Benefit assessment for innovative models of Inventory Financing

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Here’s to the crazy ones.

The misfits. The rebels. The troublemakers. The round pegs in the square holes.

The ones who see things differently.

They’re not fond of rules. And they have no respect for the status quo.

You can quote them, disagree with them, glorify or vilify them.

About the only thing you can’t do is ignore them.

Because they change things. They push the human race forward.

And while some may see them as the crazy ones, we see genius.

Because the people who are crazy enough to think they can change the world, are the ones who do.

Apple “Think different” ad, 1997
Acknowledgments

From Alessandro and Pietro

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Thank you.

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Abstract

In the last years the economic and financial scenario pictured a situation where Small-Medium Enterprises (SMEs) are the most damaged because they often need liquidity, but financial institutes face several difficulties granting them funds due to their low creditworthiness. Thus, since SMEs are the weakest companies in a supply chain, they are also the riskiest one, facing constantly the risk of bankruptcy. In this context, several Supply Chain Finance (SCF) solutions have been developed, among which Inventory Financing (IF). IF is a type of asset based lending, namely a short-term loan granted to a company whose inventory serves as collateral for the financial provider; then, if the business can not repay the loan, the financial provider will become the owner of the collateral.

The academic literature has addressed the IF topic often just with a qualitative approach such as researches and theoretical models that explain the typical processes and benefits tied up with this SCF approach.

The main objective of the work is to evaluate the benefits of two Innovative Inventory Financing solutions (IIFs), namely Control Mode (CM) and Delegation Mode (DM), through a mathematical model that explains the processes occurred in a supply chain after the adoption of one of these IF solutions.

The model provides different insights on the optimal conditions under which CM and DM work better and the scenarios where they do not perform well. Furthermore, the model investigates and assesses the benefit of a supply chain combining an IIFS with a specific inventory reorder policy.
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List of Acronyms

List of abbreviations used in this work.

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<td>SC</td>
<td>Supply Chain</td>
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<td>SCM</td>
<td>Supply Chain Management</td>
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<td>SCF</td>
<td>Supply Chain Finance</td>
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<td>CCC</td>
<td>Cash Conversion Cycle</td>
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<td>SME</td>
<td>Small Medium Enterprise</td>
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<td>IF</td>
<td>Inventory Financing</td>
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<td>3PL</td>
<td>Third Party Logistics</td>
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<tr>
<td>LSP</td>
<td>Logistic Service Provider</td>
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<td>ILFS</td>
<td>Integrated Logistics and Financing Service</td>
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<td>IIFS</td>
<td>Innovative Inventory Financing Solution</td>
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<td>TM</td>
<td>Traditional Mode</td>
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<td>DM</td>
<td>Delegation Mode</td>
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<td>CM</td>
<td>Control Mode</td>
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<td>PMI</td>
<td>Piccola Media Impresa</td>
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EXECUTIVE SUMMARY

Introduction
The current financial and economic situation is making increasingly necessary the development of new financing solutions in order to help the most critical actors of the supply chains; indeed, strict regulations combined with a strong general distrust still prevent SMEs from proper financing services. Thus, SMEs are not only the weakest companies in a supply chain but they are also the riskiest ones, facing constantly a high risk of bankruptcy. In this context, several Supply Chain Finance solutions have been developed, among which Inventory Financing (IF). IF is a type of asset based lending, i.e. a short-term loan granted to a company whose inventory serves as collateral for the financial provider; then, if the business can not repay the loan, the financial provider will become the owner of the collateral. The purpose of this thesis is to evaluate the benefits of Innovative Inventory Financing solutions (IIFSs). We are going to compare the benefits of two approaches of IIFS, that we will name respectively Delegation Mode (DM) and Control Mode (CM), according to the terminology adopted by Chen and Cai (2011). More in details, the benchmark, used to assess the benefits of the DM and CM, is represented by a traditional IF solution that we name Traditional Mode (TM). Furthermore, we assess the benefits of a combination between an IIFS and a specific inventory reorder policy (adopted by the same actor who is implementing the IIFS). In particular, we will consider two policies concerning a continuous inventory control logic (Two-Bin and Min-Max) and two concerning a periodic one (Base-Stock and Hybrid).

Concluding, we base the model on a supply chain made up of one supplier, one Third Party Logistics (3PL), one financial provider and one retailer; specifically, the latter is the critical actor due to its budget constraints.

Objects
The objectives of our research can be summarized in three Research Questions (RQ).

RQ1. How much does the supply chain benefit if the budget-constrained company implements an innovative Inventory Financing solution combined with a specific inventory policy?
Thanks to our quantitative benefits assessment model, we can compare the IIFSs with a traditional IF solution basing on the whole supply chain profit gained thereafter the budget constrained player has simultaneously implemented a specific IF solution and an inventory reorder policy. Moreover, thanks to the sensitivity analysis, we can figure out how the different supply chain profits change if the variability of the demand grows.

RQ 2. When does the Delegation Mode generate similar or even better benefits than the Control Mode?

According to Chen and Hu (2011), the Delegation model is an innovative solution of IF but not so innovative as the Control model, thus they present the latter as a better and more profitable IF solution than the former. In this thesis, we deeply study and analyze both the solutions just mentioned above through the development of, respectively, our Delegation Mode and Control Mode. Implementing the model, we are able to investigate and discover whether exist some potential context where the DM could equal, or even overcome, the CM. In other words, we provide to the current literature a quantitative tool that allows the user to figure out which is the best IIFS, given specific initial conditions and the inventory reorder policy adopted by the budget constrained firm.

RQ 3. Does a specific inventory reorder policy, if combined with an Innovative Inventory Financing solution, affect the entire supply chain profit?

We reply to this question analyzing the benefits obtained after the implementation of four different inventory reorder policies by the budget constrained player. Thus, we compute the supply chain profit gained through a specific combination between an IIFS and one of the inventory reorder policies implemented. Moreover, by means of the sensitivity analysis, we are going to study how the results change if the variability of the demand varies.

**Literature Review**

Since the topic of IF is quite recent, we have investigated many different sources. The most significant basis of the literature consists of academic papers and journal articles (57% of the total). Then we investigated specialized conferences reports (15% of the total) and manuals (13% of the total). These references provide the operational processes and some qualitative and quantitative benefits evaluation of IF solutions already present in literature. The remaining part is made of different sources (15% of the total) such as master graduation theses and case studies stemming from websites.
To conclude, the expert advices of Prof. Xiangfeng Chen (Fudan University) have played a crucial role in our work. More in details, he has supported us on all the researches and on the model development, especially concerning assumptions and formulas definition.

**Methodology**

The methodology of this work is split in two main processes: one concerning the model development (orange frame in the Figure 0.1) and another concerning the model application (purple frame in the Figure 0.1).

The first one starts with the analysis of the literature that has already provided theoretical models of IF. Concerning the different inventory reorder policies, they have already been strongly accomplished and used in real work situations, so we direct implement them due to their high reliability. Then, once all the information and ideas are collected, we develop the model through two main passages: the model development and the benefits assessment. The former concerns the framework of the model, including all parameters definitions, formula computations and processes advancement. The latter establishes the benefits achieved by each player and by the whole supply chain thereafter the implementation of an IIFS combined with a specific inventory reorder policy. The second process starts with the analysis of case studies, reports and academic documents in order to obtain real data needed for the practical application of the model. In this way, we are able to carry out a quantitative comparison between the different IF solutions. However, even if the application has been made using real data, the model is based on assumptions which make the results even an

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**Figure 0.1 - Model methodology**

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approximation of the reality. Thus, in order to understand the robustness of the pursued results, we decided to deepen the research through a sensitivity analysis which allow us to figure out under which conditions each IF solution performs better results.

**Model Description**

We have created a quantitative benefits assessment model which allow the user to compute the profit of the whole supply chain thereafter the implementation of an IF solution under a specific inventory reorder policy. More in details, the model is based on analytical formulas, so it mathematically proves how different IF solutions, combined with specific inventory policies, can affect the profit of each involved actor and as consequence the profit of the entire supply chain. The model encloses the development of three different typologies of IF solutions, one represents a traditional solution (Traditional Mode) whereas the other two can be categorized as innovative ones, respectively Delegation Mode and Control Mode.

Concluding, in all the previous solutions of IF we always consider the retailer as the budget-constrained company of the supply chain, thus the model is based on its own perspective.

**Traditional Mode**

The retailer’s purchase orders, being it a capital constrained firm, may be limited. Thus, it will try to borrow funds, through an IF solution. In this situation, the bank may grant a loan to the borrower (retailer) evaluating its credit risk based both on its initial capital and on the value of its inventory used as collateral. The 3PL carries out just traditional logistics services because its only one task is to transport the ordered good from the supplier to the retailer; thus, concerning the financing topic, the 3PL covers a complete passive role in this model. The main problem of this situation is that the bank has not possibility to screen the information about the retailer’s initial capital, so the latter can falsify it in order to obtain a lower interest, thus increasing its profit. Moreover, the bank is not able to carefully monitor the collateral due to the low level of visibility on retailer’s internal processes. High information asymmetry and low visibility between lender and borrower are the main limiting factor of the TM. Indeed, banks might refuse to grant loans under these conditions. This is also the main reason why, most of times, SMEs are not able to borrow loans from financial institutions.

We have easily modeled the TM always assuming the bank does not grant the loan to the SME (retailer), so we can consider the situation as a no-financing one.
**Delegation Mode**

This solution is designed to solve the kind of issue present in the TM; in particular, the Delegation Mode reduces significantly the high asymmetric information level and at the same time improves the visibility on the collateral between the financial provider and borrowing firm. In the DM, the 3PL assumes an important role because it helps the bank by sharing borrower’s real information and by tracking the collateral of the loan (e.g. inventory). After having assumed the retailer’s CCC turns negative thanks to the implementation of DM, we modeled this solution as in the Figure 0.2.

At the beginning, the retailer defines the amount of products to order with the purpose to satisfy the market demand [step 1.a]. The trigger point of the DM is when the retailer becomes aware that it has not enough funds to place the order, so it asks an Inventory Financing request to the bank. The retailer sends part of its inventory of Product_X (which represents the goods available to be pledged) to the 3PL’s warehouse [step 1.b]. After having received the goods, the 3PL starts to analyze and check the collateral conditions, then it shares all the information about the collateral with the bank [step 1.c]. Now, the bank is going to pay in advance the 3PL, on behalf of the retailer, the total cost of the services (e.g. collateral holding and monitoring) that it provides [step 1.d]. In the same period, the bank grants the loan to the retailer [step 1.e], which now has enough funds to place the order and specially to carry out the payment of $W\%$ of the order value to the supplier [step 1.f]. At $t=r$, the 3PL delivers the goods to the retailer [step 2.a] who starts to sell them to its customers [step 2.b] getting immediately the $Y\%$ of the sales value [step 2.c]. At $t=j$ the retailer gets the remaining $1-Y\%$ [step 3.a] of the total revenue and in $t=h$ (in this case we suppose $h=j$) it pays the remaining part $(1-W$
%) of the order value placed at \( t=0 \) [step 3.b]. Concluding, in \( t=g \) the retailer has to payback the whole debt to the bank [step 4.a] and, just when this payment will be completed, the bank authorizes the 3PL to give the pledged goods back to the retailer [step 4.b].

With DM solution, it is possible solve the difficulty of the SME financing and decrease the bank’s risk at the same time. However, also in this solution, an important issue continues to persist: the retailer may divert funds in loans to a higher risk project, leaving the bank with a higher risk. As consequence, the latter would be unwilling to offer loans if it has not any chance to monitor the borrower’s real procurement behaviors.

**Control Mode**

In this solution of IF the 3PL provides not only logistics but also financing services. When the retailer has insufficient capital, the 3PL procures the products from the supplier through trade credit financing and then transports them to the retailer. The innovative feature of the CM is that financial provider (that now it is a logistic operator) offers trade credit and no longer a loan; in this way it also has total visibility on the retailer’s procurement behaviors, so the latter cannot divert funds in other high risk projects. Moreover, all the goods financed by trade credit must be moved just inside the logistics network of the 3PL. Acting as a conductor of all flows, the 3PL is able to solve all the problems present both in the previous solutions. Now the retailer has to declare sincerely all the information requested and in addition it has no longer the possibility to divert the capital loans to other riskier project because the lending fund goes directly from the 3PL to the supplier. Also here we assume the retailer’s CCC turns negative after the implementation of CM and we modeled this situation as in the Figure 0.3.

At the beginning, as in the DM, the retailer defines how many products ordering with the purpose to satisfy the market demand [step 1.a]; the trigger point of the CM is when the retailer becomes aware that it is

![Figure 0.3 - Control Mode process]
not able to place the order due to its lack in funds, so it asks an Inventory Financing request no longer to a bank but to a Logistic Operator which also offers financing services. Precondition to make the CM solution possible, is a multi-party agreement among all the players. After this, the next passage [step 1.b] is the retailer’s order placement whose value is partially paid (Q%) immediately by the financial provider via trade credit line [step 1.c]. After having received the first part of the payment, the supplier sends the goods that will be received by the retailer at t=r (it’s crucial to highlight that this shipping is moved and handled just by the 3PL-Bank in its own transportation network) [step 2.a]. Once the goods are received by the retailer, it starts selling them [step 2.b] to its customers who pay immediately the Y% of the total sale value [step 2.c]. At t=j, the retailer gains the remaining 1-Y% of the the total revenue [step 3.a] and in t=h (also in this case we suppose h=j) pays the supplier the remaining part (1-Q%) of the order value placed at t=0 [step 3.b]. To conclude, at t=g, the 3PL-Bank has to receive back the total value of the credit line increased by an interest rate [step 4.a].

**Results**

In order to test the reliability and accuracy, we performed an application by feeding the model with real data obtained from case studies, reports and academic documents. Furthermore, with the purpose of figuring out how the results change if the external scenario becomes different, we carried out a sensitivity analysis varying the values of three parameters: the standard deviation of the market demand, interest rate applied by the financial providers to the retailer and inventory level of Product_X available to be pledged (respectively \( \sigma \), \( i \) and \( Inventory(X)_{3\, months} \)). In particular, the sensitivity analysis has been developed on three levels, where each of them represents a different combination of the previous parameters (see Figure 0.4).

The first level immediately reveals that the "profit gap" between innovative and traditional IF solutions increases if the variability of the demand grows. For “profit gap” we mean the
difference between the supply chain profits obtained by the application of an IIFS and a traditional one. In this way we are able to reply the first research question. Thanks to this level, we can also investigate and find a possible answer to the third research question. Specifically, varying the demand uncertainty level, we have studied how a specific inventory policy can affect the supply chain profit obtained after the application of an IIFS (DM or CM). Therefore, depending on which IIFS is adopted by the retailer, different results emerge (see Figure 0.5).

![Inventory Policies](image)

**Figure 0.5 - Benefits trends of IIFSs according to different inventory policies**

Under the Control Mode, when the demand standard deviation is low, Hybrid and Base-Stock systems perform better results because they allow the budget-constrained firm to reduce its management inventory costs, thus saving fund usable to issue the next order bigger. On the other hand, when the demand standard deviation takes on a medium-high level, the previous policies are not able anymore to face such demand, indeed the stock out costs overpass the potential savings of a periodic inventory control logic. Thus, Two-Bin and Min-Max systems, thanks to their continuous inventory control logic, become the best solutions which can ensure a greater profit for the whole supply chain. Specifically, the Min-Max system is better since it is still more flexible and dynamic than the Two-Bin one. Concerning the Delegation Mode situation, the best inventory policies result to be always the ones with a continuous inventory control logic (Two-Bin and Min-Max systems). The systems with a periodic inventory control logic, independently of the demand standard deviation level, generate always lower profits than Two-Bin and Min-Max policies. More in details, the Two-Bin system ensures better results when the level of demand standard deviation is low (\(\sigma < 20\)), then the Min-Max system starts offering a higher supply chain profit. With the purpose to answer to the second research question, we change our analysis
perspective focusing on the comparison between the CM and DM, both always considered under the same inventory control logic. In order to express this comparison, we adopt the variable $\lambda_{Inv\ Policy}$ which is estimated as follows:

$$\lambda_{Inv\ Policy} = \text{SC \ PROFIT}^{\text{Control\ Mode}}_{Inv\ Policy} - \text{SC \ PROFIT}^{\text{Delegation\ Mode}}_{Inv\ Policy}$$

In particular, in order to make the result as clear and direct as possible, we consider the difference between CM and DM, not for each inventory policy, but for each inventory control logic. Thus, we define the variables $\lambda_{\text{Continuous}}$ and $\lambda_{\text{Periodic}}$ as follows:

$$\lambda_{\text{Continuous}} = \frac{\lambda_{\text{TwoBin}} + \lambda_{\text{MinMax}}}{2}, \quad \lambda_{\text{Periodic}} = \frac{\lambda_{\text{BaseStock}} + \lambda_{\text{Hybrid}}}{2}$$

Remaining in the first level of the analysis, we study how $\lambda_{\text{Continuous}}$ and $\lambda_{\text{Periodic}}$ behave, discovering that the difference between CM and DM under a continuous review logic increases when the variability of demand gets higher; instead under a periodic inventory control logic, $\lambda_{\text{Periodic}}$ follows the opposite trend, this because when the demand is highly variable the losses due to adopting a “wrong” logic to reorder the inventories (i.e. a periodic inventory control logic under a high demand uncertainty) are so high to almost nullify the benefits of a CM solution (see Figure 0.6).

![Figure 0.6 - $\lambda_{\text{Continuous}}$ and $\lambda_{\text{Periodic}}$ trends under different values of $\sigma$](image)

Moving to the second level of the analysis, we find out a relation between $\text{inventory}(X)_{3\ months}$ and the variables $\lambda_{\text{Continuous}}$ and $\lambda_{\text{Periodic}}$ (see Figure 0.7). Specifically, when the first one assumes a low value, the difference between CM and DM gets very high in both the inventory control logics. This behavior makes sense because the DM, when the retailer has a very few amount of Product_X available to be pledged,
becomes very similar to the Traditional Mode (where the retailer cannot pledge anything due to none IF solution is underway), hence the difference with a Control Mode is huge. Increasing the value of inventory(𝑋)3 months the difference between CM and DM decreases significantly, making the benefits of the two solutions very similar. Moreover, if we continue increasing the amount of Product_X, both the value of \( \lambda_{\text{Continuous}} \) and \( \lambda_{\text{Periodic}} \) slowly start to increase. We justify the last statement because now the Product_X can no longer be considered anymore as secondary product (this because we assumed the Product_X quantity proportional to its future demand).

Concluding, the third level of the analysis reveals that increasing the interest rate, also the difference between CM and DM proportionally increases in both the inventory control logics (see Figure 0.8). This because, in the DM, the bank applies the interest rate on the loan value plus other costs (e.g. collateral management cost), whereas in the CM, the 3PL-Bank applies the interest rate just on the value of the trade credit granted to the retailer. Thus, receiving the same amount of funding, in the CM the retailer pays a lower interest.
SOMMARIO

Introduzione

L’attuale situazione economica sta rendendo sempre più necessario lo sviluppo di nuove soluzioni di finanziamento che possano aiutare gli attori più deboli delle supply chain; infatti, regole severe, combinate con una forte sfiducia generale, impediscono ancora oggi alle PMI di ricevere finanziamenti adeguati. Quindi, quest’ultime non sono solo le aziende più deboli, ma anche le più rischiose, in quanto devono costantemente fronteggiare un elevato rischio di fallimento. In questo contesto, sono state sviluppate diverse soluzioni di Supply Chain Finance, tra le quali è presente l’Inventory Financing (IF). Quest’ultima è un tipo di prestito asset-based, cioè un prestito a breve termine concesso ad una società le cui scorte servono come garanzia per il provider finanziario; quindi, se l’azienda non potrà rimborsare il prestito, il provider finanziario diventerà il proprietario delle scorte.

Lo scopo di questa tesi è quello di valutare i benefici delle Soluzioni Innovative di Inventory Financing (IIFS). Più in dettaglio, confrontiamo i vantaggi di due IIFS, che chiameremo rispettivamente Delegation Mode (DM) e Control Mode (CM), ispirandoci alla terminologia adottata da Chen e Cai (2011). In particolare, il benchmark di riferimento, usato per la valutazione dei benefici del DM e del CM, è rappresentato da una soluzione tradizionale di IF che chiameremo Traditional Mode (TM).

Inoltre, valutiamo i vantaggi di una combinazione tra una specifica politica di riordino delle scorte (adottata dallo stesso attore che sta attuando la IIFS) e una IIFS. In particolare, prenderemo in considerazione due politiche di riordino riguardanti una logica continua di controllo del magazzino (“Two-Bin” e “Min-Max”) e due per quanto riguarda una logica periodica di controllo del magazzino (“Base-Stock” e “Hybrid”).

Infine, basiamo il nostro modello su una supply chain costituita da un fornitore, un operatore logistico (3PL), un provider finanziario ed un retailer; in particolare, quest’ultimo è l’attore critico in quanto dispone di una liquidità limitata (budget-constrained retailer).

Obiettivi

Gli obiettivi della nostra tesi possono essere sintetizzati sotto forma di tre Domande di Ricerca (DR).
DR1. Quanto una supply chain può beneficiare dall’implementazione, da parte dell’azienda budget-constrained, di una IIFS combinata con una specifica politica di riordino delle scorte?

Grazie al nostro modello di valutazione quantitativa dei benefici, possiamo confrontare le IIFS con una soluzione tradizionale di IF, guardando il profitto globale della supply chain generato dopo che l’azienda budget-constrained implementa contemporaneamente una specifica IIFS e una specifica politica di riordino delle scorte. Inoltre, grazie all’analisi di sensitività, siamo in grado di capire come i differenti profitti della supply chain cambino all’aumentare della variabilità della domanda.

RQ 2. Quando il Delegation Mode genera benefici simili o addirittura migliori rispetto al Control Mode?

In accordo con Chen e Hu (2011), il Delegation model è una soluzione innovativa, ma non così innovativa come il Control model; pertanto essi presentano quest’ultima come una migliore e più profittevole soluzione di IF rispetto alla soluzione Delegation model. In questa tesi studiamo e analizziamo attentamente entrambe le soluzioni sopra menzionate attraverso lo sviluppo di, rispettivamente, il Delegation Mode e del Control Mode. Implementando il modello siamo in grado di investigare ed individuare se esiste un potenziale contesto dove il DM eguaglia, o addirittura supera, i benefici del CM. In altre parole, forniamo alla letteratura corrente uno strumento quantitativo che permetta all’utente di capire quale sia la migliore IIFS, date le specifiche condizioni iniziali e la politica di riordino delle scorte adottata dall’azienda budget-constrained.

RQ 3. Una specifica politica di riordino delle scorte, se combinata con una IIFS, influenza il profitto dell’intera supply chain?

Rispondiamo a questa domanda analizzando i benefici ottenuti dopo l’adozione di quattro diverse politiche di riordino delle scorte da parte dell’azienda budget-constrained. Quindi, calcoliamo il profitto della supply chain ottenuto in seguito all’implementazione di una specifica combinazione tra una IIFS e una delle quattro politiche di riordino delle scorte adottate. Quindi, per mezzo dell’analisi di sensitività, studiamo come i precedenti risultati cambiano al variare dell’incertezza della domanda.

Analisi della letteratura

Dal momento che la tematica dell’IF è abbastanza recente, abbiamo indagato diverse tipologie di fonti. La base più significativa dell’analisi della letteratura consiste in
pubblicazioni accademiche e articoli scientifici (57% del totale). Inoltre abbiamo considerato reports di conferenze specialistiche (15% del totale) e manuali (13% del totale). Questi riferimenti ci hanno fornito i processi operativi e alcune valutazioni qualitative e quantitative già presenti in letteratura. La restante parte è costituita da altre fonti (15% del totale) che sono principalmente tesi di laurea e casi di studio provenienti da siti web.
Per concludere, i consigli del Prof. Xianfeng Chen (Fudan University) hanno ricoperto un ruolo importante nel nostro lavoro. In particolare, egli ci ha supportato lungo tutte le ricerche e lo sviluppo del modello, soprattutto per quanto riguarda la definizione delle assunzioni e delle formule su cui esso è basato.

**Metodologia**

La metodologia di questo lavoro è suddivisa in due processi principali: uno relativo allo sviluppo del modello (riquadro arancio della Figura 0.1) e un altro che riguarda l'applicazione del modello (riquadro viola della Figura 0.1).

Il primo processo parte con l'analisi della letteratura che fornisce i modelli teorici di IF. Per quanto riguarda le diverse politiche di riordino delle scorte, esse risultano già fortemente affermate e usate nella realtà lavorativa, pertanto sono state direttamente implementate nel modello grazie alla loro elevata credibilità. In seguito, si arriva al cuore del processo che è rappresentato da due passaggi principali: lo sviluppo del modello e la valutazione dei benefici. Il primo passaggio riguarda la struttura del modello, cioè tutte le definizioni dei parametri, delle formule e dei processi di avanzamento. Il secondo passaggio determina i benefici ottenuti da ogni attore e da tutta la supply chain in seguito all'attuazione di una IIFS combinata con una specifica politica di riordino delle scorte.

**Figura 0.4 - Metodologia del modello**
Il secondo processo parte con l’analisi di casi di studio, reports e documenti accademici, con lo scopo di ottenere dati reali necessari per l’applicazione pratica del modello. In questo modo, siamo in grado di effettuare una comparazione quantitativa tra differenti soluzioni di IF. Tuttavia, anche se l’applicazione viene eseguita con dati reali, il modello è basato su assunzioni, le quali rendono i risultati ancora un’approssimazione della realtà. Quindi, con l’obiettivo di capire la robustezza dei risultati perseguiti, abbiamo deciso di approfondire la ricerca effettuando un’analisi di sensibilità che ci permetta di valutare sotto quali condizioni ogni soluzione di IF ottiene i migliori risultati.

**Descrizione del Modello**

Abbiamo creato un modello quantitativo di stima dei benefici che permetta all’utente di valutare il profitto di ogni singolo attore e dell’intera supply chain in seguito all’implementazione simultanea di una soluzione di IF e di una specifica politica di riordino delle scorte. In particolare, essendo basato su formule analitiche, il modello effettua una valutazione matematica di come differenti soluzioni di IF, combinate con determinate politiche di gestione del magazzino, agiscono sul profitto di ogni singolo attore della supply chain e di conseguenza anche sul profitto della supply chain stessa. Il modello racchiude al suo interno lo sviluppo di tre differenti soluzioni di IF: una rappresenta una soluzione tradizionale (Traditional Mode), invece le restanti due descrivono soluzioni innovative di IF, rispettivamente il Delegation Mode e il Control Mode.

Infine, in tutte e tre le diverse situazioni, il retailer viene considerato come l’attore critico che implementa la soluzione di IF, pertanto il modello è strutturato sul suo punto di vista.

**Traditional Mode**

Gli ordini di acquisto del retailer, a causa dei suoi problemi di liquidità, potrebbero subire forti limitazioni. Per evitare che questo accada, esso cercherà di ottenere finanziamenti tramite l’implementazione di una soluzione di IF. In una tale situazione, la banca prima di concedere il prestito valuta il livello di rischiosità del retailer analizzando sia il suo capitale iniziale sia il valore della merce impegnata come collaterale. L’operatore logistico svolge solo la funzione di trasporto della merce; pertanto esso ha un ruolo completamente passivo per quanto riguarda i finanziamenti che avvengono nella supply chain.

XXVII
Il problema principale di questa situazione è che la banca non ha alcuna visibilità sulle informazioni inerenti al capitale del retailer, pertanto quest’ultimo potrebbe modificare le sue informazioni ottenendo un tasso di interesse inferiore ed aumentando così i suoi profitti. Inoltre la banca non è in grado di mantenere costantemente monitorato il collaterale a causa della poca visibilità concessa dal retailer sui suoi processi interni. Alta asimmetria informativa e bassa visibilità tra la parte che concede il prestito e quella che lo riceve sono il limite principale del TM. Infatti le banche potrebbero rifiutarsi di concedere prestiti in queste circostanze. Questo fattore è spesso la principale causa per cui le PMI non sono in grado di accedere a prestiti offerti da istituti finanziari.

Abbiamo semplificato la modellizzazione del TM assumendo sempre che la banca non conceda alcun prestito alla PMI (retailer), pertanto è come se fosse una una situazione in cui non è presente alcun tipo di finanziamento.

**Delegation Mode**

Questa soluzione è stata sviluppata con lo scopo di sanare le problematiche presenti in una situazione tradizionale di IF. In particolare, il DM riduce significativamente l’alta asimmetria informativa e, allo stesso tempo, migliora la visibilità sul collaterale tra la parte concedente il prestito e quella destinata a riceverlo. Nel DM l’operatore logistico comincia a ricoprire un ruolo importante all’interno della supply chain in quanto condivide con la banca informazioni attendibili sul retailer ed inoltre svolge l’attività di monitoraggio del collaterale. Dopo aver assunto che il CCC del retailer diventi negativo grazie all’implementazione del DM, abbiamo modellizzato tale soluzione come riportato nella Figura 0.2.

Il primo passaggio prevede che il retailer vada a definire la dimensione dell’ordine con l’obiettivo di riuscire a soddisfare la domanda del mercato prevista [step 1.a]. Il trigger
point del DM avviene quando il retailer viene a conoscenza di non essere in grado di emettere l’ordine poiché non dispone di fondi sufficienti, quindi invia una richiesta di IF alla banca. In seguito il retailer invia parte delle sue scorte di Product_X (rappresentante i prodotti disponibili ad esser impegnati) al magazzino del 3PL [step 1.b]. Dopo aver ricevuto il collaterale, il 3PL inizia ad analizzarlo e a controllare le sue condizioni per poi procedere con l’invio e la condivisione di tutte queste informazioni con la banca [step 1.c]. La banca paga al 3PL, per conto del retailer, il costo dei servizi che esso sosterrà (per esempio la gestione e il monitoraggio del collaterale) [step 1.d]. Nello stesso periodo la banca concede il prestito al retailer [step 1.e], il quale ora dispone di fondi sufficienti per emanare l’ordine di acquisto ed in particolare per pagare subito al fornitore un importo pari al W % del valore dell’ordine [step 1.f]. In t=r il 3PL consegna la merce al retailer [step 2.a], il quale inizia subito l’attività di vendita [step 2.b] incassando immediatamente una somma pari al Y % del valore totale delle vendite [step 2.c]. In t=j il retailer incassa la restante parte delle vendite pari a 1-Y% [step 3.a] e in t=h (in questa situazione abbiamo assunto h=j) esso paga al fornitore la restante parte (1-W%) dell’ordine effettuato in t=0 [step 3.b]. Infine in t=g il retailer ripaga il prestito alla banca [step 4.a] e, solo dopo aver completato tale pagamento, la banca informa il 3PL di restituire il collaterale al retailer [step 4.b].

Con una soluzione di DM, è possibile risolvere le difficoltà finanziarie in cui intercorrono le PMI e allo stesso tempo ridurre il rischio che le banche corrono quando concedono un finanziamento. Tuttavia in questa soluzione persiste un’altra problematica: il retailer potrebbe divergere i fondi ottenuti tramite il prestito in progetti molto rischiosi facendo così aumentare i rischi per la banca. Di conseguenza quest’ultima potrebbe decidere di non concedere il prestito senza prima aver avuto completa visibilità sui processi di acquisto del retailer.

**Control Mode**

In questa soluzione di IF il 3PL offre non solo servizi logistici, ma anche servizi finanziari. Quando il retailer ha fondi insufficienti per effettuare un ordine, il 3PL gli finanzia buona parte di esso tramite una linea di credito. In seguito lo stesso operatore logistico si incarica del trasporto e della consegna della merce. La caratteristica innovativa del CM è che il provider di servizi finanziari (che in questa soluzione risulta esser anche l’operatore logistico) offre un credito e non più un prestito; in questo modo esso ha piena visibilità anche sugli acquisti del retailer, il quale non ha più alcuna possibilità di divergere i finanziamenti in progetti ad alto rischio. Inoltre tutta la merce finanziata tramite il credito
offerto dal 3PL viene movimentato dallo stesso, esclusivamente all’interno della sua rete logistica. Agendo come gestore di tutti flussi della supply chain, il 3PL è quindi in grado di risolvere i problemi sorti nelle precedenti soluzioni. Ora il retailer è costretto a dichiarare correttamente tutte le informazioni richieste ed inoltre non ha più nessuna chance di divergere il prestito in progetti ad alto rischio, questo poiché, trattandosi di un credito, il finanziamento arriva direttamente al fornitore.

Anche qui, dopo aver assunto che il CCC del retailer diventi negativo in seguito all’implementazione del CM, abbiamo modellizzato tale soluzione come mostrato in Figura 0.3.

Come nel DM, inizialmente il retailer definisce la dimensione dell’ordine in funzione di soddisfare la domanda di mercato prevista [step 1.a]; il trigger point del CM è quando il retailer, consapevole di non esser in grado di emettere l’ordine per mancanza di fondi, invia una richiesta di IF non più ad una banca ma ad un operatore logistico offerente anche servizi finanziari. Condizione necessaria affinché si possa realizzare il CM è la presenza di un accordo multilaterale tra tutti gli attori della supply chain. Dopo aver definito il contratto, il retailer effettua l’ordine [step 1.b] di cui una parte (Q%) viene immediatamente pagata dal 3PL attraverso la linea di credito offerta [step 1.c].

Una volta ricevuta la prima parte del pagamento, il fornitore spedisce la merce al retailer, il quale la riceverà in $t=r$ (è fondamentale sottolineare che questa spedizione è movimentata e gestita esclusivamente dalla rete di trasporto del 3PL) [step 2.a]. Una volta ricevuta la merce, il retailer inizia subito la vendita [step 2.b], incassando immediatamente una somma pari al $Y\%$ del valore totale delle vendite [step 2.c]. In $t=j$ il retailer incassa la restante parte delle vendite pari a $1-Y\%$ [step 3.a] e in $t=h$ (anche in questa situazione supponiamo essere $h=j$) esso paga al fornitore la rimanente parte ($1-Q\%$) dell’ordine effettuato in $t=0$ [step 3.b]. Infine in $t=g$ il retailer restituisce al 3PL una somma pari all’ammontare del credito concesso incrementato di un tasso di interesse [step 4.a].
Risultati
Con lo scopo di testarne l’affidabilità e l’accuratezza, abbiamo eseguito un’applicazione del modello alimentandolo con dei dati reali provenienti da casi di studio, reports e documenti accademici. In aggiunta, per capire come i risultati cambiano al variare del contesto esterno, abbiamo effettuato un’analisi di sensitività basata su tre parametri: la deviazione standard della domanda, il tasso d’interesse applicato dal financial provider al retailer e la quantità di scorta del Product_X disponibile per essere impegnata (rispettivamente $\sigma$, $i$ e $Inventory(X)_{3\ months}$). In particolare, l’analisi è stata sviluppata su tre livelli, dove ognuno di essi rappresenta una differente combinazione dei precedenti parametri (vedi Figura 0.4).

![Diagrama](image.png)

Figura 0.4 - Processo dell’analisi di sensitività

Il primo livello rivela immediatamente che il “profit gap” tra una IIFS e una soluzione tradizionale di IF aumenta all’aumentare della variabilità della domanda. Dove il “profit gap” è la differenza tra i profitti della supply chain ottenuti rispettivamente dall’applicazione di una IIFS e da una soluzione tradizionale di IF. In questo modo rispondiamo alla prima domanda di ricerca.

Grazie a questo livello, siamo anche in grado di investigare e trovare una possibile risposta alla terza domanda di ricerca. In particolare, variando il livello d’incertezza della domanda, abbiamo studiato come una specifica politica di riordino delle scorte influenza il profitto della supply chain ottenuto dopo che il retailer ha implementato una IIFS (DM o CM).

![Diagrama](image.png)

Figura 0.5 - Trends dei benefici delle IIFSs secondo differenti politiche di riordino delle scorte
Sulla base della IIFS implementata, emergono differenti risultati (vedi Figura 0.5).

Nella situazione di CM, quando la deviazione standard della domanda è bassa, le politiche Hybrid e Base-Stock sono le migliori perché permettono all’azienda “budget constrained” di ridurre i suoi costi di gestione delle scorte, risparmiando così liquidità per eseguire un ordine futuro più grande. Al contrario, quando la deviazione standard della domanda assume un valore medio-alto, le precedenti politiche non sono più in grado di far fronte a tale domanda, infatti i costi di stock-out superano i potenziali risparmi di una logica periodica di controllo del magazzino. Quindi le politiche Two-Bin e Min-Max, grazie alla loro logica continua di controllo del magazzino, diventano le migliori soluzioni per quanto riguarda il profitto dell’intera supply chain. Più in dettaglio la politica Min-Max è migliore, poiché ancora più flessibile e dinamica rispetto a quella Two-Bin.

Per quanto riguarda la situazione di DM, le migliori politiche di riordino delle scorte risultano essere sempre quelle con una logica continua di controllo del magazzino (Two-Bin e Min-Max). Al contrario, le politiche con una logica periodica di controllo, indipendentemente dall’incertezza della domanda, generano sempre benefici minori. Più in dettaglio, la politica Two-Bin assicura i migliori risultati se la deviazione standard della domanda è bassa ($\sigma < 20$); quando invece l’incertezza della domanda inizia ad aumentare la politica Min-Max diventa quella predominante.

Con l’obiettivo di rispondere alla seconda domanda di ricerca, cambiamo la prospettiva dell’analisi focalizzandoci sulla comparazione tra CM e DM, considerandoli sempre sotto la medesima logica di controllo del magazzino. Quindi, per esprimere questa comparazione, adottiamo la variabile $\lambda_{\text{InvPolicy}}$, che è stimata come segue:

$$\lambda_{\text{InvPolicy}} = SC PROFIT_{\text{Inv Policy}}^{\text{Control Mode}} - SC PROFIT_{\text{Inv Policy}}^{\text{Delegation Mode}}$$

In particolare, al fine di rendere i risultati più chiari e diretti, andiamo a considerare la differenza tra CM e DM, non per ogni singola politica di riordino, ma più semplicemente per ogni logica di controllo del magazzino. Definiamo quindi le variabili $\lambda_{\text{Continuous}}$ e $\lambda_{\text{Periodic}}$ come segue:

$$\lambda_{\text{Continuous}} = \frac{\lambda_{\text{TwoBin}} + \lambda_{\text{MinMax}}}{2}, \quad \lambda_{\text{Periodic}} = \frac{\lambda_{\text{BaseStock}} + \lambda_{\text{Hybrid}}}{2}$$

Restando nel primo livello dell’analisi, studiamo come la variabile $\lambda_{\text{Continuous}}$ e $\lambda_{\text{Periodic}}$ si comportano, scoprendo che la differenza tra CM e DM sotto una logica di controllo continuo del magazzino aumenta all’aumentare della variabilità della domanda; al
contrario, sotto una logica di controllo periodico del magazzino, la variabile $\lambda_{\text{Periodic}}$ segue il trend opposto, questo perché quando la domanda è molto variabile le perdite causate dall’adozione di una logica “errata” di controllo delle scorte (cioè una logica di controllo periodico di magazzino sotto un elevato livello di incertezza della domanda) sono così elevate da quasi annullare i benefici di una soluzione di CM (vedi figura 0.6).

![Figura 0.6 - $\lambda_{\text{Continuous}}$ e $\lambda_{\text{Periodic}}$ trends secondo differenti valori di $\sigma$](image)

Spostandoci nel secondo livello dell’analisi, scopriamo una relazione tra la variabile $\text{inventory}(X)_{3\text{ months}}$ e le variabili $\lambda_{\text{Continuous}}$ e $\lambda_{\text{Periodic}}$ (vedi Figura 0.7). Nello specifico, quando la prima risulta bassa, la differenza tra CM e DM è molto elevata per entrambe le logiche di controllo. Questo comportamento ha senso poiché il DM, quando il retailer possiede una bassa quantità del Product_X disponibile per essere impegnata, diventa molto simile al TM (dove il retailer non impegna nulla in quanto non attiva alcuna soluzione di IF), quindi la differenza con il CM è molto elevata.

Aumentando l’ammontare di $\text{inventory}(X)_{3\text{ months}}$ la differenza tra CM e DM diminuisce significatamente, rendendo i benefici delle due soluzioni molto simili. Tuttavia se continuiamo ad aumentare l’ammontare del Product_X, il valore di entrambe le variabili $\lambda_{\text{Continuous}}$ e $\lambda_{\text{Periodic}}$ inizia lentamente a risalire. Legittimiamo quest’ultimo risultato in quanto ora il Product_X non può essere più considerato come un prodotto secondario (poiché è stato assunto che la quantità di Product_X è direttamente proporzionale alla sua domanda futura).
Infine, il terzo livello dell’analisi rivela che la differenza tra CM e DM aumenta in modo proporzionale al valore del tasso d’interesse ed indipendentemente dalla logica di controllo del magazzino adottata dal retailer (vedi Figura 0.8). Questo perché, nel DM, la banca applica un tasso d’interesse su un imponibile costituito dal valore del prestito e da altri costi sostenuti (per es. i costi di gestione del collaterale), mentre nel CM, il 3PL-Bank applica il tasso d’interesse solo sul valore del credito concesso al retailer. Quindi, a parità di valore del presito ricevuto, nel CM il retailer paga un interesse totale minore.

Figura 0.7 - $\lambda_{\text{Continuous}}$ e $\lambda_{\text{Periodic}}$ trends secondo differenti valori di $\text{Inventory}(X)_{3\text{ months}}$

Figura 0.8 - $\lambda_{\text{Continuous}}$ e $\lambda_{\text{Periodic}}$ trends secondo differenti valori di $i$
1 LITERATURE REVIEW

This chapter illustrates the most relevant contributions in the literature that represent a fundamental theoretical basis for the development of this work. We first introduce the reader to the concepts of supply chain, supply chain management and supply chain finance. Then we focus on the Inventory Financing (IF) solution, which is the core of this thesis, stating its definitions, frameworks and describing its processes and benefits.

1.1 Supply Chain and Supply Chain Management

“Business practices of the future will be defined in a new unit of analysis: the supply chain (not the individual organization) [...] will become the effective unit of competition.”

(Handfield, 2002)

The supply chain concept has been subjected to huge evolution in the last 40 years, since this topic has been intensely studied.

A supply chain is a system of organizations, people, activities, information and resources involved in moving a product or service from supplier to customer. Supply chain activities involve the transformation of natural resources, raw materials, and components into a finished product that is delivered to the end customer (Van Drunen, KPMG¹, 2011).

Poirier and Quinn (2004) offered a five-phase supply chain maturity model in their article “How are we doing? A Survey of Supply Chain Progress” (see Figure 1.1). The first phase of the Poirier and Quinn model involves enterprise integration that strives for corporate alignment (vertical integration), whereas the second phase has the aim to achieve corporate excellence. The focus of these first two phases is internal (i.e. intra-enterprise).

In the third phase, organizations look externally to develop partner collaboration. In phase four, supply chain stakeholders work to create value chain collaboration (improved supply chain transparency and visibility). The aim of these last two phases was to reduce costs while increasing products quality because each partner is now focused on just one part of the process.

¹ KPMG was founded in 1987 after merging Peat Marwick International and Klynveld Main Goerdeler. It is a global network of professional firms providing Audit, Tax and Advisory services. They operate in 155 countries and have more than 162,000 people working in member firms around the world. Its global headquarter is located in Amsterdam, Netherlands.
In the fifth and final phase, when business is becoming too complex for just a single company, supply chain stakeholders achieve full network connectivity in order to better respond to a more dynamic demand and to accelerate the globalization pace. Thus, enterprises started to forge closer alliances with their trading partners, trying to retain customers and maintain the leading edge in an increasingly competitive market.

**Figure 5.1 - Supply Chain Maturity Model (Poirier and Quinn, 2004)**

To conclude, as Done (2011) said, companies along the whole supply chains must become more integrated by increasing the collaboration between upstream and downstream partners. This would allow them to achieve better results and benefits. Nowadays, however, the majority of existing supply chains are still focused on asset, data and information elements of exchange between supply chain partners, but an optimal integration and collaboration clearly require the exchange of more complex elements at the expertise and knowledge levels.
1.1.1 Supply Chain Definitions

When an organization tries to focus on supply chain management, its leaders must determine what the supply chain encompasses. Just as you can not manage what you do not measure, you can not plan and execute what you have not clearly defined. Hence, it is important to articulate the overall purpose, scope, and components of a supply chain (Gibson et al. 2013).

Below there are useful supply chain definitions that highlight critical aspects of a supply chain:

- From Christopher (1992) — The network of organizations that are involved, through upstream and downstream linkages, in the different processes and activities that produce value in the form of products and services delivered to the ultimate consumer;
- From the CSCMP\(^2\) (2010) — The material and informational interchanges in the logistical process, stretching from acquisition of raw materials to delivery of finished products to the end user. All vendors, service providers, and customers are links in the supply chain;
- From Mentzer et al. (2001) — Supply chain is defined as a set of three or more entities (i.e. organizations or individuals) directly involved in the upstream and downstream flows of products, services, finances, and/or information from a source to a customer;
- From Coyle et al. (2013) — A series of integrated enterprises that must share information and coordinate physical execution to ensure a smooth, integrated flow of goods, services, information, and cash through the pipeline.

One important feature of these definitions is the concept of an integrated network or system.

A simplistic description of a supply chain, as represented in Figure 1.2, suggests that a supply chain is linear, with organizations linked to their upstream suppliers and downstream customers.

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\(^2\) CSCMP (Council of Supply Chain Management Professionals): Founded in 1963, the Council of Supply Chain Management Professionals (CSCMP) is the preeminent worldwide professional association dedicated to the advancement and dissemination of research and knowledge on supply chain management. With over 8,500 members representing nearly all industry sectors, government and academia from 67 countries, CSCMP members are the leading practitioners and authorities in the fields of logistics and supply chain management.
Specifically, the supply chain encompasses the steps to get a product or a service from the supplier to the customer. Supply chains include every company that comes into contact with a particular product (H. Chen et al., 2014); for example, the supply chain for most products will encompass all the companies manufacturing parts for the product, assembling it, delivering it and selling it.

### 1.1.2 Structure and Actors

Supply chains require a multiplicity of relationships and numerous paths through which products and information travel (Lambert and Cooper, 2000). This is better reflected by the Figure 1.3, in which the supply chain is a network of participants and resources. To gain maximum benefit from the supply chain, a company must dynamically draw upon its available internal capabilities and the external resources of its supply chain network to fulfill customer requirements.

This network of organizations, with their facilities and transportation linkages, facilitate the procurement, the transformation of materials into desired products and distribution to customers.

Moreover, as Londe and Masters (1994) said, a supply chain needs to be a set of actors that pass materials forward. In fact, normally, several independent players are involved in manufacturing a product and in placing it in the hands of the end user in a supply chain. These members may be raw material and component producers, product assemblers, wholesalers, retailer merchants and transportation companies.
According to Gibson et al. (2013), another logical segmentation basis for supply chain participants is their ownership stake in the product. More in detail, entities that own the goods at various stages of the supply chain are direct stakeholders. This group may include the final consumers, retailers, distributors, manufacturer and suppliers. On the other hand, entities that support the flow of materials, information and money are supply chain facilitators. They do not typically take title to the goods, but play a critical role in the safe and efficient execution of the supply chain activities. This facilitator group includes logistics services providers, information technology companies, consultancies, financial institutions, government agencies, equipment providers and indirect materials suppliers. To conclude, Lora Cecere, founder and CEO of Supply Chain Insights<sup>3</sup>, bears that it is crucial to understand that no two supply chains are exactly alike because an organization’s supply chain structure and relationships will be influenced by its industry, geographic scope of activity, supply base, product variety, fulfilment methods and demand patterns.

<sup>3</sup> Supply Chain Insights was founded in February 2012. It is a company focused on delivering independent, actionable and objective advice for supply chain leaders. They help other company to better understand supply chain trends, evolving technologies and which metrics matter.
1.1.3 Supply Chain Management Definitions

In the literature there are several definitions of Supply Chain Management (SCM) that could be little different depending to the author.

Below some of the most important definitions of the SCM concept we have found in the literature:

• According to Stevens (1989) — the objective of managing the supply chain is to synchronize the requirements of the customer with the flow of materials coming from suppliers. This, in order to carry out a balance between a high customer service and a low inventory level, which are usually considered as conflicting goals;

• According to GSCF\(^4\) — SCM is the integration of key business processes from end user to original suppliers. It provides products, services and information that add value for customers and other stakeholders;

• According to Cooper at al. (1997) — SCM is an integrative philosophy to manage the total flow of a distribution channel from supplier to the ultimate user;

• According to Mentzer et al. (2001) — SCM is defined as the systemic, strategic coordination of the traditional business functions and the tactics across these business functions within a particular company and across businesses within the supply chain. This is carried out with the aim of improving the long-term performance of the individual companies and the supply chain as a whole;

• According to Lummus et al. (1998) — SCM is a way of obtaining vertical integration benefits without its formal ownership costs. Indeed, SCM is the integration of key business processes among industry partners. Thus, it tightly links together several consecutive elements of the industry value chain, that starts from upstream suppliers and ends with the customers, passing through subassembly manufacturers, final manufacturers and distributors. This is carried out with the aim of making the business processes more efficient and the end products and services more differentiated, thus achieving a higher value added for the customers.

\(^4\) The Global Supply Chain Forum (GSCF), a group of non-competing firms and a team of academic researchers, has been meeting regularly for the past 6 years with the objective to improve the theory and practice of SCM.
In order to simplify and better understand the concept of SCM we have tried to discover a single and encompassing definition. Pulling together these disparate aspects of supply chain management, the definition that for us better suits all the above concepts is the one given by the Council of Supply Chain Management Professionals (CSCMP):

“Supply Chain Management encompasses the planning and management of all activities involved in sourcing and procurement, conversion, and all logistics management activities. Importantly, it also includes coordination and collaboration with channel partners, which can be suppliers, intermediaries, third-party service providers, and customers. In essence, supply chain management integrates supply and demand management within and across companies. Supply Chain Management is an integrating function with primary responsibility for linking major business functions and business processes within and across companies into a cohesive and high-performing business model. It includes all of the logistics management activities noted above, as well as manufacturing operations, and it drives coordination of processes and activities with and across marketing, sales, product design, finance and information technology”.

1.1.4 Techniques and Benefits

The article “Supply Chain Management Techniques in Medium-to-Small Manufacturing Firms”, written by Higginson and Alam (1997), explains in a very thorough way the most common techniques of SCM (see Figure 1.4).

These are the followings:

- Developing strong and long-term relationship with supply chain members to improve products, reduce costs and develop more efficient processes;
- Dealing with fewer suppliers and carriers to encourage closer working relationships and allow greater use of supplier and carrier expertise;
- Working with SC members to reduce channel-wide inventory levels and cycle times, thus improving the customer service while reducing costs;
- Regularly sharing information with other SC members allowing quicker responses to changes;
- Working with SC members to maintain high quality products;
• Building commitment at all levels of the organization to encourage implementation and continued improvement.

**Figure 1.4** - Techniques to implement Supply Chain Management (Higginson and Alam, 1997)

The reason behind the creation of a SCM is to increase supply chain competitive advantage. According to Porter (1985), two types of competitive advantage exist: cost leadership and differentiation. Thus, it is proposed that the implementation of SCM enhances customer value and satisfaction, which, in turn, leads to enhance competitive advantage for the supply chain as well as for each member firm. The result is an improvement of the profitability of the entire supply chain.

Common benefits of a better management of supply chain activities include reduced cycle time, lower inventory levels and costs, increased delivery reliability and responsiveness to changes. Moreover, the closer working relationship between members of a supply chain can be led (increasing the sharing of expertise and risks), the more efficient purchasing and demand forecasting processes will be.

Barriers to successful use of SCM include the lack of strong management commitment, unclear definitions, legal issues in sharing data, inefficient information system and incompatible systems at channel members (Higginson and Alam, 1997).
According to a survey of 1000 successfully companies conducted by Lockheed Martin\textsuperscript{5} and Penn State’s Center for Supply Chain Research\textsuperscript{6}, the most critical SCM drivers are the profit and customer satisfaction. The research also highlights how Purchasing Management and Inventory Management functions are the areas where are collected the highest return on investment from the SCM (see Figure 1.5).

\begin{figure}[h]
\centering
\includegraphics[width=\textwidth]{critical-drivers-perceived-benefits}
\caption{Critical drivers (left) and Perceived benefits (right) of SCM (Lockheed Martin and Penn State’s Center for Logistics Research, 2012)}
\end{figure}

\subsection{Supply Chain Finance}

Supply chain finance (SCF) is a subject that is gaining interest and importance since several years but, although the supply chain management topics are already deeply studied and refined by firms, the financial slant is still “in progress”; this is, nowadays, one of the reason why a lot of companies are facing financial issues with their own individual points of view (Lamoureux and Evans, 2011). In line with this analogy, in recent years, SCF experienced a growth spurt in the development: much valuable data has become available from the

\textsuperscript{5} Headquartered in Bethesda, Maryland, Lockheed Martin is a global security and aerospace company that employs approximately 126,000 people worldwide and is principally engaged in the research, design, development, manufacture, integration and sustainment of advanced technology systems, products and services.

\textsuperscript{6} The Center for Supply Chain Research was founded in 1989 and has since become one of the nation’s leading institutes dedicated to supply chain management research and education. Its faculty and affiliate members encompass a broad range of disciplines including business logistics, management science, operations management, business law, geography, agricultural economics and industrial engineering.
widespread implementation and the use of SCF tools and significant contributions have been made to theory. However, as a field of research, SCF has not yet reached maturity. Although there is now much more clarity on concepts and applications, the exact definition and boundaries of the discipline are still evolving (Bryant and Camerinelli, 2014).

Pfohl et al. (2009) denominate the flow of financial resources as the “financial supply chain” and locate the latter at the interface between the fields of logistic and finance. The financial supply chain consists of the sequence of financial events and processes that take place when commercial transactions are executed. These events and processes include flows of financial information (e.g. sending an invoice to a customer) and money between supply chain members.

Potential fields of financial supply chain include financing mobile and immobile assets within the supply chain, financing the working capital in order to leverage the best cost of capital within the chain, optimizing the financial processes using standards and IT systems and managing the cash in order to optimize the Cash Conversation Cycle.

Two important authors who introduced the term “Supply Chain Finance” were Stemmler and Seuring (2003), they spoke about the control and optimization of financial flows induced by logistics. Optimizing the financial structure and the cash flow within the supply chain can be named Supply Chain Finance. SCF solutions represent a combination of technology solutions and financial services that closely connect supply chain actors (e.g. suppliers, manufactures, financial institutions, technology and logistic service providers, etc.). These are designed to improve the effectiveness of financial supply chains by preventing detrimental cost shifting and by improving the visibility, availability, delivery and cost of cash for all participants (Lamoureux and Evans, 2011).

1.2.1 Definitions

Supply Chain Finance is a term that is commonly used in the marketplace, however, upon closer examination of the literature, it could be defined in two different ways. One approach explains SCF in the context of technology solutions, for example Pezza (Aberdeen Group, 2011) defines it as follows:

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8 Aberdeen Group is a provider of fact-based business intelligence research founded in 1988, trying to understand the implications and results of process innovation, methodology advancements, technology deployments and business re-engineering.
“A SCF solution is a combination of trade financing provided by a financial institution, a third-party vendor, or an enterprise itself, and a technology platform that unites the trading partners and the financial institution electronically and provides the financing triggers based on the occurrence of one or several supply chain events”.

The second approach treats SCF as a broader topic, focusing more on the effects and goals achievable by adopting SCF solutions; for example, one of the most famous and important definition of SCF made by Pfohl and Gomm (2009) affirms:

“SCF is the inter-company optimization of financing as well as the integration of financing processes with customers, suppliers, and service providers in order to increase the value of all participating companies. The task of SCF is to save capital cost by means of better mutual adjustment or completely new financing concepts within the supply chain, eventually in combination with a changed role or task sharing”.

Our conclusion is that there isn’t a strict and universal definition of SCF but, broadly speaking, it refers to IT tools and products that together help businesses optimize their cash flow by better managing payments and receipts.

Concluding, in line with the article “Supply Chain Finance, its Practical Relevance and Strategic Value” (de Boer et al. 2015), we can achieve a definition of SCF throw the development of two different trends:

- Corporate Finance: CF looks at the financial decisions that a corporation makes with the purpose of increasing the firm’s value. Essentially, these decisions answer two questions: what investments should the corporation make (management of real assets) and how should it pay for those investments (management of financial assets) (Brealey et al., 2014);

- Supply Chain Management: as described in the previous chapter, SCM takes into account both the logistical integration process and the involvement of all business functions in order to avoid a sub-optimization of the supply chain which occurs when each organization in the supply chain attempts to optimize its own results rather than integrate its goals and activities with other organizations to optimize the results of the chain.
The Figure 1.6 shows the above trends describing them using two different axes:

- **Vertical axis:** vertical collaboration between supply chain members: both SCM and finance are extending their scope from the organization interface level to tier-1 supplier level and moving further up the supply chain to tier-2 level, etc.\(^9\);
- **Horizontal axis:** Functional partnering, i.e. there is a tendency from corporate finance side to build stronger cross-functional relationships with the supply chain function. At the same time, there is a growing awareness within the supply chain that it needs the finance function in order to be successful.

After this reasoning, the authors came to the following definition of SCF:

"SCF aims at the optimization of the flows and allocation of financial resources in a supply chain with the aim to increase value, requiring the collaboration of at least two primary supply chain members, possibly facilitated by external service providers. As such, SCF’s purpose is to improve supply chain efficiency (financial performance), effectiveness (delivery performance) and sustainability (social performance)".

---

\(^9\) Financial collaboration is not limited to suppliers (upstream) but can also extend towards customers (downstream).
1.2.2 Supply Chain Finance Framework

In order to better understand the meaning of SCF, we refer to the diagram designed by Pfohl and Gomm (2009) (see Figure 1.7) which suggest us to consider who, and on which terms, decide to finance assets within a supply chain.

![Diagram of Supply Chain Finance Framework](image)

**Figure 7.7 - Framework for Supply Chain Finance (Pfohl and Gomm, 2009)**

**Objects**

The objects of SCF are fixed assets and the Net Working Capital (NWC), where the latter term is calculated as circulating assets minus the short-term liabilities.

A useful vehicle to better figure out the NWC is the Cash Conversion Cycle (CCC), computed as follows:

\[
CCC = DSO^{10} + DII^{11} - DPO^{12}
\]

Lamoureux and Evans (2011) described the CCC as a commonly-used benchmark adopted to calculate the timing difference between the moment when cash leaves a company to pay suppliers and the time the same company takes to convert inventory into cash (see Figure 1.8). The longer the CCC, the longer the company will need to borrow funds to bridge this gap.

---

10 Days Sales Outstanding (DSO) measures how long it takes for a company to be paid by his customers.

11 Days in Inventory (DII) measures how long it takes to sell a stock of finished goods.

12 Days Payable Outstanding (DPO) measures how long it takes for a company to pay his suppliers.
However, looking at the CCC from a supply chain perspective, Hofmann and Kotzab (2010) show that extending DPOs towards suppliers that already have a lower creditworthiness and often problematic access to capital is ‘absurd’. As cost of capital is not equal for companies that differ in creditworthiness, a change in payment terms is a non-zero sum game (Randall and Farris, 2009), meaning that the loss of one participant (namely the supplier) is bigger than the gain of the other participant (in this case the focal company).

Figure 1.8 - Cash Conversion Cycle (Lamoureux and Evans, 2011)

![Cash Conversion Cycle Diagram](image)

Figure 1.9 - The impact of a payment term extension from a supply chain CCC perspective (R. de Boer et al. 2015).
The Figure 1.9 illustrates this by showing the effect of extending the CCC of a supplier with a high capital cost: although it reduces the capital cost of one individual company (namely the credit-worthy buyer), it increases the total capital cost in the supply chain. By taking a network perspective, it is possible to determine an optimal combination of member CCCs that outperforms a single-company perspective by leveraging the differences in capital cost between members in the chain.

**Actors**

Pfohl and Gomm (2009) classify the actors within the supply chain, that participate in a SCF solution, in primary-members and supporting-members. The former are suppliers, customers and the focal company of a supply chain, whereas the latters are the logistics service providers and the financial intermediaries. Another interesting actors’ classification is made by Hoffman (2005) who divides them in two different categories:

- Macro-institutional actors: the industrial or commercial company (buyer), the supplier, the logistics service providers and the financial institutions;
- Micro-institutional actors: all departments involved with the operational activities (e.g. purchasing, production, distribution and logistics units).

**Levers**

The levers of financing within SCF comprise three aspects: the amount of assets to be financed (volume of financing), how long the financing lasts (duration of financing) and what is the cost to get the loan (capital cost rate). Multiplying these three factors it is possible to compute the minimum capital cost for pursuing a profitable investment.

*Figure 1.10 - Cube of Supply Chain Finance (Gomm, 2010)*
The Figure 1.10 shows the Cube of SCF, designed by Gomm (2010) in his article entitled “Supply chain finance: applying finance theory to supply chain management to enhance finance in supply chains”, where he describes and analyzes these three main levers of SCF. It is important to note that they are not fully independent of each other; for example, the volume or the duration of financing can influence the capital cost.

\[
\text{Capital Cost (\$)} = \text{Volume (\$)} \cdot \text{Duration (t)} \cdot \text{Capital Cost Rate (\%t)}
\]

1.2.3 Supply Chain Finance Solutions: focus on Inventory Financing

With the purpose to facilitate the identification of Inventory Financing among all others SCF solutions, the “SCF solution classification framework” developed by the Osservatorio of Supply Chain Finance, Politecnico di Milano (2015) becomes a very useful reference (see Figure 1.11) that distinguishes the main "families" of SCF services.

---

13 The “Supply Chain Finance Osservatorio” of Politecnico di Milano School of Management was established in 2013 to satisfy the increasing interest of firms and Public Administrations to the opportunities of working capital optimization and access to credit provided by supply chain finance solutions. The Osservatorio is also part of the International Supply Chain Finance Community (ISCFC), which aims to share and improve analysis and researches at the European level.
The first axis of classification looks at the “impact on the main working capital items”:

- The first category takes into account all the services that affect receivables and payables, changing their amount or their time payment/collection. This category is divided into two parts according to the actor who provides the service. Hence, we have a “financial” intermediary or "non-financial" operator (offering services such as Invoice Auction, Dynamic Discount, etc.);
- The second category includes the models developed with the aim of reducing and optimizing stocks volumes within the customer-supplier relationship (Supply Chain Visibility solutions, VMI, CPFR, etc.).

The second axis is the "level of innovation", which is divided into traditional and innovative models.

The third axis is the "use of digitalization", which means the impact that digital technologies can have in the development of the different offers of SCF.

As we can see in the above matrix, Inventory Financing (IF) is classified as an innovative and digital solution offered by a financial intermediary. This means that IF is based on digitalized processes and, at the same time, it is a solution which tries to fully exploit the potential of new technologies in order to make available several opportunities of collaboration (integrating supply chain subjects, financial institutions, logistic operators and IT providers).

These features award to IF a significant position within the all the SCF solutions, in fact, it is shown that through IF is possible to achieve greater and broader benefits for several actors along the entire supply chain.

1.2.4 Benefits

The role of SCF is to optimize both the availability and cost of capital by aggregating, packaging and utilizing information generated during supply chain activities. Moreover, SCF tries to match these information with the physical control of goods. Coupling information and physical control of the goods enables lenders to mitigate financial risk within the supply chain. Thus, the mitigation of the risk allows the borrower to get more capital in quicker way and with a lower interest rate (Zhang et al., 2008).
Making a brief evaluation of benefits and taking inspiration from the “Report of the supply chain finance working group” published by ACT\textsuperscript{14} on July 2010, it should be appropriate to identify two basic situations in which classify SCF solutions:

- **Seller-based\textsuperscript{15}:**
  The seller allows buyers for longer payment terms, but in exchange they have to approve the supplier invoice information.
  SCF solutions provide to the seller instant liquidity, which allows businesses to grow more rapidly, thank the possibility to make more investments using funds that were previously tied up. In addition, by providing extended terms of payment, sellers improve also their image, reputation and relationship with buyers.
  On the other side, buyers increase their DPO and consequently their CCC will be reduced.
  The main difference compared to the following buyer-based solutions is the discount rate offered by the financial provider, which is based on the credit rating of the supplier (which, in turn, relies on his sale base). Thus, the cost of financing is usually higher than the buyer-based solution;

- **Buyer-based\textsuperscript{16}:**
  As a large global enterprise, the company’s credit rating is stronger than many its suppliers. SCF solutions allow firms to get funds at more favorable rates than those offered by their local banks. In return, the buyer can negotiate better terms and conditions with sellers, such as extending days payable outstanding.
  Suppliers, participating in a supply chain finance program, broaden their access of capital and reduce its cost by not drawing on their current credit lines. The on-demand nature of supply chain finance also helps suppliers to improve their cash flow forecasting and flexibility.

\textsuperscript{14}The Association of Corporate Treasurers (ACT) is the only British professional body specialized in the profession of corporate treasury. Originally founded in 1979, it was re-established on 1 January 2013 by Royal Charter requiring it to operate in the public interest. It is both an examining body, providing a wide range of qualifications for those working in treasury, risk and corporate finance, and a membership organization which supports and represents its members.

\textsuperscript{15}The supplier has high credit worthiness and manages a wide sale base, which often is segmented in buyers with different risk and size.

\textsuperscript{16}The buyer has high credit worthiness and manages a wide supply base, which often is segmented in suppliers with different risk and size.
Moreover, if suppliers pay less to finance materials and productions, consequently they can decrease the cost of the goods, obtaining a better position to compete versus who is subjected to high local bank lending rates.

Finally, it is necessary to point out that there is also a global benefit achieved by the entire supply chain. In fact, SCF not only offers capital cost benefits, but may enhance supply chain competences and mitigate disruptions, reaching a higher level of integration, visibility and loyalty along entire the supply chain (van der Vliet et al., 2013).

1.3 Supply Chain Finance for Small-Medium Enterprises

We dedicate a specific paragraph to supply chain finance for Small-Medium Enterprises (SMEs) because, as defined by Ata (2013) in the article “Financing SME supply chain”, they play a pivotal role in the social and economic well-being of their host countries. However, unlike larger companies, SMEs struggle with finance as a limiting factor rather than a lever for value generation. Hence, according to Lihong and Fangchun (2011), SCF might be a new way to relieve financing predicament of a SME. In fact, SCF can weaken the bank restriction on a small-medium enterprise, considering it in the whole supply chain and no longer as a single unit. Therefore, SME information is more unblocked and the bank is apt to grasp and control the potential risk any time.

1.3.1 Importance of SMEs

SMEs are often referred to as the cornerstone of the European economy, contributing significantly to the GDP growth through their overall importance and their ability to innovate and grow. This is mainly due to the fact that SMEs represent over 99% of companies across the EU27 according to “Finance for growth: Report of the high level expert group on SME and infrastructure financing” (Giovannini and Moran, 2013). Therefore, as shown in the Table 1, they account for a large share of employment and value

---

17 GDP is the acronym of Gross Domestic Product. This is the monetary value of all the finished goods and services produced within a country’s borders in a specific time period.

18 EU27 is the latest enlargement of the European Union signed in 2007.
added, representing around two thirds of the European workforce and nearly 60% of value in the EU27 economy.

<table>
<thead>
<tr>
<th>Category</th>
<th>Employees</th>
<th>Percentage of firms</th>
<th>Employment</th>
<th>Value added</th>
<th>Productivity</th>
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</thead>
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<td>32.6</td>
<td>41.9</td>
<td>131</td>
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<td>58.1</td>
<td>87</td>
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<td>50 - 249</td>
<td>1.1</td>
<td>17.2</td>
<td>18.4</td>
<td>110</td>
</tr>
<tr>
<td>Small</td>
<td>10 - 49</td>
<td>6.5</td>
<td>20.6</td>
<td>18.5</td>
<td>91</td>
</tr>
<tr>
<td>Micro</td>
<td>0 - 9</td>
<td>92.2</td>
<td>29.6</td>
<td>21.2</td>
<td>71</td>
</tr>
</tbody>
</table>

**Table 1** - Importance of SMEs in the EU27 (as a percentage of total business economy)

However, labor productivity, that is the value added per employee, is higher for large firms. This apparent productivity divergence may reflect differences in labor skills and in capital intensity, as well as effects not related to both inputs, such as technological dynamism (Giovannini and Moran, 2013). Moreover, as shown in the Figure 1.12, in the most important European countries, the revenues of SMEs, in percentage of the revenues of all non-financial firms, is always at least half of the total turnover. The indicator reaches even a score of 69 in Italy, meaning SMEs assume a decisive role for the economical progress of this country.

**Figure 1.12** - Turnover of SMEs in percentage of the turnover of all non-financial firms (source: Eurostat)
Expanding the boundaries of research, SMEs are playing a key role also for Asia’s economic growth. In fact, according to Ata (2013), it is estimated that SMEs comprise more than 98% of the number of enterprises in the Asia-Pacific. However, the sheer number of SMEs is not the only reason why they are so important for the Asia’s prosperity. In fact, they promote also business ownership, entrepreneurial skills and creation of new job opportunities as it happens also in Europe.

1.3.2 Financial Characteristics of SMEs

According to Ata 2013, SMEs are characterized by the following financial constraints:

- Working capital constraints: SMEs are under pressure due to the constraints of day-to-day working capital. However, SMEs might use some levers such as line-of-credit with the suppliers, advance payments or loans in order to alleviate some of this pressure. Therefore, if SMEs are able to apply at least one of these solutions, they would be able to operate with greater confidence;

- Fixed capital constraints: SMEs are usually businesses with high investments in fixed assets upfront and a lower rate of return on these investments. Thus, scalability is constrained even when an opportunity to grow with further investment arises;

- Inability to qualify for loans: this is because SMEs' lack of documentation, bills and receipts that demonstrate the cash flow of the businesses. SMEs also lack the collateral required for financing because most of their asset are leased or rented;

- Lack of motivation, interest and education: most of SMEs lack the motivation and entrepreneurship, which is a key ingredient for innovation. Coupled with a lack of education, the growth and maturity of the business is not realized to its full potential.

1.3.3 Issues for SME Financing

According to Giovannini and Moran (2013), two of the most important problems in relation to SMEs' access to funds are the asymmetric information and the transaction costs. The former is typically because they have great opaqueness of their balance sheets and low visibility of corporate capabilities, which are the result of less informative financial statements and short operating track records. This situation leads also to bigger transaction
costs because banks are less well-disposed to grant credit and if they do, they apply a very high financing costs.

In addition, according to the article “Financing SMEs supply chains”, another trouble for financing SMEs is the fact that the banks want to see at least two sources of repayment to justify the ability of the lender to repay the loan. These sources are the cash flow from the business and the presence of a secondary source such as a collateral. However, as we said before, SMEs are not able to provide past financial statements (helpful for the analysis of their cash flows) and they also do not possess so many assets (in order to reach the minimum required collateral), as consequence it is very difficult for banks to extend loans to a SME.

A further proof of these last statements comes from Xu and Zhong (2011), indeed they claim SMEs have to face severe financial challenges due to the presence of unsecured assets, asymmetry of information, lack of management capacity, not clear model of profit and the issue of little ability of anti-risk.

### 1.4 Inventory Financing

Since the start of the financial crisis, most companies have made net working capital management a key priority. The scarcity of cash reduced the available options for companies to obtain capital. Simultaneously, demand volatility increased, which demanded greater investments in safety stock and holding more precautionary cash (Pezza, 2011). At the same time, it has become harder for a large group of companies to get their increased financing needs met. Due to higher perceived risk caused by factors such as informational asymmetry, asset structure and management experience, banks have traditionally been less eager to grant loans to SMEs. Since the credit crunch of 2008, however, banks have become even more reluctant to grant SMEs loans mainly due to stricter regulations (Angelkort and Stuwe, 2011).

Along with the rapid development of SCF, a lot of innovative solutions, such as Invoice Auction, Purchase Finance and Inventory Financing are emerged in order to solve the previous issues. Being the inventory the basic element of logistics and, at the same time, the mostly available asset in an enterprise with fair fluidity, Inventory Financing (IF) fulfills an
important role in SCF (Y. Li, 2010).

According to Bank of America Merrill Lynch, we can consider IF as a form of asset-based lending that allows businesses to use their inventories as collateral in order to obtain a revolving line of credit. Companies do this in order to free up cash that otherwise would be tied up in inventory; this money can be used to supplement working capital needs, such as cash needed for import-export financing or also to help a business get through seasonal fluctuations in cash flow.

1.4.1 Definitions

Nowadays it is not easy to investigate and find out a clear and univocal definition for the concept of IF because it is still a very recent solution.

One of the latest definitions is provided by UNECE\(^{19}\) (2012):

“Inventory finance is a form of trade finance in which goods are held in a warehouse until needed. This is a typical supply chain finance instrument for qualifying commodities and products. The funding institution provides flexible warehouse and inventory financing facilities to accommodate transaction flows. Using securely stored goods as collateral, allows companies to obtain financing by depositing the inventory in a qualified third-party warehouse usually managed by a collateral manager”.

During the same year Li et al. (2012) drafted another important definition:

“Inventory financing, also called financing warehouse, refers to enterprises gain financing support by their own operating or producing inventory as pledge and is a loan way according to the total inventory to obtain revolving credit”.

In the literature analyzed, the different authors mostly tend to slightly customize their definition of IF, each of them emphasize a different feature, but they always share the same basic concept. One of the most thorough definition is made by Xu and Fu (2010), who define IF as:

\(^{19}\) The United Nations Economic Commission for Europe (UNECE) was set up in 1947 by ECOSOC. It is one of five regional commissions of the United Nations. UNECE’s major aim is to promote European economic integration. To do so, it brings together 56 countries located in the European Union, non-EU Western and Eastern Europe, South-East Europe and Commonwealth of Independent States (CIS) and North America.
“A system in which the borrowing company uses its own inventory resource as a pledge to obtain loans from a bank. After examination and approval, the bank will transfer the inventory to a Third Party Logistics provider (3PL) who will store and monitor the inventory. At the end of the financing period, the borrowing company must repay the loan and interest, and then she can have her pledged inventory returned and available for sale”.

Y. Yin et al. (2009) give us another similar definition, they defined IF as:

“The inventory financing is a kind of service innovation, a solution to a company difficulty of getting funds, and to the traditional 3PL’s problem of low profit margin. It is a structured method of financing, wherein funds are extended to manufacturers and processors based primarily on the underlying asset - commodities as identified by a warehouse receipt issued by an independent collateral manager appointed by the bank”.

From the above definitions stands out that the basic working mechanism of IF is to convert company’s assets into collaterals needed by the bank in order to grant a loan. Thus, firms can more easily get a loan with also a lower interest rate applied by the financial provider. Summarizing, IF is about a short-term loan granted to a company whose inventory serves as collateral for the bank. Hence, if the business can not repay the loan, the financial provider will become the owner of the collateral.

Concluding, an IF solution may be very useful especially for businesses which have positive CCC. In fact, lacking in working capital to carry out daily operations is one of the main problem faced by a budget constrained business. Thus, IF allows these “in trouble” firms to enhance their cash flows and consequently to reduce their own CCC.

1.4.2 Inventory Financing: European and Chinese situation

Although SCF has grown rapidly during the past few years, it remains a category of trade finance solutions that is still in an early stage of development. For instance, the survey “Securing Growth, Supply Chain Finance”, conducted by Demica20 in May 2010, shows that only 25% of European corporations were using SCF solutions (however this was a strong

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20 Founded in 1992, Demica is a world expert in providing working capital solutions to medium and large companies. It provides working capital solutions for banks, private equity sponsors, corporations and financial institutions in the United Kingdom and internationally. It specializes in offering securitization, supply chain finance (SCF) and invoice discounting solutions.
increase from the previous year, when only 15% of respondents declared to use SCF solutions). In Italy, as in Europe, there are not many businesses that provide and benefit from solutions of SCF. In fact, basing on the results obtained by the Osservatorio Supply Chain Finance, Politecnico di Milano (2015), companies that take advantage of SCF techniques should be about 500, where the majority of them just use traditional solutions, without focusing on innovative ones. As previously said, in Europe the use of SCF applications is steadily growing, however the concept of IF is still as immature as necessary. If we consider the European pharmaceutical industry, as shown in the case study “Inventory Financing through Logistics Service Provider” provided by Technische Universität Darmstadt (2010), a lot of firms have a very high inventory situation and the majority of them are also interested in methods to increase liquidity, so IF would be the most suitable solution that these companies can adopt (see Figure 1.13). But, IF is still in an immature stage of implementation since just 4% of the entire pharmaceutical industry has already benefited from it.

Figure 1.13 - Current IF practices in Europe by Technische Universität Darmstadt (2010)

In China the situation is completely different, in fact the adoption of SCF solutions is more common than in Europe and the IF is one of the first source of financing adopted by Chinese SMEs. As in Europe, SMEs are playing an important role in the Chinese socio-economic infrastructure, such as providing more jobs for the community, contributing to national tax
incomes and improving the overall economy of the country (Hua, “Supply Chain Perspectives and Issues in China”, 2011).

According to Zhang (2008), in 1979, Chinese private-owned enterprises only accounted for 1% of the country’s total GDP, but at the end of 2001, 99% of the Chinese registered enterprises were small and medium sized, thus constituting a much larger GDP share (Gazette on Second National Census of Basic Units, 2003).

A recent publication by Liu et al. (2015), shows that the topic of SCF has much interest among Chinese academics: since 2005, more than 150 Chinese academic articles have been published on this topic. However, the authors conclude that SCF, as perceived by Chinese academics and practitioners, differs from the SCF view hold by mature markets. They identify two main factors that drives this development: the Chinese economy (i.e. rapid expansion in a developing economy) and current Chinese banking system (i.e. SMEs face serious financing constraints and legal restrictions).

As thus, the typical SCF solution that is implemented in China revolves around a tri-partite agreement between a bank, an SME and an LSP. In many of these implementations, a strong focal company participates in the arrangement, enabling the SME to assess affordable funding, based on the buyer’s creditworthiness.

Recently, there has been a significant improvement concerning the financial situation of the small-medium Chinese companies as claimed by Liu et al. (2015):

“In China the emergence of a supply chain finance solution in recent years has improved the situation: by pledging their movable assets, such as raw materials and consumer products, to banks as security, SMEs are able to borrow funds from banks from which they could not borrow in the conventional loaning system”.

From this last quote is clear and unchallengeable the fact that them are speaking about IF as main and more adopted SCF solution. Moreover, the “Chief Finance Officer” of a Chinese business magazine has stated in the article “2012 China Supply Chain Financing Demand Report” that more and more SMEs, which had been unable to pass the rating auditing and, as consequence, to obtain credit support, have now turned to the SCF approach. Likewise, CI Consulting reported that the scale of financing by SCF solutions in 2011 was 5.75 billion Yuan, increased now to 6.9 billion Yuan (registering a growth rate of 20%).

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21 CI Consulting is a leading professional institution in the field of industry research in China.
Concluding, Hofmann (2009) states that little research has been done on IF but, while this might be true for academic literature in the western world, in China this method of financing has been extensively used for over a decade. As example, in 1999, an LSP (i.e. China National Materials Storage and Transportation, CMST) joined forces with commercial banks to start China’s first inventory pledge financing business.

1.4.3 Players

Before describing the models, the most involved players should be introduced and specified. According to Hofmann (2009), for each actor related below are also presented its classic and common market objectives:

- **Supplier**: as a seller its first goal is to sell the products as fast as possible to transfer the ownership to the recipient. Another primary objective is to reduce the duration of tied-up capital. In order to achieve this last goal, the supplier has to shorten the time of payment, for example asking for prepayment or using a more aggressive way of managing outstanding receivables (reducing its DSO);

- **Buyer**: it is a customer and, so it wishes to assume ownership of products at the moment its demand occurs. Preferably, it not only seeks to determine the time but also the quantity of a delivery according to its needs. These goals help it to keep its inventory capital costs low and to reduce its DII. At the same time, the customer tries to pay the supplier as late as possible in order to keep DPO as high as possible;

- **Financial Service Provider**: in 99% of cases they are banks and they want obviously gain a profit form the loan, thus, they first demand a risk-adjusted price for the provided debt capital in the form of interest rate and second, they want to ensure that the underlying counterparty risk does not deteriorate beyond priced expectations (i.e. migration risk) to avoid credit events causing default;

- **Logistic Service Provider (LSP)**: it is interested in process such as transportation, warehousing and distribution. Obviously also it wants punctual payments of invoices by their debtors. Under equal conditions the LSP does not have a preference for a specific party as debtor (the service provider will favor the party with the lowest transaction costs and the lowest default risk as debtor). Thanks to IF, LSPs also pursue market-oriented goals offering new value-added services.
1.5 Inventory Financing framework

The following paragraph is going to show and analyze the different methods of IF already available and studied in the literature. After a thorough analysis of the literature, we observed that IF is a technique that can be adapted to different marketplace situations. First, taking inspiration from Chen and Hu (2011) we decided to classify IF solutions in three main categories, namely: Traditional model, Delegation model and Control model. Concerning the first two methods, they are already presented and quite deeply analyzed by the existing literature; whereas as regards the third one, the researches are still at an early stage and a final evaluation of the benefits is yet to be estimated.

According with the authors, the previously mentioned models refer to the influence that a Third Party Logistic (3PL) firm may cover into an IF solution:

- In the Traditional model the 3PL provides only the traditional logistics services when the capital-constrained company tries to borrow capital from the bank;
- In the second, Delegation model, the 3PL is aligned with the bank, thus providing together both an integrated logistics and a financing service to the capital-constrained company;
- In the Control model, the 3PL provides logistics services and trade credit financing to the capital-constrained company.

Finally, we consider important to point out that all models of IF (that will be proposed and studied in the next paragraphs) are solutions concerned and applied by Chinese companies. This because, as previously explained, the implementation of IF solutions in China appears to be much more advanced and mature than in Europe. Thus, we decided to focus ours researches and interests on Chinese SMEs that apply IF, but always trying to understand and to select all possible methods that could be replayed in Europe as well.

1.6 Traditional model

In this IF solution, the 3PL provides only traditional logistics services among the actors of the supply chain. An application of the Traditional model comes from Hofmann (2009), he describes this model from the supplier point of view (see Figure 3.2). The supplier is the budget-constrained firm, so it needs money to carry out its production, thus satisfying an
order coming from its customer. Moreover, it has not a so high bargaining power to be paid in advance or in a short time from its customer. Therefore, the supplier is forced to use an IF solution, which helps it getting an immediate loan from the bank in exchange for a quantity of stock as collateral (securities in the Figure 1.14). However, before granting the loan, the financial provider demands all the available information about both the company and the financed goods (type, amount, duration, price, etc.) in order to get a comprehensive overview; but, on the other hand, the supplier does not want to provide more information than necessary. Hence, Hofmann (2009) claims that this asymmetrical information distribution causes transaction costs in the financing service as well as higher financing costs for the borrower. At last, 3PL carries out just traditional logistics services: it moves the ordered good from the supplier to the retailer. Thus, concerning the financing topic, the 3PL covers a complete passive role in the model.

![Figure 1.14 - Flow of goods and cash in the Hofmann's Traditional mode (reviewed by the authors)](image)

Another application of the Traditional model is given by Chen and Cai (2011), their model takes into account a capital constraint retailer trying to implement an IF solution. Due to its budget limits, the retailer may limit its order quantity, thus it asks the bank to implement an IF solution with the purpose of borrowing funds, so it will be able to order the prearranged order quantity and to directly pay the supplier for the stock purchased. Also here the role of 3PL is passive and its payoffs depend only on the retailer’s order quantity. In this situation, bank may provide a loan contract to the borrower (the capital-constrained retailer) evaluating its credit risk based both on its initial capital and on the value of its inventory used as collateral. But in a traditional situation there is no device to screen the
information on the retailer’s initial capital, thus the latter can falsify its initial capital information and get a corresponding contract with the aim of increasing its profit. This is possible because the capital constraint firm may overstate its initial capital, thus getting a lower interest rate of the loan. Furthermore, the bank is not able to carefully monitor the collateral due to the low level of visibility on retailer’s processes.

To conclude, both this asymmetric information and low visibility between the bank and the borrower is the main limiting factor of the Traditional model. Thus, as shown by Chen and Cai (2011), banks might refuse to grant a loan under these conditions. This is also the main reason why, most of times, the SMEs are not able to borrow loans from a financial institution during the operations in supply.

1.7 Delegation Model

This solution is designed to solve the kind of issue present in the Traditional model, reducing significantly both the asymmetric information and the low visibility between lender and borrower (Chen and Hu, 2011).

The poor visibility level and the asymmetric information about flows, data and initial capital may break the balance between the actors and move part of revenue from the bank to the borrower. Hence, the bank can not get its expected return from a loan and, as a consequence, some banks might leave the financial market because of too high credit risk, thus hurting capital-constrained firms. Chen and Cai (2011) confirm and demonstrate the existence of this crucial problem affirming that:

"Under asymmetric information, the budget-constrained retailer has an incentive to overstate its initial budget to the bank”.

The above definition occurs because the bank would charge a lower interest rate on the loan if the retailer has a higher initial budget that imposes a lower risk for the bank (as Figure 1.15 shows, interest rate decrease when the initial capital increase). Thus, under asymmetric information (that occurs especially during the Traditional model), the retailer may take advantage of this characteristic and deliberately report a false but higher initial budget.
In the Delegation model, 3PL assumes an important role because it helps the bank sharing borrower’s real information and/or tracking liquid collateral of loan (e.g. inventory). Thus, the problem solved by Delegation models is that the borrower has no longer the chance to overstate its initial capital and at the same time the visibility, between lender and borrower, increases thanks to the 3PL’s monitoring service. However, the retailer may divert funds in loans to a higher risk project, leaving the bank with a higher risk. Hence, the bank would be unwilling to offer loans to the capital-constrained actor if she has no effective approach to monitor the borrower’s real procurement behavior (Chen and Hu, 2011). This issue will be solved by Control model, where the bank will grant to a capital-constrained actor a trade credit instead of a traditional loan.

To conclude, Chen and Cai (2011) bear that under asymmetric information of borrower’s initial capital, in the Delegation models the 3PL might force the borrower to declare its real information and help to achieve the equilibrium into the entire supply chain.

1.7.1 Characteristics of the Delegation Model

In the Delegation models analyzed in the literature, there is always the presence of all the four actors introduced before (supplier, buyer, bank and 3PL).
Particularly, the features and functions of each of the above players characterize different applications of the Delegation method.

The analysis of the literature highlights that in all the studied situations there is always the presence of just one actor with budget limitations (obviously this actor has to be chosen between the supplier or the buyer/retailer).

This first feature of the models is also one of their main source of differentiation, indeed we will talk about "Delegation model with supplier budget-constrained" and "Delegation model with buyer budget-constrained".

Summarizing, there is a case where the borrower is the supplier, while in the second situation it is the buyer, but in both cases the borrower is always considered as a SME.

In both cases, as confirmed by Li et al. (2012), the budget-limited firm, in order to obtain the loan, has to pledge inventory (e.g. raw materials, semi-finished or finished products) that will be take as collateral from the lender: the borrower usually brings goods (such as productions which it has already produced but can not be converted into cash immediately or some raw materials which it has already purchased but can not be used in a short time) into a certified warehouse monitored by a reputable third-party (usually a 3PL) which has an agreement with the bank. Alternatively, the borrower can also use his own warehouse, but the pledged goods must be under the supervision of the third party logistics enterprises. The loan granted by the bank is defined considering the borrower’s financing precondition, such as initial capital, pledged collateral and bankruptcy risk.

According to Luo and Ying (2010), a second important feature, common to both models, is concerning the role and function of the LSP. The latter carries out the role as a collateral management company, in fact it is also responsible for operating the warehouse by monitoring goods, managing inventory and arranging goods transportation; in other words, it carries out a value assessment of the borrower’s movable asset. The LSP, through issuing a warehouse receipt containing all the details about collateral situation, ensures to the bank the real-time value of the pledge.

Below, the Figure 1.16 represents an excellent sketch of a Delegation model that summarizes all the main processes and actors’ rules, showing the players involved and their behaviors in this type of IF collaboration.
With this type of solution, IF could both solve the difficulty of SME financing and decrease the bank’s risk at the same time. Buzacott and Zhang (2004) in their article “Inventory management with asset-based financing” tried to incorporate asset-based financing into production decisions. Using a simple deterministic model, they proved that with the SME’s assets mortgaged in the warehouse as a security base, both the bank and the SME borrower can expect less risk and bigger gain with lower interest borrowing rate than unsecured financing.

In order to better understand the relationships between production and financing decisions, according to Y. Yin et al. (2009), it is necessary to analyze the IF contract that is drawn by actors. The key factor of the contract, that has the aim of determining whether the asset-based financing could operate effectively, is the loan-to-value ratio which is strictly influenced by the collateral marketability.

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22 Loan-to-value ratio is the ratio of the face value of loan to the collateral value pledged against the debt. This ratio is included between 0 and 1. Thus, at time zero, bank grants to borrower an amount of money corresponding to the quantity of collateral multiplied for its unit price multiplied for a coefficient, that is precisely the loan-to-value ratio. This coefficient is applied by the banks in order to hedge themselves from the risk of the market value fluctuation of the collateral. According to Li et al. (2006) the loan-to-value ratio is positively correlated to the level of risk tolerance of the bank and to the frequency of marking to market used for checking the spot price of the collateral. On the other hand, it is negatively correlated to the price volatility of the collateral and to the annualized default probability of the borrower.

23 Marketability: the marketability of a product is its ability to not lose value over time and thus its ability to be resold at the same price during its cycle life. This aspect is very important for the determination of the loan-
At last, IF can be seen as an effective method to solve not just borrower’s financing difficulty but also a way to improve 3PL’s profit. 3PLs, which decide to differentiate themselves adding to their classic logistic role this new “collateral management” function, can be more profitable and gain more profit attracting and catching more clients.

1.7.2 Buyer budget-constrained

Now, we are going to introduce the case where the borrow firm is represented by the buyer among the supply chain players. The literature analyzed shows that this is the most studied situation, indeed several authors develop an IF model in this circumstance. The following paragraph is going to describe different IF models, explaining also in detail their processes, structures and relation between the actors.

Model I
The retailer faces a situation similar to the classical newsvendor situation, where it purchases a single product from the manufacturer and then starts to sell it to its customers (without knowing the actual demand of the product at the time of purchasing). The most common and practical problem is that the retailer is capital constrained in the procurement process. In order to ease its financial situation and to settle on time payments it chooses IF as a means to rectify its lower creditworthiness. This type of financing can help to free up some of the cash that the capital-constrained corporates have tied up in inventory, thus facing more pressing needs.

Y. Zhang et al. (2007) assume that the retailer has an initial level of inventory $q_0$, but at the same time has no fixed asset such as land, machinery and buildings to use as security for to-value ratio. In fact, if the borrower fails the, bank will have to sell the collateral in order to regain the lost money. But, if the value of the collateral is less than the initial, the bank will get less money than expected. Furthermore, it is possible that the bank fails to sell the collateral because it is specific to a particular company or sector.

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24 Newsvendor situation is the problem of controlling the inventory of a single item with stochastic demands over a single period. This problem is also known as the Newvendor Problem because the prototype is the problem faced by a newsvendor trying to decide how many newspapers to stock on a newsstand before observing demand. The newsvendor faced both overage and underage costs if he orders too much or if he orders too little. The Newvendor Problems is therefore the problem of deciding the size of a single order that must be placed before observing demand when there are overage and underage costs.
the loans. This reflects the situation of most of SMEs that want to finance their processes just using loans secured by their inventory.

Now, we are going to describe (see Figure 1.17) each step of the model described by Y. Zhang et al. (2007).

![Figure 1.17 - Inventory Financing solution by Y. Zhang et al., 2007 (reviewed by the authors)](image)

**Process:**

1. At the starting period, the retailer chooses the order quantity $q$ that it will order from the supplier;
2. The retailer mortgages his inventory $q_0$ to the bank placing it into a warehouse handled by a 3PL (previously agreement between 3PL and bank);
3. 3PL analyzes the pledging goods and sends all the details and information to the bank;
4. The bank decides the “loan-to-value ratio” ($0 \leq t \leq 1$), according to the mortgaged asset, in order to maximize its revenue and grant the loan $tcq0$ to the retailer (assuming that the bank chooses the wholesale price $c$ as per-unit value of the asset);
5. After obtaining the loan, the retailer can order $q$ from the supplier paying $cq$ in advance;
6. The supplier sends good quantity $q$ to the retailer;
7. After receiving the goods, the retailer starts to sell them to the market earning its profit;
8. The retailer now is able to pay back the loan (with the interest) to the bank;
9. The bank advises 3PL about retailer loan payment and authorizes the logistic operator to return the pledging goods $q_0$ to the retailer.

**Model II**

L. Yin et al. (2010) suggests another case that perfectly suits the application of an IF solution. They refer to the clothes supply chain, where the supplier provides a product (e.g. fabrics, cloths, etc.) to a clothing manufacturer (i.e. buyer) with stochastic demand.

Below some characteristics of the actors involved in this model:

- The manufacturer own funds can not meet the manufacturing demand, thus, to ensure its production, it has to resort the external financing from some financial institutions;
- For the bank, it has to carefully consider the risks of providing loans to enterprises, especially if the enterprises are SMEs;
- The supplier also hopes to sell as more materials as possible in case of the manufacturer has the financial security.

In order to achieve a win-win situation, the supplier, the manufacturer, the bank and a 3PL negotiate a multi-parties contract, which is known as IF.

In order to better understand how the entire IF process works for the apparel supply chain in the Figure 1.18 are represented all the financial, informational and material flows.

![Figure 1.18 - Inventory Financing process (L. Yin et al., 2010)](image-url)
**Process:**
The clothing manufacturer submits the pledged loan applications to the bank (step 1); after this request, a multi-party agreement has to be signed (in addition to the manufacturer and the bank, also the supplier and a 3PL are included in the agreement) because the bank must fully investigate the manufacturer’s pledge and its partners’ credit level in the supply chain. The agreement should contain pledge selection, profit distribution and other mechanisms (step 2).
The clothing manufacturer transfers the selected pledge to the specified warehouse in accordance with the agreement (step 3).
The next stage (step 4) is the trigger point that differentiate this model from the others IF solutions: here the bank pays in advance the supplier on behalf of the manufacturer (the bank grants a trade credit against the manufacturer); thus, the buyer has the guarantee that the supplier can receive the payment for goods safely and rapidly, so the buyer can receive the needed raw material in time.
After receiving the payment, the supplier delivers goods to the buyer (step 5). The received goods will be manufactured and after sold by the clothing manufacturer that will start to repay part of the loan (step 6).
Every time the buyer pays back part of the loan, the bank will send the payment information to 3PL (step 7), so the latter can return the appropriate amount of collateral to the clothing manufacturer in order to continue its production or sales activities (step 8).
At this point, the process undergoes in a loop (step 9): repeating steps 6 to 8, until the clothing manufacturer redeems all the collateral and pays off the pledged loan, this is a termination of the agreement.
If there is default of the contract, transfer to (step 10): in this situation, the collateral would be repurchased by the supplier or be sold at low prices by the bank.

**Model III**
Yan and Sun (2013) analyzed an IF system with a manufacturer (i.e. supplier), a bank and a capital-constrained retailer under demand uncertainties and where the pledged goods will stay in the borrower warehouse and not in 3PL’s one, even if the latter constantly supervises and monitors the collateral on behalf of the bank (see Figure 1.19).
Yan and Sun focus their work in particular on the bankruptcy risk of the retailer and how the bank could bypass it.
The IF implementation process is similar to the previous models except for the location where are placed the pledged goods. The retailer has an initial capital $Kr$, but its budget limitation in the procurement process causes a capital gap $B(q)$. Through an IF solution, it carries on the request for a loan (pledging the warehouse receipt which is issued by the logistics enterprise and accepted by the bank). After evaluating the collateral and the retailer’s credit rating, the bank may set a suitable scheme of loan size $L(\theta)$ at a given interest rate $Rr$ considering both the financial risks (e.g. depreciation, bankruptcy) and operational risks (e.g. dead stock, stock-out). When the retailer gets the funds, it is able to place an order of size $q$ at a cost of $w$ per unit to the manufacturer (without knowing the actual demand $x$). Obviously, if the real demand will be too low, the retailer would have a large backlog of inventory, which may result in low revenues. In this case, the retailer would not be able to repay the loans and would face the risk of bankruptcy. If the retailer faces a bankruptcy risk and its revenues are insufficient to cover the loan, the bank undertakes the bankruptcy risk and will have the priority of liquidation of the collateral (acquiring all the sales revenue of the retailer). Moreover Yan and Sun (2013) formulated a multi-level Stackelberg game\(^{25}\) in

\(^{25}\) Stackelberg game, also called Stackelberg duopoly, is a model of imperfect competition based on a non-cooperative game. It was developed in 1934 by Heinrich Stackelberg in his “Market Structure and Equilibrium” and represented a breaking point in the study of market structure, particularly the analysis of duopolies. In game theory, a Stackelberg duopoly is a sequential game. There are two firms, which sell homogeneous products, and are subject to the same demand and cost functions: one firm, the leader, is perhaps better known or has greater brand equity, and is therefore better placed to decide first which quantity $q_1$ to sell, and the other firm, the follower, observes this and decides on its production quantity $q_2$. 

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Figure 1.19 - Framework of a SCF system with limited credit (Yan and Sun, 2013)
which the manufacturer acts as the leader and the bank as the sub-leader. Considering the bankruptcy risks of the retailer, they analyze the optimal credit line for the commercial bank, the optimal order quantity for the retailer and the optimal wholesale price for the manufacturer, respectively:

- The retailer’s optimal order quantity in traditional supply chains is dependent on cost and revenue parameters only (Cachon, 2003). However, the retailer’s optimal order in an Inventory Financing solution also relies heavily on the financial interest and credit line, as it determines its financing cost and bankruptcy risk;

- The bank’s optimal credit line for the capital constrained retailer is dependent not only on the borrower’s financial conditions (e.g. initial capital) but also on its operational parameters (e.g. retailing price, order quantity, wholesale price), because for example the bank might set a relatively lower credit line to respond to higher orders:

  “Under the given initial capital, the more the retailer orders, the bigger the capital gap will be, and the more the retailer would wish to borrow from the bank, the higher the insolvency risk would be. Hence, a rational bank would choose a lower credit line to reduce the loan size” (Yan and Sun, 2013).

  This shows again that exist an inextricable relationship between operational decisions and financing decisions;

- As the leader of the Stackelberg game, the manufacturer would not only rely on the retailer’s best response, but also on the bank’s response. Hence, the manufacturer’s optimal wholesale price relies on both operational parameters (e.g. production cost, retail price, optimal order) and financial parameters (e.g. interest rate, credit limit).

### 1.7.3 Supplier budget-constrained

Many SMEs are manufacturers who export their products to other buyers. Often, the latters are larger and therefore may have a stronger bargaining power against the exporter, thus, it happens that the supplier can find difficulties handling its cash flow (Spina, 2012). Afterwards, a likely consequence is the supplier renunciation of some orders due to lack of
funding; this situation can also lead the supplier to lose the customer, which is the worst damage an exporter may suffer. These problems also reverberate throughout the supply chain that will suffer a loss of effectiveness and efficiency.

About the previous situation (buyer budget-constrained) the literature figures out several applicability releases, whereas about the current circumstance, where the actor with liquidity problems is the supplier, we did not find many variants, so we are going to show just the main case of this situation.

The case of IIG Capital LLC26 (see Figure 1.20) perfectly suits the situation we are going to analyze: the supplier’s pledged inventory is stored in a certified warehouse, monitored by a reputable third-party collateral management company, and released only when financial institution (IIG Capital) is repaid directly by the off takers.

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26 IIG Capital LLC is the trade finance affiliate of The International Investment Group (“IIG”), an investment management firm founded in 1994 and a registered investment advisor with the SEC since 1995. Since 1997, IIG Capital has specialized in trade finance, one of the original forms of credit, with a focus on emerging markets. It is instrumental in providing financings to small and medium-sized merchants, traders and processors with a need for supply chain financing. IIG Capital is headquartered in New York City, but has representatives around the world.
Describing the process, at first the supplier puts part of its manufactured goods as mortgage in the 3PL’s warehouse authorized by a bank (step 1). Now the 3PL is responsible for operating the warehouse by monitoring goods, managing inventory and arranging goods transportation from the suppliers to the buyers. When all the analyses are conducted, the 3PL issues a mortgage receipt (step 2) to the bank which is now inclined to grant a loan in favor of the supplier (step 3). Of course, the financial institution will require frequently inventory inspection certificates to the collateral management company to ensure that the inventory is properly collateralized. To conclude, buyers holding that receipt owns inventory covered by it, and pays the receipt directly to the bank (step 5), in this way they pay a portion of the supplier’s loan.

Trying to explain the above situation in a more detailed way, we rely on the document written by Y. Yin et al (2009), which describes the same process but thoroughly investigating every single step (see Figure 1.21). They also put strong emphasis and attention on the possible problems and difficulties that players may encounter in each stage of the process.

![Figure 1.21 - Framework and step of Inventory Financing (Y. Yin et al., 2009)](image-url)
<table>
<thead>
<tr>
<th>Step</th>
<th>Description</th>
<th>Possible difficulties</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Store goods: supplier stores goods in the 3PL’s warehouse in order to get a loan from the bank;</td>
<td>Reliability: delivery on time; Uncertainty of demand – demand from the buyer directly affects the amount of the loan and thus the goods to be mortgaged;</td>
</tr>
<tr>
<td>2</td>
<td>Apply for loan: supplier applies to the bank (linked with the same 3PL) for a loan;</td>
<td>Possible failure to get a loan: a lot of possible risks contribute to fail this step (this failure is mainly caused by insufficient credit history or warrant);</td>
</tr>
<tr>
<td>3</td>
<td>Supervise and monitor goods: the 3PL performs regular warehouse service on the collaterals, including supervision, maintenance and ensuring the minimum/safety inventory;</td>
<td>Cost of storing goods in 3PL’s warehouse; Damage and corruption of goods during storing in the warehouse may cause bad quality; The quantity of collaterals in the warehouse may decrease below the safety amount for a loan. The 3PL should strictly monitor and manage the collateral quantity;</td>
</tr>
<tr>
<td>4</td>
<td>Issue the receipt;</td>
<td>Without the satisfactory receipt issued by the warehouse, the bank may not grant a loan;</td>
</tr>
<tr>
<td>5</td>
<td>Sanction a loan: after receiving the receipt, the bank authorizes granting a loan to the supplier;</td>
<td>The bank may not grant a loan based on the credit of the suppliers and buyers;</td>
</tr>
<tr>
<td>6</td>
<td>Deliver goods: the 3PL directly transports part of the collateral from the warehouse to the buyers;</td>
<td>Transportation: late deliveries due to lack of communication, traffic jams or wrong carriers selected; Unqualified or wrong goods are sent back; Improper delivery causes the collaterals are below the agreed minimum amount;</td>
</tr>
<tr>
<td>7</td>
<td>Store the loan: after or at the same time of receiving goods from the warehouse, buyers pay by depositing payables to the bank, rather than directly to the supplier;</td>
<td>Failure to pay on time due to the buyer’s financial problems; Due to the currency exchange rate fluctuation over certain time period, the collateral might depreciate when paid;</td>
</tr>
<tr>
<td>8</td>
<td>Subtract the supplier’s loans: the buyer literally pays the bills for the supplier. After a circle completes, the bank now can advance more cash to the supplier;</td>
<td>Because it is a bank’s inner transaction, there is no risk in this state concerning the whole supply chain;</td>
</tr>
</tbody>
</table>
1.8 Control model: Joint LSP-Bank Financing

Due to globalization, the amount of time spent and the amount of capital tied up in transporting goods around the world is increasing (Gomm, 2010). However, many financial institutions do not include the inventory in-transit in the borrower’s lending base or collateral (Cao and Zhang, 2013). This makes it difficult for smaller companies to obtain working capital to overcome the financing gap before buyers pay for the goods. Even when financial institutions do consider in-transit inventory as part of the lending base, the small company will most likely receive less than optimal interest rates. This is because financial institutions are not specialized in offering in-transit inventory financing and the risks incurred are deemed greater than the general risk appetite of financial institutions (Cao and Zhang, 2013).

In trade finance, this difficulty in financing was identified early on and pre-export finance was designed to meet the needs of small exporters and raise financing for inventories in-transit. With the increasing digitalization of goods flows, new financing opportunities have emerged for inventories in-transit. An important role is reserved for a third-party logistic (3PL) firm or logistic service provider (LSP). Because LSPs already have access to relevant information on supply chain activities and material flows, they are highly suitable for this type of financing activities (Chen and Hu, 2011).

Based on the definition of SCF, the 3PL firm plays an important role, since it is able to access several and different information, that are generated by supply chain’s activities, and then marry this information with the material flows.

The coupling of information and material flows enables lenders to mitigate financial risk within the supply chain, thus reducing the credit risks of the financing service. The mitigation of financing risk allows capital-constrained firms in the supply chain to get funds and, at the same time, to raise more capital at a lower interest rate.

Chen and Hu (2011) define the “integrating logistics and financing service (ILFS)” as an alliance between a third party logistics firm and a financial institution generating a new type of player in the Supply Chain which is now able to provide concurrently both logistics and financial solutions to capital-constrained companies. Thus, ILFS means that 3PL firm provides not only logistics services but also financing service to the retailer (in the Control model we mainly focus on the situation where the budget-constrained actor is the retailer/buyer and not the supplier).
While the retailer has insufficient capital to order directly from the supplier, the 3PL firm procures the products from the supplier for the retailer through trade credit financing and then transports them to the retailer, thus, in addiction the 3PL firm can effectively track and monitor the whole transaction of the products.

The literatures considering jointly operations and financial decisions in the SCM area are increasing, but just few literatures characterize the value and the role of 3PL firm in the supply chain with capital constraint. Hofmann (2005) introduces some conceptual insights about the 3PL’s role in an IF solution, but the first analysis on ILFS topic is made by Chen (2008) which examines the value of a 3PL firm with integrated logistics and financing services and by Lu et al. (2009) which inspected the incentive of third party logistics to provide also financial support along the supply chain.

Finishing, Chen and Cai (2011) investigate an extended supply chain model with a supplier, a retailer, a bank and a 3PL, in which the retailer has insufficient initial budget and may borrow or obtain trade credit from either a bank (named Traditional Role) or a 3PL firm (named Control Role). Their analysis indicates that the Control Role model leads to higher profits not only for the 3PL firm but also for the supplier, the retailer and the entire supply chain.

The article written by Chen and Hu (2011) faces two main problems concerning the topic of the information symmetry level between the borrower and the lender.

Under asymmetric information, the bank might refuse to offer financing service to the capital-constrained firm, the main reasons lie in two factors:

\[ \text{Problem I.} \quad \text{The borrower has the incentive to overstate its initial capital} \]
\[ \text{Problem II.} \quad \text{The borrower could divert the loan to projects with higher risks} \]

In the Traditional model, the 3PL provides just transportation service and does not provide any screening effect, so both the Problem I and Problem II appear in the Traditional model, where the bank has very low visibility on the borrowing company processes, flows and data.

The Delegation model acts as an evolution of the Traditional one, indeed the bank starts collaborating with a 3PL firm which becomes more important along the supply chain because it plays a more meaningful role in the financing process. The result of this alliance is a higher level of symmetry information between the bank and the borrowing firm because the 3PL can monitor the transactions of products from the supplier to the retailer.
Consequently, as we have already mentioned, the retailer will have no longer the possibility to falsify its cash flows with the purpose of overstating its initial capital. However, in the Delegation model the second problem is still present because lenders have not yet figured out some ways to keep far the capital-constrained companies from diverting the loan to other riskier projects.

Further development of Traditional and Delegation models leads to the most recent definition of the Control model where 3PL and bank act as a single actor, offering directly trade credit to the budget-constrained retailer.

In the Control model, as in the Delegation one, the Problem I is solved by the high level of visibility between lender and borrower. The innovative feature of the Control model is that financial provider offers trade credit and no longer a loan, in this way it can also control where are placed its money, to whom the funds are addressed and how much money are needed by the retailer to satisfy its orders. Moreover, all the goods financed by trade credit must be moved just inside the logistics network of the 3PL.

Acting as a conductor of all flows, the 3PL is able to solve also the Problem II because the retailer has to declare sincerely private information and data of its initial capital and moreover has no longer any chance to divert the capital loans to other riskier project because the lending fund goes directly from the 3PL to the supplier (Chen and Hu, 2011).

**Real case: Chinese Material Shortage Transportation Group**

Chinese Material Shortage Transportation Group (CMST) is one of the largest logistics enterprises in China. Many small and medium size paper manufacturers in Mainland China purchase materials from international suppliers. It is not uncommon that the financial system is unable to provide adequate services to support these manufacturers though they are short of capital. As a result, most of these small manufacturers find themselves making suboptimal procurement decisions. CMST viewed this gap as a business opportunity and, since 2002, started financing these small paper manufacturers to buy paper materials from international suppliers while simultaneously providing the logistics services required in these transactions.
According to the Control model descriptions found in the literature, especially in the article “The value of Supply Chain Finance” (Chen and Hu, 2011), and also on some real cases (e.g. UPS Capital), we have reported a possible general model in order to clarify how the Control model could functionally work (see Figure 1.22).

Under this credit contract, the paper manufacturer pays a fraction of the wholesale price charged by the supplier as a deposit and CMST covers the difference. After the sale season, the manufacturer repays CMST the remaining fraction of the wholesale price. With this supply chain financing service, CMST has become one of the leading logistics-financing service providers in China. As the CMST example unveils, bringing financing services into supply chain management has the potential to improve the operational efficiency and the profits of the entire supply chain.
Process:
The budget-constrained retailer is not able to totally satisfy the market demand, thus, it requires funds to a financial provider which is no longer the bank but a 3PL (step 1). The financial and logistic operator starts to analyze and evaluate some particular characteristics of the retailer such as its revenue, the type of goods it wants to import from the supplier and also the its location. After, if the evaluation gets a positive feedback, the 3PL will confirm and accept retailer’s request of credit (step 2). With the 3PL’s aid, now the retailer can place the order to the supplier (step 3) which will be paid in advance or after the goods shipment (depending on the agreement) by the 3PL (step 4). According to the reviewed literature it’s important to reveal that the 3PL usually doesn’t pay all the amount of the order but about 50-70% of it, where the remaining unpaid part will be paid by the retailer.

The key point is that this solution enables small-medium importers to use their in-transit inventory shipments as collateral for loans, reducing the need to rely on paper-intensive letters of credit to finance international trade transactions.

The ordered goods, after supplier’s shipping, start moving just inside the 3PL’s distribution and transportation network until they arrive to the retailer (step 5); Often the goods are also managed by the 3PL for the downstream part of the retailer distribution system (step 6), this gives to the 3PL a more complete view and control on the process of the retailer.

After selling products, the retailer collects payments from its customers (step 7) and pays back the 3PL according to the terms of the trade credit line (step 8).

Most of SMEs global trade transactions are financed via letters of credit or cash in advance, with trading on open account terms typically available only to large companies (while letters of credit are time-intensive and costly, cash-in-advance transactions can strain cash flow for small companies). By adopting a Control model solution, a budget-constrained retailer can use its in-transit inventory as collateral for loans, reducing the need to rely on paper-intensive letters of credit to finance his international trade transactions. With quicker access to funding, the retailer (with 3PL’s aid) can pay its suppliers earlier. This last situation improves the relationships between retailer and supplier, because the latter often starts to apply a lower cost of goods, giving retailer the ability to increase inventory orders and potential sales volume with greater financial security.
Concluding, traditional financial service companies may be hesitant to lend against goods that are in-transit, this is one of the reason why just a 3PL firm, using his visibility and control along the chain, can offer it.

Chen and Cai (2011), give a quantitative demonstration that the Control model yields are better than Traditional ones.

“For the 3PL firm, retailer, and supplier, the control model outperforms the traditional model”

This proposition relies on the matter that in the Control model the 3PL more significantly shares the visibility of demand with the retailer while offering the trade credit and logistics services at the same time. Thus, the retailer benefits thanks to a lower interest rate, the supplier benefits thanks to a larger order quantity and the 3PL firm benefits because, integrating the financing and traditional logistics services, it differentiates himself from its competitor (Chen and Hu, 2011).

The Figure 1.23 shows how the interest rate ($r^*$) evolves with increasing of the borrow firm’s initial capital [B] in both Control model and Traditional model.

![Figure 1.23 - Interest rate in Traditional and Control models (Chen and Cai, 2011)](image)

It is clear from this figure that the interest rate is always lower in the Control model than in the Traditional one. The gap between these two different models increases as the initial
capital \((B)\) grows, which means the advantage of the Control model is more significant when the initial budget is higher.

Moreover, the optimal interest rate decreases in \(B\), because from the lender’s perspective, the financial risk decreases as the initial budget grows.

To conclude, as Figure 1.24 demonstrates, the supply chain profit\(^{27}\) \([\Pi]\) is always higher in the Control model than in the Traditional one.

The graph shows that the supply chain profit decreases at first and then increases as \(B\) grows, this because at the beginning the retailer (having a very low budget) tends to order a higher quantity because its maximal loss will be small due to its limited disposal, but increasing \(B\) the retailer’s risk also increases, hence, the order quantity will decrease to avoid a potentially huge loss.

After this initial reduction, the profit starts growing as \(B\) increases because the trade credit provider significantly lowers the interest rate; hence, the tradeoff between loss risk and potential financial benefit leads toward the latter.

When \(B\) is sufficiently high, the retailer does not borrow and the supply chain behaves the same as in the Traditional Model.

\[\text{Figure 1.24 - Retailer profit in Traditional and Control Mode (Chen and Cai, 2011)}\]

\(^{27}\) The overall supply chain profit includes the profits of the supplier, retailer, 3PL and/or the bank.
1.8.1 The case of UPS Capital

UPS Capital is the financial services business unit of United Parcel Service\(^ {28} \) and it offers traditional and non-traditional financial services and insurance products.

A real example of the previous described situation occurs with UPS Capital that enables smarter trade credit solutions through cargo and parcel insurance, trade finance and payment solutions.

UPS Capital offers a service, named UPS Capital Cargo Finance (UPS CCF) that typically traditional lenders aren’t willing to give (see Figure 1.25).

UPS CCF takes the risk of financing the in-transit inventory with an unsecured loan but, because the inventory moves within the reliable and efficient UPS network, UPS has the visibility and control necessary to provide financing.

Robert J. Bernabucci, ex-president of UPS Capital, said:

“Because UPS manages the shipment of the goods and provides visibility, UPS Capital is able to do something banks and other financial services companies may not be willing to do provide financing earlier in the transaction (...). Not only are payments to suppliers accelerated, but transit times for the receipt of goods also may be improved. The true value of an efficient supply chain can only be realized when the physical movement of goods is married with the efficient funding of those goods”.

![Figure 1.25 - Process and cash flows of UPS Capital Cargo Finance (UPS Capital)](image)

\(^{28}\) United Parcel Service (UPS) is the world's largest package delivery company and a provider of supply chain management solutions. The global logistics company is headquartered in Sandy Springs, Georgia. UPS delivers more than 15 million packages a day to more than 6.1 million customers in more than 220 countries and territories around the world.
There are several requirements that potential borrowers need to respect in order to get a successful result in the applying process of UPS CCF service: the principals are that the borrowing firm must be a U.S company (now this service is available just for borrower located in the U.S.) with an annual revenue over 2 $million (this last eligibility point perfectly suits SMEs characteristics).

UPS Capital Cargo Finance offers competitive advance rates up to 70% of the commercial invoice value of the in-transit inventory that must be moved just within the UPS distribution channels. UPS CCF extends credit lines of $300,000 to $750,000 with terms up to 60-75 days. Moreover, there is no need for letters of credit since UPS CCF issues a negotiable bill of lading once your inventory is loaded in an ocean or air-freight container.

Confirming the benefits achievable from this solution John O’Hare, CEO of Pedors, a U.S. company that has been using the service to finance imports for its orthopedic footwear business, said:

“Since implementing UPS Capital Cargo Finance into our supply chain, we have realized significant cash flow improvements and have streamlined the flow of goods within our supply chain (...). The best part is that we have strengthened our relationship with our Chinese supplier, enabling us to negotiate better terms because, with the help of UPS Capital, we are able to pay our supplier immediately rather than later in the transaction. As a small-business owner, having extra working capital can make all the difference as we look to grow and expand our business”.

1.9 Benefits of Inventory Financing

This section is going to describe the main benefits, emerged from the literature, that each actors of the supply chain could achieve applying an IF solution. At the end, there will point out also the benefits for the entire supply chain.

How can inventory financing benefit a SME?

- The first and most intuitive benefit is the possibility for SME to get financing even when banks deny it, indeed they might find this type of asset-based lending when they are turned down by a bank because of their poor credit history or inadequate cash flow. Thus, according to the IF process, SME can use current products as
collateral and get a direct availability of additional liquidity from a financial provider;

- SMEs can get assistance during periods of lagging cash flow: while retailers see an influx of business during a certain period of the year, there are other periods where sales may not be so high. During these times, cash flow could be lagging, which can make operating at normal levels difficult. Thus, businesses that run into these periods of slow cash flow can apply an IF solution to solve this problem;

- Another advantage is the opportunity for a SME to negotiate large discounts, indeed thanks to liquidity resulting from the implementation of an IF solution, retailer is able to order a larger quantity of products from its supplier, thus there is a highest probability to obtain a quantity discount;

- An additional and very important benefit is that the SME can increase its cash flow faster. According to Yan and Sun (2013), IF can effectively solve retailer’s financial constraints and improve the cash flow by getting funds thanks to the inventory. In fact, the average value of the retailer’s cash flow with inventory financing is 1.94 times higher than without financing, as shown in the Figure 1.26.

![Figure 1.26 - SME's cash flow under no financing and under IF (Yan and Sun, 2013)](image)

- Yan and Sun (2013) also highlighted another important benefit: with IF a SME’s stock-out level is close to zero. This because when the SME is without enough cash to place an order, it will face the risk of shortage. Therefore, adopting an IF solution, a SME will have sufficient cash flow to increase its order quantity, thus avoiding the risk of
stock-out. Figure 1.27 shows that the average stock-out without financing is 4.05 times more than with financing.

![Chart showing stock-out comparison](image)

**Figure 1.27** - SME's stock out under no financing and under IF (Yan and Sun, 2013)

**How can Inventory Financing benefit a bank?**

- According to Hofmann (2009), IF greatly reduces the credit risk for a bank thanks to the presence of a collateral, which becomes property of the bank in case the borrower fails. Moreover, banks can effectively better monitor the flow and implementation of the inventory pledge through the cooperation with the 3PL because the latter has more precise notion of the effective risks than external players, such as financial service providers, might ever have (3PLs usually have more information about turnover of goods, shipping lead-times and stock levels of the borrowing firm);

- Taking inspiration from Hofmann (2009), it is important also to stress that banks must pay attention on a particular parameter on which a lot of their benefits rely on: the marketability of the inventories. Indeed, unlike accounts receivables, inventory does not turn to cash by itself, it has to be sold. Moreover, the closer the inventory is to being a commodity item, the easier it is for the lender to sell it, so the higher will be the collateral value. Thus, work-in-progress or semi-finished goods, that require additional production activities to be converted in saleable merchandise, have limited liquidation value. For this reason, a shipper obtains easier an external financing for raw materials or finished goods than for work-in-progress or semi-finished ones.
How can inventory financing benefit a 3PL?

Applying an IF solution, 3PL can pursue market-oriented goal offering new value-added services (Hoffman, 2009), thus creating new competitive advantage.

Hence, new opportunities for creating a competitive advantage is the main benefit achievable by a 3PL which decides to introduce himself in an IF collaboration. Indeed, 3PL might play a key role thanks to its ownership of many information about actor’s turnover of goods, shipping lead-times and stock levels.

The LSP benefits from earning interest rates for carrying inventory in addition to regular logistics services (Chen and Cai, 2011). Especially when the inventories financed are close to a commodity item, the marketability of goods increases. This could result in higher collateral value because the risk perception of the financier is reduced, in this case the LSP (Lasher, 2013). By offering IF as an LSP, it can also enhance its attractiveness to both buyers and sellers. As a direct consequence the LSP can expand its market share at the expense of competitors and acquire new business revenues (Cao and Zhang, 2012).

Although inventory financing can deliver benefits to a LSP, the risks should also be managed accordingly due to the complexity. Yan and Sun (2013) identify four types of risks that are present in ‘logistics finance’ and should be taken into account by any 3PL that is considering offering this service:

- **Credit risks**: if counter parties fail to comply with contractual obligations, this can result in considerable losses. Default risks, market risks and earnings risks all come under this type of risk. Default risks are mainly caused by events that are unpredictable and have a large impact, for example natural disasters. Market risks result from price fluctuations of the goods financed. Finally, earnings risks are present if margins are not sustainable and firms are exiting the business;

- **Moral risks**: risks that come from fraudulent transactions, where false information is provided to hide the real state of affairs;

- **Legal risks**: these risks stem from two main factors. First, not all laws in jurisdictions are always clear and perfect when it comes to logistics financing and illegality clauses can occur. Secondly, the ownership pledge of the 3PL can be disputed and the validity of the pledge could be doubted on occasions;

- **Management risks**: these risks refer to inaccurate decisions, incorrect pledge management or errors in managing the operations by 3PLs and financial institutions.
How can inventory financing benefit the entire supply chain?

According to Yan and Sun (2013), in a pull supply chain system, manufacturer makes production decision based on the retailer’s order quantity. So, when the retailer is capital-constrained and it has no enough cash to order more, it will face a stock-out, reducing the output of the manufacturer as well.

![Figure 1.28](image.png)

Figure 1.28 - Manufacturer’s production rate under no financing and under IF (Yan and Sun, 2013)

Therefore, thanks to IF, the retailer can solve its shortage of capital and make a bigger order, thus avoiding the risk of stock-out. So, the growing of the retailer’s order quantity will automatically increase manufacturer’s output (as shown in Figure 1.26 where the average weekly output of the manufacturer with financing is 1.32 times more than without financing) and will enable him to expand production, thus getting more profit margin.

To conclude, we can say that IF scheme can greatly reduce the market stock-out rate, increase the retailer’s cash flow and enhance the manufacturer’s production, thereby improving the operational efficiency of the entire supply chain effectively.
1.10 Inventory Financing Matrix

In this final chapter we are going to outline what we said so far about IF. In order to compute this analysis, we will use a matrix (see Figure 1.29) constituted by three dimensions: 3PL’s influence, information symmetry and pledging presence. After a brief explanation of each dimension, we will try to insert the different Inventory Financing solutions in the respective boxes.

**Figure 1.29 - Inventory Financing MATRIX (created by the authors).**

1st Dimension: 3PL’s influence
This dimension indicates how strategic is the role covered by the 3PL firm within its supply chain. In particular, we want to describe how important is the 3PL’s role in adding value to all players and to whole supply chain as well.

According to Chen and Cai (2011), the 3PL firm assumes a growing relevance moving from Traditional model to Control model. In fact, in the first one the 3PL just provides traditional logistic services. In the Delegation model, the logistics operator is allied with a bank, helping the latter to track the liquid collateral of the loan and share the retailer’s real information. In the Control model, the 3PL firm provides both logistics services and trade credit financing to the capital-constrained firm. Therefore, we can consider the 3PL influence lower in the Traditional model, medium in the Delegation model and higher in the Control model.
2nd Dimension: Information symmetry
This dimension measures the level of information symmetry between the bank and the borrowing firm. The information symmetry covers a relevant role in the IF solutions because it is the variable that more distinguishes them (according to Chen and Hu, 2011). The level of information symmetry grows if we move from Traditional to Control model. In fact, in the Traditional model there is almost none information symmetry between bank and borrower so the latter can overestimate its initial capital (thus getting a lower interest rate), causing a high risk for the bank. In the Delegation model the level of information symmetry increases thanks to the collaboration between the bank and the 3PL firm. In this way, being 3PL firm able to track the liquid collateral of loan and share the retailer’s real information, the bank may grant more easily a loan to a capital-constrained firm. In the Control model, the joint 3PL-bank carries out a trade credit to the borrowing firm. In this last situation is achieved the highest level of information symmetry, in fact, the joint 3PL-bank knows exactly the destination of lent money (the borrower cannot divert the loan to projects with higher risks, as it could happen in the delegation mode).
Concluding, we can consider the information symmetry lower in the Traditional model, medium in the Delegation model and higher in the Control model.

3rd Dimension: Pledging presence
This dimension indicates the possible use of the pledging during an IF solution. According to what we have already described, the Traditional and the Delegation model use this type of instrument, instead the Control model does not need it. In fact, in the Traditional situation the bank asks to the borrower to freeze part of its inventories as collateral in case the latter will be unable repay the loan (according to Hofmann, 2009). In the Delegation model the situation is very similar to the previous one, but now the 3PL covers a more active role, indeed it takes care of pledging goods by storing and checking them on behalf of the bank. In the Control model, the collateral is represented by the “in-transit” stock, thus it is not present any kind of pledging thanks to the highest level of information symmetry, therefore a very low probability of losing money (according to Chen and Hu, 2011).

In the light of the above considerations, we may build a three-dimensional matrix where the three axes correspond to the three dimensions previously described. Each dimension can take on certain values only, that are “Low”, “Medium”, “High” for 3PL’s firm influence.
and information symmetry axes and “Yes” or “No” for pledging presence axis.
Concluding, in order to develop an easy and clear classification of different IF solutions, we may insert them in this matrix (see Figure 1.29).

1.11 3PL as Supply Chain Orchestrator

To date, in most SCF models, the role of a 3PL firm is either insignificant or non existent (Chen et al., 2015). This due to the fact the 3PL firm is generally considered as an auxiliary component of the supply chain. In fact, it usually covers the role of delivering purchased products from the vendor to the buyer, so the main contribution of the 3PL is the shipping process. However, according to Chen et al. (2015), the situation in the real world is changing since competition in the 3PL industry is intensifying and the shipping service alone no longer generates substantial revenues. Thus, as mentioned by the authors, 3PLs are looking for expanding their businesses beyond their traditional services. The roles 3PLs cover in the IF models are an evident example of this. More in details, we have shown as the 3PL’s role becomes increasingly important passing from the Traditional model, where it carries out only shipping, packaging and warehousing tasks, to the Delegation model, where it starts also helping bank in monitoring the pledged goods, and finally reaching the Control model, where 3PL carries out also financial services in order to grant a trade credit to the borrower without the use of any pledged goods. Chen et al. (2015), suggest that the latest evolution is to consider the 3PL firm as a supply chain Orchestrator. To better understand the meaning of this topic, we show three main real examples.

Case I: ETERNAL ASIA

First, they speak about the innovative procurement service provided by ETERNAL ASIA, a large Asian 3PL firm that offer a procurement service to Chinese SMEs (in particular retailers/buyers) since 1998, mostly buying components and parts from established manufacturers in the U.S. and Europe (e.g. Cisco and GE). Thus, ETERNAL ASIA collects orders from several buyers to the same supplier and submits the consolidated order to the manufacturer. With larger and more regular orders, ETERNAL ASIA is able to negotiate
more favorable payment terms from the supplier than the single buyers can achieve. In particular, instead of collecting the order payment from each buyer at the time the order is placed, the strong supplier allows ETERNAL ASIA to pay at a later time, usually after the products are delivered. When ETERNAL ASIA delivers the products to a buyer, he collects both the purchase payment and logistics fee from the buyer. Moreover, she can also extend the credit terms to the buyers. Therefore, the buyers do not need to communicate directly with the manufacturer, so the 3PL becomes the intermediary for both ordering and payments.

Case II: Li & Fung Ltd.
Second case concerns Li & Fung Ltd., an Asian 3PL firm that offer a global supply chain management mainly for US and EU brands, department stores, hypermarkets, specialty stores, catalogue-led companies, and e-commerce sites. Thus, when a client has a new style of garment designed for a particular season, for instance, Li & Fung Ltd. will find and work with the best suitable material supplier, garment manufacturers and logistics providers to deliver the final product to retail shelves on time. Moreover, in this process, Li & Fung Ltd. not only make sourcing and production planning, but also perform quality control and provide financing services.

Case III: PCH International Ltd.
The last example is about PCH International Ltd., an Irish custom design manufacturing company that, sourcing from its network of Asian suppliers, helps global technology firm manufacture and distribute their customized products worldwide. It also develops information systems to allow the clients’ customers to trace and track the product flow. In addition, it provides also financing services to cash-constrained supplier.

Concluding, thanks to these examples we can consider the 3PL firm as a kind of Supply Chain Orchestrator, meaning that it provides integrated procurement, logistics and financing services for its customers.
2 OBJECTS AND METHODOLOGY

In this chapter, we are going to show which are the objectives of our research and which is the methodology we have followed to pursue them. In order to do this in a clearer way, we have split this part in two sections. The former describes the objectives of our thesis in the form of research questions, instead the latter describes the methodology used in the different phases that have characterized the development of our thesis, starting with the analysis of the literature, through the development of the model and finally to its application.

2.1 Objects

The objectives of our research can be summarized in three Research Questions (RQ).

RQ1. How much does the supply chain benefit if the budget-constrained company implements an innovative Inventory Financing solution combined with a specific inventory policy?

In literature, there are several contributions showing the operational processes of the traditional and innovative IF solutions taken into account in our model (Chen and Cai, 2011; Hofmann, 2009; Liu et al., 2015; Zhang et al., 2007; Yin et al., 2010; Yan and Sun, 2013; Y. Yin et al., 2009; Chen and Hu, 2011).

Others references carry out a qualitative benefit evaluation for either a single (Li et al., 2012 and Luo and Ying, 2010) or more actors (Chen and Cai, 2011; Chen and Hu, 2011) in the supply chain where has been implemented a specific IF solution.

Moreover, there are several quantitative benefit evaluations concerning a specific topic, such as:

- comparison between supply chain profit gained by a traditional IF solution and an innovative one: in particular, Chen and Cai (2011) demonstrate that the optimal order quantity in the “Control Role” (considered ad an IIFS) is no less than in the “Traditional Role”; while the interest rate in the “Control Role” model is no more than in the “Traditional Role” one;
comparison between a no financing solution and an IF one: in particular, Yan and Sum (2013) demonstrate that an IF solution always exceeds a no financing solution concerning the manufacturer's production rate, the SME’s stock out level and cash flows;

• IF risk analysis from the 3PL’s perspective (Luo and Ying, 2010);
• evaluation of supply chain, market and currency risk after the implementation of an IF solution (Ying Yin et al., 2009);
• retailer bankruptcy risk evaluation from the bank’s perspective (Yan and Sun, 2013);
• relationship between the loan to value and the retailer initial capital (Zhang et al., 2007);
• collateral selection and pledge rate’s determination (Lina Yin et al., 2010);
• relationship between the retailer operational and financing decisions after having adopted an IF solution (Buzacott and Zhang, 2004; Yan and Sun, 2013).

We joined the operational processes with both qualitative and quantitative benefit evaluations already present in literature; this in order to create a general quantitative tool which has the purpose of computing the whole supply chain profit gained after that one of the players (the budget-constrained firm) has simultaneously implemented a specific Innovative Inventory Financing Solution (IIFS) and a specific inventory reorder policy, thus adding a new interesting contribution to current literature.

RQ 2. When does the Delegation Mode generate similar or even better benefits than the Control Mode?

According to Chen and Hu (2011), the Delegation model is an innovative solution of IF but not so innovative as the Control model, thus they present the latter as a better and more profitable IF solution than the former.

In this thesis, we deeply study and analyze both the solutions just mentioned above through the development of, respectively, our Delegation Mode and Control Mode. Implementing the model, we are able to investigate and discover whether exist some potential context where the DM could equal, or even overcome, the CM.

In particular, we reply this question by means of the application and the sensitivity analysis. In fact, feeding the model with real data (stemming from the external scenario the user has
to face) and then changing some values of these, we are able to figure out under which conditions DM generates similar or even better benefits than CM.

In other words, we provide to the current literature a quantitative tool that allows to compute which is the best innovative IF solution, given specific initial conditions, including which specific inventory policy is adopted by the budget-constrained firm.

**RQ 3. Does a specific inventory reorder policy, if combined with an Innovative Inventory Financing solution, affect the entire supply chain profit?**

We reply to this question by analyzing the benefits obtained by the supply chain after the budget-constrained player’s (it is the same actor who is implementing an IIFS) implementation of four different inventory reorder policies. Thus, we compute the supply chain profit gained through the combination between an IIFS and a specific inventory reorder policy. Moreover, by means of the sensitivity analysis, we are going to study how the results change if the variability of the demand varies.

### 2.2 Methodology

The methodology of the research is composed of three primary aspects which correspond to the sections of this paragraph:

I. the first shows the sources we used to develop and arrange the literature analysis;
II. the second refers to the followed methodology for the model development;
III. the last section describes the steps taken into account for the model application and for the sensitivity analysis.

#### 2.2.1 Literature Review

Considering the nature of the model, the literature review constituted a fundamental part of the whole process: from the formulation of the Research Questions, to the models developing and the conclusions drawing.
Since the topic of IF is quite recent, we investigated many sources: not only academic literature, but also journal articles, reports, specialized conferences reports, manuals or manual chapters, unpublished working papers, Master graduation theses, websites (see Figure 2.1) and expert advices.

The academic papers and the journal articles were the most used sources, so we consider worthwhile to describe more in detail which journals we have utilized:

- European Journal of Operational Research, (1);
- International Journal of Logistics Management, (3);
- International Journal of Physical Distribution & Logistics Management, (4);
- Information Technology Journal, (1);
- Journal of Applied Mathematics, (1).
- Journal of Business Logistics, (3);
- Journal of Business Venturing, (1);
- Journal of Operations Management, (1);
- Journal of Small Business and Enterprise development, (1).

**Figure 2.1** – Sources divided by category
2.2.2 Model Development

First of all, we would like to advise the reader that the methodology we follow, in order to develop the model, is shown in the Figure 2.2 (orange frame).

We start analyzing the literature review, figuring out what are the traditional and the IIFSs already presented and described in the literature. In order to better organize these solutions, we have decided to adopt the model classification used by Chen and Hu in their article “The Value of Supply Chain Finance” (2011). Thus, following their classification, we use the Traditional Mode to describe traditional solutions, whereas we use the Delegation

Figure 2.2 - Model development and Model application
Mode and the Control Mode to describe the innovative ones (respectively the Delegation model and the Control model).

These three models allow us to describe and group very well all the current IF solutions present in literature.

Hence, starting from the literature analysis, first we studied the processes of these three different IF solutions, understanding how they work and who could achieve better benefits after their implementation.

An important feature of our model is the matching of an IF solution with different inventory replenishment decisions. All the different inventory policies implemented in the model have already been strongly accomplished and used in real work situations, so we easily adopt them due to their high reliability.

Once all information and ideas are collected we start developing the model with the aim of building a tool capable to offer a quantitative benefits evaluation of IIFSs. The model is based on two main parts: the model development and the benefits assessment. The first one concerns the framework of the model, including all the parameters definition, the formulas computation and the processes advancement; in particular, the developed tool can be considered as a:

- **Parametric model**, because it is able to change the most interesting input data, thus understanding what happen to the supply chain profit if the context changes;

- **Discrete model**, because the activities between the actors may be better described using a discrete time bucket sequence rather than a continuous one.

Concluding, the second part of the model establishes the benefits achieved by each player and by the whole supply chain thereafter the budget-constrained company has simultaneously implemented an IIFS and a specific inventory reorder policy.

### 2.2.3 Model Application and Sensitivity Analysis

With the purpose to make a quantitative comparison between the Delegation Mode and Control Mode, we first carry out a practical application of the model and then, in order to understand the robustness of the pursued results, a sensitivity analysis of the same. With the purpose to make the reader’s understanding simpler, we represent the model application phases in the Figure 2 (purple frame).
To run the model application, we feed the model with real data stemming from case studies\(^1\), reports and academic documents\(^2\).

However, even if the application has been made using real data, the model is also based on assumptions which make the results an approximation of the reality.

Then we decide to deepen the research through a sensitivity analysis; in fact, we change the values of three different parameters that we consider as the most interesting ones\(^3\), namely:

- the market demand variability because according to our model it is the variable that mostly influences the results;
- the financial provider’s interest rate because it is the variable which more than any represents the financing component in the model;
- the quantity of goods available to be pledged because it is the trigger point for the majority of IF solutions.

Finally, being able to better compare different IIFSs, we compute the supply chain benefit for each different scenario, figuring out both where Innovative IF solutions achieve their best performances and where they perform similar results.

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\(^1\) In particular, we refer to: UPS Capital, SINOTRANS (China National Foreign Trade Transportation Group Corporation) and ICBC (Industrial and Commercial Bank of China), Schneider Logistics.

\(^2\) In particular, we refer to Fagiuoli and Graziosi, “Reverse Factoring: Benefits and Concerns Addressed with a Formal Method”, (2014).

\(^3\) According to the consultation of Prof. Xiangfeng Chen (Fudan University)
3 THE MODEL

The model we are going to introduce in this chapter is an assessment tool for the evaluation of different Innovative Inventory Financing solutions (IIFs), with specific reference to the most recent ones based on the collaboration between a LSP and Financial Institutions. The IIFs, subject of our model, are the Delegation Mode (DM) and Control Mode (CM), both follow the features of, respectively, the Delegation model and Control model presented in the literature review. Moreover, we have developed four different scenarios according to the inventory policy adopted by the budget-constrained retailer, so the model considers a specific combination of an IIFS and an inventory policy (as shown in the Figure 3.1). This detailed study of the model allows to manage a deeper, more realistic and especially more interesting analysis because the comparison of so many different situations gives us the chance to study and work on a wider range of possibilities and combinations.

![Model Diagram](image)

**Figure 3.1 - Framework of the model**

3.1 Model Introduction

Our model studies and analyzes, through a discrete and spreadsheet based approach, the possible benefits for a company which decides to introduce an IIFS. The output of the model is a comparison between DM and CM, identifying the best one. Chen and Cai (2011) in their article “Joint logistics and financial services by a 3PL firm” investigated the differences between a traditional IF solution and an innovative one
(Control Role), proving that the latter exceeds the performances of the former one. The outcomes of our model will represent a further investigation of the results obtained by Chen and Cai (2011) because we mainly focus on the differences between two IIFSs, considering the traditional solution just as a benchmark for the benefits assessment. Moreover, in order to make a deeper comparison between the DM and CM, we have also assessed the effects of four different inventory policies. This last study adds a totally new investigation level to the existing literature.

It is considered useful to use a framework IDEF0\(^1\) of the model operation (see Figure 3.2), in which are highlighted the input variables, the support information and the outputs in order to offer to the reader a further understanding.

![IDEF0 Model](image)

**Figure 3.2 - IDEF0 Model (developed by the authors)**

\(^{1}\) The IDEF0 Functional Modeling method is designed to model the decisions, actions, and activities of an organization or system. Each activity is described by a verb-based label placed in a box. Inputs are shown as arrows entering the left side of the activity box while output are shown as exiting arrows on the right side of the box. Controls are displayed as arrows entering the top of the box and mechanisms are displayed as arrows entering from the bottom of the box.
**Inputs**

The model has two main inputs, the first one are the features of the market in terms of weekly demand (with the respective variability and possible trends). The second input concerns the financial data that characterize the supply chain actors. More specifically, the model requires a description of the chain players through different variables, including:

- Financial data as purchasing and selling prices, transformation costs, order costs, transportation costs and stock maintenance rates;
- Cash to Cash Cycle, stated in all its components: Days Payable Outstanding (DPO), Days Inventory Holding (DIH) e Days Sales Outstanding (DSO);
- Other operative parameters such as interest rates, loan-to-value ratio, loan payback time, budget for purchasing, service level and delivery lead times.

**Controls**

The aspects, essential for a correct interpretation of the outputs, which influence the model can be grouped in three different levels:

- Socioeconomic scenario: the reader has to consider that the model better suits a small or medium company situation than a big enterprise one;
- Source of data: in order to keep the model reliable, information can be detected by financial statements or can be collected, in the form of operating data, by interviews or surveys;
- Point of view for the analysis: it is crucial to understand that the model is focused on the budget-constrained firm’s point of view, but the final solution obtained by the model is the best solution from a supply chain perspective. This means the model does not focus on a local optimum (results that maximize only the benefits of the budget-constrained firm) but on a global optimum in order to maximize the supply chain benefit.

**Mechanism**

The resources that help and support the model, allowing a proper processing of it, are basically two:

- The first one is about the three different types of IF solutions (Traditional, Delegation and Control models) which are mainly based on Xiangfeng Chen’s papers and his consulting;
• The second resource are the different types of inventory policies that a company may adopt; nowadays all these policies are already deeply studied and aslo well established in the real working situations, so we easily adopt them thanks to their high reliability. We consider four different inventory policies: Two-Bin System, Min-Max System, Base-Stock System and Hybrid System (we are going to deeply explain the functions and the processes of these policies in the next paragraphs), that can be arranged in two different macro-categories according to the inventory review logic adopted: the first one is about policies operating with a continuous control of the inventory (Two-Bin and Min-Max system), whereas the other one concerns inventory policies operating with a periodic control of the stocks (Base-Stock and Hybrid system).

**Outputs**

The model determines a reliable assessment of the benefits achievable through the introduction of an IIFS combined with a specific inventory policy. Thus, the main output of the model is the identification of the best combination “IIFS – Inventory Policy” which maximizes the benefits from a supply chain perspective.

### 3.2 Model Ontology

Below, in order to allow a further understanding to the reader, is reported a brief description of the terms that will be often used in the next paragraphs of the paper:

- **Borrowing firm**: is the company that using an IF solution is able to obtain funds (or trade credit) from a financial provider;
- **Financial provider**: is the company which provides the loan in the DM or the trade credit in the CM;
- **Pledging goods**: these products are part of the borrowing firm’s inventory and are use by the latter one to get a loan from the financial provider. These goods could be either raw material or semi-finished products or final products; depending of the marketability of these goods the borrowing firm can get different amount of funds;
• *Continuous control policies:* are the inventory polices, adopted by the retailer, operating with a continuous logic to control the inventories, namely the Two-Bin and Min-Max systems;

• *Periodic control policies:* are the inventory polices, adopted by the retailer, operating with a periodic logic to control the inventories, namely the Base-Stock and Hybrid systems.

### 3.3 Model Development: Inventory Policies

In this paragraph will be shown and explained the different inventory policies we have decided to introduce in the model.

First of all, we can organize these different policies in two macro-categories: policies which operate with a continuous logic to control the inventory and polices which adopt a periodic logic to control the inventory.

Secondly, it is very important to point out that in all the following graphs and diagrams, which represent how the different inventory policies affect the stocks over time, it has been assumed a lead time (LT) null\(^2\).

#### 3.3.1 Logic: Continuous Review of the Inventory

In business and accounting, perpetual inventory or continuous inventory describes systems of trading stock where information on inventory quantity and availability is updated on a continuous basis as a function of doing business. In the continuous review process, the inventory levels are continuously reviewed, and as soon as the stocks fall below a predetermined level (i.e. reorder point, or reorder level), replenishment order is placed. As more and more companies start using sophisticated IT systems to track their inventories in real-time, the continuous review method becomes a viable and optimal way to plan the replenishment.

\(^2\) We set this assumption with the purpose to make simpler the graphical representation of the stock over time for each inventory policy. Thus, in each graph has been assumed a LT null, but in the model the LT value is positive; this is the reason why the variable LT will be used in the following formulas.
This type of inventory review permits real-time updates of inventory counts, which can make it easier to know when to reorder items to replenish inventory. This method also facilitates accurate accounting, since the inventory system can generate real-time costs of goods sold. The main disadvantage of this method of inventory review is the cost of implementation: bar code scanners, inventory software and computer systems are all necessary to maintain perpetual inventory review.

In this category are included two of the four inventory policies adopted: respectively, the Two-Bin System and the Min-Max System.

**Two-Bin System**

This process uses a fixed “order quantity” with a continuous review, the resulting process is shown below in the Figure 2.2.

![Figure 3.3 - Inventories over time adopting a Two-Bin System (LT=0 is assumed)](image)

The orders are placed as soon as the inventory falls below the pre-determined reorder level (these are shown in the Figure 3.3 as the red dots). As the order quantity is fixed, the resulting inventory level varies basing on the starting inventory when the order is placed. The benefit of this approach is that it triggers an order as soon as the stocks fall below the reorder level, therefore rarely eating into underlying safety stock layer.

In the model we adopt this logic assuming the hypothesis that the demand (D) and the lead time (LT) are two random variables distributed according to a normal distribution:
\[ D \sim N(\mu_D; \sigma_D) \]
\[ LT \sim N(\mu_{LT}; \sigma_{LT}) \]

This assumption is placed in order to define and calculate the safety stocks (SS) using the following formula:

\[ SS = k \cdot \sigma_{D,LT} \]

where

\[ \sigma_{D,LT} = \sqrt{LT \cdot \sigma_D^2 + \sigma_{LT}^2 \cdot \mu_D^2} \]

\[ k = \text{service level (probability of meeting demand during LT without a stockout)} \]

In this first process the order quantity is fixed and represents the exact amount of pieces that will be ordered, it is determined through the Economic Order Quantity (EOQ) model. This method defines the order quantity that minimizes the total holding and ordering costs, it is calculated as follows:

\[ EOQ = \sqrt{\frac{2 \cdot e \cdot D_{\text{year}}}{m \cdot P}} \]

In the formula is present the fixed cost for each order placed \((e)\), regardless of the number of units ordered. There is also the cost for each unit held in storage \((m)\), commonly known as holding cost (sometimes it is expressed as a percentage of the purchase cost of the item). The other two required parameters to the solution are the total demand for the year \((D_{\text{year}})\) and the purchase cost for each item \((P)\).

When we are using this policy, the reorder level, also called Reorder Point (RP), is set as the trigger level and it is determined as follows:

\[ RP = D_{LT} + SS \]

where the variable \(D_{LT}\) is the average demand during the lead time.
**Min-Max System**

This method uses a pre-determined “order up-to Level quantity” \((\text{OUTL})\) to determine the size of the order. The inventory is reviewed continuously, and the orders are placed as soon as the inventory level fall below the reorder level.

![Figure 3.4 - Inventories over time adopting a Min-Max System (LT=0 is assumed)](image)

The process targets to fill the inventory stocks to a pre-determined level and therefore the order size varies based on the “on-hand” inventory level (see Figure 3.4). When using this policy, the reorder point field is the minimum whereas the order up-to level quantity is the maximum (i.e. the number to which the inventory level is restored). Also here we made the assumption that demand \((D)\) and lead time \((LT)\) are two random variables distributed according to a normal distribution, so we calculated the safety stock in the same way of the Two-Bin System:

\[
SS = k \cdot \sigma_{D,LT}
\]

In this second process we define the pre-determined “order up-to level” as follow:

\[
\text{OUTL} = \text{RP} + \text{EOQ}
\]

where the reorder point \((\text{RP})\) and the \(\text{EOQ}\) are calculated as in the previous method:

\[
\text{RP} = D_{LT} + SS
\]
\[ EOQ = \sqrt{\frac{2 \cdot e \cdot D_{\text{year}}}{m \cdot P}} \]

The actual order quantity at the time \( t \) (\( AOQ_t \)) is determined as the difference between the pre-determined \( OUTL \) and the on-hand stock on the review day (\( INV_{level_t} \)).

\[ AOQ_t = OUTL - INV_{level_t} \]

It is crucial to understand in this process that the order quantity will differ from one order to another depending on the on-hand quantity on the day of the review.

### 3.3.2 Logic: Periodic Review of the Inventory

This system of inventory management makes updates on a periodic basis, therefore the inventory levels are reviewed as a set frequency.

This approach provides a viable process alternative to the continuous review by segmenting the merchandise into review buckets. This makes it easier to manage when the process is manual, or the number of items involved is extremely large, or when constraints on ordering-day exist.

Periodic inventory review reduces the time a business owner spends analyzing inventory counts, which allows more time for other aspects of running the business. However, it may not provide accurate inventory counts for businesses with high-volume sales.

With a periodic control policy, the owner must make assumptions between inventory review periods regarding inventory counts. This can make it difficult to ascertain when reordering items is necessary, moreover it also can make accounting less accurate.

In this category are included the remaining two inventory policies adopted by our model: The Base-Stock System and the Hybrid System.

**Base-Stock System**

This method is based on a periodic review of the inventory. This technique does not consider any pre-determined reorder point, so an order replenishment is always placed when the inventory review occurs (see Figure 3.5).
As we did in continuous control policies, also this approach requires to assume the hypothesis that the demand (D) and the lead time (LT) are two random variables distributed according to a normal distribution:

\[ D \sim N(\mu_D; \sigma_D) \]
\[ LT \sim N(\mu_LT; \sigma_LT) \]

This assumption is placed in order to define and calculate the safety stocks (SS) using the following formula:

\[ SS = k \cdot \sigma_{D,LT+T} \]

where \( k \) defines the service level and \( \sigma_{D,LT+T} \) is the standard deviation of the demand during the range period (LT+T) and it’s calculated as follows:

\[ \sigma_{D,LT+T} = \sqrt{(LT + T) \cdot \sigma_D^2 + \sigma_{LT}^2 \cdot \mu_D^2} \]

\( k = \text{service level (probability of meeting demand during LT without a stockout)} \)

As in the Min-Max system, we don’t have a fixed reorder quantity but the order size varies from one to the next order.
The total amount of pieces ordered in each order ($AOQ_t$) is established as the difference between the pre-determined “order up-to level” ($OUTL$) and the on-hand stock on the review day ($INVlevel_t$):

$$AOQ_t = OUTL - INVlevel_t$$

where, unlike continuous inventory policies, the $OUTL$ is calculated as sum between safety stock ($SS$) and average demand in a reorder period plus lead-time ($\bar{D}_{(LT+T)}$):

$$OUTL = SS + \bar{D}_{(LT+T)}$$

where

$$\bar{D}_{(LT+T)} = \mu_d [\text{unit/week}] \cdot \left( \mu_{LT} [\text{week}] + T[\text{week}] \right)$$

**Hybrid System**

The main feature of this last method is to make a sort of merging between the two type of review logics adopted, namely continuous and periodic inventory control logics.

In a first phase the Hybrid System operates like a Base-Stock System (periodic review of the inventory) so at the time of review, if the stock level is below the pre-determined level, (Reorder Point) an order for replenishment is placed. Otherwise, if the stock level is over the Reorder Point the method does not place any order, but after this moment the system changes its reorder logic from a periodic to a continuous review.

![Figure 3.6 - Inventories over time adopting a Hybrid System (LT=0 is assumed)](image-url)
Now the Hybrid System starts to operate like a Min-Max System: it checks the inventory level every time bucket and places an order replenishment just when the stock level is below the Reorder Point. After any order placement the system gets back to a periodic inventory control logic (see Figure 3.6).

The red dots in the Figure 3.6 show the ordering points, whereas the green dots show a review when no order is placed since the inventory level is higher than the reorder level at the time of the review. The safety stock (SS) are calculated as in the Base-Stock System (always under the assumption that demand (D) and lead time (LT) are two random variables distributed according to a normal distribution):

\[ SS = k \cdot \sigma_{D,LT+T} \]

We define the Reorder Point (RP) as sum between the safety stock level and the average demand during the lead time:

\[ RP = SS + D_{LT} \]

where

\[ D_{LT} = \mu_D [\text{week}] \cdot \mu_{LT}[\text{week}] \]

The “order up-to level” (OUTL) is defined in the same way used in the Base-Stock System, whereas the total amount of pieces ordered in each order (AOQt) is defined as in the Min-Max System:

\[ OUTL = SS + D_{(LT+T)} \]

\[ AOQt = OUTL - INV_{level} \]

### 3.4 Model Development: General Assumptions

In this paragraph there will be listed and explained all the assumptions used in order to make the model as reliable as possible.

The fundamental feature of the following assumptions is that they are all shared by both DM and CM, so they can be considered as common assumptions (whereas the assumptions
that are more particular and especially not shared, will be described during the introductive part of the respective models).

First of all, it is very important to figure out that both models study a supply chain where the budget-constrained actor is represented by the retailer. We assume this retailer is managing two different products: Product_A and Product_X. These two products belong to different classes according to the ABC Analysis\(^3\): the Product_A can be considered as an A-Class product, whereas the Product_X can be considered as a B/C-Class product.

So the retailer categorizes its stocks according to this ABC Classification method, which is based on the Pareto principle\(^4\) where the inventory is classified depending on the value of the units.

Accordingly, this product classification can be described as follows:

- A-Class items comprise 20% of SKU\(^5\) and contribute to 80% of $ spent;
- B-Class items comprise 30% of SKU and contribute to 15% of $ spent;
- C-Class items comprise 50% of SKU and contribute to 5% of $ spent.

Other important assumption adopted by both models are the followings:

- we set a weekly time bucket, meaning that we consider and check everything (e.g. revenues, costs, demand, lead time, etc.) with a weekly frequency;
- we suppose that the retailer always buys the entire quantities of Product_A from the same supplier.

Moreover, we also set important assumption regarding the Product_A transportation:

- we assumed the possible dimension, volume and weight of Product_A (this in order to understand if the container will be first filled first for volume or weight reason);

---

\(^3\) ABC Analysis is an inventory categorization technique. ABC analysis divides an inventory into three categories: "A items" with very tight control and accurate records, "B items" with less tightly controlled and good records, and "C items" with the simplest controls possible and minimal records.

\(^4\) The Pareto principle (also known as the 80–20 rule) states that, for many events, roughly 80% of the effects come from 20% of the causes.

\(^5\) Stock Keeping Unit (SKU): In the field of inventory management, a stock keeping unit is a distinct type of item for sale, such as a product or service, and all attributes associated with the item type that distinguish it from other item types. For a product, these attributes could include, but are not limited to, manufacturer, description, material, size, color, packaging and warranty terms.
• the transportation price per unit is calculated considering that the containers used to send Product_A to the retailer are always completely full (thanks also to the presence of other firms’ products, so they can be defined as mix containers);

• all the transportation costs are on charge of the buyer, i.e. the supplier in our model.

Concluding, the last assumptions regard the stock-holding cost: in particular, to compute this value, we do not consider the In-Transit stock and we use the purchasing price of the Product_A.

### 3.5 Delegation Mode

In this paragraph, at first we will define all the remaining assumptions specifically dedicated to this model, subsequently we will deeply explain how the model works representing the entire process step by step.

#### 3.5.1 Specific Assumptions

The next assumptions, adopted just by DM, have been defined in order to ease the model in some of its steps and to ensure continuity to the whole process.

First assumption refers to the pledging availability of the retailer: the latter is allowed to make a pledge just if it has already received back the collateral goods of the previous pledging iteration; this means that the retailer can use this financing instrument (i.e. Delegation Mode) at minimum every $K$ periods, where $K$ represents the periods taken by the financial provider to give back the collateral goods to the retailer.

One of the most important assumption adopted in the DM, is based on one of the IF principles we previously reported in the literature review:

“...the pledging products are some productions which the borrower has already produced but cannot be converted into cash immediately or some raw materials which he has already purchased but cannot be used in a short time”.

82
The previous citation could be translated as the retailer can pledge a product just for a short period of time in which it cannot be directly turned into value.

This is the reason why we decide to set that the retailer has at most $M_n$ units of the Product_X available to be pledged, where $M_n$ represents the demand (of the Product_X) that will occur in $n$ periods from now. For example, in order to make the reader’s understanding simpler, we could assume that in the 1st period (week) the retailer already has $M_{n=12} = 400$ unit of Product_X even if the actual demand of it will start in $n = 12$ weeks from now. Hence the retailer is able to pledge these 400 units of the Product_X for 3 months (12 weeks) being sure to receive them back in time for the sales.

With the purpose to ensure a continuous availability of the Product_X to the retailer, it is necessary to see Product_X not as just one single product but as at least as two different products (e.g. Product_X1 and Product_X2) having similar demand and value.

So if we analyze the collateral:

- In each single pledging iteration, the collateral is made up of all same type of products;
- On the other hand, if we consider all the different pledging iterations, the collateral could be represented by different products (e.g. iteration1-Product_X1, iteration2-Product_X2, etc.).

This situation allows the retailer, once received back the pledging of the Product_X1, to be immediately able to apply for another loan through the pledging of the Product_X2, because, as mentioned above, now the Product_X1 is no longer available to be pledged since it has its own demand and therefore it can be transformed directly into value. This assumption definitely simplifies the model because allows the retailer to always have on its shelves Product_X available to be used as collateral.

Concluding, we can define $M_n$ as the Product_X quantity available to be pledged because its demand will be null for the next $n$ periods, so the retailer can pledge it because it cannot be converted into money.

Thanks to this continuous possibility to get a loan from the bank, we also assume that a part of any retailer’s order is always financed using funds obtained by the pledging, in particular, the retailer uses its own money just when the loan received by the financial provider isn’t enough to order all the needed quantity (always respecting the budget for purchase).
Considering that in the CM the Product_X is untied, then the retailer can respond more reactively to a sudden demand. Thus, in order to quantify the lower efficiency that the retailer has in the DM, we decide to partially reduce the profit gained by the sales of the Product_X.

Last assumption concerns the retailer’s CCC which it is supposed to turn negative after the implementation of an IIFS (in order to ease the model development we assume a DII null\(^6\)), in particular:

- The retailer gets \(Y\) (%) of the revenue at \(t = r\) and the \(Z\) (%) at \(t = j\) (where \(Y < Z \land Z = 1 - Y \land r < j\));
- The supplier is paid by the retailer for the \(W\) (%) of the order value at \(t = 0\), whereas the remaining part \(Q\) (%) at \(t = h\) (where \(W < Q \land Q = 1 - W \land h \geq j\));
- The financial provider immediately grants the loan \((t = 0)\) to the retailer which has to pay it back (plus an interest) at \(t = g\) (where \(g \geq h\));

\[\text{Figure 3.7 - Cash flows in the Delegation Mode}\]

### 3.5.2 Process

This section explains the whole steps process that occurs in a single iteration of ours DM solution. In order to ease the process and simplify the reader’s understanding we have designed a framework (see Figure 3.8) in which are represented all the main passages performed by our model.

---

\(^6\) DII null means that the goods, once arrived in the seller’s warehouse, are immediately sold.
At the beginning, the retailer defines how many products ordering with the purpose to satisfy the market demand [step 1.a]; the trigger point of the DM is when the retailer becomes aware that it has not enough funds to place the order, so it asks an IF request to the bank. The retailer starts sending part of its inventory of Product_X available to be pledged ($M_B$), to the 3PL’s warehouse [step 1.b]. After having received the goods, the 3PL starts to analyze and check the collateral conditions, then it sends all the information about a legit and reasonable Loan-to-Value ratio and about the collateral to the bank [step 1.c]. Now, the bank is going to pay in advance the 3PL, on behalf of the retailer, the total cost of the services that will be provided by the 3PL ($BANK\ COSTS = PHP_{3PL} + PMP_{3PL}$) [step 1.d]. In the same period, the bank grants the loan to the retailer ($LOAN_T = \Omega \ast Pledging\ Value$) [step 1.e], which now has enough funds to place the order ($ORDERED_Q(A)_T$) and especially to carry out the payment of $W\%$ of the order value ($PC(A)_T$) to the supplier [step 1.f].

At $t=r$, the 3PL delivered the goods to the retailer [step 2.a] who starts to sell them to its customers [step 2.b] getting immediately the $Y\%$ of the sales value [step 2.c]. At $t=j$ the
retailer gets the remaining $Z\%$ [step 3.a] of the total revenue and in $t=h$ (in this case we suppose $h=j$) pays $Q\%$ of the order value placed at $t=0$ [step 3.b].

At $t=g$ the retailer has to payback the whole debt (TOTAL PAYBACK VALUE) to the bank [step 4.a] and, just when this payment will be completed, the bank authorizes the 3PL to return the pledged goods to the retailer [step 4.b].

Now we are going to deeply explain all the operations that we have developed in the DM. We arrange this process explanation in six main phases (see Figure 3.9), where each one of them will be spread and intensely analyzed through showing and revealing to the reader all the internal procedures.

---

**Figure 3.9** - Delegation Mode main stages

1. As a first stage the model generates a through a normal distribution $N(\mu_A;\sigma_A)$ the demand of Product_A. Facing this demand, the retailer orders in the period $T$ a quantity of products $q$ (in the model is named ORDERED\_QT).

   At first, the order quantity is defined according to the inventory policy adopted by the retailers ($EOQ$ for Two-Bin System and $AOQ_t$ for Min-Max, Base-Stock and Hybrid Systems), in the model this value has been named NEEDED\_QT.

   The NEEDED\_QT doesn’t necessarily represent the real ordered quantity of the retailer; in fact, before placing any order, the retailer must ensure that the budget allocated to
purchases in the period $T$ ($BUDGET_{FOR\_PURCHASE_T}$) is sufficient to order the entire $NEEDED_Q_T$.

Hence, the real ordered quantity (named $ORDERED_Q_T$) can be defined as the least between the $NEEDED_Q_T$ and the achievable ordering quantity allowed by the retailer’s budget ($BUDGET_{FOR\_PURCHASE_T}$):

$$ORDERED_Q(A)_T = \min \left(\frac{BUDGET_{FOR\_PURCHASE_T}}{\text{Purchasing Price}(A)}, NEEDED_Q(A)_T\right)$$

In the previous formula, the $BUDGET_{FOR\_PURCHASE_T}$ is calculated as follows:

$$BUDGET_{FOR\_PURCHASE_T} = (\alpha[\%] \cdot CR_{t\rightarrow T}) + (\beta[\%] \cdot CL_{t\rightarrow T})$$

where:

- $CR_{t\rightarrow T}$ represents the cumulated revenues since the last order placement ($t$) to the current period ($T$);
- $CL_{t\rightarrow T}$ represents the cumulated net liquidity since the last order placement ($t$) to the current period ($T$). This in order to offer a growing opportunity to the retailer which will be able to enlarge its order quantity.

II. The second stage concerns the retailer’s loan amount: the bank, just after having completed the evaluation of the retailer’s goods (with the 3PL’s aid) and decided the Loan-to-value Ratio ($\Omega$), grants a loan (LOAN) to the borrower. In the model we define the value of the LOAN as follows:

$$LOAN = \Omega \cdot Pledging\_Value$$

$$Pledging\_Value = M_n \cdot Selling\_Price(X)$$

where

$$M_n = \text{Quantity of Product}_X \text{ available to be pledged}$$
III. The third phase starts just after the loan granting, now the pledging goods move from the retailer to the 3PL’s warehouse, where the latter keeps stocked and checked the collateral throughout the entire duration of the loan.

The 3PL offers 2 different types of services: the first one is the classic service of transportation because it transports the \( \text{ORDERED}_Q(A)_T \) from the supplier to the retailer, whereas the second service concerns all the “collateral manager” activities, namely the storing (\( PLEDGE \text{ HOLDING PRICE}_{3PL} \)) and the monitoring (\( PLEDGE \text{ MONITORING PRICE}_{3PL} \)) of the pledged goods.

In order to consider all these different services, we model the following prices required by the 3PL:

\[
PLEDGE \text{ HOLDING PRICE}_{3PL} = \left( \text{Pledging Value} \cdot SMR_{3PL} \cdot \frac{K}{12} \right) \cdot (1 + MU_{3PL})
\]

where

\[
SMR_{3PL} = \text{Stock Maintenance Rate} \ [\%/\text{year}]
\]

\[
K = \text{Loan Payback Time} \ [\text{month}]
\]

\[
MU_{3PL} = \text{Mark-Up} \ [%]
\]

The collateral monitoring service carried out by the 3PL regards at first the certification that the pledging goods are intact (the goods must not be damaged or compromised). Another activity included in this service, is to support the bank defining a proper \( Loan-to-value \text{ Ratio} \) for the collateral since the 3PL is aware of more information regarding the possible marketability of the collateral.

These two activities are quite complex to quantify because they strictly depend on the typology of the product we are considering; indeed, we haven’t quantified the second one because it exclusively represents a qualitative activity.

In order to ease this complexity, we establish a variable (\( \Psi \)) which represents how many pledged goods the 3PL has to monitor to get 1$.

\[
\Psi = \frac{1 [\$]}{\text{Amount of pledging goods value to get 1$} \ [\$]}
\]
Now, it is easier to define the price requested by the 3PL for this second service:

\[
\text{PLEDGE MONITORING PRICE}_{3PL} = \Psi \cdot Pledging\ Value
\]

It is worth to explain that these two services (i.e. collateral holding and monitoring) are paid in advance by the bank on behalf of the retailer. Indeed, as we will carefully show in the next part of this paragraph, the bank will add these costs (plus an interest) to the loan payback of the retailer.

The last service carried out by the 3PL is the transportation of \(\text{ORDERED}_Q(A)_T\) from the supplier to the retailer.

Focusing on the transportation price, we calculate it as follows:

\[
\text{TOTAL TRANSPORTATION PRICE}(A)_T = \text{ORDERED}_Q(A)_T \cdot \text{Transp\ Price}
\]

where the variable Transp\ Price represents the sum among the following items:

\[
\begin{align*}
TP_{water} &= \text{water transportation price per unit} \ [\$/\text{unit}] \\
TP_{road} &= \text{road transportation price per unit} \ [\$/\text{unit}] \\
TP_{customs} &= \text{customs clearance price per unit} \ [\$/\text{unit}]
\end{align*}
\]

IV. The fourth main stage defines the amount of money that the retailer has to rectify in favor of the bank (TOTAL PAYBACK VALUE). This value is calculated as the sum between the loan payback plus interest (LOAN PAYBACK VALUE) and the 3PL’s costs that the bank has paid in advance on behalf of the retailer (BANK COSTS), considering that an interest rate will be charged also on these last costs.

\[
\text{LOAN PAYBACK VALUE} = \text{LOAN} \cdot \left( 1 + i \cdot \frac{K}{4 \cdot 12} \right)
\]

\[
\begin{align*}
i &= \text{annual interest rate} \ [%] \\
K &= \text{Loan Payback Time} \ [\text{week}]
\end{align*}
\]
\[ \text{BANK COSTS} = (\text{PHP}_{3PL} + \text{PMP}_{3PL}) \]

\[ \text{PHP}_{3PL} = \text{Pledge Holding Price}_{3PL} \]
\[ \text{PMP}_{3PL} = \text{Pledge Monitoring Price}_{3PL} \]

\[ \text{BANK SERVICE} = \text{BANK COSTS} \cdot \left(1 + i \cdot \frac{K}{4 \cdot 12}\right) \]

\[ \text{TOTAL PAYBACK VALUE} = \text{LOAN PAYBACK VALUE} + \text{BANK SERVICE} \]

V. The fifth step is focused on the estimation of the stock out costs faced by the retailer, in particular we calculate this cost as the product among the stock out units and the selling price of Product_A:

\[ \text{STOCK OUT COST}(A)_T = \text{Stock Out}(A)_T \cdot \text{Selling Price}(A) \]

where:

\[ \text{Stock Out}(A)_T = \begin{cases} 
\text{DEMAND}(A)_T - \text{INVENTORY}(A)_T, & \text{if } \text{INV}(A)_T < \text{D}(A)_T \\
\emptyset, & \text{if } \text{INV}(A)_T > \text{D}(A)_T
\end{cases} \]

VI. The sixth and last stage of the model is the benefit estimation for all the involved players:

**Retailer’s benefit**

Starting from the retailer’s situation, we define three different “main items”: the retailer’s liquidity (\(R.\text{LIQ}_T\)), the retailer’s effective liquidity (\(R.\text{EFF\_LIQ}_T\)) and the retailer total liquidity (\(R.\text{TOT\_LIQ}_T\)).

The first one is calculated every period \(T\) summing all the incomes (such as revenue and loan) and after subtracting all the costs in that period.
\[ R_{LIQ_T} = Tot_{Rev(A)_T} + LOAN_T - SHC(A)_T - Tot_{TP(A)_T} - PC(A)_T \]

- The variable \( Tot_{Rev(A)_T} \) represents all the incomes originated from the sales of the Product_A. It’s crucial to consider that in the period \( T \) the retailer gets the \( Y \) (%) of the revenue of that period plus the \( Z \) (%) of the revenue gained \((j-r)\) periods before (basing on the assumptions listed in the paragraph 3.5.1 Specific assumptions).

\[ Tot_{Rev(A)_T} = Y(\%) \cdot Rev(A)_T + Z(\%) \cdot Rev(A)_{T-(j-r)} \]

The single value \( (Rev(A)) \) is calculated as the product between the selling price of the Product_A and the minimum value between the actual demand in \( T \) and the retailer’s Product_A inventory level in \( T \):

\[ Rev(A)_T = Selling_Price(A) \cdot \min[Demand(A)_T; Inventory(A)_T] \]

- The variable \( LOAN_T \) represents the value of the loan that the retailer obtains from the bank and, as we have already defined, it’s calculated as follows:

\[ LOAN_T = \Omega \cdot Pledging_Value \]

- The variable \( SHC(A)_T \) defines the retailer’s stock holding cost of the Product_A. The retailer sustains this cost to keep the storage of the goods. It is calculated as the product between three different items: the unsold products in the period \( T \), the value of the product and the annual stock maintenance rate (\( SMR^{retailer} \)).

\[ SHC_T = [Inventory(A)_T - Demand(A)_T] \cdot Purchasing_Price(A) \cdot SMR^{retail} \cdot \frac{1}{4 \cdot 12} \]

- The variable \( Tot_{TP(A)_T} \) represents the cost in which the retailer incurs for the transportation service offered by the 3PL. Previously, we already calculated it as follows:

\[ TOTAL\ TRANSPORTATION\ PRICE(A)_T = ORDERED_Q(A)_T \cdot Transp_Price \]
The variable $PC(A)_T$ defines the retailer’s purchasing cost of the Product_A in the period $T$. It’s easy calculated as the product between the effective ordered quantity and the purchasing price (reminding that this payment is split into two different phases according to the assumptions listed in the paragraph 3.5.1 Specific assumptions):

$$PC(A)_T = W(\%) \cdot ORDERED_Q(A)_T \cdot Purchasing\_Price(A) + Q(\%) \cdot ORDERED_Q(A)_{T-h} \cdot Purchasing\_Price(A)$$

Focusing now on the retailer’s effective liquidity ($R.EFFLIQ_T$), it has been defined in order to mathematically ease the process development, indeed it is calculated as the following linear formula:

$$R.EFFLIQ_T = R.LIQ_T - TOTAL\ PAYBACK\ VALUE_T + PLEDGE\ LOST\ VALUE_T$$

Unlike the first two items in the formula, that have been previously defined, we have not taken into account yet the third component ($PLEDGE\ LOST\ VALUE_T$). It represents the value of an eventual amount of pledging goods that could be lost by the retailer ($PLEDGE\ LOST_T$). This situation only occurs when the retailer is unable to pay back the entire debt, so part of the collateral will become property of the bank.

$$PLEDGE\ LOST\ VALUE_T = PLEDGE\ LOST_T \cdot Selling\_Price(X)$$

We can compute the retailer’s loss of pledged goods as follows:

$$PLEDGE\ LOST_T = \begin{cases} \emptyset, & \text{when } TPV_T \leq R.LIQ_T + R.TOT.LIQ_{T-1} \\ TPV_T - (R.LIQ_T + R.TOT.LIQ_{T-1}), & \text{when } TPV_T > R.LIQ_T + R.TOT.LIQ_{T-1} \end{cases}$$

where

$$TPV_T = TOTAL\ PAYBACK\ VALUE_T$$
The variable $R_{TOT\_LIQ_T}$ represents the third “main item” touched upon in this section. It is the total liquidity of the retailer until the period $T$, and it is easy calculated as sum between the retailer’s total liquidity of the previous period ($T\_LIQ\_T\_1$) and the gained liquidity of the current period.

$$R_{TOT\_LIQ_T} = R_{EFF\_LIQ_T} + R_{TOT\_LIQ_{T-1}}$$

Concluding, the retailer’s benefits are assessed considering its final total liquidity ($RETALER\_FINAL\_LIQUIDITY$) that is calculated as the sum between:

- The value of the retailer’s total liquidity at the last period ($R_{TOT\_LIQ_{last\_period}}$), which defines the total amount of money the retailer has been able to earn and preserve along the entire duration of this IIFS;
- The value of the total profit gained from the sales of the Product_X ($Tot.\_Profit(X)$) decreased by $\kappa$ [%] as set in the paragraph 3.5.1 Specific assumptions.

$$RETALER\_FINAL\_LIQUIDITY = R_{TOT\_LIQ_{last\_period}} + [Tot.\_Profit(X) \cdot (1 - \kappa)]$$

**Supplier’s Benefit**

We estimate this value as the sum of all profits the supplier gets throughout the duration of the model. Every single profit is easily calculated as the product between the selling price of the Product_A (this value corresponds to $Purchasing\_Price(A)$ that is the purchasing price for the retailer), and the margin that the supplier gains on the sales:

$$SUPPLIER\_PROFIT_T =$$

$$= Purchasing\_Price(A) \cdot [(W(\%) \cdot ORDERED\_Q(A)_T) + (Q(\%) \cdot ORDERED\_Q(A)_{T-h})] \cdot margin$$

$$SUPPLIER\_TOTAL\_PROFIT = \sum_{T=last\_period}^{T} SUPPLIER\_PROFIT_T$$
3PL’s Benefit

In order to define the benefits for the Third Party Logistics we follow the same way of thinking adopted in the supplier case. At first, it’s necessary to calculate the 3PL’s profit for each period and secondly to sum all these values; so the result of this last sum will be the total profit gained throughout the application of the IF solution.

\[ 3PL \text{ TOTAL PROFIT} = \sum_{T=1}^{T=\text{last period}} 3PL \text{ PROFIT}_T \]

where:

\[ 3PL \text{ PROFIT}_T = [Tot\_TP(A) \cdot margin_{tr}] + [PHP_T \cdot margin_{sh}] + [PMP_T \cdot margin_{mon}] \]

The three variables \( margin_{tr}, margin_{sh} \) and \( margin_{mon} \) are percentage values representing the margin applied to the respective service, namely: transportation, pledge holding and pledge monitoring.

Bank’s Benefit

The benefit of the bank comes from the difference between the \( TOTAL \text{ PAYBACK VALUE}_T \) paid by the retailer and the expense the bank has faced \((T-g)\) periods before, such as the loan disposal and the advance payment of the 3PL’s collateral services.

\[ BANK \text{ PROFIT}_T = TOTAL \text{ PAYBACK VALUE}_T - \text{LOAN}_{T-g} - BANK \text{ COSTS}_{T-g} \]

\[ BANK \text{ TOTAL PROFIT} = \sum_{T=1}^{T=\text{last period}} BANK \text{ PROFIT}_T \]
3.6 Control Mode

In this paragraph, we are going to follow the same framework of the previous solution, indeed will be firstly defined the specific assumptions and then will be deeply explained how this IIFS works, representing the entire process step by step.

3.6.1 Specific Assumptions

These assumptions are adopted just by CM and they have been selected, after many research activities (including the consulting of Prof. Xiangfeng Chen), in order to develop this solution as real as possible.

Concerning the retailer’s CCC, also here we assume that it turns negative after the implementation of an IIFS (in order to ease the model development, we assume a DII as null), in particular:

- The retailer gets $Y$ (%) of the revenue at $t = r$ and the $Z$ (%) at $t = j$ (where $Y < Z \lor Z = 1 - Y \land r < j$);
- The supplier is paid by the 3PL-Bank for the $Q$ (%) of the order value at $t = 0$, whereas the remaining part $W$ (%) is paid by the retailer at $t = h$ (where $W < Q \land W = 1 - Q \land h \geq j$);
- The financial provider immediately ($t = 0$) grants the trade credit, which is equals $Q$ (%) of the order value, to the retailer which has to pay it back (plus an interest) at $t = g$ (where $g \geq h$);

![Figure 3.10 - Cash flows in the Control Mode](image)

---

7 DII null means that the goods, once arrived in the seller’s warehouse, are immediately sold
The main assumption adopted concerns the credit line value offered by the financial provider to the budget constrained retailer. We set this value equals to the $Q\%$ of the order value which the retailer is going to place to the supplier.

With the aim of ensuring continuity to this Inventory Financing solution, we assume that a part of any retailer’s order is always financed using funds obtained by a trade credit line even if it has enough own funds to place the order. In particular, in the Control Mode, the retailer uses its own money just to place the remaining part of the value of the order which is not financed by the 3PL-Bank’s trade credit line.

### 3.6.2 Process

This section explains the process that occurs in one iteration of the CM solution that we have developed. Like the DM, we have designed all the main passages in a framework (see Figure 3.11) in order to make simpler the reader’s understanding.

![Diagram of Control Mode process](image)

**Figure 3.11 - Control Mode process**

At the beginning, as in the DM, the retailer defines how many products ordering with the purpose to satisfy the market demand [step 1.a]; the trigger point of the CM is when the
retailer becomes aware that it has not enough funds to place the order, so it asks an IF request no longer to bank but to a Logistic Operator which also offers financing services. Precondition to make the CM solution possible, is a multi-party agreement among all the players. After this, the first passage [step 1.b] is the retailer’s order placement of the quantity \( ORDERED_Q(A) \), whose value is partially paid (Q\%) in advance by the financial provider via trade credit line \( (TRADE\ CREDIT(A)) \) offered to the retailer [step 1.c]. After having received the first part of the payment, the supplier sends the goods that will be received by the retailer at \( t=r \) (it’s crucial to highlight that this shipping is moved and handled just by the 3PL-Bank in its own transportation network) [step 2.a]. Once the goods are received by the retailer, he starts selling them [step 2.b] to his customers who pay immediately the Y\% of the total sale value [step 2.c].

At \( t=j \), the retailer gains the remaining Z\% of the the total revenue [step 3.a] and in \( t=h \) (in this case we suppose \( h=j \)) pays W\% of the order value placed at \( t=0 \) \( (ORDER\ VALUE(A)^{Retailer}_T) \) [step 3.b].

To conclude, at \( t=g \), the 3PL-Bank has to receive back the total value of the credit line increased by an interest rate \( (TOTAL\ PAYBACK\ VALUE_T) \) [step 4.a].

Now we are going to deeply explain all the operations that we have developed in the CM. We arrange this process explanation in six different phases (see Figure 3.12), where each one of them will be spread and intensely analyzed through showing and revealing to the reader all the internal procedures.

\[
\begin{align*}
\text{I. ORDER DEFINITION} & \\
\text{THE MODEL DEFINES RETAILER’S ORDER QUANTITY Basing on:} & \\
\quad & \text{- DEMAND ASSESSMENT; } \\
\quad & \text{- ADOPTED INVENTORY POLICY; } \\
\quad & \text{- AVAILABLE BUDGET FOR PURCHASES.} \\
\text{II. TRADE CREDIT DEFINITION} & \\
\text{Basing on the order value, the model defines the trade credit offered by the 3PL-Bank to the retailer.} \\
\text{III. RETAILER’S COSTS} & \\
\text{THE MODEL DEFINES THE COSTS OF THE RETAILER:} & \\
\quad & \text{- STOCK HOLDING (Prod_A); } \\
\quad & \text{- STOCK HOLDING (Prod_X); } \\
\quad & \text{- TRANSPORTATION;} \\
\text{IV. PAYBACK} & \\
\text{THE MODEL (BASING ON TRADE CREDIT VALUE AND INTEREST RATE) DEFINES THE TOTAL AMOUNT OF MONEY THE RETAILER OWES TO THE 3PL-BANK.} \\
\text{V. STOCK OUT COST} & \\
\text{THE MODEL DEFINES THE RETAILER’S STOCK OUT COSTS.} \\
\text{VI. BENEFITS ASSESSMENT} & \\
\text{THE MODEL EVALUATES THE BENEFITS FOR ALL THE ACTORS.}
\end{align*}
\]

\text{Figure 3.12 – Control Mode main stages}
I. As a first stage the model generates, through a normal distribution \( N(\mu_A; \sigma_A) \), the demand of Product_A. The retailer faces this demand and reacts ordering in the period \( T \) a quantity of products \( q \) (in the model is named \( ORDERED_Q \)) to its supplier. This first part repeats exactly the same steps already shown in the Delegation Mode:

\[
ORDERED_Q(A)_T = \min \left( \frac{\text{BUDGET_FOR_PURCHASE}_T}{\text{Purchasing Price}(A)} \right)
\]

Where the \( \text{BUDGET_FOR_PURCHASE}_T \) is calculated as follows:

\[
\text{BUDGET_FOR_PURCHASE}_T = (\alpha[\%] \cdot CR_{t\rightarrow T}) + (\beta[\%] \cdot CL_{t\rightarrow T})
\]

where \( CR_{t\rightarrow T} \) and \( CL_{t\rightarrow T} \) represent, respectively, the revenues and the net liquidity cumulated since the last order placement \((t)\) to the current period \((T)\).

II. The second step regards the definition of the credit line offered by the 3PL-Bank to the retailer, in particular we estimate this value as follows:

\[
\text{TRADE CREDIT}(A)_T = Q(\%) \cdot (\text{ORDERED VALUE}(A)_T)
\]

where \( Q(\%) \) represents the percentage of the order value that the 3PL-Bank intends to finance by trade credit. The \( \text{ORDERED VALUE}(A)_T \) is calculated as product between the purchasing price and the total ordered quantity of the Product_A:

\[
\text{ORDERED VALUE}(A)_T = \text{ORDERED}_Q(A)_T \cdot \text{P_Price}(A)
\]

The unpaid part of the order value, that will be paid by the retailer, is established as follow:

\[
\text{ORDER VALUE (A)}_{T\text{Retailer}} = \left[ 1 - Q(\%) \right] \cdot \left[ \text{ORDERED VALUE}(A)_T \right]
\]
III. In the third stage, the model defines the transportation and the stock holding costs (namely TOTAL TRANSPORTATION PRICE(A)\textsubscript{T} and \(SHC(A)\textsubscript{T}\)) that the retailer has to face. In the Control Mode there is not provide any kind of pledging because the collateral is made up by the “in transit” goods; as consequence the collateral goes directly into the retailer’s warehouse which has to take all the stock maintenance costs of both Product\(_A\) and Product\(_X\):

\[
SHC(A)\textsubscript{T} = \\
= [Inventory(A)\textsubscript{T} - Demand(A)\textsubscript{T}] \cdot Purchasing\_Price(A) \cdot SMR\textsubscript{retailer} \cdot \frac{1}{4 \cdot 12}
\]

\[
SHC(X)\textsubscript{T} = Stock\_Level(X) \cdot Purchasing\_Price(X) \cdot SMR\textsubscript{retailer} \cdot \frac{1}{4 \cdot 12}
\]

where the variable \(SMR\textsubscript{retailer}\) is the retailer’s stock maintenance rate.

Concerning the transportation cost, it is estimated following the same directions adopted in the Delegation Mode:

\[
TOTAL\_TRANSPORTATION\_PRICE(A)\textsubscript{T} = ORDERED\_Q(A)\textsubscript{T} \cdot Transp\_Price
\]

IV. The fourth stage, as in the Delegation Mode, concerns the evaluation of the total amount of money the retailer has to pay back in favor of the 3PL-Bank. This value includes the trade credit value and the transportation cost (\(Tot\_TP(A)\)) of the goods ordered (\(T-g\)) periods before, where just the former is increased by an interest rate:

\[
TOT\_PAYBACK\_VALUE\textsubscript{T} = Tot\_TP(A)\textsubscript{T-g} + [TRADE\_CREDIT\textsubscript{T-g} \cdot (1 + i \cdot \frac{K}{412})]
\]

where

\[
i = annual\_interest\_rate\ [%]
\]

\[
K = Payback\ _Time\ [\text{week}] 
\]
V. The fifth step estimates the stock-out costs faced by the retailer. Here, in order to calculate this value, we adopt the same process as the Delegation one:

\[
STOCK\ OUT\ COST(A)_T = Stock\ Out(A)_T \cdot SellingPrice(A)
\]

where

\[
Stock\ Out(A)_T = \begin{cases} 
(Demand(A)_T - Inventory(A)_T, \text{ if } Inv(A)_T < D(A)_T \\
\emptyset, \text{ if } Inv(A)_T > D(A)_T 
\end{cases}
\]

VI. The sixth stage of the model is the benefit estimation for all the involved players:

Retailer’s Benefit

Starting from the retailer situation, as in the Delegation Mode, we define three different “main items”: the retailer’s liquidity \( R.LIQ_T \), the retailer’s effective liquidity \( R.EFF.LIQ_T \) and the retailer total liquidity \( R.TOT.LIQ_T \).

The first one is calculated as follows:

\[
R.LIQ_T = Tot_Rev(A)_T - SHC(A)_T - SHC(X)_T - ORDER\ VALUE (A)_T^{Retailer}
\]

Where:

- the variable \( Tot_Rev(A)_T \) represents all the incomes originated from the sales of the Product_A. According to the previous paragraph 3.6.1 Specific Assumptions the revenues are split in two transactions: the Y\% of the sales is immediately gained by the retailer, whereas the remaining part is paid \((j-r)\) periods after.

\[
Tot_Rev(A)_T = Y(\%) \cdot Rev(A)_T + Z(\%) \cdot Rev(A)_{T-(j-r)}
\]

The value \( Rev(A) \) is calculated as the product between the selling price of the Product_A and the minimum value between the actual demand and the retailer’s Product_A inventory level:

\[
Rev(A)_T = Selling\ Price (A) \cdot \min[Demand(A)_T;\ Inventory(A)_{T}]
\]
the variables $SHC(A)_T$ and $SHC(X)_T$ represent namely the stock holding cost for the Product A and the stock holding cost for the Product_X. Both these variable have been previously defined;

the $ORDER\ VALUE\ (A)_{retailer}^T$ has been already defined, it represents the part not-financed by the trade credit line, therefore the retailer has to pay it by its own.

Focusing now on the retailer’s effective liquidity ($R.EFF._{LIQ}T$), it is simply calculated as the following linear formula:

$$R.EFF._{LIQ}T = R.LIQ_T - TOTAL\ PAYBACK\ VALUE_T$$

Above we have already defined and described both the components, namely the retailer’s liquidity and the retailer’s total payback. We also urge the reader to remember that if this value ($R.EFF._{LIQ}T$) is negative, this means the expenditure are higher than the income in that single period.

When the $R.LIQ_T$ is not enough to cover all the $TOTAL\ PAYBACK\ VALUE_T$ the retailer has to check its $R.TOT.LIQ_{T-1}$ in order to become aware if it is able to pay everything back or not.

This last variable, $R.TOT.LIQ_T$; it represents the total liquidity of the retailer until the period $T$, and it is calculated as follows:

$$R.TOT.LIQ_T = R.TOT.LIQ_{T-1} + R.EFF._{LIQ}T - DEBT^{3PL-Bank}_T$$

At first, we sum the retailer’s total liquidity of the previous period and the gained liquidity of the current period, secondly we subtract the value of a possible debt against the financial provider ($DEBT^{3PL-Bank}_T$), where this last value is calculated as follows:

$$DEBT^{3PL-Bank}_T =$$

$$= \begin{cases} 
TPB_{T-g} - (R.LIQ_T + R.CAP_{T-1}), & \text{if } TPB_{T-g} > R.LIQ_T + R.CAP_{T-1} \\
DEBT^{3PL-B}_{T-1} - (R.LIQ_T), & \text{if } DEBT^{3PL-B}_{T-1} \neq 0 \land DEBT^{3PL-B}_{T-1} > R.LIQ_T \\
0, & \text{if } TPB_{T-g} < R.LIQ_T + R.CAP_{T-1} \lor DEBT^{3PL-B}_{T-1} = 0 
\end{cases}$$
where $TPB_T$ is an abbreviation of the variable $TOTAL \ PAYBACK\ VALUE_T$.

Concluding, the retailer’s benefits are assessed considering its final liquidity ($RETAILER\ FINAL\ LIQUIDITY$) that is calculated as the sum between:

- The value of the retailer’s total liquidity at the last period ($R.TOT\_LIQ_{last\ period}$), which defines the total amount of money the retailer has been able to earn and preserve along the entire duration of this Inventory Financing solution;
- The value of the total profit gained from the sales of the Product_X ($Tot.\ Profit(X)$) throughout the duration of the Inventory Financing solution.

$$RETAILER\ FINAL\ LIQUIDITY = R.TOT\_LIQ_{last\ period} + Tot.\ Profit(X)$$

**Supplier’s Benefit**

We estimate supplier’s benefit as the sum of all profits it gets throughout the duration of the model. Every single profit is easily calculated as the product between the selling price of the Product_A, that corresponds to the purchasing price for the retailer ($Purchasing\_Price(A))$, and the margin that the supplier gains on the sales:

$$SUPPLIER\ PROFIT_T =$$

$$= Purchasing\_Price(A) \cdot [TRADE\ CREDIT(A)_T + ORDER\ VALUE\ (A)^{Retailer}_{T-h}] \cdot margin$$

$$SUPPLIER\ TOTAL\ PROFIT = \sum_{T=1}^{T=last\ period} SUPPLIER\ PROFIT_T$$

**3PL-Bank’s Benefit**

In order to define the benefit for the financial provider we can follow the same way of reasoning adopted in the supplier case. First we calculate the 3PL-Bank’s profit for each period and secondly we sum all these values. Then, the result will be the total profit gained throughout the application of the Inventory Financing solution.
3PL – BANK PROFIT\(_T\) =  
\[= \text{TOTAL PAYBACK VALUE}_T - \text{TRADE CREDIT}_T - \text{TRADE CREDIT}_{T-\delta} + \text{TRANSPORTATION PROFIT}_T\]

where:

\[\text{TRANSPORTATION PROFIT}_T = \text{Tot}_TP(A)_T \times \text{margin}_{\text{transp}}\]

The benefit of the 3PL-Bank comes from the difference between the total payback value paid by the retailer (\(\text{TOTAL PAYBACK VALUE}_T\)) and the initial amount of credit granted (\(\text{TRADE CREDIT}_T - \text{TRADE CREDIT}_{T-\delta}\)). Moreover, in a Control Mode the Third Party Logistics and the bank are merged together, so in the 3PL-Bank’s benefit must be considered also the profit originated by the transportation activity (\(\text{TRANSPORTATION PROFIT}_T\)).

Concluding, the final profit is calculated as follows:

\[3PL - BANK TOTAL PROFIT = \sum_{T=1}^{T=\text{last period}} 3PL - BANK PROFIT_T\]

### 3.7 Traditional Mode

In this paragraph we are going to explain how we modeled the Traditional Mode (TM) which represents a traditional IF solution.

The main assumption of this model formulation takes inspiration from the literature review where we have noticed that exists, in a traditional IF situation, a high information asymmetry and at the same time a low visibility between the financial provider and the borrower (e.g. respectively the bank and the retailer). These problems happen because, before granting the loan, the bank demands several information about the company and the financed goods in order to get a comprehensive overview; but, on the other hand, the retailer does not want to provide all that information than necessary. Thus, as said by Chen and Cai (2011), banks might often refuse to grant a loan to the borrowing firm. According with this last statement, we set up the TM as an extreme situation where the bank never offer a loan to the borrower (see Figure 3.13). In other words, we have modeled this solution
as a no financing situation. Therefore, the retailer can place an order just with its own funds, inevitably decreasing the ordered quantity and likely increasing its stock out cost.

Second assumption, since we need this model just as a benchmark, we want to ease it as much as possible. Thus, we consider for the retailer two different logics of inventory reorder policies, one under a continuous and one under a periodic review logic.

Concerning the process, it exactly equals the Delegation Mode one, except for some substantial differences, that are the followings:

- The bank does not grant any loan to the retailer, so the latter will place the orders just with its own funds and will not pledge any goods (Product_X);
- Since the loan does not exist, the 3PL will not provide any “collateral manager” activities such as storing and monitoring the pledged goods. Thus, the only service, the 3PL is paid for, is the goods transportation \( TOTAL\, TRANSPORT\, PRICE(A)_T \);
- Regarding the total profit of the retailer, the retailer’s effective liquidity \( R.EFF.LIQ_T \) becomes equal to the retailer’s liquidity value \( R.LIQ_T \), because the former has no longer the component \( LOAN_T \) in its computation.

Figure 3.13 - Traditional Mode process
Thus, the retailer total liquidity \( R.TOT.LIQ_T \) is established as follows:

\[
R.TOT.LIQ_T = \sum_{t}^{T} R.LIQ_t
\]

Concluding, the retailer final liquidity is calculated as the sum between the retailer’s total liquidity at the last period \( R.TOT.LIQ_{\text{last period}} \) and the value of the total profit gained from the sales of the Product_\( X \) \( (\text{Tot.Net.Profit}(X)) \):

\[
\text{RETAILER FINAL LIQUIDITY} = R.TOT.LIQ_{\text{last period}} + \text{Tot.Net.Profit}(X);
\]

• Regarding the total profit of the Third Party Logistics, it is the following:

\[
3PL TOTAL PROFIT = \sum_{T=\text{last period}}^{T=\text{last period}} 3PL PROFIT_T
\]

where:

\[
3PL PROFIT_T = Tot_{TPT(A)_T} \cdot \text{margin}_{\text{transp}}
\]

• Regarding the Bank total profit, it is null since the bank does not grant a loan to the retailer:

\[
\text{BANK TOTAL PROFIT} = \emptyset
\]
4 SENSITIVITY ANALYSIS

In this paragraph we are going to carry out a sensitivity analysis of our model, thus figuring out, under a specific scenario (e.g. a specific combination of input data), which is the Inventory Financing (IF) solution and the corresponding inventory reorder policy that generates the best output for all the actors of the supply chain (e.g. the highest supply chain profit).

4.1 Model Application

We based the sensitivity analysis on a possible practical application of our model. In order to make it, we set up each IF solution on further assumptions and we fed the model with real data stemming from case studies, reports and academic documents reviewed during the literature analysis.

4.1.1 Shared Assumptions

If we consider all the models, their practical application requires some additional assumptions as the followings.

With the aim of conferring more importance to the Product_A than the Product_X, we set the selling price of the latter 30% higher than the Product_A one. For the same reason we also set up a higher percentage margin for the Product_A compared to the Product_X one, that are respectively 65% and 50%.

We have assumed that the retailer’s initial budget for purchasing will be always enough to satisfy the first order. Then, whenever the retailer needs to place an order, we estimate the budget for purchase as sum of:

- 45% (= \( \alpha \)) of the cumulate revenue obtained summing the revenues since the last order placement;
- 15% (= \( \beta \)) of the liquidity cumulated since the last order placement (this in order to offer a growing opportunity to the retailer which will be able to enlarge its order quantity).
The demand of the Product_A follows a normal distribution, whereas the Product_X demand is constant during the whole period:

\[ D_A \sim N(\mu_{D_A}; \sigma_{D_A}) \]
\[ D_X \sim N(\mu_{D_X}; 0) \]

The delivery lead time of the Product_A follows a normal distribution as well:

\[ LT_A \sim N(\mu_{LT_A}; \sigma_{LT_A}) \]

In our case we assume that the 3PL takes four weeks to deliver the goods to the retailer (with a possible variation of 1 week).

We set up that the transport from the supplier to the retailer takes 4 weeks. This because we have supposed an international delivery (e.g. from China to Europe), deciding to use “container TEU” as transport unit. Basing on web researches and real data, we have estimated the water transportation price, the road-transportation price and the customs clearance price, per container TEU, respectively US $ 1800, 600 and 300.

Concerning the supplier’s internal costs (of the Product_A), it’s been assumed that they represent the 50% of the supplier’s selling price (or rather the supplier gains a 50% margin on the selling price).

Concluding, the value of the loan granted by the bank to the retailer is established in accordance with the Loan_to_value_ratio (Ω). After several researches we found out different possible values of this variable, but all of them are included in a range between 50% and 70%. Therefore, we decided to consider as reasonable and truthful value the average of the previous range, that correspond to 60%.

### 4.1.2 Delegation Mode Assumptions

If we consider the Delegation Mode (DM), its practical application requires some additional assumptions as the followings.
We assumed that, unlike the Traditional Mode (TM) where the retailer’s Cash Conversation Cycle stays positive, here, after the adoption of the DM, it turns negative. Thus, basing on some real cases and testimonies, we arrange the CCC as follows:

- The retailer immediately gets 30% of the revenue and the remaining 70% after 4 weeks;
- The supplier is paid by the retailer for the 30% of the order value at $t = 0$, whereas the remaining 70% after 8 weeks;
- The financial provider immediately grants the loan ($t = 0$) to the retailer which has to pay it back (plus an interest) after 12 weeks;
- Furthermore, 3PL takes 4 weeks to delivery the ordered goods from the supplier to the retailer, but the latter pays the Third-Party-Logistics after 4 weeks since he has received the order, so the 3PL gets his revenue after 8 weeks since the order placement.

Since we couldn’t find any information or reliable data, we decided to assume the value of $\Psi$ equals to 1%, meaning that the 3PL gets $1 every $100 of pledging goods analyzed:

$$\Psi = \frac{1\$}{\text{Amount of pledging goods value to get } 1\$} = \frac{1\$}{100\$} = 0.01$$

To conclude, we also need to consider that in the Control Mode the Product_X is untied and it is stocked in the retailer warehouse, so the retailer can respond more reactively to a sudden demand. Thus, in order to quantify the lower efficiency that the retailer has in the DM, we have decided to subtract to the profit, gained by the sales of the Product_X, a percentage equal to 10%.

4.1.3 Control Mode Assumptions

If we consider the Control Mode (CM), the practical application of this solution requires the following additional assumptions.

The main assumption adopted in this solution concerns the credit line value offered by the financial provider to the budget constrained retailer. We set this value equals to the 70% of the order value that retailer is going to issue to its supplier.
Moreover, like the DM, the retailer’s CCC turns negative after the adoption of this IF solution:

• The retailer immediately gets 30% of the revenue and the 70% after 4 weeks;
• The supplier is immediately \( (t = 0) \) paid by the 3PL-Bank for the 70% of the order value, whereas the remaining 30% is paid by the retailer after 8 weeks since the order placement;
• The financial provider immediately \( (t = 0) \) grants the trade credit to the retailer which has to pay it back (plus an interest) after 12 weeks;
• 3PL-Bank takes 4 weeks to delivery the ordered goods from the supplier to the retailer, but the latter pays the 3PL-Bank after 4 weeks since it has received the order.

4.2 Scenario definition and Results

The different scenarios, which constitute the sensitivity analysis, are made of a specific combination of variables. These variables, suggested by Prof. Xiangfeng Chen as the most interesting, are: the standard deviation of the Product A demand \( \sigma \), the interest rate of the loan granted by the financial provider to the retailer \( i \) and the inventory level of Product_X available to be pledged \( \text{inventory}(X) \). Two of last three parameters, \( \sigma \) and \( \text{inventory}(X) \), are always considered as a function of the market demand average value \( \mu \) and they are established as follows:

- \( \sigma = x [\%] \cdot \mu \);
- \( \text{inventory}(X) \text{ units per 3 months} = 3 \cdot 4 \cdot (y [\%] \cdot \mu ) \).

In particular, we set and keep the value of the average demand equals to 100 units per week \( (\mu = 100 \text{ unit/week}) \) throughout the whole analysis.

In Table 2, for example, we show the basic scenario through which we start the sensitivity analysis: here the values of the three previous variables are \( \sigma = 0,3 \cdot \mu \), \( i = 2\% / \text{year} \) and \( \text{inventory}(X) \text{ units per 3 months} = 3 \cdot 4 \cdot (0,33 \cdot \mu ) \).

<table>
<thead>
<tr>
<th>Variable</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>standard deviation (( \sigma ))</td>
<td>30</td>
</tr>
<tr>
<td>interest rate (( i ))</td>
<td>2%</td>
</tr>
<tr>
<td>inventory level (( L_X ))</td>
<td>400</td>
</tr>
</tbody>
</table>

Table 2 - Example of variables describing the 1st scenario taken into account
Finally, we consider very important to propose again what are the different policies implemented by the retailer in order to manage its inventory, classifying them according to the followed review logic (see Table 3).

<table>
<thead>
<tr>
<th>INVENTORY REVIEW LOGIC</th>
<th>INVENTORY REORDER POLICY</th>
</tr>
</thead>
<tbody>
<tr>
<td>CONTINUOUS control of the inventory</td>
<td>Two-Bin System</td>
</tr>
<tr>
<td></td>
<td>Min-Max System</td>
</tr>
<tr>
<td>PERIODIC control of the inventory</td>
<td>Base-Stock System</td>
</tr>
<tr>
<td></td>
<td>Hybrid System</td>
</tr>
</tbody>
</table>

Table 3 – Adopted inventory policies

4.3 Inventory Financing: Traditional vs Innovative solutions

The first part of our sensitivity analysis has the aim of comparing the traditional IF solution (Traditional Mode) with an Innovative Inventory Financing solution (IIFS) taken into account and developed by our model (Delegation or Control Mode).

The main purposes of this action are to quantify the benefits and advantages due to the implementation of an IIFS and to understand how they change depending on the demand uncertainty level. In order to do this, we build up a sensitivity analysis as follows.

Methodology

First, we start computing the supply chain profit\(^1\) obtained when the retailer applies a Traditional Mode \((TM)_{inv,logic}\), considering separately the situation with a continuous review logic from the one with a periodic review logic (as shown in the Table 4).

\(^{1}\) We also call the supply chain profit as supply chain benefit and it is calculated as sum of all players’ profits: specifically, it is the sum between the retailer’s Final tot liquidity, the supplier’s Total Profit, the Bank’s Total Profit and the 3PL’s Total Profit (see Table 4).
Table 4 - SC profit in a TM using a “continuous” or “periodic” logic to reorder the inventory

Secondly, we define and evaluate the benefits achieved by an IIFS comparing them with the benefits gained by the supply chain in a traditional situation. With the aim of easing this assessment, we decide to consider a “general” supply chain benefit $\Pi_{IFS_{invLOGIC}}$ which represents the benefits achieved by an IIFS.

In particular, we define the last value averaging the benefits of the two IIFSs taken into account by the model, namely the Delegation Mode ($\Pi_{DM_{invPolicy}}$) and Control Mode ($\Pi_{CM_{invPolicy}}$), keeping always separate the solutions originated by different review logics. At the end of this step, we get two different values of $\Pi_{IFS_{invLOGIC}}$ corresponding to the average supply chain benefit when the retailer relies on a continuous ($\Pi_{IFS_{Continuous}}$) or a periodic ($\Pi_{IFS_{Periodic}}$) review logic.

\[
\Pi_{IFS_{invLOGIC}} = \begin{cases} 
\frac{\Pi_{DM(2Bin)} + \Pi_{DM(MinMax)} + \Pi_{CM(2Bin)} + \Pi_{CM(MinMax)}}{4} & = \Pi_{IFS_{Continuous}} \\
\frac{\Pi_{DM(BaseStock)} + \Pi_{DM(Hybrid)} + \Pi_{CM(BaseStock)} + \Pi_{CM(Hybrid)}}{4} & = \Pi_{IFS_{Periodic}}
\end{cases}
\]
Using the benefits of the Traditional Mode as benchmark, we estimate and quantify the achievable benefits through an IIFS. Specifically, we carry out the difference between the value $\bar{\Pi}(IIFS)_{\text{inv}\_\text{LOGIC}}$ and the supply chain benefit gained with a TM ($\bar{\Pi}(TM)_{\text{inv}\_\text{LOGIC}}$), both under the same typology of inventory review logic (the result of this difference corresponds to the item “NET BENEFIT” in the Table 4).

$$\text{NET BENEFIT}_{\text{inv}\_\text{LOGIC}} = \bar{\Pi}(IIFS)_{\text{inv}\_\text{LOGIC}} - \bar{\Pi}(TM)_{\text{inv}\_\text{LOGIC}}$$

<table>
<thead>
<tr>
<th>IF VS TRAD MODE</th>
<th>CONTINUOUS CONTROL</th>
<th>PERIODIC CONTROL</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>NET BENEFIT</td>
<td>$$250.384$</td>
</tr>
<tr>
<td></td>
<td>% BENEFIT</td>
<td>$17%$</td>
</tr>
<tr>
<td></td>
<td>NET BENEFIT</td>
<td>$$512.841$</td>
</tr>
<tr>
<td></td>
<td>% BENEFIT</td>
<td>$42%$</td>
</tr>
</tbody>
</table>

**Table 5** - Differences between the SC benefits achieved applying the IIFSs and the TM

Moreover, we compute how much, in percentage, the IIFSs overcomes the TM (this value correspond to $\%\text{BENEFIT}$ in the Table 5).

This data results being very important and meaningful because it makes clear the advantages achievable after the introduction of an IIFS.

We estimate this value as follows:

$$\%\text{BENEFIT}_{\text{inv}\_\text{LOGIC}} = 1 - \frac{\bar{\Pi}(IIFS)_{\text{inv}\_\text{LOGIC}}}{\bar{\Pi}(TM)_{\text{inv}\_\text{LOGIC}}}$$

This benefits assessment is performed just on a basic situation of the context ($i = 2\%/\text{year}$ and $\text{inventory}(X)_{3\text{months}} = 3 \cdot 4 \cdot (0.33 \cdot \bar{\mu})$) where the only parameter considered appropriate to be variable is the standard deviation of the demand.
We test the model with different values of demand uncertainly, from $\sigma = 10\%$ to $\sigma = 80\%$ of the average value of the demand ($\bar{\mu}$); more in details, for each single value of demand standard deviation we carry out several iterations but we consider as result the mean value between those obtained (see Table 6). The last process allows us to obtain a more significant array of data in order to better perform the sensitivity analysis.

<table>
<thead>
<tr>
<th>$\sigma$</th>
<th>Continuous control</th>
<th>Periodic control</th>
</tr>
</thead>
<tbody>
<tr>
<td>10</td>
<td>$$441.642$</td>
<td>$$642.129$</td>
</tr>
<tr>
<td>20</td>
<td>$$427.559$</td>
<td>$$588.055$</td>
</tr>
<tr>
<td>30</td>
<td>$$414.101$</td>
<td>$$626.032$</td>
</tr>
<tr>
<td>40</td>
<td>$$483.275$</td>
<td>$$631.020$</td>
</tr>
<tr>
<td>50</td>
<td>$$515.740$</td>
<td>$$655.238$</td>
</tr>
<tr>
<td>60</td>
<td>$$543.532$</td>
<td>$$686.689$</td>
</tr>
<tr>
<td>70</td>
<td>$$537.864$</td>
<td>$$613.968$</td>
</tr>
<tr>
<td>80</td>
<td>$$568.221$</td>
<td>$$664.873$</td>
</tr>
</tbody>
</table>

Table 6 - SC profit gaps (absolute and percentage) between IIFSs and TM

### 4.3.1 RESULTS

We computed, for each review logic, the value of % $\text{BENEFIT}_{\text{inv.logic}}$ for all the different levels of the demand standard deviation, then we report the minimum and the maximum value of the percentages obtained. Thus, we have noticed that, if the retailer applies continuous inventory policies, the IIFSs perform from 32% to 47% better results than the TM. Instead, if the retailer applies periodic reorder policies, the IIFSs perform from 49% to 67% better results than the TM (as shown in the Table 7).

<table>
<thead>
<tr>
<th>$\sigma$</th>
<th>Continuous control</th>
<th>Periodic control</th>
</tr>
</thead>
<tbody>
<tr>
<td>10</td>
<td>$$441.642$</td>
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<tr>
<td>50</td>
<td>$$515.740$</td>
<td>$$655.238$</td>
</tr>
<tr>
<td>60</td>
<td>$$543.532$</td>
<td>$$686.689$</td>
</tr>
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<td>70</td>
<td>$$537.864$</td>
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</tr>
<tr>
<td>80</td>
<td>$$568.221$</td>
<td>$$664.873$</td>
</tr>
</tbody>
</table>

Table 7 - Min and Max profit gap percentage under both continuous and periodic review logic

---

2 All the following results have been established by allocating the average demand ($\bar{\mu}$) a value of 100 units per week (e.g. if $\sigma=10\%$, it means that the demand variability equals 10 unit per week).
We decide to graphically represent the obtained results in two different graphs, each one corresponding to a specific inventory review logic (see Figure 4.1 and Figure 4.2).

**Figure 4.1** – Supply chain profit obtained through innovative and traditional solutions, both combined with a continuous inventory review logic

![Graph showing the relation between innovative and traditional solutions with continuous inventory control logic.](image)

**Figure 4.2** - Supply chain profit obtained through innovative and traditional solutions, both combined with a periodic inventory review logic

![Graph showing the relation between innovative and traditional solutions with periodic inventory control logic.](image)
In both situations there is a negative correlation between the benefit trends and the demand standard deviation, meaning that higher is the value of the demand standard deviation, the lower is the supply chain profit.

Moreover, both the graphs are perfectly consistent with the data shown in Table 7, in fact it is clear how the trends difference increases when the demand uncertainty gets higher. This last statement proves that IIFSs are less sensitive to the demand variability than traditional IF solutions, so in high uncertainty context the difference between innovative and traditional IF solutions reaches its maximum level.

Concluding, thanks to these results, we are able to add a further contribute to current literature because we have developed a quantitative tool capable to define how much IIFSs overcome a traditional solution and in which specific context (i.e. uncertainty level of the market demand) the gap is the most.

4.4 Innovative Inventory Financing solutions: Delegation and Control Mode

In this section, we are going to compare two IIFSs, namely Delegation Mode and Control Mode. The main goal of this comparison is to find out some specific and clear situations where one solutions largely overcomes the other one.

In the first part is presented the methodology followed by us in order to develop the sensitivity analysis as accurate as possible, then all the results will be shown and described.

Methodology

We decided to set up the sensitivity analysis computing ten iterations for each scenario\(^3\) taken into account.

As first step, in each iteration we analyze and check the supply chain profit of each combination between a specific inventory policy and IIFS. In order to do this first step, we build up the dashboard represented in the Table 8, where the “supply chain profit” is calculated as sum of all players’ profit.

---

\(^3\) Each scenario is made up by a specific combination of the three chosen variables: standard deviation, interest rate and inventory level of Product\_X available to be pledged \((\sigma, i, \text{Inventory}(X)_{3\text{ months}}))\.
Then, we start to collect all the different values assumed by the variable $\lambda_{Inv\, Policy}$ which represents the difference between the supply chain profit gained using the CM and the one obtained through the DM, maintaining fixed a certain inventory policy. Specifically, we calculate $\lambda_{Inv\, Policy}$ as follows:

$$\lambda_{Inv\, Policy} = SC\, PROFIT_{Control\, Mode}^{Inv\, Policy} - SC\, PROFIT_{Delegation\, Mode}^{Inv\, Policy}$$

When the value of $\lambda_{Inv\, Policy}$ is negative, it means that the DM performs better than the CM and vice versa (see Table 9).

Example:

$\lambda_{Two\, Bin} = 1.792.481-1.780.122 = 12.359; \quad \lambda_{Min\, Max} = 1.800.853-1.769.087 = 31.766;\n\lambda_{Base\, Stock} = 1.794.891-1.724.906 = 69.985; \quad \lambda_{Hybrid} = 1.789.217-1.756.903 = 32.314.$

Table 8 - Total supply chain profit obtained with different inventory policies and IIFs

<table>
<thead>
<tr>
<th></th>
<th>DELEGATION MODE</th>
<th>CONTROL MODE</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Two-Bin</td>
<td>Min-Max</td>
</tr>
<tr>
<td>Retailer</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Final Profit</td>
<td>$0$</td>
<td>$0$</td>
</tr>
<tr>
<td>Stock out cost</td>
<td>$0$</td>
<td>$0$</td>
</tr>
<tr>
<td>Supplier</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total Profit</td>
<td>$1.346$</td>
<td>$762$</td>
</tr>
<tr>
<td>Bank</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 9 - SC differences between CM and DM

$\lambda_{Inv\, Policy}$

Table 8, the retailer’s Final Profit, the supplier’s Final Profit, the bank’s Final Profit and the 3PL-Baan’s Final profit mean respectively the RETAILER FINAL LIQUIDITY, the SUPPLIER TOTAL PROFIT, and the 3PL – BANK TOTAL PROFIT computed in both the paragraphs 3.5.2 Process and 3.6.2 Process.
The last step of each iteration is to find out which combination of inventory policy and IF solution ensures the best supply chain profit. With the purpose to make the result clearer, we highlight the best combination using an azure square in the Table 8 and a green square in the Table 10.

Table 10 – SC differences between CM and DM with best solution

<table>
<thead>
<tr>
<th></th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
<th>10</th>
<th>CONTROL vs DELEGATION</th>
</tr>
</thead>
<tbody>
<tr>
<td>BASE STOCK</td>
<td>69.985</td>
<td>49.252</td>
<td>673.185</td>
<td>47.057</td>
<td>185.198</td>
<td>29.000</td>
<td>49.185</td>
<td>165.311</td>
<td>45.676</td>
<td>38.082</td>
<td></td>
</tr>
<tr>
<td>HYBRID</td>
<td>32.314</td>
<td>41.883</td>
<td>207.629</td>
<td>39.104</td>
<td>197.656</td>
<td>25.660</td>
<td>31.944</td>
<td>206.420</td>
<td>31.256</td>
<td>34.469</td>
<td></td>
</tr>
</tbody>
</table>

To conclude the analysis, we compute the average of the ten different values of \( \lambda_{\text{Inv Policy}} \) obtained by a single inventory policy in each iteration (see Table 10). This last computation has the purpose to understand when the CM and DM are closer, allowing us to more easily perceive in which direction we have to deepen the sensitivity analysis in order to find out some possible scenarios where the DM could overcome the CM.

Table 11 – Average SC difference between CM and DM

<table>
<thead>
<tr>
<th></th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
<th>10</th>
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<td>45.676</td>
<td>38.082</td>
<td></td>
</tr>
<tr>
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<td>25.660</td>
<td>31.944</td>
<td>206.420</td>
<td>31.256</td>
<td>34.469</td>
<td></td>
</tr>
</tbody>
</table>

Now, with the aid of the Table 11, we are able to better explain how an iteration works and how one scenario is analyzed. The columns (from 1 to 10 in the Table 11) represent the ten iteration needed in order to analyze a certain scenario, whereas each brick reports the value

---

5 As addressed by Chen and Hu (2011), the DM should be less performant than the CM, because the former is considered less innovative than the latter.
of $\lambda_{Inv \ policy}$ in that specific situation. Hence, for example, in the square corresponding to the row “Two Bin” and the column “1” we find the value $12.359$, that is the difference between the supply chain profit obtained in the CM and in the DM, when the retailer applies a Two-Bin inventory policy. In this case, the difference is positive, meaning that CM performs better than DM.

Instead, in the square corresponding to the row “Min Max” and the columns “3”, the DM performs better than CM, as demonstrated by the presence of a negative value (also represented with the color red); more in details, here the DM produces a higher supply chain profit than the CM, overcoming the latter by $1.535$.

The green squares stand for the best supply chain profit achieved in each iteration. For example, the green square, corresponding to the row “Base Stock” and the column “7”, means that the highest supply chain profit is obtained thanks to the application of a Base-Stock inventory policy in a CM solution (this last statement because the value of $\lambda_{Inv \ policy}$ is positive).

Concluding, the column “CONTROL vs DELEGATION” computes the average of each row of the table, thus thanks to this last column we are able to figure out which inventory policy makes the DM closer to the CM in terms of profit achieved by the whole supply chain.

We developed the sensitivity analysis on three different levels, where each of them investigates in a deeper way the level before (see Figure 4.3). This because in the first level we just acted on the value of the demand standard deviation; in the second level we make variable the inventory level of Product_X available to be pledged; concluding, in the third level we also varied the interest rate value.

**Figure 4.3 – Levels of the sensitivity analysis**
Level I
The first level is characterized by the analysis of eight different scenarios. These various situations are the result of keeping stable two of the three parameters previously introduced, so we maintain fixed the values of $i$ and $Inv(X)_{3\,months}$, but we change the values of $\sigma$.

In particular, we set:

- $i = 2\%/year$;
- $inventory(X)_{3\,months} = 3 \cdot 4 \cdot (0,33 \cdot \bar{\mu}) = 12 \cdot (0,33 \cdot \bar{\mu})$;
- $\sigma = 10\%, 20\%, 30\%, 40\%, 50\%, 60\%, 70\%, 80\%$ of $\bar{\mu}$.

For example, with the aim to ease the reader’s understanding, if we set the value of the average demand equals 100 units ($\bar{\mu} = 100 \, unit/week$), in this first level each scenario will be constituted by $i = 2\%/year$, $inventory(X)_{3\,months} = 400 \, units$ and $\sigma = 10,20,30,40,50,60,70,80$.

Level II
The second level has been developed to further investigate the results obtained in the previous level. Basically, here we turn into a variable parameter also the $inventory(X)_{3\,months}$, maintaining fixed just the value of the interest rate $i$.

In particular, we set:

- $i = 2\%/year$;
- $inventory(X)_{3\,months} = 12 \cdot (0,16 \cdot \bar{\mu}) or 12 \cdot (0,33 \cdot \bar{\mu}) or 12 \cdot (0,5 \cdot \bar{\mu})$;
- $\sigma = 10\%, 20\%, 30\%, 40\%, 50\%, 60\%, 70\%, 80\%$ of $\bar{\mu}$.

Hence, this second level is composed by twenty-fours different scenarios, each of them characterized by different values of both interest rate and quantity of Product_X available to be pledge.

For example, if we set the $\bar{\mu} = 100 \, unit/week$, in this second level each scenario will be constituted by $i = 2\%/year$, $inventory(X)_{3\,months} = 200,400,600 \, units$ and one of the eight specific values of $\sigma$ said in the previous level.
**Level III**

The third level deeply investigates the outcomes of the previous two levels, indeed here all the parameters become variable, so this last part represents the area where we reached the highest and deepest level of detail in our analysis.

In particular, we set:

- \( i = 1\% \text{/year or } 2\% \text{/year or } 4\% \text{/year}; \)
- \( \text{inventory}(X)_{3 \text{ months}} = 12 \cdot (0,16 \cdot \bar{\mu}) \) or \( 12 \cdot (0,33 \cdot \bar{\mu}) \) or \( 12 \cdot (0,5 \cdot \bar{\mu}) \);
- \( \sigma = 10\%, 20\%, 30\%, 40\%, 50\%, 60\%, 70\%, 80\% \text{ of } \bar{\mu}. \)

So, considering all the various possible combinations, in this level we develop the analysis of seventy-two different scenarios.

Always with the aim to make simpler the reader’s understanding, if we set \( \bar{\mu} = 100 \text{ unit/week}, \) in this third level each scenario will be constituted by \( i = 1\%, 2\%, 4\%, \)

\( \text{inventory}(X)_{3 \text{ months}} = 200, 400, 600 \text{ units} \) and \( \sigma = 10, 20, 30, 40, 50, 60, 70, 80. \)

**4.4.1 RESULTS**

In this section are presented the main results achieved by the model after having thoroughly analyzed all the outcomes of the sensitivity analysis\(^6\).

Before showing the results obtained, we consider important to state that we have achieved the following results by focusing on the difference between the Control and Delegation Mode obtained under the same review logic \( (\lambda_{\text{InvLogic}}). \)

In particular, with the aim to simplify the analysis and to make the results as direct and clear as possible, we define two new parameters: \( \lambda_{\text{Continuous}} \) and \( \lambda_{\text{Periodic}} \) that represent the differences between CM and DM under a continuous and periodic review logic respectively.

---

\(^6\) All the graphs, that there will be presented in the following paragraphs, have been established by allocating the average demand \( (\bar{\mu}) \) a value of 100 units per week. As consequence, all the values of the others variables \( (\sigma, \text{inventory}(X)_{3 \text{ months}} \text{ and } \lambda_{\text{InvPolicy}}) \) must be considered in relation with \( \bar{\mu} = 100. \)
We calculate these two last parameters as follows:

\[
\lambda_{Inv, LOGIC} = \begin{cases} 
\frac{\lambda_{TwoBin} + \lambda_{MinMax}}{2} = \lambda_{Continuous} \\
\frac{\lambda_{BaseStock} + \lambda_{Hybrid}}{2} = \lambda_{Periodic} 
\end{cases}
\]

*Result n.1: Relation between IIFSs and market uncertainty*

As main result, the sensitivity analysis highlights a relation between an IIFS (DM and CM) and the level of the demand standard deviation, where the latter one represents the uncertainty of the market. This relation can already be noticed in the first level of our sensitivity analysis and then confirmed by the two subsequent levels. In order to ease the reader’s understanding, first of all we consider separately the outcomes obtained with the two different logics of inventory control and secondly we show the results through a graphic instrument (see Figure 4.4).

![Graph showing the relation between IF solutions and market uncertainty](image)

*Figure 4.4 – Difference between CM and DM varying the demand variability*
In the above graph is represented the trend of $\lambda_{InvLogic}$ in both the situations: retailer adopting “continuous” reorder policies (Two-Bin or Min-Max systems) and “periodic” reorder policies (Base-Stock or Hybrid systems) which refer to $\lambda_{Continuous}$ and $\lambda_{Periodic}$ respectively.

Analyzing the results when the retailer adopts a continuous review logic, we noticed a positive correlation between the demand standard deviation value and the variable $\lambda_{Continuous}$. This means that the higher is the value of the demand standard deviation, the higher is the difference between CM and DM (in favor of the first one). In this situation the CM always overcomes the DM but it is important to understand that when the standard deviation is lower than the 30% of the average demand ($\sigma \leq 0.3 \cdot \mu$) the two different IF solutions perform quite similar outcomes.

Concerning the scenarios when the retailer is adopting a periodic review logic, the results seem to be opposite if compared with the previous ones; indeed, there is a negative correlation between the demand standard deviation value and $\lambda_{Periodic}$. In this context, when the uncertainty of the market is low, the model registers the highest value of $\lambda_{Periodic}$, whereas when the demand variability increases, the difference between DM and CM becomes quite small. In other words, the higher is the value of the demand standard deviation, the lower is the difference between CM and DM and in particular when $\sigma \geq 0.8 \cdot \mu$ the benefits achievable by the two IF solution are quite close. This last trend behavior ($\lambda_{Periodic}$) could be caused by the retailer’s logic to reorder its inventory; in particular we showed how the difference between CM and DM decreases when the demand standard deviation increases, this because when the demand is highly variable the losses due to adopt a “wrong logic” to reorder the inventories (such as a periodic inventory control logic) are so high to almost nullify the benefits of a CM solution.

**Result n.2: Relation between IIFSs and inventory available to be pledged**

In the second level of the sensitivity analysis we started to evaluate the results considering also different quantities of the Product_X available to be pledged ($inventory(X)_{3 months}$). Unlike the previous result where DM and CM had opposite trends, here the two IIFSs follow the same trend as easily visible form the Figure 4.5, which shows how the difference between CM and DM changes depending on different values assumed by the variable $inventory(X)_{3 months}$. 
We discover a relation between this inventory$(X)_{3\text{months}}$ and $\lambda_{\text{inv:LOGIC}}$; in particular, when the first one assumes its minimum values, the difference between CM and DM gets very high. This behavior makes sense because the DM, when the retailer has a very few amount of Product_X available to be pledged, becomes very similar to the TM (where the retailer can not pledge anything), hence the difference with a CM is huge. Increasing the value of the variable inventory$(X)_{3\text{months}}$ the difference between CM and DM decreases significantly, making the benefits of the two solutions very similar (the DM, with a “periodic inventory control logic” adopted by the retailer, seems to be even better than the CM). Moreover, if we continue increasing the amount of Product_X available to be pledged an interesting result comes to light: when the value of inventory$(X)_{3\text{months}}$ is higher than $3 \cdot 4 \cdot (0,45 \cdot \mu)$, the value $\lambda_{\text{inv:policy}}$, which was previously decreased, slowly starts to increase. We justify this last statement considering that the situation, when the amount of Product_X reaches a quite high value, means the Product_X can not be considered anymore as secondary product (it’s crucial to remember that the amount of Product_X is linked with its market demand, so if its quantity increases its demand increases as well)

![Relation between IF solutions and inventory level of Product_X](image)

**Figure 4.5** - Difference between CM and DM varying the quantity of Product_X

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7 As we have supposed in the paragraph 3.4 General Assumptions.
Concluding, even if both $\lambda_{\text{Continuous}}$ and $\lambda_{\text{Periodic}}$ follow the same first decreasing and then increasing trend, we should consider separately their behaviors because $\lambda_{\text{Periodic}}$ has a more accentuated trend and especially because their respective minimum points are different. Thus, we can summarize the behaviors of $\lambda_{\text{Continuous}}$ and $\lambda_{\text{Periodic}}$ in three different value ranges:

\[
\text{Trend of } \lambda_{\text{Continuous}} = \begin{cases} 
\text{when } 0 \leq \text{inventory}(X)_{3 \text{ months}} < 12 \cdot (0,25 \cdot \mu), & \text{very high } \lambda_{\text{Continuous}} \\
\text{when } 12 \cdot (0,25 \cdot \mu) \leq \text{inventory}(X)_{3 \text{ months}} < 12 \cdot (0,35 \cdot \mu), & \text{low } \lambda_{\text{Continuous}} \\
\text{when } \text{inventory}(X)_{3 \text{ months}} \geq 12 \cdot (0,35 \cdot \mu), & \text{high } \lambda_{\text{Continuous}}
\end{cases}
\]

\[
\text{Trend of } \lambda_{\text{Periodic}} = \begin{cases} 
\text{when } 0 \leq \text{inventory}(X)_{3 \text{ months}} < 12 \cdot (0,33 \cdot \mu), & \text{very high } \lambda_{\text{Periodic}} \\
\text{when } 12 \cdot (0,33 \cdot \mu) \leq \text{inventory}(X)_{3 \text{ months}} < 12 \cdot (0,5 \cdot \mu), & \text{low } \lambda_{\text{Periodic}} \\
\text{when } \text{inventory}(X)_{3 \text{ months}} \geq 12 \cdot (0,5 \cdot \mu), & \text{high } \lambda_{\text{Periodic}}
\end{cases}
\]

**Result n.3: Relation between IIFSs and interest rate applied by the Financial Provider**

The last result shown by the sensitivity analysis is a strong positive correlation also between the interest rate $i$ offered by the financial provider and $\lambda_{\text{inv.LOGIC}}$.

It was possible to find this correlation thanks to the third level of our analysis, where we spread the study also on different possible values of the interest rate. Here, as the following graph shows (see Figure 4.6), the different variables $\lambda_{\text{Continuous}}$ and $\lambda_{\text{Periodic}}$ follow the same increasing trend.

The analysis shows that the lower is the value of the interest rate, the smaller is the difference between CM and DM and vice versa, indeed it is clear from the Figure 4.6 how both the trend of $\lambda_{\text{Periodic}}$ and $\lambda_{\text{Continuous}}$ rise up when $i$ increases.
This last behavior is due to, in the DM, the bank applies the interest rate on the loan value plus the costs paid to the 3PL for the collateral management ($BANK COSTS$):

$$TOTAL PAYBACK VALUE = (LOAN + BANK COSTS) \cdot \left( 1 + i \cdot \frac{K}{4 \cdot 12} \right)$$

where

$$BANK COSTS = (Pledge Holding Price_{3PL} + Pledge Monitoring Price_{3PL})$$

In the CM, the 3PL-Bank applies the interest rate just on the value of the trade credit granted to the retailer:

$$TOTAL PAYBACK VALUE = TP(A) + \left[ TRADE CREDIT \cdot \left( 1 + i \cdot \frac{K}{4 \cdot 12} \right) \right]$$

In the last case the retailer has not to pay an interest on extra costs (i.e. $BANK COSTS$ in the DM); this means that receiving the same value of funds (the value of the $LOAN$ in the DM equals the value of the $TRADE CREDIT$ in the CM), the amount of interests that the retailer has to pay, will be lower in the CM than in the DM.
Cross-Analysis of the Results

Deepening the analysis, in order to find further interesting results, we decide to start analyzing and studying all the results previously discovered varying more than one variable simultaneously. In other words, for each situation we plot the trend of $\lambda_{\text{inv.\ LOGIC}}$ changing at the same time the value of two of the three main parameters used for our sensitivity analysis, namely: the standard deviation ($\sigma$), the quantity of Product_X available to be pledged ($\text{inventory}(X)_3\text{ months}$) and the interest rate ($i$).

With the purpose of making the study more orderly and to ease the reader’s understanding we decide to split the analysis in two different cases based on which logic of inventory control (continuous or periodic) is adopted by the retailer.

Cross-analysis [$\sigma$; $i$]

Analyzing the crossing results obtained by varying the parameters $\sigma$ and $i$, we obtain a very interesting and useful outcomes that can be used as a sort of “summary” in order to synthesize, in just one solution, the different tendencies taken by $\lambda_{\text{inv.\ LOGIC}}$.

Now, we are going to study the trend of $\lambda_{\text{inv.\ LOGIC}}$ when the variability of the demand ($\sigma$) grows, repeating this process for different values of the interest rate $i$. The expected result is to have on the same graph as many trend curves as many different values we assign to $i$.

![Figure 4.7 - Cross analysis [$\sigma$; $i$], under a continuous inventory review logic](image)

*Relation among IF solutions (with a CONTINUOUS inventory control logic) moving market uncertainly [$\sigma$] and interest rate [$i$]*

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Under a “continuous inventory control” (see Figure 4.7), all the curves of $\lambda_{\text{Continuous}}$, although they correspond to different values of the interest rate ($i = 1\%, 2\%$ and $4\%$), follow the same increasing trend (this effect is perfectly consistent with what we previously showed in the Result n.1).

Focusing now on the other situation (when the retailer applies an inventory policy with a “periodic inventory control” logic), the trend followed by all the curves is negative, meaning that the difference between $CM$ and $DM$ decrease when we increase the value of $\sigma$ (see Figure 4.8).

![Figure 4.8 – Cross analysis [$\sigma; i$], under a periodic inventory review logic](image)

Concluding, in both the graphs, it appears to be very clear that increasing the interest rate, the respective curve of both $\lambda_{\text{Continuous}}$ and $\lambda_{\text{Periodic}}$ take up a higher position in the graph. This last result confirms what we have already introduced in the Result n.3, so now we can affirm that the increase of the interest rate plays an important role in favor of the $CM$. 

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Cross-analysis \([i; \sigma]\)

In order to deepen the study, we make another analysis with the same parameters but moving first the interest rate and secondly the demand standard deviation. The trends of \(\lambda_{INVLOGIC}\) obtained through this cross analysis are perfectly consistent with the previous outcomes showed and described in the Result n.1 and Result n.3. In fact, in both these situations (continuous and periodic), the trend of \(\lambda_{INVLOGIC}\) is growing as the interest rate, charged by the financial provider, increases its percentage value.

As in the Result n.2, also here it is easy to see and understand how, for different values of \(\sigma\), the curves move on the vertical axis, changing their “altitude” in the graph.

With a continuous review logic, the higher is the value of the demand standard deviation, more upwards is the curve position in the graph, which means that the difference between CM and DM gets higher (see Figure 4.9);

![Figure 4.9 - Cross analysis \([i; \sigma]\), under a continuous review logic](image)

With a periodic review logic, if we increase the value of the demand standard deviation the exactly opposite effect is generated; indeed, here trend curves corresponding to a higher value of \(\sigma\) are always more downwards in the graph (see Figure 4.10).
Cross-analysis $[\sigma; \text{inventory}(X)_{3\text{ months}}]$ 

We now focus on how is the trend of $\lambda_{inv\text{Policy}}$ when we adjust the values of both the demand standard deviation and the value of $\text{inventory}(X)_{3\text{ months}}$.

If we are considering the situation where the retailer uses a continuous approach to control the inventory, we can find out that:

- $\lambda_{Continuous}$, as we expected, increase their value when the market uncertainly is high;
- $\lambda_{Continuous}$ follow the same trend we presented in the Result n.2, indeed the difference between CM and DM is the highest when the retailer has not too many Product_X available to be pledged (blue line in the Figure 4.11) but, increasing the value of $\text{inventory}(X)_{3\text{ months}}$ until a certain amount, we can definitely notice $\lambda_{Continuous}$ in a lower level in the graph (e.g. the yellow line in the Figure 4.11). Moreover, it is important to display that, if we substantially increase the amount of Product_X, the variable $\lambda_{Continuous}$ starts to increase its values again (e.g. the green line in the Figure 4.11).
Both these statements can be easily seen in the Figure 4.11 in which are plotted four different curves representing the trends of $\lambda_{Continuous}$, each one obtained through a different value of $inventory(X)_{3 months}$.

Figure 4.11 - Cross analysis [$\sigma; inventory(X)_{3 months}$], under a continuous inventory review logic

Concerning the other situation (when a periodic review logic is adopted by the retailer), if we move the value of $inventory(X)_{3 months}$, the variable $\lambda_{Periodic}$ follows the same, first decreasing and then increasing, trend showed in the “continuous logic” situation with the only difference that now $\lambda_{Periodic}$ has a negative correlation with the uncertainly of the market which means that increasing the demand standard deviation there will be registered a lower value of the difference between CM and DM (see Figure 4.12).

According to the Figure 4.12, if we move from $inventory(X)_{3 months} = 200$ to $inventory(X)_{3 months} = 600$ the curve of $\lambda_{Periodic}$ goes down in the graph (see the blue, yellow and red lines); but after a certain value of $inventory(X)_{3 months}$ the curve of $\lambda_{Periodic}$ starts to ascend again (see the green line).
Cross-analysis \(\text{inventory}(X)_{3 \text{ months}}; \sigma\)

In order to complete our analysis, we also study the changes of \(\lambda_{\text{Inv.LOGIC}}\) if we analyze it basing first on \(\text{inventory}(X)_{3 \text{ months}}\) and secondly on different values of the demand standard deviation. Also here, with the purpose to make more clear the solution and ease the reader's understanding, we plot separately the situations concerning the two different type of inventory control logics, namely continuous (see Figure 4.13) and periodic (see Figure 4.14).

Plotting the results on a graph it is easier to see and understand how the trends move. In both the situations, the graphs show that at the beginning (for low values of \(\text{inventory}(X)_{3 \text{ months}}\)) there is a decreasing trend but, after reaching its minimum point, the values of \(\lambda_{\text{Inv.LOGIC}}\) start to increase.

If we compare the the two different situations, \(\lambda_{\text{Continuous}}\) and \(\lambda_{\text{Periodic}}\), two main differences are revealed:

- the lowest point, reached by the trend of \(\lambda_{\text{Periodic}}\), is slightly shifted on the right side and a little lower if compared with the minimum point of \(\lambda_{\text{Continuous}}\).
going beyond the minimum point, the trend of $\lambda_{\text{Continuous}}$ seems to increase more rapidly than the trend of $\lambda_{\text{Periodic}}$.

**Figure 4.13** - Cross analysis \([\text{inventory}(X)_{3 \text{months}}; \sigma]\), under a continuous inventory review logic

**Figure 4.14** - Cross analysis \([\text{inventory}(X)_{3 \text{months}}; \sigma]\), under a periodic inventory review logic
To conclude, both the situations show similar trends of $\lambda_{\text{Continuous}}$ and $\lambda_{\text{Periodic}}$, this proves that the difference between CM and DM is minor when the retailer has enough quantity (but not to much as well) of Product_X available to be pledged.

Additionally, the results also prove that if the retailer adopts a "continuous inventory control" logic, when we apply a lower value of $\sigma$, lower will be the values assumed by $\lambda_{\text{Continuous}}$; whereas when the retailer implements a "periodic control" logic the result is exactly the opposite (this last result is perfectly consistent with the outcomes shown in the Result n.1). To better understand this last statement, we suggest the reader to focus on the trend of $\lambda_{\text{InvLogic}}$ with $\sigma = 10$ (orange line) in both the figures above: in the first graph $\lambda_{\text{Continuous}}(\sigma = 10)$ is almost always the lowest trend, whereas in the second graph $\lambda_{\text{Periodic}}(\sigma = 10)$ is often over the others trend lines.

4.5 Inventory Reorder Policies under Innovative Inventory Financing Solutions

In this section we investigate, through the sensitivity analysis, how a specific inventory policy can affect the entire profit of a supply chain where an IIFS is underway.

Methodology

We set up the sensitivity running ten different iterations for each specific situation, where for every iteration we check the profit gained by the entire supply chain.

The first part of the sensitivity analysis follows the same process used in the previous scenario, thus we use again the dashboard represented in the Table 8.

Subsequently, we do not consider anymore the differences between DM and CM but we start to focus just on the profit gained by all players (supply chain profit) in each specific situation.

In order to make the study clearer, we split the analysis in two parts, one concerning situations under the DM and one regarding situations under the CM.

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8 For “specific situation” we mean a specific combination made up by the inventory policy adopted by the retailer, the in use Inventory Financing solution and the level of demand uncertainty.
For this analysis we decide to move just the demand standard deviation ($\sigma$) values, this because we consider it as the most important variable and, as consequence, the one which can generate more interesting and useful results.

Thus, for each specific level of $\sigma$ and at the same time for both CM and DM, we start recording the supply chain profits obtained through every single inventory policy. After ten iterations we stop recording and we calculate the average supply chain profit (the Table 12 represents the CM situation, whereas the Table 13 represents the DM one).

<table>
<thead>
<tr>
<th>CONTROL MODE ($\sigma=10$)</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
<th>10</th>
<th>SC PROFIT</th>
</tr>
</thead>
<tbody>
<tr>
<td>HYBRID</td>
<td>1.751.315</td>
<td>1.752.206</td>
<td>1.751.565</td>
<td>1.757.148</td>
<td>1.746.688</td>
<td>1.754.443</td>
<td>1.756.058</td>
<td>1.739.055</td>
<td>1.755.370</td>
<td>1.750.077</td>
<td>1.752.593</td>
</tr>
</tbody>
</table>

**Table 12 – SC profits under CM**

<table>
<thead>
<tr>
<th>DELEAGION MODE ($\sigma=10$)</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
<th>10</th>
<th>SC PROFIT</th>
</tr>
</thead>
<tbody>
<tr>
<td>MIN MAX</td>
<td>1.713.576</td>
<td>1.715.009</td>
<td>1.689.652</td>
<td>1.713.301</td>
<td>1.697.037</td>
<td>1.708.101</td>
<td>1.706.740</td>
<td>1.682.136</td>
<td>1.714.007</td>
<td>1.697.807</td>
<td>1.703.812</td>
</tr>
</tbody>
</table>

**Table 13 – SC profits under DM**

Once we collected all the average supply chain profits, in order to better understand how different inventory policies affect the benefit of a supply chain (where an IIFS is underway), we plot the result on a graph through which we are more capable to study and comment, for each different level of demand standard deviation, the benefits achievable by the entire supply chain.

### 4.5.1 RESULTS

Through the sensitivity analysis, we deduce different types of correlation between inventory policies and demand uncertainty, depending on which specific solution of IF has been adopted by the budget-constrained firm.
We start studying the trends of supply chain profit under a CM (see Figure 4.15); the first result we notice is, as we expected, a clear reduction when the uncertainty level of the demand gets higher. It is very interesting to notice how the best inventory policy, under a CM, moves from the Hybrid system to the Min-Max one, passing through the Base-Stock and Two-Bin systems. More in details, the best inventory policy is:

- Hybrid system when the demand uncertainty level is very low ($\sigma < 15$);
- Base-Stock system when $15 \leq \sigma < 30$;
- Two-Bin system in a medium level of the demand uncertainty ($30 \leq \sigma < 50$);
- Min-Max system when the demand variability assumes a high level ($\sigma \geq 50$).

![Inventory Policies Under Control Mode](image)

**Figure 4.15** - SC profit with different inventory policies, under the CM

It is worth to state that, when the demand uncertainty level is low, the differences between supply chain profits, each one gained with different inventory policies, are lower than the differences measured when the demand variability is high (all the trend curves are closer in $0 \leq \sigma < 30$).

At the beginning, Hybrid and Base-Stock systems result better because they allow the budget-constrained firm, when it is facing a demand with a low uncertainty level, to reduce its management inventory costs, thus saving fund usable to make the next order bigger.
On the other hand, when the demand standard deviation takes on a medium-high level, the periodic reorder policies (Base-Stock and Hybrid systems) are not able to face such demand, indeed the stock out costs overpass the potential savings of a periodic review. Thus, Two-Bin and Min-Max systems, thanks to their continuous review logic, become the best solutions which can ensure a greater profit for the whole supply chain. Specifically, Min-Max system is better due to it is still more flexible and dynamic than Two-Bin system. Specifically, Min-Max system, in $\sigma > 50$, turns to be the best method due to it is more flexible and dynamic than Two-Bin system; this because the order quantity in the Min-Max system can be variable whereas in the Two-Bin system it is fixed\(^9\).

Concerning the results obtained under a DM (see Figure 4.16), as in the previous situation, the behavior of supply chain profit follows a decreasing trend: higher the demand uncertainty level, the lower are the supply chain profits.

![INVENTORY POLICIES UNDER DELEGATION MODE](image)

**Figure 4.16** - Supply chain profit with different inventory policies, under the DM

If we compare this situation with the CM one, the main difference is that in a DM the best inventory policies result to be always the ones with a continuous review logic (Two-Bin

\(^9\) See paragraph 3.3 Model development: Inventory Reorder Policies
and Min-Max systems). The systems with a periodic review logic, independently of the demand standard deviation level, generate always lower profits than Two-Bin and Min-Max policies. More in details, the Two-Bin system ensures better results when the level of demand standard deviation is low ($\sigma < 20$), then the Min-Max system starts offering a higher supply chain profit.
5 CONCLUSIONS

The conclusive chapter provides the answers to the research questions of this work, summarizing the outcomes of the model. Furthermore, we are going to explain the limitations and the future researches which can enlarge the results of the current work.

5.1 Answer to research questions

RQ1. How much does the Supply Chain benefit if the budget-constrained company implements an innovative Inventory Financing solution combined with a specific inventory policy?

We are able to reply this question through the model presented in this work. In fact, we developed a quantitative tool which allows the user to quantify the benefits, for each actor and also for the entire supply chain, achievable thanks to the implementation of an Innovative Inventory Financing Solutions (IIFS).

The IIFSs taken into account are the Delegation Mode (DM) and the Control Mode (CM), then the model combines each of these with a specific inventory policy. More in details, we consider four different types of inventory policies, two of them operate with a continuous inventory control logic (Two-Bin and Min-Max systems), whereas the other two with a periodic logic (Base-Stock and Hybrid systems).

In order to quantify the tangible benefits for a supply chain after the adoption of an IIFS we needed a benchmark situation through with we were able to conduct a comparison and the benefits assessment. Thus, we decided to set as benchmark situation a traditional Inventory Financing (IF) solution that we named Traditional Mode (TM).

The TM represents an extreme situation because we, with the purpose to emphasize and accentuate the achievable benefits of an IIFS, assumed that the financial provider always rejects the IF request of the SME due to its very low creditworthiness.

It is worth to declare that for this analysis we do not consider separately the DM and CM, because they both are innovative solutions of IF. Thus, in order to consider these two methods joined together, we make an average of their achievable benefits, considering this average as the benefit achievable by a supply chain through the implementation of an IIFS.

Thanks to our model we are able to estimate and quantify the difference between the
benefits of a supply chain under TM and the benefits of a supply chain under IIFS.

As already addressed, Chen and Cai (2011) studied and analyzed a similar situation because they demonstrated that the optimal order quantity and the interest rate are always better in the “Control Role” (considered as an IIFS) than in the “Traditional Role” (considered as a traditional IF solution); thus, in order to add a new further investigation level on this topic, we study this situation (i.e. TM benefit against IIFS benefit) by adding two new considerations to the analysis. Specifically, we start to consider which inventory reorder policy the budget-constrained firm is adopting and also which is the uncertainty level that characterizes the market demand.

In order to ease the outcomes explanation and comprehension we decide to graphically represent the results; in particular, we arrange the results basing on which typology of replenishment logic the budget-constrained firm is implementing.

Thus, the output of this assessment are two different graphs, one representing the results obtained with a continuous inventory control logic (see Figure 5.1) and one representing the results gained through a periodic inventory control logic (see Figure 5.2). Both the graphs clearly show that the benefit achievable through an IIFS are largely higher than a TM one.

![Graph showing the relation between innovative IF and traditional solutions](image)

**Figure 5.1** - Supply chain profit through IIFSS and TM, under a continuous replenishment logic
Moreover, another very interesting result (as also shown in the Table 14) is that the difference, between the IIFS benefit and the TM one, increases when the value of the demand standard deviation grows. This result is quite visible in both the graphs (in particular under a periodic replenishment logic), indeed the distance between the two trends is higher in $\sigma = 80$ than in $\sigma = 10$ (this statement is perfectly consistent with the result presented in the paragraph 4.2.1.1 Results).

Concluding, we can state that the benefits achievable by the supply chain with an IIFS always outclass the potential benefit of a traditional situation, regardless of the adopted inventory policy or the uncertainty level of the market demand. Specifically, with a continuous replenishment logic, the IIFS benefit ranges from 32% (for low values of $\sigma$) to 47% (for high values of $\sigma$) higher than TM benefits; whereas with a periodic replenishment logic, the IIFS benefit is from 49% (for low values of $\sigma$) to 67% (for high values of $\sigma$) better than the “traditional” one (see Table 14).

<table>
<thead>
<tr>
<th></th>
<th>$\sigma = 10$</th>
<th>$\sigma = 20$</th>
<th>$\sigma = 30$</th>
<th>$\sigma = 40$</th>
<th>$\sigma = 50$</th>
<th>$\sigma = 60$</th>
<th>$\sigma = 70$</th>
<th>$\sigma = 80$</th>
<th>min</th>
<th>max</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Continuous control</strong></td>
<td>$$441.642$</td>
<td>$$427.559$</td>
<td>$$414.101$</td>
<td>$$483.275$</td>
<td>$$515.740$</td>
<td>$$543.532$</td>
<td>$$537.864$</td>
<td>$$568.221$</td>
<td>32%</td>
<td>47%</td>
</tr>
<tr>
<td><strong>Periodic control</strong></td>
<td>$$642.129$</td>
<td>$$588.055$</td>
<td>$$626.032$</td>
<td>$$631.020$</td>
<td>$$655.238$</td>
<td>$$686.689$</td>
<td>$$613.968$</td>
<td>$$664.873$</td>
<td>49%</td>
<td>67%</td>
</tr>
</tbody>
</table>

**Table 14** - Supply chain profit gap between IIFSs and TM, varying the demand variability
RQ 2. When does the Delegation Mode generate similar or even better benefits than the Control Mode?

According to Chen and Hu (2011), the Delegation model as an innovative solution of IF but not so innovative as the Control model, thus they present the latter as a better and more profitable IF solution than the former.

In this thesis, we have deeply studied and analyzed both the IIFSs just mentioned above through the development of, respectively, our Delegation Mode and Control Mode. Thus, thanks to our model we are able to investigate and discover whether exist some potential context where the DM could equal, or even overcome, the CM. In particular, we reply this question by means of the application and the sensitivity analysis of our model. In fact, feeding the model with real data (stemming from the external scenario the user has to face) and then changing some values of these, we are able to figure out under which conditions DM generates similar or even better benefits than CM.

After the application of the model, we have changed the values of the most influential variables (i.e. market demand variability, pledging goods availability and interest rate value) and studied the DM and CM’s behaviors. In this way, we noticed that CM always exceed DM except for some areas where these two perform very similar, meaning that here we do not precisely know which IIFS allows the supply chain to gain the best results.

In order to make the reader’s understanding simpler, we design a matrix made of three axes, (see Figure 5.3) where each of them represents one of the three main parameters of our sensitivity analysis:

- Vertical axis: level of Product_X available to be pledged;
- Superior horizontal axis: interest rate applied by the financial provider;
- Inferior horizontal axis: demand standard deviation level.

The matrix aims to differentiate all the possible “uncertainty” areas, i.e. where DM and CM generate similar outcomes (green spots in the matrixes), from the areas where the CM benefits clearly overcomes the DM ones (orange spots in the matrixes).

Specifically, we design two different matrixes depending on which inventory control logic is adopted by the budget constrained firm.

Under continuous inventory control policies, we identify an uncertainty area where the market demand variability is low, the pledging goods availability is medium-low and the interest rate value is low (see Figure 5.3).
In the situation when the budget constrained firm is adopting a periodic inventory control logic, the scenario made up of a high market demand variability, a medium level of pledging goods availability and a low interest rate value, defines an uncertain situation where it is difficult to declare which IIIFS is better between DM and CM (see Figure 5.4).

**Figure 5.3** - DM vs CM matrix, under a continuous inventory review

**Figure 5.4** - DM vs CM matrix, under a periodic inventory review
RQ 3. Does a specific inventory reorder policy, if combined with an Inventory Financing solution, affect the entire supply chain profit?

The answer to this question derives from the model we have developed and its sensitivity analysis.

Regarding the model, it does not compute the supply chain profit stemming just from a specific IIFS, but simultaneously also from the inventory reorder policy that is adopted by the budget constrained firm.

In particular, the model considers two different innovative methods of IF, namely DM and CM, whereas concerning the inventory policies the model takes into account four different techniques, two of them operate with a continuous inventory control logic (Two-Bin and Min-Max systems) and the other two with a periodic logic (Base-Stock and Hybrid systems).

Depending on the demand uncertainty level and on which IIFS is underway, the choice of the inventory policy is crucial to maximize the profit of the whole supply chain (see Figure 5.5).

![Figure 5.5 - Best inventory policy matrix](image-url)
The DM solution turns out to be stricter than the CM, therefore, in order to maximize the profit of the whole supply chain, when the DM is underway its lack of flexibility must be rectified by implementing flexible and dynamic inventory policies. Thus, inventory policies with a continuous inventory control logic, such as Two-Bin and Min-Max systems, result to be more suitable and performing for this situation. This is the reason why, under a DM, the maximum profit is obtained just thanks to the Two-Bin and Min-Max systems.

More in details, when the demand uncertainty level covers a medium-high value, the Min-Max method is better than the Two-Bin one, this because the former is still more flexible than the latter.

Focusing on the CM, this IIFS already ensures a good level of flexibility, therefore when the demand variability is low (so the supply chain does not need a high flexibility level), inventory polices with a periodic control of the inventory (such as Base-Stock and Hybrid systems) produce better benefits due to their low-cost approach. But, if the demand uncertainty level gets higher, the supply chain needs to be more agile, so continuous inventory control logic starts to ensure greater benefits than periodic logic.

Concluding, we can summarize the CM situation as follows:

- Hybrid or Base-Stock systems when the demand uncertainty level is low;
- Two-Bin system when the demand uncertainty level is medium;
- Min-Max system when the demand uncertainty level is high.

5.2 Limitations and future development

This paragraph is going to show which are the limitations of the model that can be released with the aim to further deepen the analysis, enabling the model to a more real approach, but at the same time increasing its complexity.

The first limitation regards the Traditional Mode: indeed, from the literature, we know that the bank might refuse to grant the loan to the budget constrained retailer. Thus, we decide to set up our TM as an extreme situation where the bank never offer a loan to the borrower. In other words, we have modeled this IF solution as a no financing situation. However, sometimes the bank can decide to issue a loan even if the retailer’s credit risk is quite high.
Therefore, a future research might deepen this circumstance, studying a TM where the retailer can obtain a loan from a financial provider.

Another limitation regards the Delegation Mode development: in fact, we assumed that Product_X is not just a single product but as at least as two different goods (e.g. Product_X1 and Product_X2) having similar demand and value.

This assumption has been considered with the purpose to ensure a continuous availability of goods to be pledged (i.e. quantity of Product_X in the model); thus, once received back the pledging of the Product_X1, the demand of this product occurs and the retailer is able immediately to apply for another loan through the pledging of the Product_X2, whose demand is not occurred yet. This assumption definitely simplifies the model because always allows the retailer to have on its shelves Product_X available to be used as collateral. However, in the reality, the retailer does not always own two products with these characteristics, so it can not always get a loan from the bank. Therefore, a future research might deepen the previous issue, studying a DM solution based on real availabilities and characteristics of the products owned by the retailer.

Another limitation regards the retailer’s CCC: in particular, we considered the DII (Days in Inventory) item as null, meaning that, as soon as the goods arrive in the retailer’s warehouse they are immediately sold. This because the model is based on a small-medium retailer point of view (where the DII item is usually quite low) but also because we want to make its development simpler. However, we might also consider a manufacturer’s point of view: in this case, the DII item turns positive because the buyer’s order will consist of raw material or semi finished goods which are kept in stock for longer periods or need further transformations before being sold. Therefore, a future research might deepen the previous topic, studying a Delegation or Control Mode solution adopted by a budget-constrained firm which is not a retailer anymore, but a manufacturer with a DII item positive.

Concluding, we have carried the sensitivity analysis changing the values of three variables (i.e. amount of Product_X available to be pledged, interest rate applied by the financial provider to the retailer and the market demand standard deviation level), but we can also consider other interesting parameters in order to find out other “uncertainty” zones between Delegation and Control Mode. These variables might be the pay back time requested by the bank to the retailer or the reorder period if the retailer is adopting a periodic review logic of the inventory.
5.3 Future researches

This section points out other emerging innovative solutions of IF, which are worth to be deepen in order to solve new possible SCF issues.

For this master thesis we have studied and analyzed two IIFSs, respectively the Delegation and the Control Mode, because they solve one of the most common problem of a supply chain: i.e. the presence of a budget-constrained actor who, having a positive CCC, lacks liquidity to carry out its operational processes. On the other hand, nowadays other IIFSs are springing up in order to solve different supply chain issues. For these new solutions do not exist neither a benefits assessment models, nor a literature that completely describes their operational processes. However, through real cases and web searches, we have been able to figure out how these solutions work, leaving their benefits assessment as an interesting topic for future researches. Thus, we present below a general overview of two new innovative approaches of IF: Tier-2 Financing and Inventory Crowd-funding.

Tier-2 Financing

This approach highlights how an IF solution can benefit a big company, which does not suffer of budget constrains, besides a SME.

To explain that, we start considering a supply chain made up by a core enterprise (i.e. the no budget-constrained firm), a 1st (Tier-1 supplier) and a 2nd level supplier (Tier-2 supplier).

In order to make the reader’s understanding simpler, we will call these last two players manufacturer and raw material supplier respectively (as shown in the Figure 5.6).

In particular, it is assumed that the focal company has a negative CCC, whereas the other two actors have a positive CCC.

![Figure 5.6 - Tier-2 Financing process](image-url)
The process begins after the manufacturer has received an order from the core enterprise, so the former in turn places an order to the raw material supplier with the aim to fulfill the request received by the core enterprise.

More in details, at the beginning the manufacturer would not be able to satisfy the request of the focal company because the former, due to its lack in liquidity, can not pay the raw material supplier (which in turn can not offer a trade credit to the manufacturer due to it has a positive CCC too).

Thus, in order to fix this problem, the focal company pays the entire order issued by the manufacturer to the raw material supplier ($RM\_Price$ in the Figure 5.6), financing the inventory of the manufacturer through trade credit. The raw material supplier, once received the payment, sends the raw materials to the manufacturer which, after having processed them, sell the finished products to the focal company. However, the latter has to pay a final price made up of the price of the finished goods ($$ in the Figure 5.6) decreased by the raw materials cost ($RM\_Price$ in the Figure 5.6) already paid, through trade credit, in a previous time period.

In this situation the 3PL’s role is crucial because it carries out not only the classical logistics activities, but also a kind of monitoring activity. Indeed, the 3PL checks that the raw materials used by the manufacturer are exactly the ones which have been paid by the focal company, avoiding possible mismatches.

This last option represents a very important advantage for the focal company because now it has the certainty about the components used to make the finished products it is going to buy; thus the focal company gets more control on its supply chain.

This solution also helps both the actors with a positive CCC, in particular:

- the raw material supplier, being paid in a short-term by the focal company, is able to reduce its DSO and as consequence its CCC;
- the manufacturer, obtaining a trade credit thanks to an inventory financing offered by the focal company, is now able to process the orders and to gain its margins.

Concluding, also the 3PL takes advantage form this IF solution because it offers an innovative service, thus it is able to gain more competitive advantage.
Inventory Crowdfunding (inspired to Kickfurther case study)\(^1\)

First of all, we briefly summarize how Kickfurther works: on Kickfurther, businesses ask backers to fund their inventory in exchange for a consigned rate. If the funding goal is met, Kickfurther buys the inventory and gives it to the business. The business then sells it, returning a percentage to the backers every month depending on the inventory sold. To safeguard against financial losses among participants, companies on Kickfurther pay backers percentage every month, and companies report on how their inventory is selling. If the business doesn’t meet its promised monthly return, the backers can vote, with those who gave more money getting more say, on whether to liquidate the assets, or to try to continue to sell them through the business at a lower cost, or sell them through another marketing channel.

We try to model and explain an IF solution based on Kickfurther principles and features; this IIFS could be very useful especially for budget-constrained companies but also for “the average person” who can’t directly invest in a private company, but thanks to this crowdfunding IF solution can find a new and creative way to do that. This solution is based on a fundamental assumption: 3PL must own a digital platform aimed at collecting money from private investors that want to finance a product of an enterprise (which is budget limited). Through this platform, with the aim of obtaining funds, companies post the expected return of the private investors and also the time horizon in which the latter are supposed to get it.

More in details, the process starts when the retailer (i.e. the budget-constrained firm) needs money in order to issue a big order.

“Product companies are often faced with a dilemma. Their success outstrips their cash flow and they are unable to increase production to meet demand. Kickfurther helps product companies fund their next inventory purchase to meet increasing demand”.

Kickfurther.com

Then, the retailer publishes its request of funds on the 3PL’s platform and the potential investors, looking at the offer, decide whether to invest their money or not. If the amount

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\(^1\) We thank Mr. De Clercq Sean, CEO of Kickfurther, for the precious support offered in order to better understand the business model of this solution.
needed by the retailer is reached, the funding process starts. The supplier sends the goods to the retailer as soon as it receives the order payment from the 3PL, which remains the owner of the inventory until the retailer sells the products (i.e. a kind of consignment stock agreement) to its final customers.

When the retailer sells its products, the revenues obtained are used to pay all the actors; in particular, the backers receive the promised interest, the 3PL gets money from the fees paid by both the retailer and the investors for the service it has provided. Moreover, another interesting advantage of the 3PL concerns the low risk it has to face, because it shares a big part of the risks with the backers. At last, the retailer earns its profit thanks to the margin obtained adding a mark up to the product’s price.

Summarizing, thanks to this crowdfunding IF solution, the retailer is able to satisfy its final demand, the supplier is paid in a short term (reducing its CCC), the backers gain the interest promised and the 3PL gets its profit, finding a new and low-risk way to earn money and built a new competitive advantage.

To conclude, this model has huge potentials and it could really increase the performance of an entire supply chain, solving the problem that banks, most of time, do not grant loans (or when they do, with a improper interest rate) to budget-constrained firms.
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