industry, the next step towards fulfilling the purpose of the paper is elaboration on the replenishment strategies. The replenishment strategies have an important role in the supply chain structure, considering their impact on the efficiency and effectiveness of the whole system.

2.3.1. Replenishment Strategy as a Crucial Topic of the Supply Chain

At all stages of the supply chain, replenishment strategy of the inventories plays an important role. The right inventory replenishment strategy can significantly improve supply chain costs and performances by having a high customer service level while maintaining a low inventory level and replenishment costs. Therefore a lot of studies have been performed on the topic and the literature on inventory replenishment policies shows a variety of approaches.

The current strategies on the literature require defining a review period for re-ordering. Re-ordering period is a term to define the frequency of review of the inventory levels. It can be continuous where the inventory levels are continuously monitored or periodic where the stock levels are reviewed at a set frequency. Similar to the review period, order quantity or replenishment amount can be defined in different ways depending on the strategy followed. Some strategies define a fixed order quantity, which implies to give an order for the same (predefined) amount, every single time a re-order decision is taken. Yet, some strategies need to determine an order-up-to-level where order quantity is calculated as the difference between order-up-to-level and on hand stock.

Based on the re-ordering review and ordering quantity parameters four basic replenishment strategy can be introduced. The first one is fixed ordering quantity with a continuous review. In this process, the inventory level is monitored continuously and as soon as the stock level falls below the predetermined re-order level, a fixed ordering quantity is ordered. The second one is the fixed ordering quantity with periodic review. As a variation of the first one, stock levels are reviewed periodically and the decision of placing an order is taken only if the stock levels are below the predetermined quantity at the time when the review is done. The third strategy uses an order-up-to-level with a continuous review. Similar to first method, the inventory levels are monitored continuously and when they drop below the predetermined level an order is placed to complete the stock levels to the determined order-up-to-level. The fourth and the last variation of these methods is where we have a predetermined order-up-to-level with a periodic review. Again the ordering amount varies depending on the on hand stock but the decision of placing or not placing an order is given in a set frequency. These four policies are summarized by Angerer (2005) as an adoption of a previous research (Vollmann, Berry et al. 1992) in Figure 3 below:

		Order Quantity	
		Fixed	**Variable**
Order Frequency	**Fixed**	**(T,Q)**	**(T,S)**
	Variable	**(s,Q)**	**(s,S)**

Figure 3: Basic Replenishment Strategies

According to the table the four basic decision rules are:

- (T,Q) Order every T period the fixed quantity Q
- (T,S) Order every T period, fill up to level S
- (s,Q) Whenever inventory drops below s, order Q
- (S,Q) Whenever inventory drops below s, fill up to level S

In the literature a lot of studies have been conducted in order to determine the parameters such as reviewing period (T), ordering quantity (Q), re-order level (s) and order-up-to-level (S) like Economic Order Quantity (EOQ) Model which composes a basis for more sophisticated models developed then after.

EOQ is the simplest and most fundamental approach of all inventory models first proposed by Harris (1913) and since then different variations and extensions of the model have been developed by other researches. The EOQ model outlines the trade-off between fixed order costs and inventory holding costs, and is the basis for the analysis of more complex systems. Like any other model, basic EOQ model has its own limitations and assumptions which are listed as below:

(i) The demand of the item of inventory for a given period is known accurately.

(ii) The usage (consumption) equal throughout the period.

(iii) There is no lead time involved. That is the item of inventory can be supplied immediately on the receipt of the order itself; there being virtually no time lag between placing an order and the receipt of the goods. Consequently, there is no likelihood of stock out, at any stage. Therefore the shortage cost is not being taken into account, as if it is nil.

(iv) Thus, there remain only two distinct costs involved in computing the total costs: ordering cost and inventory carrying cost.

(v) Further, the cost of every order remains the same, irrespective of the size of the order.

(vi) And, finally, that the inventory carrying cost is a fixed percentage of the average value of inventory.

In order to develop the EOQ model, several unrealistic assumptions must be made. The most unrealistic of these is that the demand rate is known and constant. However, even if management were comfortable with that assumption, there would be the practical problem of estimating the values of the fixed order cost and the inventory-holding cost (Schwarz, 2008). As most of the researches agree, the robustness of the model is indisputable. Yet, underlying assumptions that are also mentioned above may not be valid when it comes to real life.

As it is mentioned before, EOQ composes a very solid base for a lot of mathematical approaches which are introduced as solutions to the inventory control problems. The model has been extended to different settings, where shortages, discounts, production environments, and other extensions are considered (Hadley et al. , 1963; Nahmias, 1997; Silver et al., 1998; Zipkin, 2000; Muckstadt et al., 2009). The model has different variations with fuzzy coefficients. Park (1987), Chen et al. (1996), Maiti et al. (1997), Yao et al. (2000) and Chang (2004) have extended the well-known model by using fuzzy parameters.

Joint Economic Lot Sizing (JELS) models, first studied by Lam and Wong (1996), are aiming a coordinated inventory strategy between buyer and seller where each player has more benefits than having independent inventory management strategies.

In the literature of inventory replenishment models, a classification of models can be done in terms of the number of periods: single period models vs. multi-period models. The main difference between the single period and the multi-period model is that the multi-period model may involve stock leftovers from previous periods, which makes the optimal choice of order quantities more complicated (Ziukov, 2015).

The Newsvendor (or newsboy) problem is a single period, single product probabilistic inventory model aims to determine replenishment amount that minimizes shortage and overage costs. The mathematical problem has been widely studied since it is first introduced by Edgeworth (1888) and it is still the basis of more complex and realistic situations that is studied in the literature today. The problem, in its basic formulation, aims at finding an optimal replenishment policy of a perishable product in the face of an uncertain, stochastic demand. Such a solution is selected in a way that maximizes the expected profit, which is calculated as the difference between the expected income and the purchase cost of the good in question. Many modifications to this basic model have been proposed throughout the years, introducing additional complexity to the problem (Herrero et al. , 2015).

Multi-period inventory replenishment models, where the costs involved in receiving, retaining and shipping of the items realized more than one times which requires an advanced inventory management approach. Several papers have investigated inventory policies where ordering decisions can be done more than once. Examples of this literature includes start with Sommer

(1981) which uses fuzzy dynamic programming to determine optimal inventory and production levels in a real-world integrated multi-period inventory and production scheduling problem for an organization engaged in a planned withdrawal from a market. Later an optimal aggregate replenishment strategy is studied by Kacprzyk and Staniewski (1982) aims to set long-term management objectives. Lee et al. (1990) have introduced the fuzzy logic into material requirements planning (MRP) by defining period demand as a fuzzy number and a period balancing algorithm is developed. One year later, Lee et al. (1991) have extended their previous research on multi-period fuzzy lot sizing and have introduced fuzzy versions of the Wagner–Whitin and Silver–Meal lot sizing models. One of the last studies have been done by Liu (1999) who applies a fuzzy decision making to investigate optimal inventory policy for a multi-period inventory system with partial back orders (Jaber, 2009).

Apart from these mathematical models, there are practical cases where the replenishment decisions tightly depend on the Store manager. In real life inventory management literature might remain very theoretical. The implementation of the replenishment models in real business life is rather difficult. A solely mathematical approach to the inventory systems is not convenient (Wagner, 2002). Therefore, also the experience of store manager affects the decisions taken so as the performance of the Store in terms of the cost-side and the marketing-side. Gruen et al. (2002) highlights the relationship between the Store managers' experience and the OOS rates. As the Store manager get experienced regarding the Store managed, the performance of the Store will increase as store operations which have a significant impact on the out-of-stock rate (Gruen, Corsten et al. 2002).

2.3.2. Replenishment Strategies in the Luxury Fashion Industry

In the literature, several authors have studied on the inventory replenishment strategies of fashion goods based on the general inventory management policies literature. Yet, there is almost no academic source that deals directly with inventory replenishment models of luxury fashion goods. The challenge for the supply chain of a luxury brand is to implement the right replenishment strategy that could balance trade-offs at each stage of the supply chain to deliver the highest service level. When it comes to the replenishment strategy, two basic questions declared by Wagner (2002) remain the same: when to order and how much to order? However, as it is discussed also in the previous sections, luxury fashion industry drivers vary from other industry factors significantly and specific requirements of operating in the luxury industry should be taken into account when defining an appropriate inventory replenishment strategy for the firms.

In 2008 Brun et al. investigated that the critical success factors are significantly important on determining the supply chain configurations and management choices in luxury segment of the fashion industry. The paper also presents an important insight regarding a major trend that is taking place in the industry that is the increasing control of brand owners through the supply chain in order to maintain the control on both the supply and the distribution side of the chain. On the supply side this is due to the need to ensure product quality and availability, while on the distribution side this is even more important in order to achieve a direct relationship with the final customer (Brun et al., 2008). Although brand owners are taking some actions in order to increase their control over the supply chain, number of actors involved in the process is too many in a way that complexity of the chain is inevitable. The dynamic nature which is a result of involving too many non-constant variables makes the management of supply chains more complicated. Supply Chains are complex because they are comprised of numerous actors; moreover the competitiveness is high with little space for mistakes in stocks planning, goods replenishments or promptness of promotional campaigns (Iannone et al. , 2013).

In a concept where several players exist with different preferences, different levels of knowledge and mostly conflicting interests, it is useful to mention about the game theory approach and to try to understand the implications of it. The first known discussion about the game theory occurred in a letter written by James Waldegrave in 1713. Then it re-appeared as a discussion topic in 1928 with the study names as *Theory of Polar Games* of by John von Nuemann. In 1949 with John Forbes Nash's study the concept of equilibrium point (also known as Nash Equilibrium) was introduced (Hyksova, n.d.). Kerk (n.d.) pointed out that Nash equilibrium is based on the principle that the combination of strategies that players are likely to choose is one in which no player could do better by choosing a different strategy given the strategy the other chooses (Sihlobo, 2013). Myerson (1991) defines game theory as the study of mathematical models of conflict and cooperation between intelligent rational decision-makers. The application areas of the theory are so wide in a way that it can be applied to the fields from economics, political science, and psychology, as well as logic and biology. Turocy and von Stengel (2001) also proved that the game theory is helpful to formulate, analyze, and understand strategic scenarios.

Luxury fashion goods retailing is highly complex and competitive. When we have a look at the inventory replenishment problem from the Brand Owner perspective and store's point of view, we might end up with different solutions. It is also highly likely that none of these solutions are the one which is best for the sake of the whole supply chain. Therefore, at this point the game theory plays an important role for the structure and the formulation of the problem.

3. RESEARCH MODEL

3.1. Gaps Encountered

The overall research objective of the present Master Thesis is to craft an original and innovative replenishment model to support the strategic analysis of the changing, discontinuous and particular industry of luxury fashion goods. Within the papers collected on this topic, after a vast literature review, the gaps regarding this specific topic have been identified.

The literature review carried out, with the reference to the industry-specific studies focused on luxury fashion, as well as to a broader Supply Chain knowledge, has brought up to light the importance of replenishment from a strategic perspective. Specifically, the literature review disclosed a number of issues that deserved further attention, and that should be captured and reflected by the analysis. The key issues, which are presented as drivers for analysis are listed as followed:

- The lack of focus on the replenishment strategies in luxury fashion industry, both, in academia and companies, gives first important goal for this paper.
- The complexity of the market and the nonexistent framework of employing replenishment models provide the second incentive for this research.
- The easily identifiable benefits from having a clearly defined replenishment model present another important aspect, worth of being elaborated.

The research questions, elaborated in the following section, are targeting these drivers found through the literature review, and straightforwardly derive from their application in a framework model confirming the replenishment strategies importance.

3.2. Research Questions

The definition of a research problem states that is a specific topic which is being analyzed or addressed within a specific research study. When conveying a research, one of the initial inputs must be the definition of the research question, since it has to be clearly understood and stated in a simple way, in order to help with the problem statement (Boudah, 2011).

Identifying the research problem is an essential part of the study, as it also enables the process of creating or defining the main research questions that the study should answer the statement should be clear and specific, refer to the problem or phenomenon, and reflect and intervention in experimental work, and note the target population or participants.

In order to achieve the research objectives and the expected results, the study should be based on specific question which are going to guide the researcher throughout the study, and also provide a way to determine if the final results fulfilled the requirements stated by the research objectives. As it was stated in the introduction chapter, the goal of this research is to present an initial guideline model for replenishment decision making process for luxury fashion companies. Derived from the goal, the research questions could be stated as follows:

5. How could re-ordering policies affect inventory levels of stores?
6. How could re-ordering policies affect the performance of different players of the supply chain?
7. How could replenishment strategies' performance change for different product types?
8. How to improve replenishment strategies trough a comprehensive framework, considering lead time and selling period?

Giving answer to these four questions would make it possible to affirm that this study could indeed fulfill its purpose, as clearly most of the barriers to develop the model would be overcome and the ground variables for the model would be defined.

3.3. Research Hypothesis

A research hypothesis is a statement of the initial expectations made at the beginning of the study considering the final results, or when simplified, it gives the answer to the previously stated research questions. A research hypothesis should be brief, should contain the most important aspects of the study, and suggest the possible variables that can be tested while conveying the research (Boudah, 2011).

For this specific study, for each research question, at least one hypothesis should be presented in order to determine the possible outcomes of the study. At the end, with the comparison between the hypotheses and the results obtained from the study, the final conclusions would be drawn. In this specific case the following hypothesis were constructed:

- Hypothesis no. 1: By constructing different re-ordering policies, the profitability of the Store, the Brand Owner and the supply chain as a whole could bring the final outcome of the best practices implemented.
- Hypothesis no. 2: By making an observation of products belonging to the luxury fashion category, which have different characteristics, an image for their behavior would be given. By implementing different replenishment strategies, the results will be compared, which will lead to the most optimal replenishment model for each type of product.
- Hypothesis no. 3: Considering lead time and selling period, observations would be done on current practices, together with the simulation the possible improvements in the replenishment strategies will be implemented.

3.4. Research Framework

In an initial stage, labeled “Research Framework”, the steps for accomplishing the given goals are defined, by means of two main pillars:

- The literature review conveyed, with focus on the industry-specific studies based on luxury fashion, as well as incorporating knowledge on replenishment policies. The combination of these reviews allowed to identify the major key issues characterizing the luxury fashion industry regarding supply chain strategies;
- The model composition, which shed light on the main criticalities to be dealt with when designing a replenishment model in luxury fashion companies. The model served to confirm, refine, and further elaborate the findings derived from the literature review.

In the following table a summary of the main focuses of this paper will be presented.

	Key issues	What should be done?	How should be done?
1	Lack of knowledge about the stakeholders' performance when implementing different re-ordering policies	The impact of re-ordering policies on inventory levels and the performance of the stakeholders	Creation of different re-ordering policies, the profitability of the Store, the Brand Owner and the supply chain as a whole could show the final outcome of the best practices implemented.
2	Lack of linkage between replenishment strategies and different product types	The impact level of replenishment strategies for different product types	Observation of products belonging to the luxury fashion category, which have different characteristics. Implementation of different replenishment strategies, the results will be compared, which will lead to the most optimal replenishment model for each type of product.
3	Lack of clear guidelines for replenishment strategies improvement	The way to improve replenishment strategies, considering lead time and selling period	Considering lead time and selling period, observations on current practices, together with the simulation the possible improvements in the replenishment strategies will be implemented.

Table 1: Research Framework

4. METHODOLOGY

4.1. Assumptions

The following assumptions are done while developing the model:

- <u>**One Echelon Distribution Network**</u>

While composing the model, a single echelon distribution network is assumed where the Store is replenishing its items directly from the Brand Owner. That is to say that there are no intermediaries. The assumption can be considered as reasonable especially for the small luxury firms within the industry.

- <u>**Single Item**</u>

The initial model considers the ordering of only one stock keeping unit (SKU) at a time. In an industry like fashion where we have a wide range of products (different types, colors, sizes etc.) the assumption may not seem realistic. Yet, it is reasonable to adopt and understand the single-item replenishment approach before moving to the more complicated models. We are aware of the fact that multi-item ordering should be also introduced to the model to make it more applicable to the real business life. Applying the model separately to the each SKU of the Store and then grouping the items in a logical way to make the order logical from economical and logistics point of view could be a solution to this limitation.

- <u>**No Returns Policy**</u>

In the model no returning policy is allowed. In other words, unsold inventories are not bought back by the Brand Owner in return to a certain amount of money which increases the risk of over-stock for the Stores. At the most superficial level returns policies will encourage retailers to carry larger stocks. From the manufacturer's standpoint, the more retailers sell, the higher the manufacturer's profit will be (Chou, 2008). Yet, as the author suggests, this is the general idea of the return policies where a lot of other factors has to be considered applying it to the luxury fashion industry. Therefore, for the sake of the simplicity of the initial models we haven't considered any returns policy.

- **<u>Zero Lead Time</u>**

The first models structured assume zero lead time where the ordered items are shipped immediately. The assumption also implies that these considered items are make-to-stock not make-to-order, and the Brand Owner has infinite capacity for them. Put it differently, brand owner always has the final products on its stocks and able to ship them to the Stores as soon as the order is placed. So, not only distribution lead time but also manufacturing lead time is assumed to be zero, which may not be the case for the luxury fashion industry. Therefore, it is necessary to consider the lead time that the industry faces. Different levels of lead time depending on the company facilities and the geographical conditions etc. can be introduced later to the model developed with the zero lead time assumption.

- **<u>No Order Restrictions</u>**

Inventory replenishment systems are forced by many restrictions to deviate from an optimal calculated order quantity and replenishment time (Angerer, 2005). Minimum order quantity and minimum value of ordered items (to justify the costs of order placed) or maximum value of ordered items (security reasons, tax limitations etc.) are some of these restrictions which are mostly introduced by brand owners to the Stores. The model constructed does not consider any of them. However, once the solution is found it is possible to apply the existing restrictions and try to find a suboptimal solution with the given condition.

4.2. Model Composition

In this section, the model composition will be described. Subsequent to setting the initial assumptions, that were made to clarify the model, the distinction between evergreen and fashionable products will be explained and the model parameters will be set.

Since the results that are going to come up from this model should be used for optimization of the replenishment models in real companies scenarios, there is a need to analyze more than one option and choose the most efficient and effective one. Therefore, in this case, there are different scenarios presented, meaning that the level of detail is changed as we go deeper into the analysis.

The model is composed by using Excel Visual Basic Application (VBA) and different scenarios are generated basically changing the parameters within the code. Explanations regarding the different aspects of the model will be given below in order to have a better understanding of the whole picture.

- **Demand Generation**

Demand generation process varies from the case to the case. For this reason, it will be explained in detail within the specific cases. Yet, it is important to mention at this point that the demand for the whole selling period is expected to be normally distributed with mean 1000 and standard deviation of 100 and this assumption is taken into account while generating the demands of the periods for each case.

- **Selling Season**

The model is taking into account only one selling season with duration of 20 weeks.

- **Item Characteristics**

As previously mentioned, the products studied fall into two categories: fashionable and evergreen products. These two groups differ from each other in more than one way.

The fashionable items are characterized by a shorter lifecycle period, usually lasting only one selling season, which is taken as 20 weeks in this case. At the end of the selling season they should be either, bought back by the Brand Owner or sold with a very low discount price. In all of these cases the players (stakeholders) lose if they allow this to happen. Therefore, the risk taking level for overstocking of these items is really low. On the other hand, when observing the prices and the costs, it can be said that fashionable items have higher lost sale costs, since they also have a higher margin.

The other group is consisted by evergreen items. These items usually have a longer lifecycle lasting more than one selling season. This allows the Store to be able to take more risks on overstocking of these items on the contrary of fashionable items.

- **Number of Players**

The model considers two players and shapes the decision making process by observing the performance of these two players. One is the Store, which represents one of the decision makers, who is trying to optimize its profit, on one hand, and minimize the costs on the other hand, by ordering the optimal number of items. The second decision maker is the Brand Owner, which is the seller in this case. As stated before, the relationship between the Store and the Brand Owner can be considered as one echelon network, since the distribution is direct from the Brand Owner to the Store.

When the goals of each decision maker are analyzed, it can be noted that they might contradict from time to time. On one side, the Brand Owner has the goal of maximizing his profit which mainly depends on the number of items sold to the Store. On the other side, the Store, which has the variable costs, and also the cost of overstock and stock-out, should find the most optimal strategy to remain competitive and lower the all these costs while maintaining its revenues on a high level. Apart from these two sides, when the entire Supply Chain is observed, most probably, the two main players cannot gain the maximum profit for their own side and still have the maximum profit for the whole Supply Chain. Therefore, the decision on how to place the order by the Store, and the decision on how to set the reordering conditions by the Brand Owner, should be carefully observed. With this simulation, both the side of the Store and the Brand Owner will be analyzed, also including the maximization of the performance for the whole Supply Chain.

- **Number of replenishment possibilities**

The number of replenishments which optimizes the individuals' profits separately and also the entire supply chain network will be investigated within this study as well.

The analysis is started from the most basic scenario of not having the option to reorder. This means that the Store makes only one order at the beginning of the selling period, assuming that these items are delivered also at the beginning of the period, as stated above, with lead time equal to zero. In this first case, the main goal is for the Store to find the optimal amount of initial inventory. In order to do so, more than one scenario is going to be observed, depending on the demand changes and of course, the initial inventory quantity.

As a second stage, the option of replenishment is introduced. This number of replenishment options can vary from 1 to N-1. Since the duration of the selling period is taken to be 20 weeks, the maximum number of replenishment options is 19, assuming that there is the option to replenish on a weekly basis. The model firstly, observes how the whole Supply Chain reacts when one replenishment option is introduced. Therefore, the total number of ordered items is split into two parts, and the Store should make the decision on what is the optimal value for both of them in order to obtain the highest profit, again according to the demand. With the introduction of the reordering option, the Store is able to make a forecast for the selling quantity (demand) in the second period. Therefore, a notable improvement in the profits is expected.

As the number of replenishment option increases up to 19, depending on whether the item is evergreen or fashionable, the results are expected to be different as the natures of the products requires.

These expectations are going to be clarified more in detail later on.

4.3. Characteristics of Fashionable and Evergreen Items

As stated before, in this simulation, two different items have been taken into account. The analyzing conditions differ from each other for these items because they behave differently in the selling process. For the luxury fashion industry, it is important to take both of them into account since most of the companies have a product range consisting of items offered, belonging to both evergreen and fashionable categories. In this way, they have both, high profit which comes from the high margin for the fashionable items and stable and secure sales coming from the evergreen items.

Table 2 summarizes the main differences between the products which are going to be explained in detail in the sections coming:

	EVERGREEN ITEM	FASHIONABLE ITEM
Fashion Trends	• Does not affect the demand significantly	• Plays an important role on the demand
Lifecycle	• Several selling season	• One selling season
Selling Price	• Stable over the season	• Different percentages of discounts are applied throughout the season
Over-stock Cost	• Relatively low	• Very high

Table 2: Main differences between Evergreen and Fashionable Items

4.3.1. Evergreen Items

In the following text, the characteristics of the evergreen items are going to be observed and clarified, in order to obtain clearer market image and therefore, more accurate strategy on how to approach it.

It was been stated before that the main differences are the duration of the lifecycle, the difference between the costs and the risk the players are able of taking. First, the lifecycle period for evergreen items is much longer than the one of fashionable. Usually these items can be sold over a longer period of time which is not the case for fashionable. These items have the possibility of maintaining the same demand trend over years. Therefore, the whole costs structure is characterized differently. In the following text, the cost structure for evergreen items will be explained, so that a general picture about the items taken as evergreen in this model will be clarified.

The selling price is the actual final price of a product that the company, in this case the Store, charges a purchaser to buy the item. Usually, for evergreen items the selling price is going to be stable over the selling period. This means that there isn't any discount at the end of the selling season, because the product can be sold over a longer period of time. Furthermore, it can be noticed that when comparing selling prices of evergreen and trendy items, there are some differences. Depending on the type of product, a handbag, or a wallet from the same brand, if they fall into the category of evergreen items the selling prices tend to be lower, in comparison with a handbag or a wallet from the same brand, but considered as a fashionable item. This is mainly due to the costs structure for both items. Since the company in the product development, production, and selling phase, for evergreen items can enjoy a longer selling period, the costs are split for more items and therefore the total selling price is slightly lower.

The wholesale price is the cost for an item sold by a wholesaler, in this case, the Brand Owner. The wholesaler will usually have a price somewhat higher than the one paid for production, and the retailer (the Store) who purchases the items from the wholesaler will also increase the price again when they sell the good. When evergreen products are being observed, the difference between the selling and the wholesale price is usually 50% of the selling price. When making a comparison of evergreen and fashionable items, this characteristic is the same for both.

The variable costs are the costs that depend on the number of items sold. In this model, the variable costs for the Store which are taken into account are the inventory holding costs, shipping costs, and costs related to seasonal display adjustments. By achieving the goal of the model, maximizing the profit for the Store, the Brand Owner and the Supply Chain as a whole, the inventory holding costs will reach their optimal, generally lower value. Inventory holding costs are the costs that the Store has for keeping the items inside. They represent a major part in the Supply Chain, and according to them the Store must make a decision about its inventory levels. Inventory holding costs represent the opportunity costs, meaning the money linked to the items in the Store, when the items are not sold while the money can be deployed elsewhere. Of course, also the direct expenses, such as space, labor and other costs for keeping the items in a good state are being included. For the case of evergreen products, the inventory holding costs are going to be lower than the ones for fashionable, again for the same reason, the durability of the selling period. Since the inventory holding costs are the biggest part from the variable costs, it can be concluded that they are going to be lower when compared to fashionable items, due to the above stated reason.

The cost of lost sale is the profit foregone because the orders could not be fulfilled for some reason. There are a variety of sources for lost revenue opportunities when there is a stock-out. For the calculation of the cost, the common sources include: lost revenues, which is the most obvious cost of lost sales, representing the money gained if the customer would have bought an item, if it was available on hand. Unfortunately, most of the customers have a second option, so that they will continue their business elsewhere, and in this case the revenue that they would have paid is permanently lost. In addition to losing profit, the Store will be facing with losing customers, both future and current. By sending the customer back without the product that he wanted, the door for the competitors is open to replace the Store. And if this situation keeps reoccurring, the Store will get unwanted reputation also for the future customers, which will turn to a more reliable retailer. Finally, when the loyal customers are analyzed, one situation of stock-out will bring the whole relationship with this customer in jeopardy. For the Store, the risk of lost sale can be taken as the difference between the selling price, on one side, and the wholesale price minus the variable costs, on the other.

Lost Sale Cost = Selling Price – Wholesale Price – Variable Costs

These costs represent what the Store will lose if it doesn't have the item in stock and has the demand for it. It can be also named as Stock-out cost.

On the other hand, there is the Overstock cost, which is the cost obtained when the Store has more inventory than needed. Also for overstock costs there is more than one source. Firstly, the opportunity costs, which represent the money invested in the inventory in order to be kept in the Store or the capital that cannot be deployed elsewhere but it is tied to the items kept. Then there are the holding costs, which in this case represent the physical space to hold the inventory. And finally, the costs of expired goods, as well as the expense while disposing them. In this case, the expiry is considered when the product goes out of style or it becomes obsolete.

The overstock costs for the Store, in this model are taken as a sum of a percentage of the wholesale price and the variable costs.

Overstock Cost = Percentage of the Wholesale Price + Variable Costs

As for the evaluation of the evergreen items overstock costs, it can be said that it is generally lower. This happens due to the fact that both the wholesale price and the variable costs are lower than the ones for fashionable. Also, in the calculation process a part of the wholesale price is taken into account. This percentage varies depending on the type of evergreen product, and since the product can be carried to the next selling season, the whole wholesale price is not considered for the calculation of the overstock cost. Furthermore, since the part of the overstock cost regarding the expiration of the items, here the period until this event occurs is longer, unlike when observing fashionable products.

Most of the companies, when making decisions for their inventory levels, turn to the traditional Stock-out vs. Overstock Cost ratio. The decisions made here have to evaluate the level of risk tolerance, the ability to withstand stock-outs and the ability to pay for overstocks. In the evergreen items case, this ratio is usually bigger than one, meaning that the stock-out cost is higher, thus the Store should always have items on hand. Moreover, the risk of overstock is very low, which is another reason why there should be more inventory kept in the Store.

For the purpose of making the simulation, an example of an evergreen item is used. In the paragraphs bellow, the assumptions made involving this product will be elaborated. The item taken as an example is a man's leather wallet from one of the well established luxury brands. It is considered evergreen, because it doesn't go out of fashion for a long period of time, and it can be said that it is seen as a classic product. This follows also for the sales and costs characteristics.

Table 3 gives a summary of the key numbers regarding to chosen evergreen item:

Evergreen Item	€
Selling Price(w/ VAT)	120
Selling Price(w/o VAT)	93,6
Wholesale Price	45
Variable Cost	12
Revenue	36,6
Overstock Cost	9

Table 3: Key figures of the chosen evergreen item to be used in the simulation

The Selling Price is set to 120 Euros, including VAT (Value-Added Tax). The VAT for Italy is 22%. Then, the selling price without VAT can be calculated as 93.6 Euros. Moreover, the Wholesale Price is taken as 45 Euros. The Wholesale Price is given according to real practices of luxury companies in Italy. Following are the Variable Costs, which are 12 Euros, including inventory holding costs, costs for seasonal window adjustments and also shipping costs. As for the discount price and salvage value, for evergreen items in this model they are considered to be equal to zero, since discount is not assumed to happen and the salvage value, which is the estimated resale value of a product at the end of the useful life, also it is not taken into account, since the model is set to run for just one selling season. The revenue that can be gained selling one item is 36.6 Euros. For the calculation of the lost sales (stock-out) costs the formula stated in the text above is being used and it is taken as 36.6 Euros which is the same as the revenue since losing sale means that losing the revenue can be come from that sale. Also, for the overstock costs the formula stated above is used. Here, it is assumed that only 20% of the wholesale price will be taken into the calculation for the overstock costs. The reason for this is because it is an evergreen item, when an overstock happens, the items can still be used for the next selling season. On the other hand, the Store still has a part of the overstock costs, since it has to keep this inventory until the next selling season, but these costs are lower compared to fashionable, where the whole wholesale price is taken for the calculation. As stated above, the ratio between the Stock-out and overstock costs, is bigger than one, and with this cost structure it is around 1.7, confirming the assumptions made above. The Store will be able to take more risk and have a higher inventory level, since the risk of losing a sale will mean losing a loyal customer or losing more future customers.

4.3.2. Fashionable Items

Another product category that is taken into account when composing the model is called fashionable items. Fashionable items are different from evergreen items especially in terms of the duration of lifecycle, so as the risk of over-stocking and the costs that are attributed to items throughout their selling process.

On the contrary of evergreen items, fashionable items have shorter selling periods. In general they can be sold within the season that they have been introduced and cannot be carried to the next seasons. Since the items are subject to seasonal fashion trends, they are less likely to maintain the same demand trend in the season coming after. As the new fashionable items are taking their place on the selling windows, the old ones lose their popularity with regard to style, design, appeal etc. and become less-wanted by the customers. As a result, stores are forced to have big discounts (reaching 70%-80%) for the items that are unsold at the end of the season where they end up with high overstock costs. There are also some cases where the brands are not in favor of making discounts so the unsold items are destroyed and/or recycled for the sake of the brand protection. This would affect the cost structure of that is defined for the fashionable item and makes it different from the evergreen one. As a result, different results are expected from the inventory replenishment model structured for these different types of items.

In the following text, the cost structure for fashionable items will be explained in more detail, in order to clarify differences between evergreen items and having a complete picture of the items considered in the model.

Firstly, the Selling Price of fashionable items is likely to be higher (than the similar evergreen ones) when they first launch in the market since the costs regarding the product development, design etc. has to be covered faster. Unlike the evergreen products, fashionable products cannot enjoy long selling periods and that fact is reflected on the amount paid by customers. Yet, typically a discount is applied on the selling price throughout the selling period of the item which reaches very high percentages at the end of the season.

Secondly, the Wholesale price which is the amount paid by the Store to the Brand Owner is also higher when it compared to similar evergreen products because of the same reasons mentioned above.

Thirdly, also Variable Costs such as inventory holding costs, shipping costs, and seasonal display adjustment costs demonstrates some differences when it comes to fashionable products. Typically variable costs attributed to fashionable items are higher than the ones related to evergreens. One reason of it is the fact that the risk associated with the items is higher in general as the nature of the products requires.

Last but not the least, comes the trade-off between the Stock-out cost and the Overstock cost. As for the evergreen item the lost sale cost is calculated as the difference between Selling Price and the Wholesale price minus Variable Costs. Typically the more profitable the item, the higher the Stock-out cost associated with it. The Overstock cost of the fashionable items, on the other hand, is calculated a little bit different than the evergreen items. As it is stated before, fashionable items cannot be carried to the next seasons. Therefore, there are various options for the unsold items at the end of the season are which all creates a high overstock cost at the end. For the items that are facing with high percentage discounts, there is salvage value has to be considered when calculating the overstock cost. Another option which is to destroy the items, there is even an extra cost of disposal which increases the costs more.

We have mentioned about the Stock-out vs. Overstock cost ratio for the evergreen item which is an important tool when evaluating the inventory related decisions. For fashionable items, this ratio is typically either one or less than one depending on the product characteristics and the discount or disposal method chosen. This ratio implies that cost of overstock is higher than the stock-out cost. Therefore, stores are less likely to keep high levels of inventory by taking the risk of the lost sale.

We have chosen a representative fashionable product in order to use in the simulation. In the paragraph bellow, values regarding the cost structure of this product will be discussed in more detail. The item taken as an example is an iconic tote bag from again one of the well established luxury brands. It is in the fashionable item category, because the bag is currently very trendy. Nonetheless, this trend is considered as a passing fad and it is expected that the overstocked items will remain as unsold even if they apply really high percentage of discounts.

Table 4 summarizes the cost structure of the chosen representative fashionable item:

Fashionable Item	€
Selling Price(w/ VAT)	700
Selling Price(w/o VAT)	546
Wholesale Price	320
Variable Cost	80
Revenue	146
Overstock Cost	236

Table 4: Key figures of the chosen fashionable item to be used in the simulation

The Selling Price is set to 700 Euros, including VAT which is 22% in Italy. Then, the Selling Price without VAT can be calculated as 546 Euros. The Stores are paying 320 Euros to brand owner for each of these iconic bags and they face with a Variable cost of 80 Euros for each unit of item. A 70% discount is planned to have for this bag if at the end of the season there are still items that are unsold. Since the discount is applied on the selling price a salvage value of 164 Euros is considered:

Salvage Value = Selling Price * (1- Discount%) * (1- VAT%)

The revenue gained from the sales of each bag is 146 Euros. This value is also considered as the cost of lost sale in the model. Each bag that is unsold at the end of the season has a cost of 196 Euros which is calculated by adding Variable Costs to the Wholesale Price and then extracting the Salvage Value that is gained. Taken into consideration all these values defined the Stock-out cost / Overstock cost ratio is calculated as 0.62 for the bag.

To have a quick summary of what has been discussed and to represent the comparison of the two different kinds of products better, the table below can be composed by the help of the tables 3 and 4:

	Fashionable	Evergreen
Selling Price(w/ VAT)	700	120
Selling Price(w/o VAT)	546	93,6
Wholesale Price	320	45
Variable Cost	80	12
Revenue	226	36,6
End of Session Discount	70%	-
Salvage Value	164	-
Overstock Cost	156	21
Ratio	0,618	1,743

Table 5: Input structure for representative Fashionable and Evergreen Items

After having a brief discussion of the methodology followed, it is time to discuss each of the cases separately. It has been already mentioned that the study takes into consideration of two different players namely the Brand Owner and the Store. In the following sections, first the Store's perspective will be studied in detail and then the Brand Owner and the Supply Chain point of views will be given.

4.4. The Store's Perspective

This section deals with the inventory replenishment decisions by looking at the system from Store's point of view. We have started to study the Store's perspective by considering only one replenishment possibility throughout the whole selling season, namely 1-period game, and then continue to increase the number re-ordering possibilities.

4.4.1. 1 Period Game

After the explanation about the product types analyzed here and the model composition, the first scenario from the model will be explained from the Store's point of view. As stated above, the one period game is working under the assumption that there is only one order placing, without any other replenishment done. The period studied here is 20 weeks, taken as a whole, therefore the demand and the profit resulted from the model are valid for 20 week selling period. This happens at the beginning of the period, i.e. the selling season by the Store, where according to the forecasts orders the items. In this scenario, the decision the Store has to make is about the quantity of items that needs to be ordered at the start of the selling window.

The goal, which is supposed to be achieved with this game, is to evaluate different types of products and the decision making process for the Store, depending on the demand of the customers.

Starting from the demand which here is generated as a random number with a certain mean and standard deviation, the model is evaluating different amounts of initial inventory and calculates the profit for each case. The cost structure that is used was presented above, both for evergreen and fashionable products. Therefore, there are going to be two different scenarios, evaluating evergreen and fashionable products separately.

In the model constructed, the normal mean is equal to 1000, and the standard deviation is 100, meaning that the demand generated will be a random number around 1000.

Next, the initial inventory, representing the inventory obtained before the selling season starts, is the quantity that needs to be decided by the Store. This quantity depends on the accuracy of the forecasts done from the previous selling periods. With this model, the initial inventory (Q1) is taken as a number that can be set by the simulator, so it is an input in the model. In the table below, all the possibilities that are taken are presented.

Initial Inventory Levels	
1	1050
2	1040
3	1030
4	1020
5	1010
6	1000
7	990
8	980
9	970
10	960
11	950
12	940

Table 6: Initial Inventory Quantity

The next variable, on which the profit depends, is the EOP (End of Period) inventory level. This inventory is represented by the difference between the initial inventory (Q1) and the demand (D1). In order for this value to be always positive, the maximum between the difference between initial inventory and demand, and zero is always taken for the value.

End of Period (EOP) = min (Q1 – D1, 0)

For the calculation of the total variable costs, the following formula is being used. Since as an input the variable costs for one item are given, the total variable costs are a result of the variable cost for one item multiplied with the inventory ordered at the beginning on the period. Therefore, even if the demand is lower and the Store has products left as an inventory, it still has to pay the variable items for all items kept there.

Total Variable Cost = Variable Selling Cost * Q1

Finally, the profit is taken as a function of the revenue gained from the sold items (the minimum between the demand and the initial inventory), minus the total variable costs and the overstock cost at the end of the period for the inventory left in the Store, if any. The profit calculated, is the one at the end of the period, after 20 weeks of selling season, since 20 weeks is the reference period that is taken into consideration:

Profit = (Retail Price – Purchasing Cost) * min (Q1, D1) – Total Variable Cost – Overstock Cost * max (Q1 – D1, 0)

By replicating the demand 1000 times, and profit calculation for each demand generated, the results will have a good level of accuracy, since the final result that is taken is an average of all the replications made.

It can be noticed, that the only difference between the model construction for evergreen and fashionable item, are the inputs, i.e. the costs and the prices. The formulas for profit calculation remain the same.

4.4.2. 2 Period Game

After investigating the 1-period game where the Store is allowed to order only once throughout the whole selling period, we have continued with 2-period game where the Store is allowed to replenish its inventories one more time. At the beginning, for the sake of simplicity, we have assumed that orders can be given only in the middle of the selling period which is the week-10. Later on we broadened this assumption and try to define the best week to replenish inventories which maximizes the profit of the Store.

Like in the 1-period game, the selling period is taken as 20 weeks so that the results can be compared adequately. However, unlike the 1-period game, the question of "how many items should be ordered" is answered by the Store twice: one at the beginning and the other one at the week-10. Therefore, the whole selling period can be considered two small 1-period games where the decision regarding to second period is taken after observing what is happened in the first period. Here, it is important to notice that, the demand observed and the amount ordered in the first period strongly affect the decision taken in the second period. In other words, the first period can be played like and independent 1-period game, on the other hand in the second period, first period results and trends has to be considered together with the second period's expected demand. At this point the question arises: *how we define the re-ordering amount(Q2)?*

Before moving to the part where we have introduced different functions for Q2, a small re-cap of the 2-period game would be useful to make the concept clear:

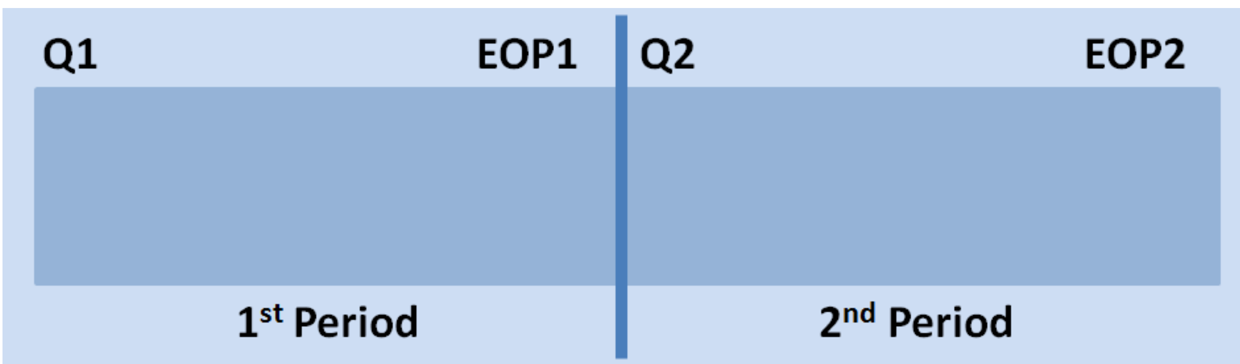


Figure 4: 2-period game overview

In sum, as it is represented in the figure above, 2-period game starts with an initial inventory (Q1). This initial inventory is subject to a demand which is generated for the first period (D1). At the end of the first period, EOP1 inventory level which is the number of unsold items at the end of the first period can be calculated as in the 1-period game:

End of Period 1 (EOP1) = min (Q1 – D1, 0)

Here it is important to notice that unsold items at the end of the first period are not charged with an overstock cost while calculating the profit since they can be sold during the second period as well. However, lost sale that has occurred during the first period is an implicit cost that decreases the total profit.

Following the EOP1, beginning of period 2 which also can be interpreted as the initial inventory that we have while starting to the second period is calculated as:

Beginning of Period 2 (BOP2) = EOP1+Q2

Similar to what happened in the first period, BOP2 is faced with the second period's demand (D2) and end of period inventory of the whole selling season is defined as below:

End of Period 2 (EOP2) = min (BOP2 – D2, 0)

This EOP which is calculated at the end of the second season represents the unsold items after the selling season is finished. So, it is subject of overstock cost which is defined differently for different types of products as it is explained in the previous sections.

In order to calculate the total profit for different scenarios, the variable costs occurred during the first period and the second should be calculated as well. The formula for the first one is given below:

Variable Cost1 = (Variable Selling Cost/2)* Q1

Here the variable selling costs which are given as 80 Euros for the sample fashionable item and 12 Euros for the example evergreen item are assumed to be for one selling season. That's why it is preferred to apply the half of the costs for the periods which are half time of the selling season. If one item keeping in the inventories for the first period, remain unsold at the end of the season is carried to the second period where the variable selling cost is applied once more. So, the variable cost of the second period is calculated as:

Variable Cost2 = (Variable Selling Cost/2)* BOP2

Finally, the profit for each scenario is calculated with the formula given below:

Profit = (Retail Price – Purchasing Cost) * (min (Q1, D1) + min (BOP2, D2)) – Variable Cost1 – Variable Cost2 – Overstock Cost * max (EOP2, 0)

The first part of the formula represents the revenues gained by the sold items throughout the first and second period. Then the profit is calculated by extracting the variable costs of the two periods and overstock costs comes from the unsold items at the end of the selling season which is the end of the second period.

The cost structures of different types of items are already represented in 1-period game: Table 3 for the evergreen item Table 4 for the fashionable. The same price and cost values are used calculating the total profit of different scenarios in the 2-period game as well. However, since in this case we have two demands namely D1 and D2, the parameters that are used on creating the demand changes as well as follows:

- Demand1(D1) ~ N(500, 71)
- Demand2(D2) ~ N(500, 71)

In the 1-period game it is assumed that the selling season has a demand normally distributed with mean 1000 and standard deviation 100. In order to keep the same assumption regarding to selling period, we have calculated D1 and D2 as below:

$$\mu_1 + \mu_2 = 1000$$

$$Var1+Var2 = (100)^2$$

Since we also assume that the second period starts at week-10 which is exactly half of the whole selling season we made the simplification of having the same demand function for both of the periods. As a result means are obtained as 500 and standard deviations are 71.

The final evaluation is done based on the average of 1000 replication. The results will be discussed in the following sections both for fashionable items and for evergreen ones.

How to define the replenishment amount (Q2)?

In the 1-period game, different levels of initial inventory (Q1) are tested and the one which optimizes the profit of the Store is chosen. The challenge with the 2-period game is that the question of "how many items should be ordered?" is answered twice throughout the selling season once in the beginning and the other one is at week-10. The initial inventory decision can be taken as it is done in the 1-period game. Yet, re-ordering amount (Q2) is affected from what has been realized in the first period. Therefore, it should be defined as a function of what has been ordered for the first period (Q1) and what has been demanded by the customers in the first ten weeks (D1). So that accuracy of forecast for the second period can be significantly improved. As a result, a better ordering decision with a higher profit can be taken.

There are numerous different ways to define Q2 as a function of Q1 and D1. Some of the functions that we believe that they make sense from the economical point of view are tested and evaluated. All in all, the replenishment amount which is ordered at week-10 is defined as below:

$$\mathbf{Q2 = Max\ (Q^* - BOP2,\ 0)}$$

The Q* in the formula represents the Q that is optimizing the profit in the 1-period game where the demand is defined as normally distributed with mean 500 and standard deviation 71. So the second period is played as a 1-period game by considering the items that are unsold from the first period. Since ordering negative number of items, or which can be considered as returning unsold items to the Brand Owner, is not possible the function get the value of zero in case of the first part of the function gets a value which is less than zero. When Q2 gets the value of zero, it means that no order is given for the second part of the period. The way the function works will be clearer in the results and findings sections where more detailed discussions will be given regarding to Q1 and Q2 values.

Another important investigation is done the relation between the demands of two periods. Until now it has been assumed that D1 and D2 are independently identically distributed which does not necessary to be the case in real life. Therefore a brief analysis is done on generating the demands correlated as well and then further studies are done to improve ordering decisions for those cases.

How to generate D1 and D2?

In order to compose the model, two demands are generated for the first period (D1) and the second period (D2). Three different cases are considered and studied differently on generating these two demands:

- Case 1 : D1 and D2 are independent
- Case 2 : D1 and D2 are positively correlated

- Case 3 : D1 and D2 are negatively correlated

The difference between the cases is basically the way that we generate the demand. Although there are some cases where demands are independent from the demand history, in some issues the dependency between demands of different time periods exist (Minner, 2000) . *Case 1* deals with two demands for two periods which are identically independent from each other. That is demand of the first period does not affect the demand for the second period. In an industry like luxury fashion where the demand unpredictability is quite high, to assume that the second periods demand will be independent from the first period's is pretty reasonable. *Case 2* assumes that the demand of period-2 is positively correlated with the demand of period-1. A high demand in one period may mean that the product is exposed to more potential customers, and a high demand can also be expected in the next period (Axsater, 2000). When it comes to fashion, trends play an important role on the purchasing decisions of customers. An item which becomes popular too fast might continue to its raise during the second period of its selling season for a few reasons. Alternatively there might be some other external reasons on having positively correlated demand between the two periods. For example, during a winter which is passing through very cold and particularly harsh, a jacket which is from a warm fabric and with a durable design should be selling a lot. If it is so, i.e. the demand is high for its first period; it is also expected to high for the second period. On the other hand *Case 3* discusses the counter examples of this case. In the case 3 demands are negatively correlated which implies that if the demand of the first period is high, demand of the second period for the same item will be low, and vice versa. In the luxury fashion industry it is possible to encounter with all of the cases for different products. Therefore, we aim to study all:

Case 1: Demands of two periods are independent

In the first case it is assumed that the demand of the first period and the second one are statistically independent from each other. In other words, D1 and D2 are independent and identically distributed (i.i.d.). So, the demand realized in a single period is characterized by a statistical distribution say $D \sim G$ and forecasting process of any future demand is simply given by a sufficient characterization of G (Simchi-Levi et al. , 2004). The G in our case is a normal distribution with mean 500 and standard deviation 71 in our case.

When it is known that the demands are independent, veritably we don't have further information about the D2 when the D1 is realized. In other words, knowing about the demand of the first period does not provide any further information about the demand of the second period. Therefore, replenishment amount (Q2) is taken as another 1-period game is going to be played. However, in the other two cases where knowing the demand of second period is correlated with the demand of the first period gives us important clues which can be used by taking the replenishment amount decision for the second period.

Case 2: Demand of the first period and second period are positively correlated

As it is mentioned above, there are some cases in the luxury fashion industry where the firms can faced with a positively correlated demand between different periods. In order to simulate these cases, D1 and D2 are generated positively correlated with a certain coefficient. Moreover, the decision regarding to replenishment amount, is tried to be improved by knowing the fact that the demand of the second period is positively correlated with the demand of first period.

In the literature, there are several ways to generate statistically correlated demands. We have chosen one that is practical and easy to apply. Basically, we have generated two independent variables which are normally distributed with mean 500 and standard deviation 71 as we have done in the first case; we shall call them as X1 and X2. Then D1 is defined as equal to X1, whereas D2 is defined as a function of X1 and the X2. The correlation coefficient is assumed to be 0.8 in this case in order to create a high correlation between the demands and see the consequences of this specific case clearly. Yet, depending on the situation different coefficients can be taken into consideration as well. So, the demands are defined as:

Demand1 (D1) = X1

Demand2 (D2) = 0.8 * X1 + 0.2 * X2

where, **X1 ~ N (500, 71) and X2 ~ N (500, 71)**

The functions above indicate that D2 is highly dependent on D1 which implies that a high D1 will follow up by a high D2 and vice versa. Knowing this fact can significantly improve the

Store's forecast regarding to demand of the second period therefore the following Q2 function is used in order to determine the replenishment amount for the second period:

Replenishment Amount (Q2) = Max (D1 – EOP1, 0)

The function above basically assumes that what has been realized as demand in the first period is also expected to happen in the second period. Although it is a very straightforward assumption, it is a valid one especially correlation coefficient approaches to 1. When we have the 1 as coefficient, D2 formula implies that in the second period we will have exactly the same amount of demand with the first period. Different Q2 formulas can be suggested depending on the correlation coefficient of the two demands. The above mentioned formula of D2 has been tested in this study and the results can be found in the upcoming sections.

Case 3: Demand of the first period and second period are negatively correlated

After investigating the case 2, we have moved one step further in order to test the opposite of this case where we have generated the demands of two periods negatively correlated. We aimed to see the D1 and D2 again with a correlated pattern yet negatively. For this purpose, similar to what has done in the case before, two independent variables are generated and D1 and D2 are defined by using these variables and a correlation coefficient:

Demand1 (D1) = Y1

Demand2 (D2) = 1.8 * Y1 – 0.8 * Y2

where, **Y1 ~ N (500, 71) and Y2 ~ N (500, 71)**

The formulas above implies that higher the demand of the first period, lower the demand of second one and vice versa. It has already been mentioned that having some degree of correlation between the demands of two periods, might help on the replenishment amount decision of stores. This time, since we expect a demand which is negatively correlated with the one that is observed before, we have defined the Q2 function as below:

Replenishment Amount (Q2) = Max (1000 – D1 – EOP1, 0)

Differently from the function that is represented for Case 2 is that here as D1 increase, Q2 will decrease and vice versa. Since in the second period a negatively correlated demand with D1 is expected, defining the number of items which are needed for the second period as below should make sense. Like it is mentioned for the Case 2 as well, it is possible to generate different functions and rules of thumb for the replenishment amount. The one that has been worked on in this study and its results will be explained in more detailed in the following sections.

The models above assume that inventories are replenished at week-10 which may not be the week that is providing the optimal profit for the Store that is playing the 2-period game. In the following section, this assumption is broadened.

When to Replenish?

Apart from conveying the experiment for 2 period games, with a replenishment possibility only in the middle of the selling season, with independent and correlated demand, additional experimentation was done by changing the time when the order is made. This means that the Store had the opportunity to replenish only once, however, the time when the replenishment was made is changed. With this study the question "when should the order be made?" is answered. The experiment is done by changing the weeks when the replenishment is done, in order to calculate the total profit, for both evergreen and fashionable items.

As seen from the 2 period game, where the replenishment is done exactly in half of the selling period, questions about the assumption, whether this is the right time arise. In order to have the possibility to clarify these doubts, the guidelines for this part of the model are going to be elaborated in the text below.

The model considers both scenarios, for fashionable and evergreen. Again, the selling period is set to 20 weeks, with the opportunity to make a reorder only once during this period. The initial inventory is fixed by the simulator as an input for the model. The cost structure that is being used is similar to the one presented for 2-period, for both items. In order to follow how both types of products behave in this situation, the ratio stock-out/overstock cost has obtained its maximum value. This means that for fashionable item, the overstock cost applied in the calculation has a really high value. On the other hand, for the evergreen item, the overstock cost has a lower value.

By implementing these values for the overstock costs, the model will see whether this parameter has a big impact on the decision when to make the reorder.

For the first half of the period there is the End of Period 1 (EOP1) inventory level, representing what has been left until the designated week to replenish, calculated in the following way:

End of Period 1 (EOP1) = min (Q1 – D1, 0)

By using the function for calculating the Beginning of Period 2 (BOP2), the quantity of items at the start of the second period is given.

Beginning of Period 2 (BOP2) = EOP1+Q2

The End of Period 2 (EOP2) quantity is calculated, as the difference between what the Store had at the beginning of the period and the items demanded from the customers. Additionally, this quantity when making the calculations for the total profit is influenced by the overstock cost, since it is the end of the selling period.

End of Period 2 (EOP2) = min (BOP2 – D2, 0)

For the purposes of the calculation of the final profit, the variable costs should be considered. For these cases, when the time the replenishment is changed, the total variable costs remain the same as given in the tables for input above. However, depending on when is the replenishment done; the variable costs will change accordingly.

In the following tables, the variable costs for evergreen and fashionable items used for the simulations are shown.

Variable Costs-Fashionable		
Weeks	1st	2nd
5	20	60
10	40	40
13	52	28
14	56	24
15	60	20
16	64	16
18	72	8

Table 7: Variable Costs for fashionable item depending on replenishing week

Variable Costs-Evergreen		
Week	1st	2nd
5	3	9
7	4,2	7,8
10	6	6
13	4,2	7,8
14	8,4	3,6
15	9	3
16	9,6	2,4
18	10,8	1,2

Table 8: Variable Costs for evergreen item depending on replenishing week

In order to calculate the total variable cost the following formulas are used, for the first and second part of the selling season:

Variable Cost1 = (Variable Selling Cost for 1st Period)* Q1

Variable Cost2 = (Variable Selling Cost for 2nd Period)* BOP2

To this end, all the variables that need to be determined in order to calculate the total profit are elaborated.

The profit function, which is the equivalent for 2 period game with fixed replenishment time at week 10, is presented again:

Profit = (Retail Price – Purchasing Cost) * (min (Q1, D1) + min (BOP2, D2)) – Variable Cost1 – Variable Cost2 – Overstock Cost * max (EOP2, 0)

When it comes to the demand calculation, the total demand is presented as a sum for the two periods, like presented before. In order to change the reordering time, the demand characteristics had to be changed accordingly. In Table 9, the used demand functions can be seen, for both fashionable and evergreen.

	Demand Generation			
Week	**1st Period**		**2nd Period**	
5	300	54,70	700	83,60
7	350	59,16	750	80,62
10	500	71,00	500	71,00
13	650	86,60	350	50,00
14	700	83,60	300	54,70
15	750	91,90	250	38,70
16	800	94,90	200	31,60
18	900	94,80	100	31,00

Table 9: Demand Generation for Fashionable and Evergreen Items

In the 1-period game it is assumed that the selling season has a demand normally distributed with mean 1000 and standard deviation 100. In this case, this assumption is still being kept. By changing the mean and standard deviation, the model considers the demand proportionally distributed depending on when the first period ends, and the second begins.

How to define Q2?

The question of how Q2 should be defined still stands. In this case, Q2 is defined the same way as previously stated, with replenishment at half of the selling season. The Q2 function considers Q1 and D1, and it is calculated as below:

$$Q2 = \mathrm{Max}\,(Q^* - BOP2,\ 0)$$

Since, the 2 period game is consisted of two periods, and Q2 represents the initial inventory (Q1) for the second period, the model can be split into two parts. Therefore, by introducing the variable Q*, which is the initial inventory for the winning function, i.e. the most profitable one; the model will be simplified, and also more accurate.

In order to implement the change in order time, the Q* variable needs to be changed accordingly. Depending on which week the replenishment is made, there is a different function using the Q* from 1 period game for the calculation of Q2. (Table 10)

	Q2 Functions	
Weeks	**Fashionable**	**Evergreen**
5	Q2 = 670 – BOP2	Q2 = 730 – BOP2
10	Q2 = 480 – BOP2	Q2 = 520 – BOP2
13	Q2 = 330 – BOP2	Q2 = 370 – BOP2
14	Q2 = 280 – BOP2	Q2 = 320 – BOP2
15	Q2 = 240 – BOP2	Q2 = 260 – BOP2
16	Q2 = 190 – BOP2	Q2 = 210 – BOP2
18	Q2 = 90 – BOP2	Q2 = 110 – BOP2

Table 10: Reorder Inventory Level (Q2) functions by using different Q*

In the results section of the paper, the optimal week when the Store should make the reorder will be presented, for both the fashionable and evergreen items, by using the above stated functions.

After discussing the different cases for 2-period game, we have continued to increase the number of replenishment possibilities for the Store. In the following section 3-period model where the Store has the opportunity of replenish its inventories 3 times.

4.4.3. 3 Period Game

The next milestone in the model composition is the introduction of 3 Period game. Mainly, with this change the model is becoming more realistic and it can be applied to real business situations, since it has the option for more than one order placement. The initial assumption made with this scenario is that the Store has the choice of making two replenishments during the selling period, which is 20 weeks. Apart from the initial inventory, i.e. the quantity of items which the Store has at the beginning of the period, there are two possibilities during the 20 period of selling when the Store can place an order to the Brand Owner. Additionally, it has to be noted that the assumptions made before are still valid also for the new order placements: lead time is equal to zero, the distribution network is without any intermediaries, and the model is taking into account only one SKU. As it is stated before, the assumptions might damage the applicability of the model to the real business life. However, the insights gained through the model are still expected to be inestimable for the extensions of the current model.

The main reason of regard this scenario is to try to find the optimal quantity of inventory when two order placements are presented to the Store.

Also in this case, as it was for the cases presented before, the main differentiation is made between evergreen and fashionable items. Inasmuch as these two types of items have different characteristics, they have to be considered separately.

In the following phase, the model construction will be clarified, with focus given on the aspects that are considered when running the simulation.

As for the initial inventory level, according to which the profit will depend is shown in Table 11.

Initial Inventory Levels	
1	300
2	320
3	340
4	360
5	380
6	400
7	420
8	440
9	460
10	480

Table 11: Initial Inventory Level

In the model, again as the previous cases, the initial inventory is decided by the simulator, usually taken as a forecasted value from the past selling periods.

The first variable that needs to be determined is the EOP1 (End of Period 1) inventory. Similar to the preceding cases, this value is calculated according to the initial inventory (Q1) level and the demand (D1) from the first of the three periods.

End of Period 1 (EOP1) = Max (Q1 – D1, 0)

It can be seen that the formula takes into account the overstock cost does not affect the Store for this period, but only for the last one.

When starting with the analysis for the second period, the need for another variable, which is describing the amount of items the Store has at the beginning of the second period, was introduced. The variable, Beginning of Period 2 (BOP2), takes into account the End of Period 1 amount.

Beginning of Period 2 (BOP2) = EOP1+Q2

When coming to the end of the second period, the calculation of End of Period 2 (EOP2) is needed. This variable looks at the difference between the BOP2 level and demand for the second period D2, since the order placement is at the beginning of the period, and there is a different demand throughout the period, at the end we are able to see how the Store is supposed to act be prepared for the third period. The calculation formula used is similar to the one presented for EOP1, for the first period, and it can be seen bellow.

End of Period 2 (EOP2) = Max (BOP2 – D2, 0)

For the third and last period, the model considers the Beginning of Period 3 (BOP3) amount which represents what is left from the previous period plus the newly ordered amount.

Beginning of Period 3 (BOP3) = EOP2+Q3

After being presented with a certain demand throughout the third part of the selling period, in order to calculate the profit, End of Period 3 (EOP3) should be calculated first. The EOP3 takes into account, again, the difference between BOP3 and D3.

End of Period 3 (EOP3) = Max (BOP3 – D3, 0)

For the last end of period inventory, the cost of overstock must be applied, since the model assumes that the items are sold for one selling period. This cost depends on the type of the product that is observed, as elaborated in the previous pages.

The profit calculation takes into account also the variable costs, which were presented in the chapter elaborating the model construction, together with the other input parameters for both, evergreen and fashionable items. The variable costs in this scenario are taken as a third for each period. Showed in the following formula, are the variable costs for the first period.

Variable Cost1 = (Variable Selling Cost/3)* Q1

As seen from the tables above, the variable costs for the evergreen item are 4, and for fashionable 26.7 Euros.

When the first period ends, the items that remain kept as an inventory in the Store are taken into consideration for the next period when the variable cost is calculated again. This is the reason why the variable cost for the separate periods are not taken as the total value, but divided into 3 separate values. Below, the formula for calculation of the variable cost for the second period is presented.

Variable Cost2 = (Variable Selling Cost/3)* BOP2

For the last period, the variable costs are calculated as for the second period, again taking into account the unsold items from the previous period.

Variable Cost3 = (Variable Selling Cost/3)* BOP3

Lastly, the profit formula is presented below.

Profit = ((Retail Price – Purchasing Cost) * min (Q1, D1) – VariableCosts1) + ((Retail Price – Purchasing Cost) * min (Q2, D2) – VariableCosts2) + ((Retail Price – Purchasing Cost) * min (Q3, D3) – VariableCosts3) – Overstock Cost * max (EOP3, 0)

The profit formula is covering the three different periods, by considering the overstock cost only for the ending period.

The demand in this scenario is taken as uncorrelated, therefore, the numbers are generated randomly for each of the 3 periods.

- Demand1 (D1) ~ N(333.3, 57.7)
- Demand2 (D2) ~ N(333.3, 57.7)
- Demand2 (D3) ~ N(333.3, 57.7)

The three demands are taken as normally distributed random numbers with a mean 333.3 and standard deviation of 57.7. By using these parameters, we have three main points. Firstly, it is presumed that the total demand will be equal for all scenarios in order to be able to make a comparison, meaning that it will be floating around the value 1000. Secondly, the selling period of 20 weeks is split into three equal parts; this is the reason why the total demand of 1000 is divided into 3. Thirdly, as a result of the equal division of the demand, the order placement time is going to be static, with a reorder point set between the 6^{th} and 7^{th} week for the first order placement, and 13^{th} and 14^{th} week for the second. The assumptions made, make the model understandable, simplified, thus, they are still valid.

How to define Q2 and Q3?

In the previous scenarios, there was option to define the order quantity only once, in the first one, and two times in the second one. In this game the option of defining this quantity three times is given. Therefore, the Store has to answer the question "How many items should be ordered?" three times throughout the selling season. As stated in the previous text, one option is given at the beginning of the selling season, and two additional options when the season is ongoing. It is assumed, as in the cases before, that the first order amount (Q1) is given as an input from the simulator. However, for the other two quantities, the decision is harder, since these amounts should be a reaction of the previous period, in order to maximize the profit. The re-ordering amount for the second period (Q2) has influence from what has happened in the first period, and the re-ordering amount for the third period (Q3) is affected of the actions in the second period. Therefore, it can be summarized that these two amounts, Q2 and Q3 can be represented as a function of amount ordered in the previous period and the realized demand throughout that period.

The formulas depicting this statement are shown below:

$$Q2 = \max(Q2^* - BOP2, 0)$$

$$Q3 = \max(Q3^* - BOP3, 0)$$

With these formulas, the amount that is optimizing the profit for 1 period game is taken into account with the part Q2* and Q3*, both for the second and third period, respectively. This means that the 3 period game is using the most profitable value for the inventory levels from 1 period game. As it was stated in the 2 period scenarios, it is not possible for the function to get a negative value, meaning that the replenishment amount has to be always positive number or zero. When the function obtains the zero value, there is no order placed from the Store.

4.4.4. N-Period Model

In this study we aim to find the number of orders which optimize the profit of the Store regardless of the possible restrictions that can be introduced by the the Brand Owner. For this purpose we have started from 1-period game and continued to increase the number of orders to see how does the profit of the Store changes with different numbers of ordering possibilities. So far, we have tried to explain briefly how we composed the models for 1-period, 2-period and 3-period games. For the following models composed such as 4-period, 5-period and so on, a similar logic with the previous ones is followed. The results of all the models composed with different numbers of periods can be seen in the following sections. Yet, at this point we believe it would be useful to wrap up the procedure followed for any number of periods, rather than giving them one by one.

Playing an N period game means that the whole selling season is divided into N periods and the Store has the possibility to order N times (N-1 times re-ordering and 1 time for initial inventory). The assumption of the equally divided periods is still valid which means for example for 10-period game, the opportunity of re-ordering is given every 2 weeks. So, for an N-period game, the whole selling period can be considered as N number of 1-period games where the decision regarding to next period is taken after observing what is happened in the previous periods. Thus, the replenishment amount for each period can be defined as a function of the demands observed and items ordered in the periods before. For example, in 2-period game we have defined Q2 as a function of D1 and Q1. Following the same idea in 3-period game Q3 should be defines as a function of Q1, D1, Q2 and D2:

Q2 = f (Q1, D1)

Q3 = f (Q1, D1, Q2, D2)

Q4 = f (Q1, D1, Q2, D2, Q3, D3)

…

$$QN = f(Q1, D1, Q2, D2, Q3, D3, Q4, D4, Q5, D5, \ldots Q(N-1), D(N-1))$$

In the same manner, initial inventory (Q1) is decided independently from other ordering decisions. In the model, profit of the whole selling season for different levels of Q1 is tested. For each Q1 value, the same amount of D1 is observed and end of the first period is calculated. Likewise the previous models with the different number of periods, only the last period's unsold items are subject to the over-stock cost, which means the Store has this cost only if the EOP-Nth period is bigger than zero. Yet, lost sales that are occurred in every period are reflected on the profit formula as lost revenue. In order to have a better understanding of beginning of period and the end of period of all periods, let's define the n as the number of periods:

$n = 1, 2, 3, \ldots N$ where, $n \in Z$

<u>For n = 1</u>

$$BOP1 = Q1$$

$$EOP1 = \max(Q1 - D1, 0)$$

<u>For n = 2, 3, … N</u>

$$BOP(n) = EOP(n-1) + Q(n)$$

$$EOP(n) = \max(BOP(n) - D(n), 0)$$

So, for every period after the first one, beginning of period can be defined as the sum of EOP of previous period and the replenishment amount for the current period. This BOP faces with the demand of that period and the number of items that is left in the Store is represents the EOP of it. Obviously, there might be no items left in the stock which implies that the end of period is zero.

Moreover, variable costs of which are defined for the whole selling period are divided in to N and applied to the items that are existing (either newly ordered or unsold ones from the previous period) during that period. Therefore in the model variable costs that are realized for each period is defined as Variable cost1, Variable cost2 and so on.

All in all, considering an "n-period" game, the profit for each scenario can be calculated with the formula given below:

Profit = (Retail Price – Purchasing Cost) * (min (Q1, D1) + min (BOP2, D2) +…+ min (BOP (n), D (n))) – Variable Cost1 – Variable Cost2 – … Variable Cost (n) – Overstock Cost * max (EOP (n), 0)

The formula calculates the profit of the whole selling season by considering the items sold throughout the whole periods, variable costs that are occurred and the costs of unsold items at the end of the (n)th period.

We have mention that the whole selling season of the N-period game can be considered as the as N 1-period game. Here, it is important to make clear how we define the demand for each period. Keeping in mind that the assumption of equally divided periods is still valid and the each periods demand is independently identically distributed with normal distribution, mean of each demand can be calculated as dividing the total mean to the number of periods, which implies that:

$$\mu_n = 1000/n$$

The formula suggests a mean of 250 for the 4-period game and 200 for the 5-period game and so on. The standard deviation, on the other hand, can be calculated by assuming each period's standard deviation will be the same following the formula:

$$(n)*(Var\ N) = (100)^2$$

By adopting the formula above, the standard deviation defined as 38.7 for the 4-period, and 31.6 for the 5-period game.

The final evaluation is done based on the average of 1000 replication. The results will be discussed in the following sections both for fashionable items and for evergreen ones.

As it can be noticed, the same procedures are followed to create the each model. We aim to see how does the total profit of the whole selling period changes as the number of periods increase. For this reason, we have done a "maximum-of-maximums" comparison where for each period we have taken into consideration the initial inventory level with the highest profit and then compared the periods among each other for each item, evergreen and fashionable separately.

4.5. Brand Owner’s Perspective

In the models composed so far, the decisions are taken by the Store with the purpose of increasing the benefits of the Store. However, as the game theory suggests, in an environment where the outcome depends on the decisions of two or more autonomous players, no single decision maker has full control over the outcomes. A game theory model is constructed around the strategic choices available to player where the preferred outcomes are clearly defined and known (Kelly, 2003). In the previous sections, the strategic choices of the Store so as the outcomes of them are discussed detailed and we believe they are defined well. However, we are aware of the fact that in the decision making process of supply chains, there are many actors with conflicting interest, and looking from the point of view of only one player is not enough. As it is also discussed in the literature review part, the actors can be encouraged to act in the interest of the whole supply chain rather than focusing only in their own self interest in return to a gain in the long-term which is bigger than their immediate profits. In other words, scholars suggest that, when the all players continue to act for the interest of the entire supply chain, rather than behaving in an opportunistic way, the long-term gains would be higher for each of the players.

In the assumptions part, it is mentioned that the model takes into consideration of a 1-echelon distribution network which is composed by one store and one brand owner. Thus, the supply chain is composed by the two players. After mentioning about the interests of the Store we also would like to discuss the Brand Owner’s point of view in order to find a way for coordination between these two players. Finally, we would like to investigate how we can make these two players to take a joint decision that is optimizing the value for both of them. Before moving to the analysis of the supply chain, it is useful to mention about the Brand Owner’s interests and concerns.

In this study, the total profit of the whole selling period is taken into consideration as the main interest of the Store and all the comparisons are done and following the decisions are taken according the profitability of the Store. For this reason, looking at the Brand Owner’s point of view we will be interested on observing the Brand Owner's profitability. As a matter of course, the profit of brand owner is affected by some other variables and the profit formula structure is composed differently than the Store. Typically, the profit formula of it can be defined as below roughly:

Profit = (Wholesale Price) * (Total # of items sold) – Logistics Cost – Production Cost

As the formula suggest, the Brand Owner is interested in increasing the total number of items sold to the Store in order to increase its profit. The study's assumptions consider an infinite-capacity for the Brand Owner stocks which implies that whenever the Store places an order the Brand Owner provides it. Moreover, since no buy-back policy is allowed in the model, the more items sold the more revenues are gained by the Brand Owner. The items are sold to the Store from the wholesale price so, the revenue is calculated by multiplying the number of items sold with that price.

The logistics costs include all the costs incurred during the movement of goods across the country or the globe such as transportation costs, managerial costs, packaging costs, ordering costs. The previous studies on the area shows that around one third to two third of the expenses of firms logistics costs are spent on transportation (Chang, 1988). In most of the studies, instead of logistics costs, transportation costs are taken into consideration since it composes the biggest part of the logistics costs and dealing with the other small costs by one by basically makes no big differences on the results. It is unquestionable the importance of the transportation costs. However, the value of transportation also varies with different industries. For those products with small volume, low weight and high value, transportation cost simply occupies a very small part of sale and is less regarded; for those big, heavy and low-valued products, transportation occupies a very big part of sale and affects profits more, and therefore it is more regarded (Tseng, 2005). Doubtlessly, luxury fashion goods are in the classification of small volume, low weight and high value. Therefore, in this study they are not taken into consideration in the profit calculations.

When it comes to production costs, it includes the cost of raw materials, design, manufacturing and fulfillment. For a product manufactured by mass production and sold with law margins but high volumes, these costs might become more of an issue. However, when the characteristics of the luxury fashion goods are considered and also the high margins that the firms are enjoying, the cost of manufacturing can be disregarded as well.

All in all, for the simplicity the profit of the Brand Owners will be calculated as:

Profit = (Wholesale Price) * (Total # of items sold)

We have defined the wholesale price as 320 Euros for the representative fashionable item and 45 Euros for the evergreen ones. Like it is done for the Store's profitability with the initial inventory level, the different values of total number of items sold is tested for the Brand Owner's profitability. Obviously, as the total numbers of items sold increase, the profitability of the Brand Owner will increase. Differently from the Store's point of view, the number of periods that the items sold does not make a difference for the Brand Owner's profitability. What it important is for this case is the total number. Regardless of the fact that sales are done throughout the season equally or with a pattern, as long as the Brand Owner sells the same amount of items to the Store, it would get the same profit. In the results section, this issue will be discussed more detailed since the number of periods does not have a direct affect on the decision making process of brand owner. Yet, it has an effect on the total number of items bought by the Store throughout the selling season, so as the Brand Owners profitability.

After studying the two players' profitability separately, we focused our analysis on the supply chain composed by these players.

4.6. Supply Chain Perspective

In this study we started by investigating the player's strategies for different scenarios separately and then proceed with the whole supply chain's profitability. It is stated before that the supply chain is composed by two players and the profitability of it is based on the profitability of those two actors. Therefore, the whole supply chain's profitability can be computed by the following equation:

Supply Chain Profit = Store Profit + Brand Owner Profit

A matrix is composed with different number of periods and different initial levels of inventory and the profit of supply chain is calculated by adding the Store profit and the Brand Owner profit for each specific case. The matrix can be found in the results section, we believe it would be more useful to discuss it after having an understanding of the behaviors of the players for different scenarios. The most interesting part here is to see how the two incentives can be convinced to take a joint decision for the sake of the entire supply chain which is also optimizing their own profit.

Obviously, the balance of power between the two players would have a great impact on the decision taken jointly. It is highly likely that brand owner introduces some restrictions to the Store in order to optimize its own profit. The numbers of periods, minimum number of items per order, and the latest time to place an order are just some examples of these restrictions. The Store on the other hand, would act in a way that optimize its own profit with the given conditions which affects the Brand Owner's profitability with the total number of items ordered through the whole selling season. The further discussion regarding the supply chain profitability will be done in the results section which follows after.

5. RESULTS

5.1. The Store’s Perspective

5.1.1. Period Game Results

In this section the results from the simulation for 1 period game will be presented, both for evergreen and fashionable items. Additionally, comments and findings that can be used to improve the replenishment strategies of companies will be given, considering this scenario.

As explained in the methodology section, two types of items were taken into consideration. The differences, focusing only on the model construction, were the input parameters, mainly the cost structure. Otherwise, the assumptions and variables fixed at the beginning were applied for both categories. The model is considering 1000 items from each category, and it replicates the calculation 1000 times. Again, as elaborated before, with this scenario the model considers only the initial inventory (Q1), which is an input into the model. The goal is, by using the functions presented in the model construction part, to find the optimal initial inventory level, when the Store does not have the option for reordering more times.

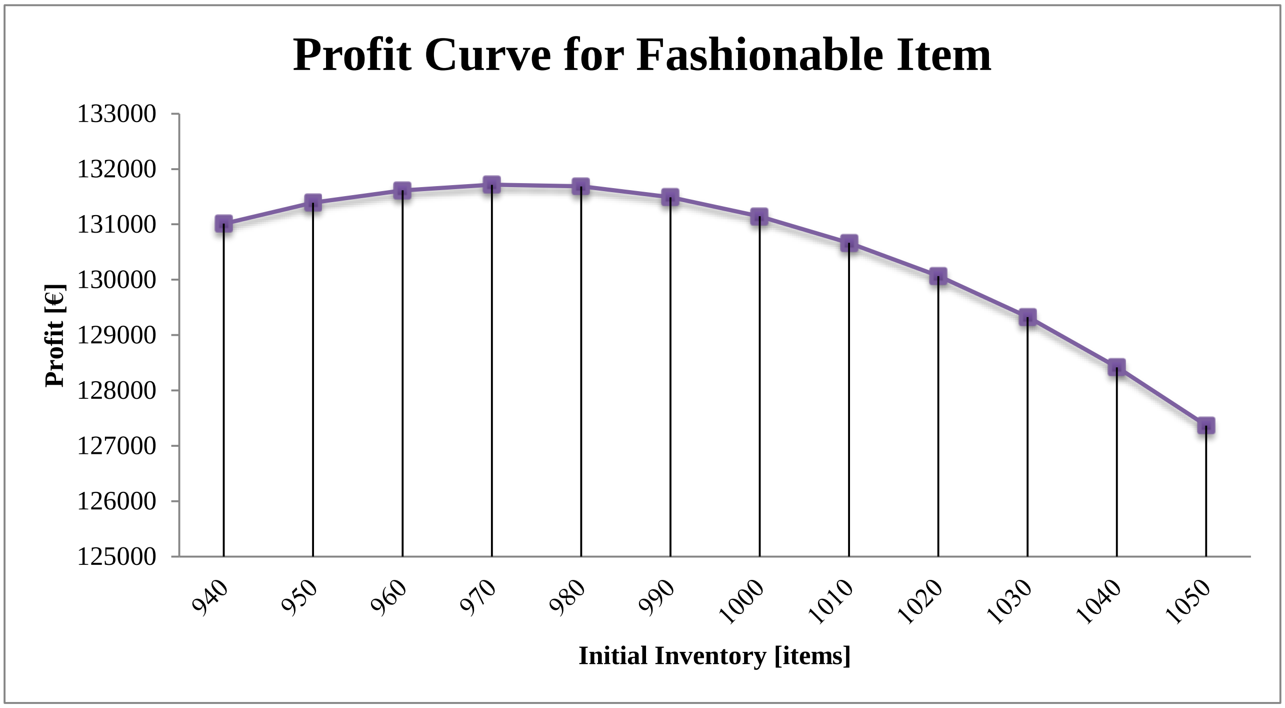
Fashionable Item

After the 1000 repetitions done for the fashionable item, by using the cost structure presented before and the function for calculation of the End of Period inventory level, the total variable costs, the profit gained by using different levels of initial inventory is presented in Table 12.

Q1	Profit (€)
940	131012
950	131391
960	131615
970	**131716**
980	131686
990	131489
1000	131145
1010	130665
1020	130066
1030	129324

Table 12: Profit for different initial inventory levels for Fashionable Item

For a better representation of the final result, in the following graph, the profit curve it is given.



Graph 1: Profit Curve for 1 Period Game for Fashionable Item

From the table and the graph, it can be seen that when the Store orders 970 items before the beginning of the selling season, the profit has the optimal value. However, it can be also noted that even if the Store chooses to have initial inventory from 940 to 990 items, the difference between the profits is still reasonable. On the other hand, if the Store chooses to order more than 1000 items, the profit drops considerably. This occurrence is due to the fact that when it comes to fashionable items, the overstock cost is generally high. Also in this example, the overstock cost taken into consideration was high. Therefore, since the model is defining the demand around 1000 items for the whole selling season; it is expected for the Store when it is ordering fashionable items, to order a lower quantity than 1000. The model considers the overstock cost, and as this value grows, the profit is lowering.

Evergreen Items

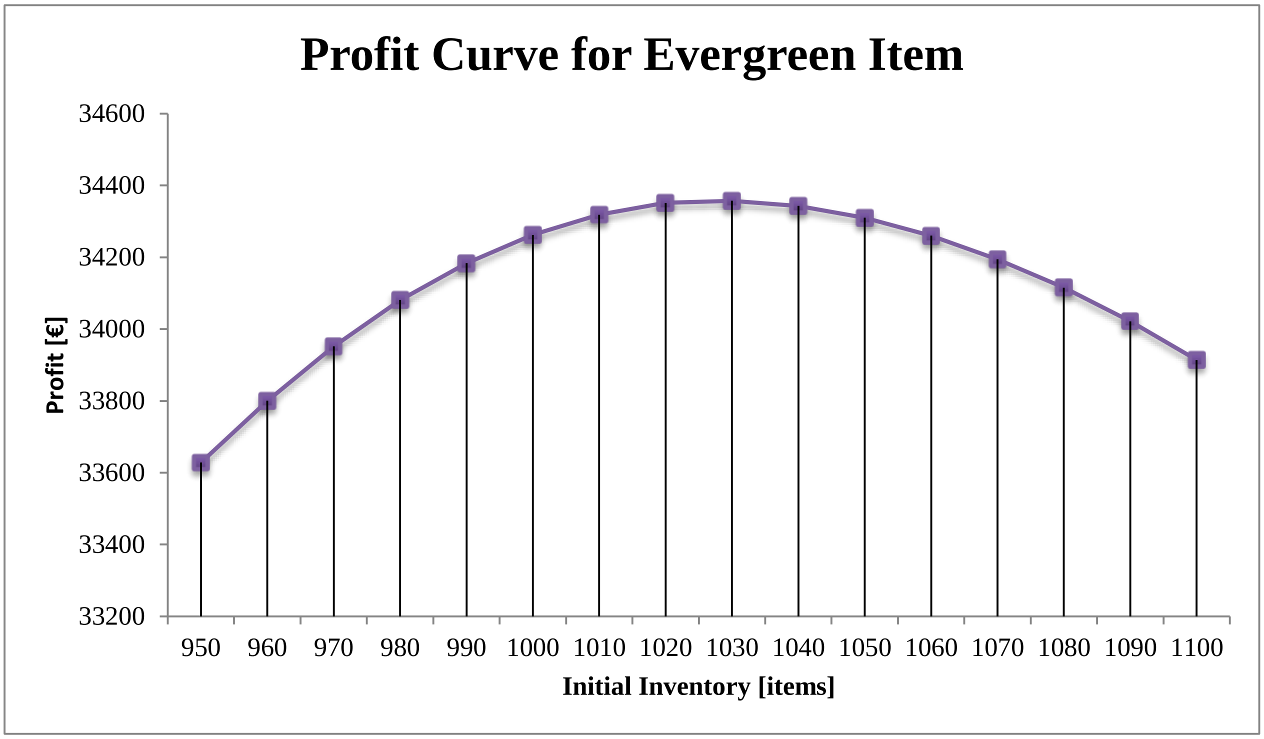
When the evergreen items are being simulated, again taking into account all the input parameters like the variable costs, the inventory level quantity set by the simulator, in order to obtain the total profit gained when applying different inventory levels, the situation is different. As the previous case, the calculation process was multiplied 1000 times, for obtaining a general picture about the behavior of this system.

In the following table for the evergreen item, the different inventory levels with the realized profit when applying each of them are shown.

Q1	Profit (€)
950	33628
960	33800
970	33951
980	34080,
990	34183
1000	34262
1010	34318
1020	34351
1030	**34357**
1040	34342
1050	34309
1060	34259
1070	34194
1080	34115
1090	34021
1100	33913

Table 13: Profit for different initial inventory levels for Evergreen Item

The results for the profit level are shown in a graphical manner in the Graph 2.



Graph 2: Profit Curve for 1 Period Game for Evergreen Item

In this scenario, the result from 1 period game is 1030 initial inventory quantity. However, as in the case of fashionable item, here there is a period of stabilization of the profit. This shows that the Store can place an order between 1000 and 1050 items, and the profit will vary by a small amount of money. Depending the on the overstock cost, the curve can vary around these quantities of initial inventory.

When comparing the two types of items, the results show that when it comes to fashionable items, it will be better for the Store to order a lower quantity of items. And for the evergreen ones, it can be seen that this quantity can be higher, due to the lower risk of overstocking. The results from this example, by using the above stated input variables, both of the types of items have a stabilization period, where the differences between profits are not that significant. However, when crossing the threshold of the optimal zone, the profits become lower in a noteworthy manner. The driver that changes the results is the value of the overstock costs.

Firstly, when observing the fashionable item, its overstock costs are considerably higher; therefore the ratio stock-out vs. overstock costs is around 1. The risk for the Store to have more inventories at the end of the period represents a big loss, since there is no buy back strategy, the discount price by which the items are sold at the end of the season is considerably lower than the normal selling price, and the items cannot be carried to the next selling season. Due to these setbacks for the Store, it is better if the risk of stock-out is taken, which means losing a sale, than to have to deal with a higher inventory than needed at the end of the season. By looking at the Table 14 the difference between fashionable and evergreen item, regarding to the initial inventory - total profit profile, can be seen clearly:

Fashionable Item		Evergreen Item	
Q1	**Profit (€)**	**Q1**	**Profit (€)**
950	131391	950	33628
960	131615	960	33800
970	**131716**	970	33951
980	131686	980	34080,
990	131489	990	34183
1000	131145	1000	34262
1010	130665	1010	34318
1020	130066	1020	34351
1030	129324	**1030**	**34357**
1040	128418	1040	34342
1050	127366	1050	34309

Table 14: 1 period game results of the both items

The situation for the evergreen item is slightly different than the fashionable one, as it can be seen from the above table as well. Since the ratio stock-out vs. overstock costs is generally bigger than one, the Store has lower overstock costs. Therefore, the Store has the opportunity to order more items at the beginning and keep them as inventory until the end of the selling period, where the items which are unsold, can be transferred to the next selling season. In this way, the Store avoids having a stock out, since it has more inventory on hand than needed. The total risk for the Store is minimized, when compared to the risks for fashionable items.

5.1.2. 2 Period Game Results

For 2 period game, three different cases were discussed with the three different ways of generating the demands and in this section results of the simulation models composed will be analyzed case by case for both of the products chosen.

Case 1: Demands of two periods are independent

In the first case the demands of the two periods are generated independently identically distributed.

<u>Fashionable Item</u>

The following results are obtained for the different levels of initial inventory (Q1) of the fashionable item:

Q1	Q2	Q1+Q2	Average Profit(€)
450	470	920	163327
475	462	937	166200
500	451	951	168353
525	436	961	169679
550	418	968	170303
<u>575</u>	<u>398</u>	<u>973</u>	<u>170376</u>
600	376	976	170006
625	352	977	169322
650	328	978	168474

Table 15: Average Profit for Fashionable Item with 2-period game and independent demands

The simulated model suggests that the profit can be maximized by ordering an initial inventory 575 items (Q1) and at week-10 re-ordering another 398 items. As it is mentioned before for the

Q1, different values are tested whereas for Q2, a function depending on D1 and Q1 is used. The previously defined Q2 function was as below:

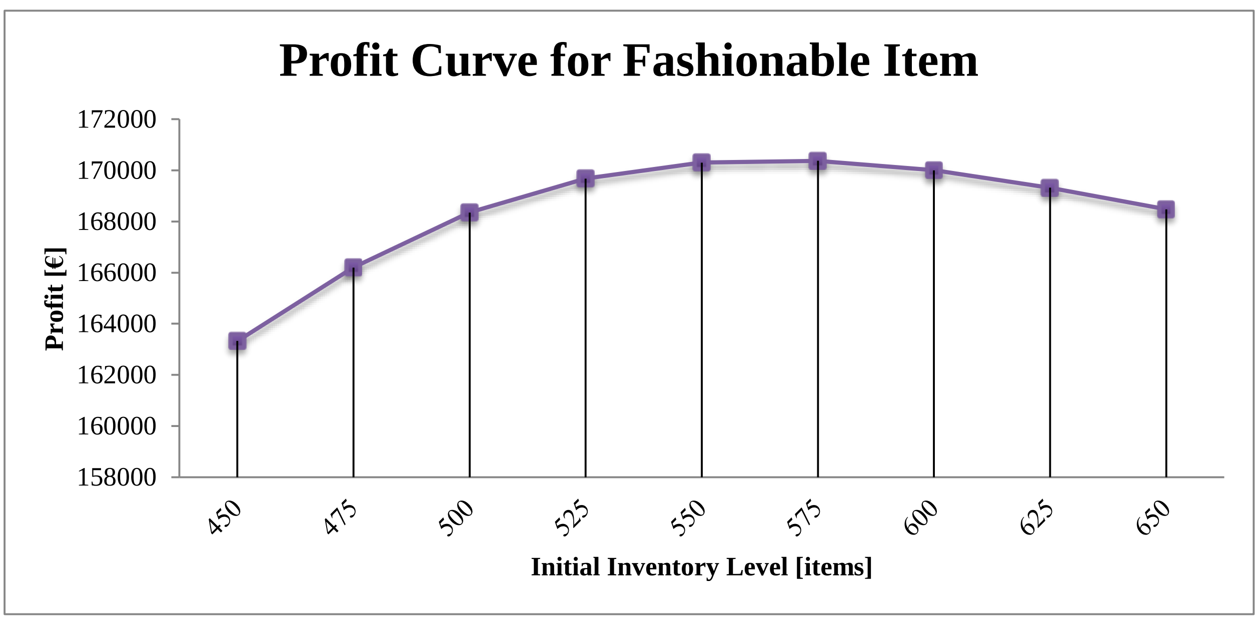
Q2 = Max (Q* – BOP2, 0)

For this specific case Q* which is the value that optimizes the profit of 1-period game of an fashionable item for a demand normally distributed with mean 500 and standard deviation of 71 is calculated as 480. So, the formula becomes:

Q2 = Max (480 – BOP2, 0)

As a result of the formula above, the replenishment amount is calculated as 398 for the second period. Defining Q1 as 575 and Q2 as 398, on the average 170376 Euros can be obtained from the whole selling period and in total 973 items are ordered from the Brand Owner for the whole season. It can be seen from the table that Q1 values are increased at intervals of 25 items. Therefore, 575 may not be the exact optimal one but the closest among the given ones and the optimal value is expected to be a number between 550 and 575 since these the Q1 values provide the two highest profits on the given table.

Looking at the initial inventory level (Q1) and the profit graph, the concept can be understood better:



Graph 3: Profit Curve for 2 Period Game for Fashionable Item

As it can be seen also in the graph, a value between the range 550 and 575 would provide the highest profit to the Store at the end of the whole selling season of a fashionable item, where the Store has two chances to order throughout the season and demands of these two periods are expected to be independent.

Evergreen Item

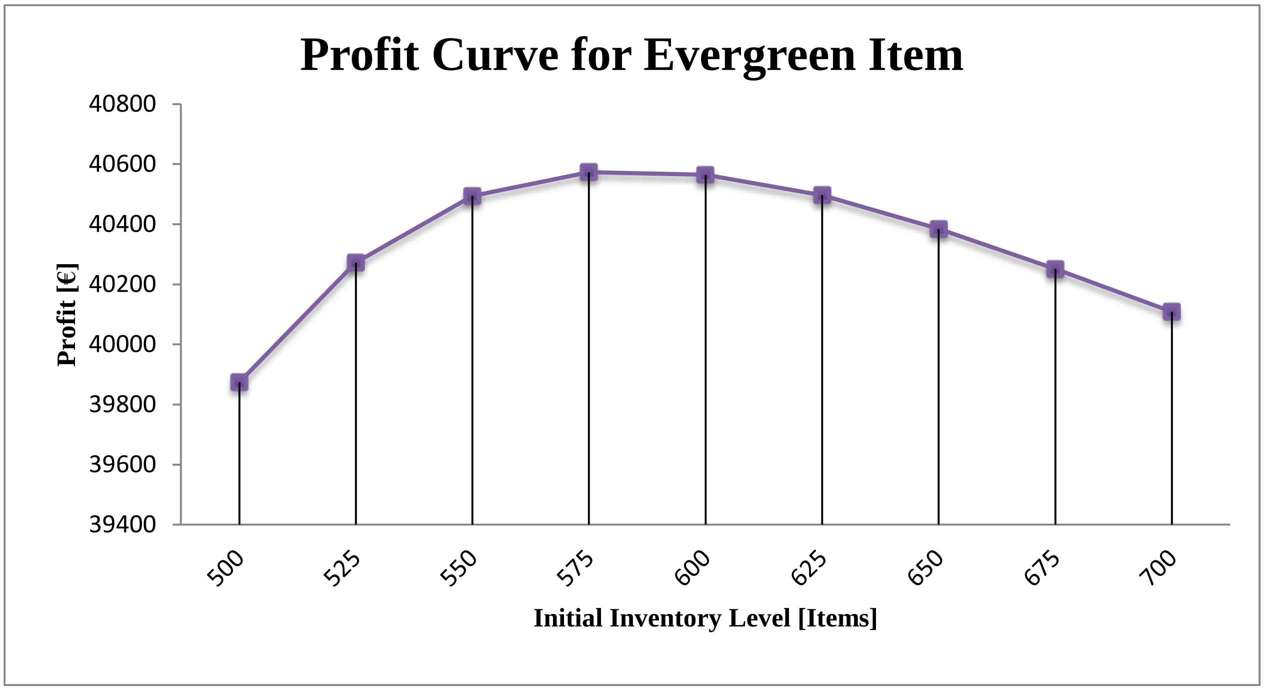
On the other hand, for the evergreen item the results table changes as below:

Q1	Q2	Q1+Q2	Average Profit(€)
500	483	983	39874
525	469	994	40272
550	452	1002	40494
575	432	1007	40573
600	409	1009	40565
625	386	1011	40497
650	362	1012	40384
675	337	1012	40251
700	312	1012	40109

Table 16: Average Profit for Evergreen Item with 2-period game and independent demand

The model again suggests ordering an initial inventory of 575 items (Q1). In the same manner, 575 is not the exact optimal but the best among the presented. Moreover, the simulation results advises to order an amount of 432 (Q2) at week-10, which is more than the one suggested for fashionable. So, in total a 1007 fashionable items are ordered and in return 40573 Euros of profit is gained on the average for the whole selling season.

The initial inventory (Q1) – profit graph of the evergreen item can be represented as below:



Graph 4: Profit Curve for 2 Period Game for Evergreen Item

This time it is expected to have an optimal initial inventory value between 575 and 600 as the results table suggest and can be seen from the table.

As it was expected, total number of items ordered for the evergreen product throughout the whole selling season is higher than the fashionable product. Like it is explained in the 1-period game, the Store is risk averse on increasing the number of orders when it comes to the fashionable product that has a high over-stock cost. On the other hand, it has a higher tendency on taking the risk for the evergreen product whose overstock cost is lower than the its lost sale cost.

Another comparison can be done between the results of 1-period game and 2-period game. For the fashionable item the maximum profit can be obtained by playing 1-period game is calculated as 131716 Euros, whereas in here we have seen that 170376 Euros can be gained if the Store can order one more time during the season. In the same way, for the evergreen item a profit of 34357 Euros can be gained at most while 2-period game provides a profit of 40573 Euros. Looking at these results, it can be said that introducing one more chance of replenishment has significantly improved the Store's profitability. The number of periods should be increased in order to see the pattern and to see how many number of replenishments will be the optimal for each item.

Moreover, when it comes the comparison of number of items ordered for fashionable and evergreen items, we see that similar to 1period game number of evergreen items ordered is higher. A cross case table prepared to compare the outcomes for the two different products would make it clearer:

Fashionable Item				Evergreen Item			
Q1	**Q2**	**Q1+Q2**	**Av. Profit(€)**	**Q1**	**Q2**	**Q1+Q2**	**Av. Profit(€)**
500	**451**	**951**	**168353**	**500**	**483**	**983**	**39874**
525	**436**	**961**	**169679**	**525**	**469**	**994**	**40272**
550	**418**	**968**	**170303**	**550**	**452**	**1002**	**40494**
575	**398**	**973**	**170376**	**575**	**432**	**1007**	**40573**
600	**376**	**976**	**170006**	**600**	**409**	**1009**	**40565**
625	**352**	**977**	**169322**	**625**	**386**	**1011**	**40497**
650	**328**	**978**	**168474**	**650**	**362**	**1012**	**40384**

Table 17: Cross case table of the different product types for the Case 1

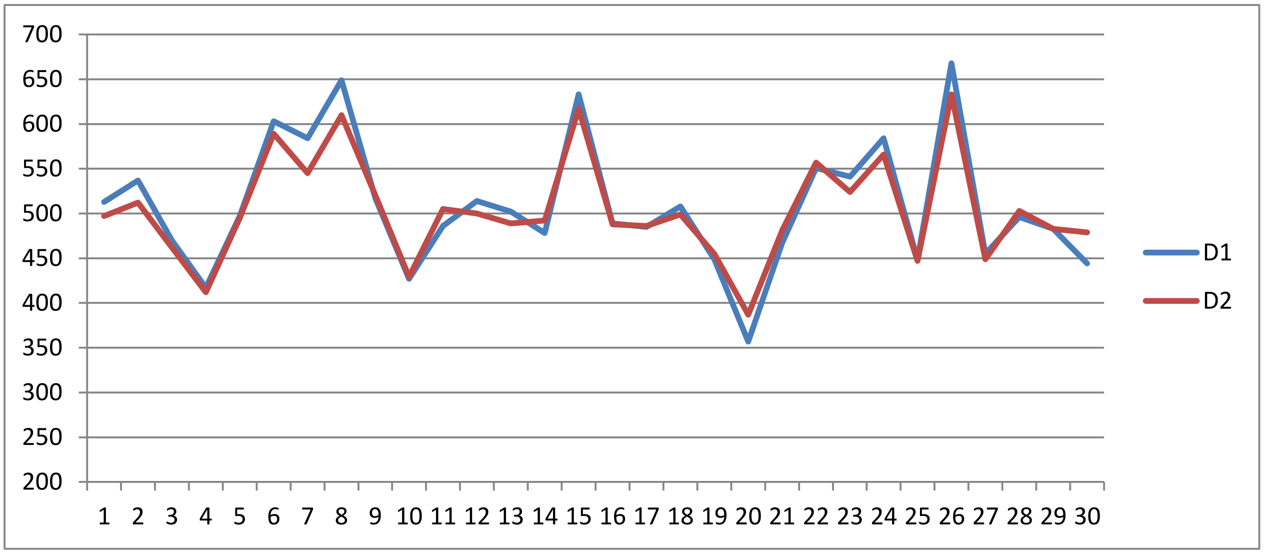
As it can be seen from the table above as well, the total number of items ordered for the whole selling season is differs as it is in the 1 period game. In the same manner the risk is more highly likely to overstock its inventories for the evergreen item, while for the fashionable one it remains as risk-averse.

Before moving to the 3-periods game results, other cases of the 2-period game where the demands of two periods are assumed to be correlated will be examined.

Case 2: Demand of the first period and second period are positively correlated

The case 2 considers the two periods' demands as they are positively correlated with each other. The way that we have generated the demand is discussed in the previous sections. With the suggested method 1000 D1 and D2 are generated as the simulation is run 1000 times.

In order to represent the relation between D1 and D2, the graph below is plotted by using the first 30 couple of demand generated:



Graph 5: An illustration of positively generated demands for the Case 2

In the previous sections, it is also mentioned that a different Q2 function is used in this case since knowing the fact that the second period's demand will be positively correlated with the demand of the first period improve the forecast accuracy. In order to show how the decision taken is improved the simulation using the same Q2 function with Case 1 will be represented first.

Fashionable Item

For the fashionable item, when the demands are positively correlated the table below is obtained:

Q1	Q2	Q1+Q2	Average Profit(€)
450	470	920	165237
475	463	938	168221
500	452	952	170478
525	439	964	171974
550	421	971	172682
575	401	976	172765
600	379	979	172411
625	355	980	171760
650	331	981	170938

Table 18: Average Profit for Fashionable Item with 2-period game and positively correlated demand

On the other hand when Q2 function is taken as:

Q2 = Max (D1 – EOP1, 0)

From the table below, it can be seen that the results are improved:

Q1	Q2	Q1+Q2	Average Profit(€)
450	490	940	171493
475	482	957	174397
500	471	971	176575
525	457	982	177973
550	439	989	178630
575	419	994	178708
600	397	997	178328
625	373	998	177673
650	349	999	176861

Table 19: Average Profit for Fashionable Item with 2-period game and positively correlated demand with improved input

The findings are anticipated. Practically, we expect that the demand during second period will be similar what has been observed during the first period. As a result, taking D1 as a merit while deciding on the number of items ordered for the second period should provide us higher profits, as we expect a similar amount of demand in the first period.

Evergreen Item

The results for evergreen items are verifying the course of thought. The first results obtained for the evergreen item with the positively correlated demands is given below:

Q1	Q2	Q1+Q2	Average Profit(€)
475	493	968	39473
500	482	982	40002
525	468	993	40363
550	450	1000	40574
575	430	1005	40649
600	407	1007	40622
625	383	1008	40530
650	359	1009	40411

Table 20: Average Profit for Evergreen Item with 2-period game and positively correlated demand

On the other hand when the Q2 function is changed with the one that is presented above, the results are changed as below:

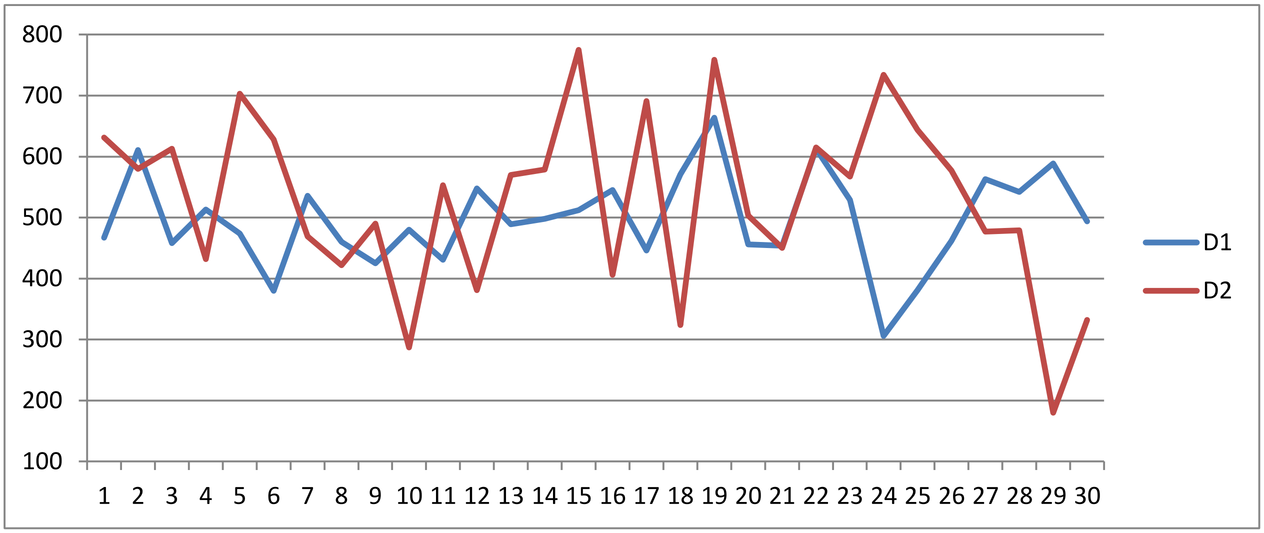
Q1	Q2	Q1+Q2	Average Profit(€)
475	480	955	40173
500	469	969	40685
525	454	979	41013
550	435	985	41190
575	415	990	41254
600	392	992	41231
625	369	994	41148
650	344	994	41027

Table 21: Average Profit for Evergreen Item with 2-period game and positively correlated demand with improved input

Although the initial inventory level is the same for both of the cases, it can be seen that the profit is improved with the change in the replenishment amount.

Case 3: Demand of the first period and second period are negatively correlated

The case 3 deals with the negatively correlated demands of different periods. In this case it is expected to have a high demand during the second period if a low demand is observed during the first period and vice versa. When we plot the graph of first 30 couples of demand for the model, it the pattern drawn by them can be seen more clearly:



Graph 6: An illustration of negatively generated demands for the Case 3

In the same manner with Case 2, different Q2 functions are used in defining the replenishment periods for the second period.

Fashionable Item

For the fashionable item, when the Q2 is calculated by the function of Max (Q* – BOP2, 0) following table is obtained:

Q1	Q2	Q1+Q2	Average Profit(€)
450	471	921	152945
475	464	939	156002
500	453	953	158279
525	439	964	159768
550	422	972	160525
575	402	977	160729
600	381	981	160463
625	357	982	159871
650	333	983	159072

Table 22: Average Profit for Fashionable Item with 2-period game and negatively correlated demand

On the other hand when we switched to Q2 function to Q2 = max (1000 – D1 – EOP1, 0) and run the simulation again, we come up with the table represented below:

Q1	Q2	Q1+Q2	Average Profit(€)
450	491	941	155788
475	483	958	158716
500	473	973	160962
525	458	983	162388
550	441	991	163044
575	420	995	163105
600	398	998	162697
625	374	999	161975
650	350	1000	161110

Table 23: Average Profit for Fashionable Item with 2-period game and negatively correlated demand with improved input

Evergreen Item

The simulation is run for the evergreen item as well and the initially the table below is showed up:

Q1	Q2	Q1+Q2	Average Profit(€)
450	500	950	37226
475	492	967	37933
500	481	981	38484
525	467	992	38863
550	450	1000	39079
575	429	1004	39154
600	407	1007	39132
625	383	1008	39048
650	359	1009	38922

Table 24: Average Profit for Evergreen Item with 2-period game and negatively correlated demand

However, switching the Q2 function provided the following one:

Q1	Q2	Q1+Q2	Average Profit(€)
450	489	939	37467
475	481	956	38192
500	471	971	38755
525	457	982	39143
550	440	990	39376
575	420	995	39468
600	398	998	39454
625	374	999	39376
650	350	1000	39255

Table 25: Average Profit for Evergreen Item with 2-period game and negatively correlated demand with improved input

In the methodology section it is mentioned about the broadening the assumption about the week that the replenishment is done. Following section provides the result of the study conveyed on the question of when to replenish the inventories in a 2-period game.

When to replenish?

With this experiment, the goal is to obtain the answer to the question "when the order should be made?" and the simulation made is by changing the possibilities for the Store considering the time of replenishment. As stated in the previous chapters, the experimentation is using a fashionable and evergreen item. In order to see whether the products are going to behave in a certain way, the input parameters used were having some adjustments, as stated in the previous text elaborating how the model was constructed.

Firstly, the results for the fashionable item are going to be elaborated, by starting stating the results from the Q* calculation. Q* was the quantity which is used to calculate the optimal Q2 or replenishment amount for the second period, and it is obtained by looking at the 2 period game as two separate 1 period games. When the question about when is the right moment to place the order arose, the calculation of Q* was a necessary part.

Depending on the week when the replenishment should take place, estimations are done in order to obtain the right amount of Q* for each case. Therefore, in the following table the results of Q* will be presented.

		Fashionable Item		Evergreen Item	
	Demand Function	**Q***	**Profit**	**Q***	**Profit(€)**
Week 5	D(700, 86,6)	670	89333,49	730	23950,9
Week 10	D(500, 71)	480	62213,86	520	16610,5
Week 13	D(350, 59.16)	330	43961,19	370	11784,97
Week 14	D(300, 54.77)	280	35986,58	320	9816,558
Week 15	D(250, 50)	240	30773,44	260	8314,108
Week 16	D(200, 44.72)	190	24374,96	210	6598,161
Week 18	D(100, 31.6)	90	10049,62	110	3047,384

Table 26: Q* Results

The value for Q* is used to calculate the Q2, since it is the optimal number of items when considering that the second period of sales is a 1 period game. Depending on where the order should be placed, the demand characteristics are going to be changed accordingly. By setting the parameters in this way the time for reordering is being fixed.

Next, the model is calculating the replenishment quantity or Q2 and then the total profit gained by using a certain initial inventory. The model is using the following functions for calculation of Q2:

$$\mathbf{Q2 = Max\ (Q^* - BOP2,\ 0)}$$

As shown in the Table 26, the results for the Q* values are being replaced here, depending on when the replenishment is supposed to happen.

To summarize the experiment construction, it can be said that the main goal is to define when the most optimal time to make the reorder is. In order to answer this question, the model is considering different weeks when the reordering should take place, and since the selling period is 20 weeks, the time is split within this time frame. For the model to consider different weeks for replenishment, the selling period was split into two periods, with different length. The variables changing in the model are:

- Demand generation – in order for the model to consider different length of the two periods, the demand also has to be changed. This was done by taking into consideration the demand for the whole selling period, which was previously set as a normally distributed random numbers, with mean 1000 and standard deviation 100. To simplify the model construction, since the selling period is fixed to 20 weeks, the demand is divided for each week separately. Therefore, depending on when is the replenishing going to happen, the proportional demand is taken into account, for both, the first and the second period. This was shown in the table 26 above.
- Q* generation – in order for the model to give a result considering the second period variables (demand, inventory level), the need to use the Q* function was presented. Q* is used for the calculation of Q2, the second inventory level ordered from the Brand Owner. By using the generated demands, again depending on when is the replenishing going to happen the right value of Q* is used in the Q2 function shown in the previous text. By implementing Q* in the model, the simulator, splits the 2 period game into two separate 1 period games, where by using the input parameters from the end of the first period in the beginning of the second, it obtains the value for Q*, which is a function of D1 and Q1, and uses it for the calculation of Q2, to represent the impact of the first period on the second. The Store has to make a decision for the Q2 quantity considering the demand from the first period (D1) and the initial quantity of items (Q1).
- Variable costs generation – in order to adjust the total variable costs, which have to be applied throughout the whole selling season for the total items that are ordered by the Store, the model is constructed in a way that the variable costs consider the length of the first period (until the replenishing is done), and also the length of the second period (after the replenishing is done, until the end of the season).

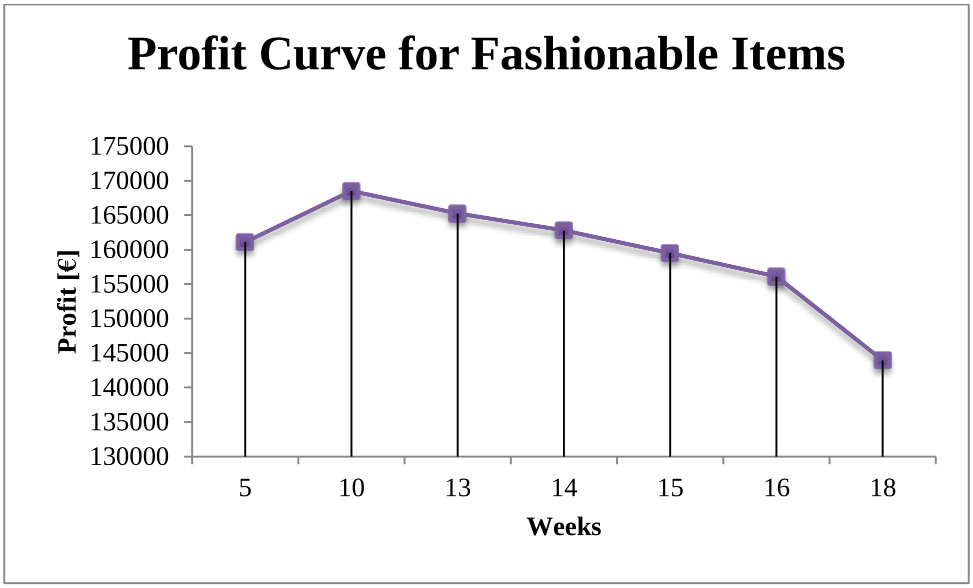
In the following pages, the results for making the reordering in different weeks will be presented.

Week 5				Week 10				Week 13				Week 14			
Q1	Q2	Q1+Q2	Av. Profit	Q1	Q2	Q1+Q2	Av. Profit	Q1	Q2	Q1+Q2	Av. Profit	Q1	Q2	Q1+Q2	Av. Profit
250	665	915	151477	400	477	877	153861	500	329	829	145062	600	276	876	150902
300	650	950	158296	450	470	920	161405	550	325	875	152955	650	267	917	157342
350	617	967	161088	500	451	951	166530	600	316	916	159506	700	248	948	161456
400	571	971	161054	550	419	969	168503	650	296	946	163704	750	216	966	162789
450	521	971	160184	600	376	976	168154	700	264	964	165261	800	175	975	161957
500	521	972	159198	650	376	978	166627	750	264	974	164739	850	175	980	159949
550	472	972	158198	700	328	979	164715	800	224	977	162856	900	130	986	157060
600	422	972	157198	750	279	979	162724	850	177	980	160435	950	86	998	152692
650	322	972	156198	800	179	979	160715	900	85	985	157399	1000	23	1023	145923
		max=	161088			max =	168503			max =	165261,07			max =	162789,3

Week 15				Week 16				Week 18			
Q1	Q2	Q1+Q2	Av. Profit	Q1	Q2	Q1+Q2	Av. Profit	Q1	Q2	Q1+Q2	Av. Profit
600	239	839	141212	700	184	884	145376	800	83	883	136900
650	235	885	148621	750	174	924	151213	850	74	924	141747
700	224	924	154624	800	156	956	154952	900	60	960	143927
750	204	954	158317	850	127	977	156108	950	43	993	142553
800	173	973	159518	900	93	993	154449	1000	26	1026	137308
850	173	984	158426	950	93	1009	150282	1050	26	1064	128033
900	134	992	155539	1000	59	1031	143663	1100	14	1106	115226
950	92	1005	150774	1050	31	1063	134078	1150	6	1151	100133
1000	28	1028	143855	1100	4	1104	121096	1200	0	1200	83810
		max =	159518,3			max =	156108,5			max =	143927,5

Table 27: Results for Fashionable Item with changed ordering time

On the graph beneath, the results presented in Table 27 are shown in a graphical way.



Graph 7: Profit Curve for Fashionable Item by ordering in different week

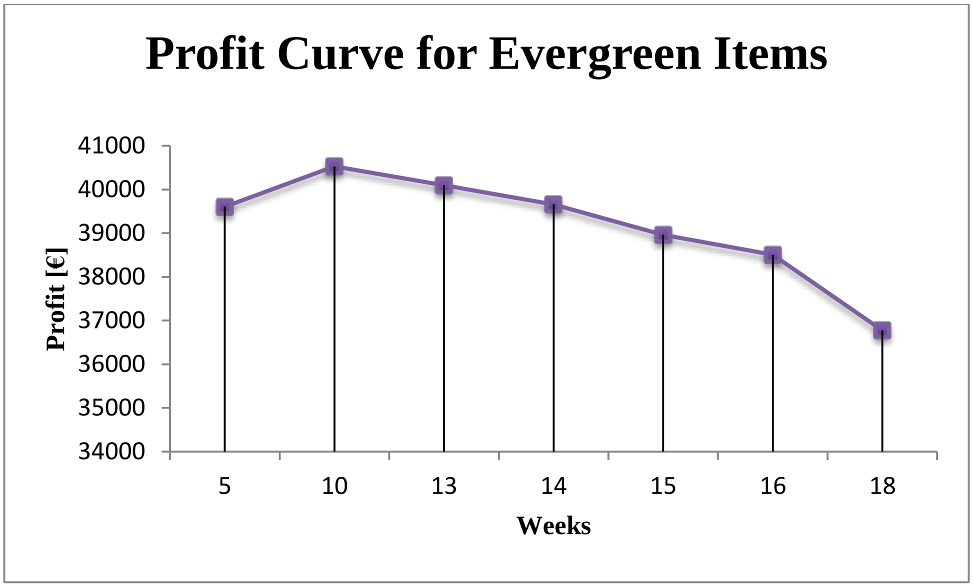
When observing the results from the model the optimal week to make the order is week 10, where the profit is the highest. With obtaining these results for fashionable means that the Store will order at half of the period, mostly because the ratio stock-out/overstock cost is quite high. Therefore when looking at the other options, ordering before week 10 will mean that there might be numerous stock-outs at the end of the period. On the other hand, ordering in the second half will bring more overstock cost.

On the other hand, the results for the evergreen item, using the input parameters, the functions and the variables are shown bellow.

Week 5				Week 10				Week 13				Week 14			
Q1	Q2	Q1+Q2	Av Profit	Q1	Q2	Q1+Q2	Av Profit	Q1	Q2	Q1+Q2	Av Profit	Q1	Q2	Q1+Q2	Av Profit
200	729	929	35308	400	517	917	36907	500	369	869	35053	600	315	915	36573
250	725	975	37378	450	509	959	38646	550	364	914	36866	650	305	955	38133
300	709	1009	38872	500	491	991	39892	600	353	953	38380	700	285	985	39153
350	675	1025	39518	550	459	1009	40465	650	334	984	39458	750	253	1003	39651
400	630	1030	39609	600	417	1017	40526	700	303	1003	40006	800	212	1012	39660
450	581	1031	39502	650	369	1019	40323	750	264	1014	40098	850	165	1015	39408
500	531	1031	39355	700	319	1019	40050	800	218	1018	39898	900	119	1019	39061
550	481	1031	39205	750	269	1019	39754	850	170	1020	39579	950	76	1026	38673
600	431	1031	39055	800	219	1019	39454	900	123	1023	39202	1000	42	1042	38274
		max =	39609			max =	40526			max =	40098			max =	39660

Week 15				Week 16				Week 18			
Q1	Q2	Q1+Q2	Av Profit	Q1	Q2	Q1+Q2	Av Profit	Q1	Q2	Q1+Q2	Av Profit
600	257	857	34389	600	209	809	31983	900	79	979	36316
650	252	902	36111	650	208	858	33825	950	59	1009	36773
700	241	941	37532	700	203	903	35529	1000	38	1038	36774
750	220	970	38511	750	192	942	36952	1050	21	1071	36439
800	189	989	38962	800	174	974	37946	1100	9	1109	35884
850	149	999	38940	850	145	995	38441	1150	4	1154	35209
900	108	1008	38668	900	111	1011	38505	1200	1	1201	34464
950	69	1019	38248	950	75	1025	38259	1250	0	1250	33677
1000	37	1037	37788	1000	44	1044	37824	1300	0	1300	32881
		max =	38962			max =	38505			max =	36774

Table 28: Results for Evergreen Item with changed ordering time



Graph 8: Profit Curve for Evergreen Item by ordering in different week

The overview of the results for the evergreen item shows that the model suggests reordering at week 10, where the profit has its maximum value. Like the fashionable item example, where the results suggested that the Store should be careful when placing the orders, these results suggest otherwise. It can be seen that it is better for the Store to have more inventories on hand for both parts of the selling season. The Store will be able to respond the customer demand, and avoid losing customers, therefore avoid having stock outs. On the other hand, even if the inventory level is not zero at the end of the second period the Store can still use these items afterwards.

When the results between the weeks are compared, by looking at the total Q ordered for fashionable and evergreen item, a noticeable difference can be seen. Even if the ordering week is the same for both products, the quantity ordered differs. This implies that the ratio stock-out/overstock cost has an impact in the decision making process, pushing an order for the fashionable item smaller than 1000 and bigger than 1000 for the evergreen item.

5.1.3. 3 Period Game Results

In the chapter 3 Period Game, the detail of how the model is composed when having two possibilities of replenishing is explained. As stated in this chapter, the 3 Period Game observes the system when the Store is offered to have two different replenishment possibilities, apart from the initial inventory. The results shown below are considering the input parameters for fashionable and evergreen items, when the selling period is divided into three equal periods. The demand function in this case is assuming that the whole demand is divided into 3 parts, which are independent and identically distributed, with a function presented below:

- D1 (333.33, 57.7)
- D2 (333.33, 57.7)
- D3 (333.33, 57,7)

Firstly, the results from the model for the fashionable item are going to be presented in the Table 29.

Q1	Q2	Q3	Total Q	Av Profit(€)
300	310	303	913	174239
320	303	303	926	176646
340	294	303	937	178529
360	282	303	945	179806
380	267	303	950	180485
400	**251**	**303**	**954**	**180720**
420	233	303	956	180677
440	214	303	957	180411
460	195	303	958	180005
480	175	303	958	179525

Table 29: Results for Fashionable Item for 3 Period Game

The results suggest that the optimal quantity of initial inventory (Q1) is 400 items. Furthermore, the Q2 and Q3, for the replenishing in week 7 and week 14 is 251 and 303, respectively. The total quantity of items ordered throughout the season is 954, with an average profit of 180720 Euros. In chapter 3 Period Game, the explanation for the functions of Q2 and Q3 was elaborated. the functions used to calculate these quantities are the following:

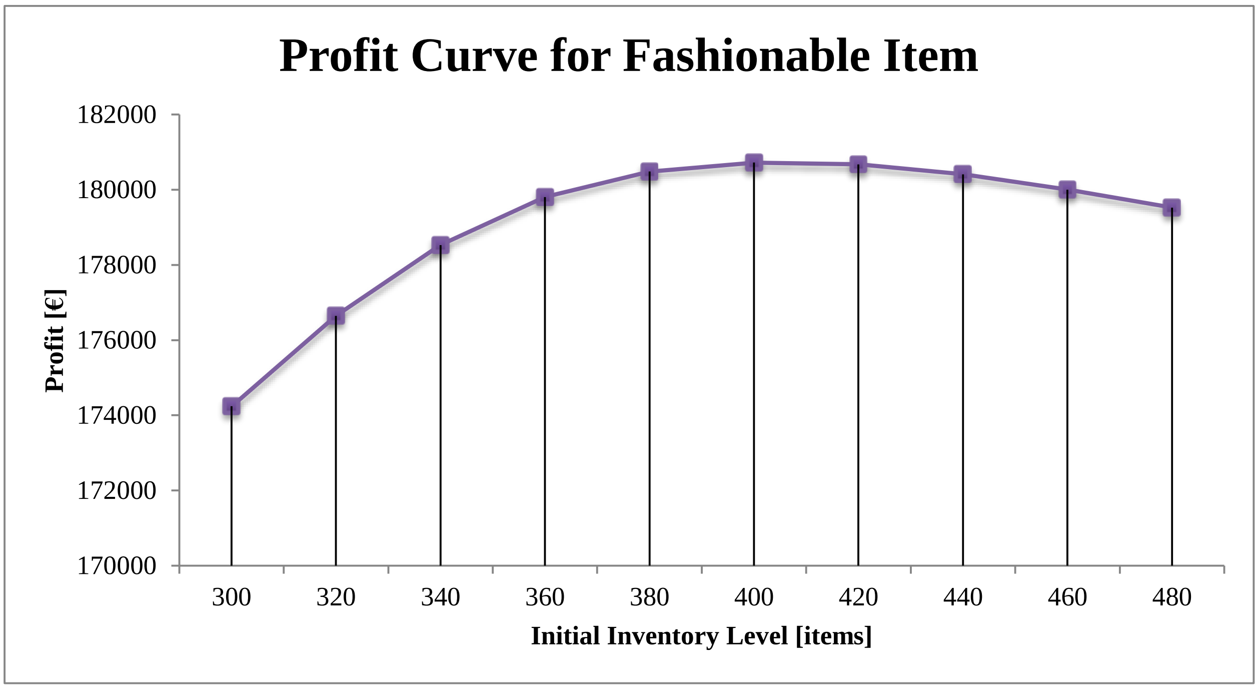
Q2 = Max (Q* – BOP2, 0)

Q3 = Max (Q* – BOP3, 0)

In this specific case, the value of Q* was calculated by taking into consideration the 3 period game as three separate 1 period games and by applying a demand with mean 333.33 and standard deviation of 57.7, the result for Q* is 320.

From the table above, it can be noted that the intervals of increasing the number of items for Q1 inventory level is 20, therefore it has to be stated that the final result might not be the optimal one. The value of the exact number of items is around 400 and 420, since with these numbers of items the average profit is the highest.

For having a better understanding of the results, on the graph below, they can be seen in a graphical representation.



Graph 9: Average Profit Curve for Fashionable Item for 3 Period Game

Also, in graph it can be seen that there is a period of stabilization of the profit. This means that the Store is suggested to make the initial order between 380 and 440, where the curve for the profit has the highest values. According to the initial inventory (Q1), the model makes the estimation for the Q2 and Q3 replenishment amounts, in order for the Store to gain the most, depending on the demand and also on the inventory ordered in the previous period.

- Similar calculation was done also for the evergreen item by using the input data presented above. Additionally, the Q* for the evergreen item used as an example is 360 which is the optimal ordering amount for 1-period game where the demand is expected to be normally distributed with the mean 333.33 and standard deviation 57.7.

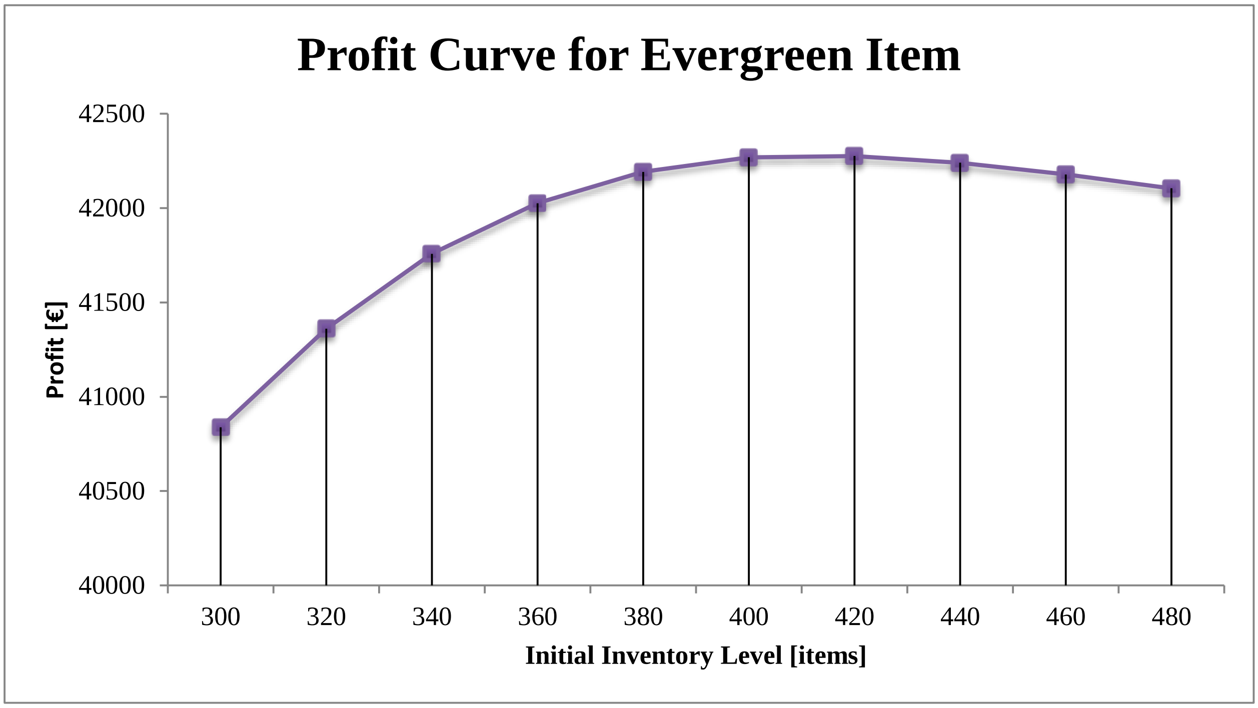
.

Q1	Q2	Q3	Total Q	Av Profit(€)
300	348	321	970	40838
320	341	321	982	41361
340	331	321	992	41758
360	318	321	999	42026
380	303	321	1004	42192
400	286	321	1007	42269
420	268	321	1009	42277
440	249	321	1010	42241
460	229	321	1010	42179
480	209	321	1011	42105

Table 30: Results for Evergreen Item for 3 Period Game

For this case, the model suggestion for the initial inventory (Q1) is 420, which is higher than the one for fashionable item. Once again, it has to be mentioned that this might not be the most optimal value, due to the fact that the increments for changing the initial inventory are 20. The Q2 and Q3 amounts that are obtained in the model are, 268 and 321, respectively. As for the total amount, or total Q, it has resulted as 1009 items. The average profit obtained from this simulation is 42277 Euros.

With the graph initial inventory – average profit a better representation of the results can be seen.



Graph 10: Average Profit Curve for Evergreen Item for 3 Period Game

The situation shown on the graphical presentation is slightly different than the one before. For the evergreen item the optimal value of initial inventory (Q1) is 420. However, the period for stabilization is longer and it is taking into account higher values of Q1. Therefore, the Store can order between, 400 and 480 items at the beginning of the selling season and obtain the highest average profit.

Lastly, when making the comparison between fashionable and evergreen products, the results show that the total number of items ordered for the whole selling season is much more higher for evergreen (1009 items), than for fashionable (954 items). This is due to the impact of the overstock costs, which is higher for fashionable items.

Another indicator for the usage of this replenishing strategy is gain by making a comparison between the results for 1-period, 2-period and 3-period game. When the fashionable item is considered, the highest average profit that can be reached is by having 2 options to replenish. With 1-period game the profit resulted was 131716 Euros, with 2-period was 170376 Euros, which shows a big improvement. However, the average profit has been increased again by using the 3-period game, reaching 180720 Euros. The same movement of the profit is resulted for the evergreen item. When applying 1-period game the profit was 34357 Euros, and 2-period was 40485 Euros. For 3-period game the resulted profit was 42277, showing the benefits of this strategy. Until this phase of the model results, the profitability for the Store has already been improved. However, further results will show the change of the profitability by introducing more replenishment options throughout the selling season.

5.1.4. N Period Game Results

In the sections where the composition of models is explained, a general framework is defined on how to build the n-period models. Following that framework we increase the number of periods, i.e. number of re-ordering possibilities throughout the season, and the result will be presented in this section. We believe that representing the results of 4-period, 5-period, 7-period and 10-period results will be enough to understand the concept and the Store's attitude towards the increasing number of periods.

4-Period Game

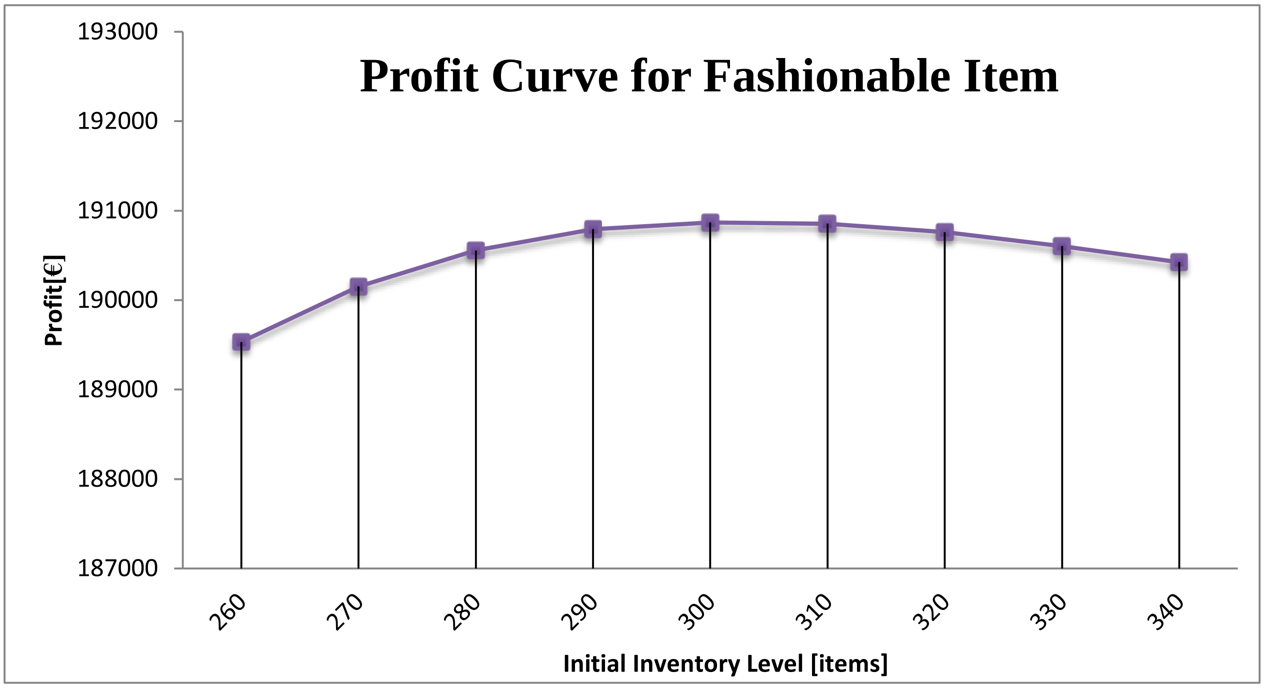
In a model where the Store has the possibility to give order in 4 different times throughout the whole selling season, one initial inventory (Q1) and three replenishment amount (Q2, Q3, and Q4) can be defined. Different initial inventory levels require different replenishment amounts which result in different profits. For the fashionable item taken into account, the following results are obtained for Q2, Q3, Q4 values and then the profit for different levels of Q1:

Q1	Q2	Q3	Q4	Total Q	Av Profit(€)
260	220	229	228	936	189532
270	213	229	228	940	190153
280	206	229	228	943	190556
290	198	229	228	945	190793
300	**189**	**229**	**228**	**946**	**190868**
310	180	229	228	947	190855
320	171	229	228	947	190760
330	161	229	228	947	190603
340	151	229	228	938	190425

Table 31: Results for Fashionable Item for 4 Period Game

The table above suggests ordering an initial amount of 300 items while playing a 4-period game for a fashionable item. Following this initial decision, replenishing an amount of 189 items at week 5, 229 items at week 10 and 228 items at week 15 ends up with gaining an average of 190868 Euros of profit for the Store at the end of the fourth period.

The profit graph for the different Q1 values is plotted as below:



Graph 11: Average Profit Curve for Fashionable Item for 4 Period Game

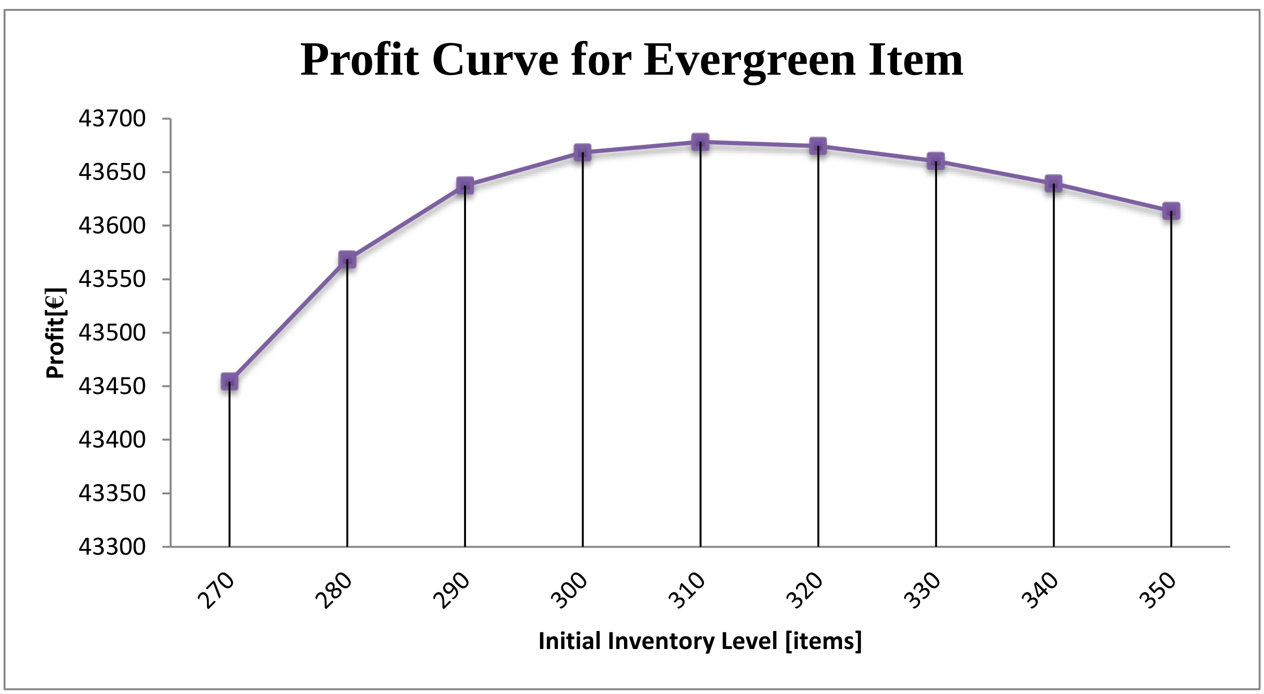
Therefore, the best thing to for the Store when having another 3 re-ordering opportunity in front, is to order an initial amount between 300 and 310. Later decisions should be taken as taken into consideration of what happened in the previous periods and by doing so a profit around 190860 Euros can be obtained.

When we consider the evergreen item for the 4-period game:

Q1	Q2	Q3	Q4	Total Q	Av Profit(€)
270	235	240	238	983	43454
280	227	240	238	986	43568
290	220	240	238	988	43637
300	211	240	238	989	43668
310	202	240	238	990	43678
320	192	240	238	991	43674
330	182	240	238	991	43660
340	173	240	238	991	43639
350	163	240	238	981	43613

Table 32: Results for Evergreen Item for 4 Period Game

For the evergreen item an amount of 310 items is chosen as initial inventory. Moreover, it is observed that the total numbers ordered during the selling season is higher than the one that is ordered for the fashionable items in a proper manner with the other games that are introduced before. The graph that belongs to 4-period game of the evergreen item is represented as below:



Graph 11: Average Profit Curve for Evergreen Item for 4 Period Game

The graph indicates a range between 300 and 310 items as the first ordering decision in order to have an average of 43670 Euros profit when closing the selling season.

When we compared the results of these two models with the 3-period game, with 4-period game we have seen that profitability of the Store has started to decline, which gives the signals of the fact that optimal number of orders might be three. However, these results will be summarized and compared all together later on. So, for the sake of the credibility, we have continued to increase the number of periods for both of the items where the results of them can be seen in following.

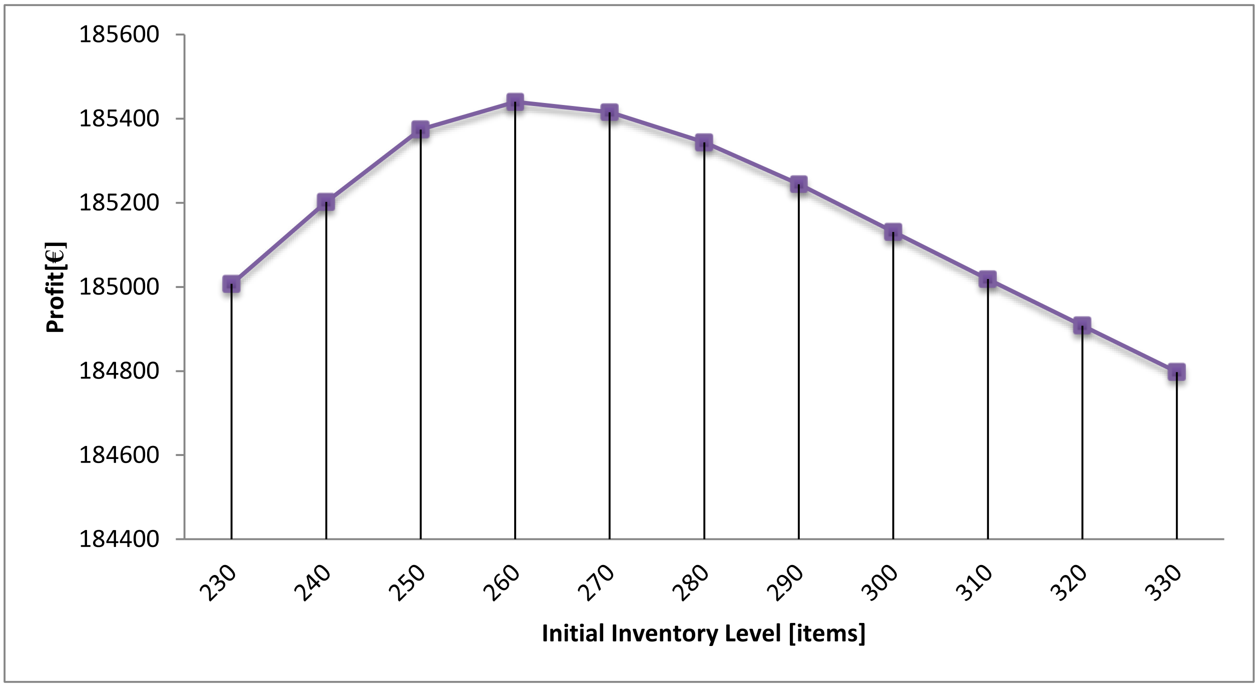
5-Period Game

When the model is composed in a way that the Store can order 5 times throughout the season, for the fashionable item, the profit is optimized with an initial inventory level (Q1) of 260 items:

Q1	Q2	Q3	Q4	Q5	Total Q	Av Profit(€)
230	154	176	178	176	915	185007
240	147	176	178	176	917	185202
250	138	176	178	176	919	185374
260	**129**	**176**	**178**	**176**	**920**	**185440**
270	120	176	178	176	921	185415
280	111	176	178	176	921	185344
290	101	176	178	176	921	185244
300	91	176	178	176	922	185131
310	82	176	178	176	922	185018
320	72	176	178	176	922	184908
330	63	176	178	176	923	184798

Table 33: Results for Fashionable Item for 5 Period Game

The graph below suggests that a Q1 value between 250 and 280 will end up with a profit higher than 1856300 Euros and from the table it can be seen that a total number of 919-921 items should be ordered in order to optimize the profit:



Graph 12: Average Profit Curve for Fashionable Item for 5 Period Game

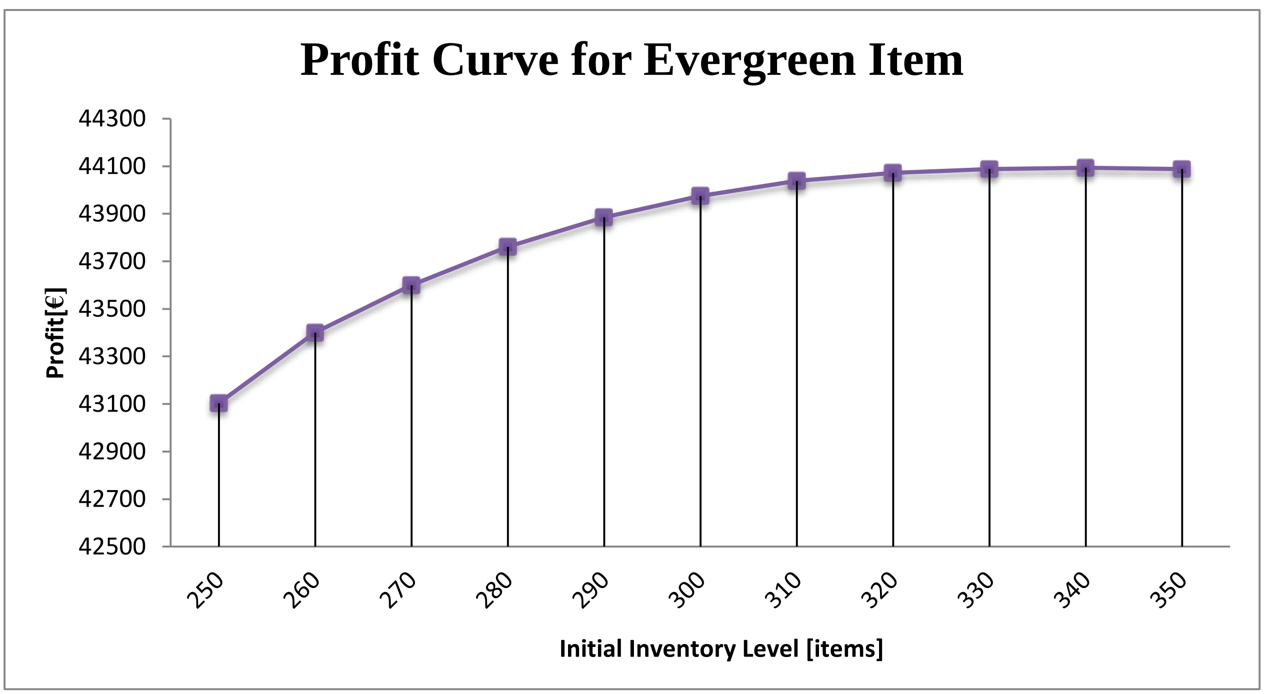
In the graph presented above, it can be seen that there is a sharp increase in the profit at the beginning and a rather slight decreasing through the end although the initial inventory levels are increased with the equal numbers. This is because, a lost sale which might occurred because of the low initial inventory level cannot be covered and it affects the profit function as an implicit cost of lost sale. Whereas, a high initial inventory level, ordered at the beginning can be covered throughout the season, since the overstock cost is charged at the end of the season and variable costs occurring arising from the carrying inventories are comparably very small to the both of the costs.

When 5-period game is introduced to evergreen item:

Q1	Q2	Q3	Q4	Q5	Total Q	Av Profit(€)
250	206	190	190	190	966	43103
260	201	190	190	190	971	43401
270	195	190	190	190	976	43599
280	189	190	190	190	979	43761
290	182	190	190	190	982	43885
300	174	190	190	190	984	43975
310	165	190	190	190	985	44038
320	156	190	190	190	986	44071
330	147	190	190	190	987	44088
340	138	190	190	190	988	44094
350	128	190	190	190	988	44088

Table 34: Results for Evergreen Item for 5 Period Game

A range between 310-350 items is preferred in order to obtain the best profit. When the graph is plotted, it can be seen that the function is at its highest values and rather flat between these two values:



Graph 13: Average Profit Curve for Evergreen Item for 5 Period Game

10-Period Game

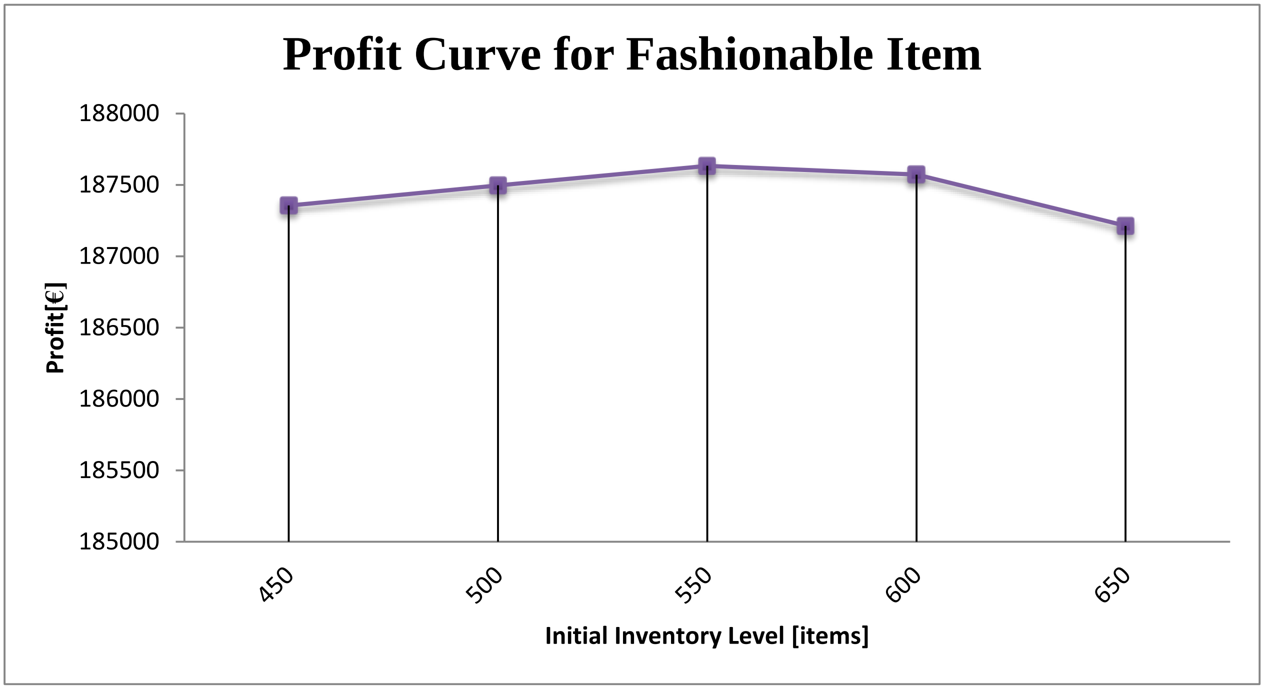
Last but not least, we also believe that representing the results of 10-period game would be interesting. In a model where the Store has to chance of ordering 10 times in a selling period, which corresponds to the possibility of placing an order every two weeks, the Store's attitude for the two different kinds of product is examined.

Starting with fashionable item, the following results are obtained:

Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Total Q	Profit(€)
450	0	0	4	43	76	82	82	84	84	905	187356
500	0	0	1	19	64	80	82	84	84	913	187496
550	0	0	0	5	43	75	82	84	84	922	187633
600	0	0	0	1	21	62	80	83	84	932	187571
650	0	0	0	0	0	0	0	0	0	940	187213

Table 35: Results for Fashionable Item for 10 Period Game

The table above provides interesting findings which are not observed in the other previous games. We see that for some of the periods, although the Store has to possibility of replenishing its inventories, it prefers not to place an order. We also see that the chosen optimal initial inventory level is quite high compared to the others which is determined as 550. After ordering a definite amount of Q1, it gives its next order at week-8 by ordering another amount of 5 units and then continues to order every 2 weeks. This result is somehow expected. As the duration of periods getting shorter, the variable cost of holding inventories throughout the period getting lower and even almost ignorable within the period. Moreover, at the beginning of the period there is no risk of overstocking, so the Store prefers the lower the risk of lost sale as much as possible and order a high number of initial inventory. Similar to other periods, it would be misleading to say 550 is the Q1 value optimizing the profit. Therefore, it can be said that and initial amount of Q1 value between 550 and 600 would provide the best possible profit.



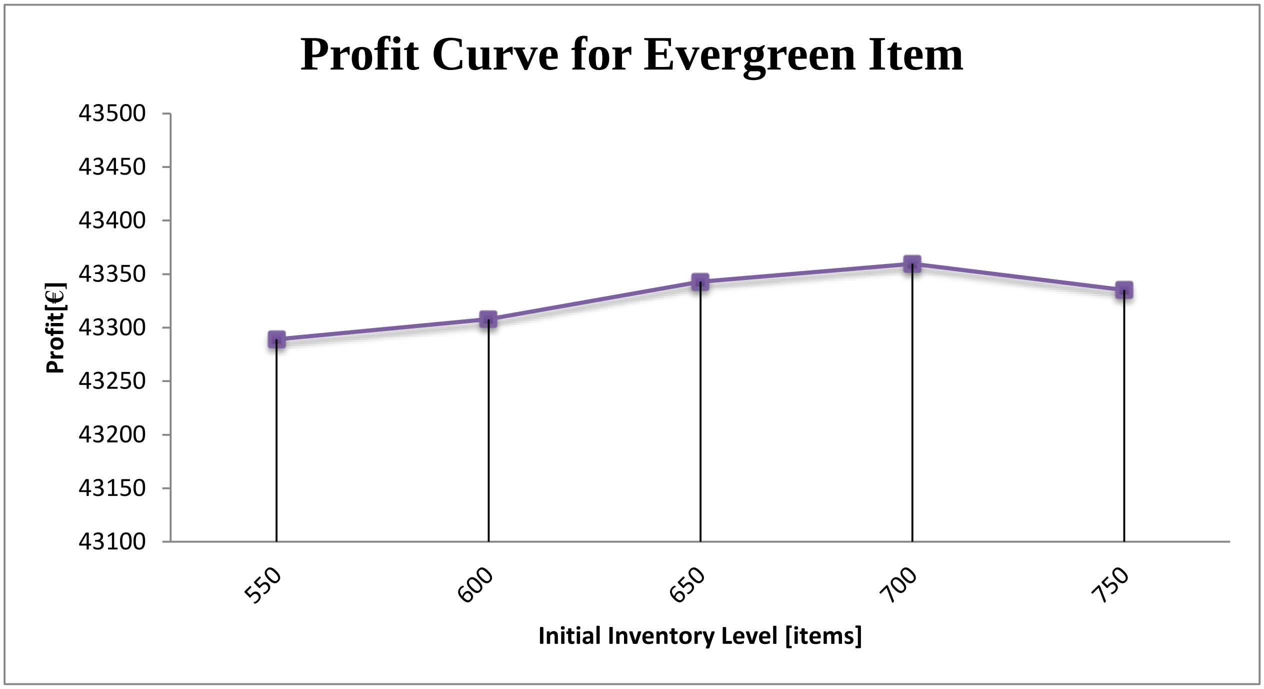
Graph 14: Average Profit Curve for Fashionable Item for 10 Period Game

Similarly for the evergreen product, 10-period game model suggests the following results:

Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Total Q	Profit(€)
550	0	0	0	8	48	82	88	88	88	952	43289
600	0	0	0	2	24	69	86	88	88	958	43307
650	0	0	0	0	9	48	81	88	88	964	43342
700	0	0	0	0	2	26	68	86	88	971	43359
750	0	0	0	0	0	0	0	0	0	977	43335

Table 36: Results for Evergreen Item for 10 Period Game

For the evergreen product the Store is even more generous for the initial inventory amount since it has a lower overstock cost. Then it prefers to replace its next order at week-10 for an amount of 2 and for the rest of the season it orders 26, 68, 86 and finally 88 items every 2 weeks. Results show that and Q1 value between 650 and 700 would provide a profit higher than 43340 Euros to the Store at the end of the season. Looking at the graph verifies this fact:



Graph 15: Average Profit Curve for Evergreen Item for 10 Period Game

All in all, as we continue to increase the number of periods, it has been observed that 4-period game provides the optimal profit for the fashionable item whereas the 5-period game has the optimal for the evergreen item. In other words, the Store prefers to replenish its fashionable item inventories 4 times and evergreen items inventories 5 times throughout a selling season in order to optimize its profit. A table about how the profit of the Store is changing with the increased number of periods will be provided in the Supply Chain Point of View Section together with the Brand Owner profitability.

5.2. Results with Respect to the Supply Chain Perspective

As it has been explained in the model composition section a table is composed which represents store, brand owner and the whole supply chain profitability for different periods.

The full table composed for the fashionable item can be seen in the Appendix A and a part of that table is given below for further explanations:

NUMBER OF PERIODS		Total Q / Profit	TOTAL NUMBER OF ITEMS ORDERED																					
			850	855	865	875	885	895	905	915	925	935	945	955	965	975	985	995	1005	1015	1025	1035	1045	1055
	1-Period	Store	0	0	0	0	0	0	0	0	0	0	131012	131392	131615	131716	131686,5	131489	131146	130666	130066	129325	128418	127366
		BO	272000	273600	276800	280000	283200	286400	289600	292800	296000	299200	302400	305600	308800	312000	315200	318400	321600	324800	328000	331200	334400	337600
		SC	272000	273600	276800	280000	283200	286400	289600	292800	296000	299200	433412	436992	440415	443716	446886,5	449889	452746	455466	458066	460525	462818	464966
	2-Period	Store	0	0	0	0	0	0	0	0	163327	166201	167277	168353	169992	169545	0	0	0	0	0	0	0	0
		BO	272000	273600	276800	280000	283200	286400	289600	292800	296000	299200	302400	305600	308800	312000	315200	318400	321600	324800	328000	331200	334400	337600
		SC	272000	273600	276800	280000	283200	286400	289600	292800	459327	465401	469677	473953	478792	481545	315200	318400	321600	324800	328000	331200	334400	337600
	3-Period	Store	0	0	0	0	0	0	0	174239	176646	178529	179806	180304	0	0	0	0	0	0	0	0	0	0
		BO	272000	273600	276800	280000	283200	286400	289600	292800	296000	299200	302400	305600	308800	312000	315200	318400	321600	324800	328000	331200	334400	337600
		SC	272000	273600	276800	280000	283200	286400	289600	467039	472646	477729	482206	485904	308800	312000	315200	318400	321600	324800	328000	331200	334400	337600
	4-Period	Store	0	0	0	0	0	0	185768	186025	187682	189740	190776	0	0	0	0	0	0	0	0	0	0	0
		BO	272000	273600	276800	280000	283200	286400	289600	292800	296000	299200	[illegible]	305600	308800	312000	315200	318400	321600	324800	328000	331200	334400	337600
		SC	272000	273600	276800	280000	283200	286400	475368	478825	483682	[illegible]	493176	305600	308800	312000	315200	318400	321600	324800	328000	331200	334400	337600
	5-Period	Store	0	0	0	0	0	185688	186067	185923	185519	0	0	0	0	0	0	0	0	0	0	0	0	0
		BO	272000	273600	276800	280000	283200	286400	289600	292800	296000	299200	302400	305600	308800	312000	315200	318400	321600	324800	328000	331200	334400	337600
		SC	272000	273600	276800	280000	283200	472088	475667	478723	481519	299200	302400	305600	308800	312000	315200	318400	321600	324800	328000	331200	334400	337600
	7-Period	Store	0	0	0	0	0	185188	185946	186228	186267	0	0	0	0	0	0	0	0	0	0	0	0	0
		BO	272000	273600	276800	280000	283200	286400	289600	292800	296000	299200	302400	305600	308800	312000	315200	318400	321600	324800	328000	331200	334400	337600
		SC	272000	273600	276800	280000	283200	471588	475546	479028	482267	299200	302400	305600	308800	312000	315200	318400	321600	324800	328000	331200	334400	337600
	10-Period	Store	0	0	0	0	185148	185824	186037	185960	185884	0	0	0	0	0	0	0	0	0	0	0	0	0
		BO	272000	273600	276800	280000	283200	286400	289600	292800	296000	299200	302400	305600	308800	312000	315200	318400	321600	324800	328000	331200	334400	337600
		SC	272000	273600	276800	280000	468348	472224	475637	478760	481884	299200	302400	305600	308800	312000	315200	318400	321600	324800	328000	331200	334400	337600

Table 37: Results with respect to the supply chain perspective for fashionable item

The table above can be interpreted as a summary of the whole work done. The first column stands for the number of the periods whereas the one next to it helps to differentiate between the profit of the Store, brand owner and the entire supply chain. The first row, on the other hand, represents the total number of fashionable items ordered throughout the season for the given the period and the player. Here the numbers represent an average rather than a single number. In other words, 850 stands for a range between the [800,900] and so as the profits are calculated as an average. The zeros that present in the Store's profitability rows are implying that given the strategy, the Store do not prefer to order in that level since those level significantly lower its profitability. As the function that is introduced for the Brand Owner's profitability requires, as the number of items ordered by the Store increases, the profit of the Store increases as well. Finally, a sum is done to calculate the supply chain's profitability for the given number of items ordered for each period's game. In the previous section, we have discussed that the Store maximize its profit while it is giving its orders 4 times in a season and the table above shows that 4-period game is also the one which maximizes the supply chain profitability with the same number of items ordered for the whole season. Before moving to a conclusion it is worth to discuss the results for the evergreen item:

NUMBER OF PERIODS	Profit \ Total Q	940	950	960	970	980	990	1000	1010	1020	1030	1040	1050	1060	1070
		TOTAL NUMBER OF ITEMS ORDERED													
1-Period	Store	0	0	0	0	34081	34184	34262	34319	34351	34357	34343	34310	34260	34194
	BO	42300	42750	43200	43650	44100	44550	45000	45450	45900	46350	46800	47250	47700	48150
	SC	42300	42750	43200	43650	78181	78734	79262	79769	80251	80707	81143	81560	81960	82344
2-Period	Store	0	0	0	0	39874	40272	40573	40251	0	0	0	0	0	0
	BO	42300	42750	43200	43650	44100	44550	45000	45450	45900	46350	46800	47250	47700	48150
	SC	42300	42750	43200	43650	83974	84822	85573	85701	45900	46350	46800	47250	47700	48150
3-Period	Store	0	0	0	40884	43668	43678	42371	0	0	0	0	0	0	0
	BO	42300	42750	43200	43650	44100	44550	45000	45450	45900	46350	46800	47250	47700	48150
	SC	42300	42750	43200	84534	87768	88228	87371	45450	45900	46350	46800	47250	47700	48150
4-Period	Store	0	0	0	42988	43569	43678	0	0	0	0	0	0	0	0
	BO	42300	42750	43200	43650	44100	44550	45000	45450	45900	46350	46800	47250	47700	48150
	SC	42300	42750	43200	86638	87669	88228	45000	45450	45900	46350	46800	47250	47700	48150
5-Period	Store	0	0	43103	43599	44094	44053	0	0	0	0	0	0	0	0
	BO	42300	42750	43200	43650	44100	44550	45000	45450	45900	46350	46800	47250	47700	48150
	SC	42300	42750	86303	87249	88194	88603	45000	45450	45900	46350	46800	47250	47700	48150
7-Period	Store	0	42482	42662	42359	41963	0	0	0	0	0	0	0	0	0
	BO	42300	42750	43200	43650	44100	44550	45000	45450	45900	46350	46800	47250	47700	48150
	SC	42300	85232	85862	86009	86063	44550	45000	45450	45900	46350	46800	47250	47700	48150
10-Period	Store	0	43308	43343	43360	43335	0	0	0	0	0	0	0	0	0
	BO	42300	42750	43200	43650	44100	44550	45000	45450	45900	46350	46800	47250	47700	48150
	SC	42300	86058	86543	87010	87435	44550	45000	45450	45900	46350	46800	47250	47700	48150

Table 38: Results with respect to the supply chain perspective for evergreen item

Similar to fashionable item, the number of periods that is optimizing the Store's profitability is also optimizing the profit of supply chain however not the Brand Owner's. At this point the policies introduced by the Brand Owner to the Store plays an important role on the decision making process. Since, at this model we haven't stated any constraint about it we can conclude that given the model conditions ordering a total amount of 990 items on average would provide a 8860 Euros of total profit, again on the average, to the players which is the best possible for the whole supply chain.

The profitability of the supply chain composed by the Store and the Brand Owner seems like it is highly dependent on the Store's profitability. Yet, looking at the current practices it can be said that the power of controlling the supply chain is still on the Brand Owner's side. The tables represented above are composed based on the free will of the Store without considering any other restrictions introduced by the Brand Owner. The Brand Owner can easily affect the optimal decision for the store, for example by introducing a minimum number ordering quantity, so as the optimal decision for the entire Supply Chain.

6. CONCLUSION

The present Master Thesis has dealt with the upfront issue of replenishment strategy analysis within the luxury fashion industry, specifically focusing on the relationship between the strategic dimensions, such as:

- Supply chain strategy
- Replenishment policies
- Luxury fashion market characteristics
- Luxury fashion product characteristics
- Link between product characteristics and replenishment policies

A conclusive approach linking the goals, the means used and the results is synthesized and proposed in Table 39:

	Key issues	What should be done	How should be done?	Results
1	Discontinuity between replenishment strategies and different product types	The impact level of replenishment strategies for different product types	Observation of products belonging to the luxury fashion category, which have different characteristics. Implementation of different replenishment strategies, the results will be compared, which will lead to the most optimal replenishment model for each type of product.	Pattern related to the product characteristics and replenishment policies was found.
2	Lack of knowledge about the Store performance when implementing different re-ordering policies	The impact of re-ordering policies on inventory levels and the performance of the Stores	Creation of different re-ordering policies, the profitability of the Store, the Brand Owner and the supply chain as a whole could show the final outcome of the best practices implemented.	The optimal replenishment strategies for all player included were defined.
3	Lack of clear guidelines for replenishment strategies improvement	The way to improve replenishment strategies, considering lead time and selling period	Considering lead time and selling period, observations on current practices, together with the simulation the possible improvements in the replenishment strategies will be implemented.	Through the vast literature review and the suggested replenishment model, the guidelines for improvement were defined.

Table 39: Conclusive approach linking the research framework and results

Replenishment strategies within the uncertain, dynamic and particular environments is a major issue both academics and executives are to address and cope with. The present Master Thesis provides a model with rigorous strategy analysis with a straightforward value for managers, as they can support the phases of strategic supply chain re-planning in order to address the changing luxury fashion market.

In the light of the previous discussion, the Master Thesis' main contributions can be synthesized as follows.

The thesis, through the literature review and the suggested replenishment model, crafts an overall reference framework for replenishment policy analysis in luxury fashion industry.

Consistently with such a reference framework, the thesis hence provides suggestions with significant and intriguing implications.

- Pattern related to the product characteristics and replenishment policies was found.

  Through a deep analysis of the products' characteristics, differentiation dimensions were defined. From here, the application of separate replenishment strategies arise, leading to the final conclusion about the system performance outcome. It was seen that the supply chain system reacts in a different manner for the two main product categories observed in this Master thesis. Moreover, looking at the fashionable items, a behavioral pattern emerged giving the suggestion that by lowering the number of replenishment throughout the selling season, the performance of the system will be optimized. On the other side of the range, the evergreen items have a contrasting behavior. In order to optimize the overall system performance, it is advised to have more replenishment options along the selling season for this product type.

- The optimal replenishment strategies for all players included were defined.

  In order to optimize the whole system, all players had to be taken into account. After having a deep analysis of the Store's role in this system, the impact of the Brand Owner and the supply chain as a whole were further investigated, leading to specific conclusions. Starting from the Store's point of view, moving to brand owner's point of view, the study led to conflicting interests, both optimizing the profit of the chosen player. However, with regard to the optimization of the system as a whole the results obtained are satisfactory for both sides.

- Through the vast literature review and the suggested replenishment model, the guidelines for improvement were defined.

The topic of the presented Master thesis provides a ground open for improvements. Through the gaps stemming from the literature review and from the suggested replenishment model a basis for further upgraded replenishment strategies is set. The thesis' findings have a significant value for the following communities:

- Academics, as the work deals with the upfront issue of strategy analysis in luxury industry and supply chain management, specifically focusing on the relationship between core strategic dimensions such as: replenishment strategies, inventory planning and control, supply chain configuration, value network configuration.
- Managers/practitioners, as the work presents a practical suggestion which can be implemented and used in luxury fashion industry. The model supports the phases of strategic analysis and re-planning of the replenishment strategies, inventory management policies and network analysis.

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7. THE WAY FORWARD

We believe that the present paper contributes to the studies on the area by not only providing some insights about the replenishment strategies of luxury fashion goods in relation with the stock-out cost/overstock cost ratios of products, but also opening new doors for further researches.

The current research and the model presented have some limitations which make it hard to apply to a real life business case. Yet, we hope that findings of this research will help to the further investigations on the field and more applicable results can be provided for the firms who are operating in the luxury fashion industry.

One of the main limitations of the research that the model developed considers replenishment of only one item at a time. A possible solution to this limitation is suggested in the previous sections but it has not been tried on this paper. Some other solutions can be found to move the model from single-item ordering to multi-item ordering or another model can be developed from the beginning by considering the replenishment of items dependently. Composing the model by assuming independent orders provided has significantly decreased the complexity that has to be handled in theory. However, we are aware of the fact that, introducing the multi-item ordering to the model would increase the applicability of it to the real life situations.

Another key assumption of the study is that it deals with zero lead time which may not be so realistic for the luxury fashion industry. However, the model can be easily adapted to the cases where the lead time presents by considering the uncertainty of the demand between the times where the order is placed and it is arrived. There are so many studies in the literature that deals with the uncertainty of demand which is created by the lead time. Some approaches from these studies are convenient to apply also the current model. In the further researches, considering the cases where the lead time also uncertain would address a very important problem that is faced in the industry. It is important being aware of the fact that there is a lead time and the lead time depends on the workload.

Another simplification done by the current study is considering the supply chain only from two players without intermediaries. As it is stated before, the assumption is valid for most of the luxury fashion industry or better to say more precisely that it is acceptable in the sense that supply chains of the luxury fashion goods are rather shorter and with less players on the distribution side with compared to the other industries such as fast moving consumer goods. However, in the future studies some intermediaries can be added which would increase the efficiency of distribution a lot and might change the attitude of stores in terms of replacing orders. Moreover, instead of considering 1 brand owner and 1 store in the model, other stores that the Brand Owner have it in its network can be included which might also need to cover a routing problem from operational research side. One step further, multi-brand stores can be taken into consideration where the products of more than one brand are sold within the same store. The current model is developed for a one brand shop however it can be applied to a multi-brand shop as well by considering the square meter reserved for each brand and the turnover gained by each of them. Yet, there are so many other factors, such as the items presented in the selling window of the Store, discounts applied, substitute items presented together etc., that increase the complexity of handling with the inventories of multi-brand shops which are supposed to be studied in detail.

In the current study two types of products are discussed namely fashionable and evergreen. In such an industry that has a wide variety of products with different characteristics, this classification may not be enough and can be extended or a different of kind can be introduced. The key factor for the classification considered by the study is the stock-out / overstock cost ratio. In the literature there are different kinds of ratios are exist as for the inventory replenishment decision tools and further models can built up on these ratios as well. Introducing them would increase the details of the study and can provide more precise solutions to the Stores and the Brand Owners.

Although the Store point of view is studied detailed on this research, the Brand Owner point of view discussed might not address all the issues that they are facing in today's industry and a little bit more attention has to be paid on that side as well in the following researches. It can be noticed that, the model developed allows to place an order even 1-item is necessary. There is no limitation on that side. However, in real life brand owners are introducing some limitations to the Stores such as minimum number of items in order to justify their shipment from the economical point of view. From this study it is also observed that, also the number of possibilities to place an order and the timing of the order can change the attitude of the Stores so as the number of items ordered. Therefore, based on this study further restrictions can be formalized for brand owners to apply on the Stores, not only to justify the cost of their shipment but also to optimize their profitability considering the favor of the whole supply chain. Talking about the Brand Owners policies, it has been also mentioned that no returning policy is considered in the study. In the luxury fashion industry, this returning policies are strictly related with the branding strategies and the lost or the gain coming from those policies and their affect on the replenishment decisions taken is another interesting area to study which would broaden the horizons of both of the player in the supply chain.

Although we think that this study takes a step towards regarding to the inventory replenishment strategies of luxury fashion goods, the issues that are pointed above and much more are still missing and require further research on the area. The challenges faced by the industry are big but so as the return of overcoming those challenges.

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APPENDIX

APPENDIX A. SUPPLY CHAIN PROFITABILITY OF THE FASHIONABLE ITEM

	Total Q / Profit	850	855	865	875	885	895	905	915	925	935	945	955	965	975	985	995	1005	1015	1025	1035	1045	1055
1-Period	Store	0	0	0	0	0	0	0	0	0	0	131012,3	131391,6	131615,4	131716,3	131686,468	131489,4	131145,9	130665,8	130066,4	129324,9	128418,4	127366
	BO	272000	273600	276800	280000	283200	286400	289600	292800	296000	299200	302400	305600	308800	312000	315200	318400	321600	324800	328000	331200	334400	337600
	SC	272000	273600	276800	280000	283200	286400	289600	292800	296000	299200	433412,3	436991,6	440415,4	443716,3	446886,468	449889,4	452745,9	455465,8	458066,4	460524,9	462818,4	464966
2-Period	Store	0	0	0	0	0	0	0	0	163327	166201	167277	168353	169992	169545	0	0	0	0	0	0	0	0
	BO	272000	273600	276800	280000	283200	286400	289600	292800	296000	299200	302400	305600	308800	312000	315200	318400	321600	324800	328000	331200	334400	337600
	SC	272000	273600	276800	280000	283200	286400	289600	292800	459327,3	465400,7	469677,1	473953,4	478791,8	481545	315200	318400	321600	324800	328000	331200	334400	337600
3-Period	Store	0	0	0	0	0	0	0	174239	176646	178529	179806	180304	0	0	0	0	0	0	0	0	0	0
	BO	272000	273600	276800	280000	283200	286400	289600	292800	296000	299200	302400	305600	308800	312000	315200	318400	321600	324800	328000	331200	334400	337600
	SC	272000	273600	276800	280000	283200	286400	289600	467038,9	472646,4	477728,9	482205,9	485903,8	308800	312000	315200	318400	321600	324800	328000	331200	334400	337600
4-Period	Store	0	0	0	0	0	0	195025	195025	187682	189740	190776	0	0	0	0	0	0	0	0	0	0	0
	BO	272000	273600	276800	280000	283200	286400	289600	292800	296000	299200	302400	305600	308800	312000	315200	318400	321600	324800	328000	331200	334400	337600
	SC	272000	273600	276800	280000	283200	286400	484625	487825	483682	488939,8	493175,7	305600	308800	312000	315200	318400	321600	324800	328000	331200	334400	337600
5-Period	Store	0	0	0	0	0	185688	186067	185923	185519	0	0	0	0	0	0	0	0	0	0	0	0	0
	BO	272000	273600	276800	280000	283200	286400	289600	292800	296000	299200	302400	305600	308800	312000	315200	318400	321600	324800	328000	331200	334400	337600
	SC	272000	273600	276800	280000	283200	472088,3	475666,7	478722,6	481518,5	299200	302400	305600	308800	312000	315200	318400	321600	324800	328000	331200	334400	337600
7-Period	Store	0	0	0	0	0	185188	185945,9	186227,8	186266,8	0	0	0	0	0	0	0	0	0	0	0	0	0
	BO	272000	273600	276800	280000	283200	286400	289600	292800	296000	299200	302400	305600	308800	312000	315200	318400	321600	324800	328000	331200	334400	337600
	SC	272000	273600	276800	280000	283200	471588	475545,9	479027,8	482266,8	299200	302400	305600	308800	312000	315200	318400	321600	324800	328000	331200	334400	337600
10-Period	Store	0	0	0	0	185148	185824,1	186036,5	185960,1	185883,8	0	0	0	0	0	0	0	0	0	0	0	0	0
	BO	272000	273600	276800	280000	283200	286400	289600	292800	296000	299200	302400	305600	308800	312000	315200	318400	321600	324800	328000	331200	334400	337600
	SC	272000	273600	276800	280000	468348	472224,1	475636,5	478760,1	481883,8	299200	302400	305600	308800	312000	315200	318400	321600	324800	328000	331200	334400	337600

APPENDIX B. SUPPLY CHAIN PROFITABILITY OF THE EVERGREEN ITE

	Total Q / Profit	940	950	960	970	980	990	1000	1010	1020	1030	1040	1050	1060	1070	1080	1090	1100
1-Period	Store	0	0	0	0	34081	34184	34262	34319	34351	34357	34343	34310	34260	34194	34115	34022	33914
	BO	42300	42750	43200	43650	44100	44550	45000	45450	45900	46350	46800	47250	47700	48150	48600	49050	49500
	SC	42300	42750	43200	43650	78181	78734	79262	79769	80251	80707	81143	81560	81960	82344	82715	83072	83414
2-Period	Store	0	0	0	0	39874	40272	40573	40251	0	0	0	0	0	0	0	0	0
	BO	42300	42750	43200	43650	44100	44550	45000	45450	45900	46350	46800	47250	47700	48150	48600	49050	49500
	SC	42300	42750	43200	43650	83974	84822	85573	85701	45900	46350	46800	47250	47700	48150	48600	49050	49500
3-Period	Store	0	0	0	40884	43668	43678	42371	0	0	0	0	0	0	0	0	0	0
	BO	42300	42750	43200	43650	44100	44550	45000	45450	45900	46350	46800	47250	47700	48150	48600	49050	49500
	SC	42300	42750	43200	84534	87768	88228	87371	45450	45900	46350	46800	47250	47700	48150	48600	49050	49500
4-Period	Store	0	0	0	42988	43569	43678	0	0	0	0	0	0	0	0	0	0	0
	BO	42300	42750	43200	43650	44100	44550	45000	45450	45900	46350	46800	47250	47700	48150	48600	49050	49500
	SC	42300	42750	43200	86638	87669	88228	45000	45450	45900	46350	46800	47250	47700	48150	48600	49050	49500
5-Period	Store	0	0	43103	43599	44094	44053	0	0	0	0	0	0	0	0	0	0	0
	BO	42300	42750	43200	43650	44100	44550	45000	45450	45900	46350	46800	47250	47700	48150	48600	49050	49500
	SC	42300	42750	86303	87249	88194	88603	45000	45450	45900	46350	46800	47250	47700	48150	48600	49050	49500
7-Period	Store	0	42482	42662	42359	41963	0	0	0	0	0	0	0	0	0	0	0	0
	BO	42300	42750	43200	43650	44100	44550	45000	45450	45900	46350	46800	47250	47700	48150	48600	49050	49500
	SC	42300	85232	85862	86009	86063	44550	45000	45450	45900	46350	46800	47250	47700	48150	48600	49050	49500
10-Period	Store	0	43308	43343	43360	43335	0	0	0	0	0	0	0	0	0	0	0	0
	BO	42300	42750	43200	43650	44100	44550	45000	45450	45900	46350	46800	47250	47700	48150	48600	49050	49500
	SC	42300	86058	86543	87010	87435	44550	45000	45450	45900	46350	46800	47250	47700	48150	48600	49050	49500