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PLM as an innovative solution and a strategic approach supporting the Product Development process in the Fashion Industry

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To my beloved Family,
that taught me the importance of reading and many
other beautiful things

CONTENTS

LIST OF FIGURES

LIST OF TABLES

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Finally, thanks to the readers. Keep in your mind that I perfectly know that everything I have written is improvable. This thesis is a picture of three years as a PhD student and as a consultant. Perhaps my perspective is not enough comprehensive. However, these years changed me much more than I thought. I hope you will appreciate my attempt to write something scientific, useful and beautiful.

ABSTRACT

This manuscript is the result of the author's work as a PhD student and as a PLM consultant.
The research objective is to improve and streamline the product development process in Fashion companies through Product Lifecycle Management.
Two meanings are ascribable to PLM: it is a strategic approach allowing companies to change their traditional practices, reducing the time to develop products; and it is also an enterprise solution that allows to manage all the product information, from its concept to its disposal. This collaborative tool is interfaced with upstream and downstream Information and Communication Technologies (ICTs), as creative solutions and Enterprise Resource Planning (ERP).
Moreover, the Fashion industry is a particular setting, characterised by high product and process complexities. The Fashion Supply Chain (SC) involves many players, with different objectives and perspectives. Timing is forcing the industry to be reactive to customers' needs, delivering the right product, in the right place and in the right moment. Quality is also crucial, above all for high-end companies, that strongly believe in the handcrafted traditions behind their products.
Given this scenario, product development represents the most value added process and Fashion companies are investing resources and are addressing their strategies in improving it, above all through PLM platforms.
The following Research Questions guide the overall thesis:

1. What is the role of the product development process in respect to the entire Fashion SC?
2. How information and data are managed throughout the product development process?
3. What are the performance measures enabling to monitor and control product development in the Fashion industry?
4. Which are the initiatives that a Fashion company may evaluate to improve the product development process?
5. What is the role of PLM, in its strategic meaning, in Fashion companies?
6. How a PLM implementation project is conducted to fit the needs of the Fashion industry?
7. What are the performance measures enabling to monitor and control a PLM initiative in its adoption stage?
8. What are the similarities between Fashion and other Luxury industries in terms of product development process and data management?
9. In comparison to the Fashion industry, what is the role of PLM in other Luxury industries?

A literature review prepares the ground for a further and deep analysis, conducted through multiple and single, in-depth case studies.
The purpose is exploratory and explanatory, aiming at describing the features of product development and PLM in the Fashion industry, and also at filling the literature gap, due to the lack of industry-specific contributions.
Eight Fashion companies and two firms, belonging to Food and Furniture sectors are involved in the researches.
Strategies, business models, products, tasks and performance characterising the product development process, within the Fashion SC, are thoroughly analysed.
The main information exchanged and the involved ICTs are modelled, thanks to Enterprise Architecture Diagrams.
Improvement initiatives, allowing Fashion companies to switch from their current state to a future state, where PD is streamlined and PLM is implemented, are described.
PLM projects are, then, deeply analysed, including a focus on strategic issues and the need for change management. These are also examined from an operative perspective, highlighting the planning, implementation and adoption stages.
Cross- industry analyses conducted in Food and Furniture companies are discussed, analysing strategies, product development tasks and PLM features. This analysis permits to compare behaviours and choices of the three sectors that are leading Made in Italy to its success.
The overall set of researches conducted over the years, have had several implications on ICTs and SC management, including order and production aspects.
The assessment of PLM maturity, the definition of business models and strategies, allow to find theoretical relationships and to provide insights for practitioners.
Throughout the entire study, the author adopts a process-oriented approach, which is one of the most original elements in the manuscript, as well as the attempt to analyse the underexplored Fashion industry and to define an industry-specific framework for PLM implementation.
The research could be extended to the examination of more cases, representative of different market segments, allowing to better generalise the results. Moreover, projects involving custom-made PLM and PLM solutions from different vendors, should be experienced and reported.

CHAPTER 1 – INTRODUCTION

There aren't greater and minor histories.

There are only correct ways to influence History and effective ways to teach it

(Maria Giuseppina Muzzarelli, Moda. Storia e storie)

Research Topic

This PhD thesis represents the structured synthesis of my three-years work as a researcher and as a PLM consultant.
Before introducing the reader to the details of this research, I would like to provide an overview of the background.
During these three years, I have worked with a system integrator company, specialized on PLM and the projects we have conducted together have always been framed in Fashion companies. Hence, two key-words emerge: PLM and Fashion.
Moreover, the activities I have carried out as a researcher have always involved the Fashion industry and its players. From this perspective, my activities have been more heterogeneous: I have researched on Fashion Supply Chain (SC), Product Lifecycle Management (PLM), Information and Communication Technologies (ICTs), Knowledge Management (KM), Fashion Retailing, Performance Measurement and Collaborative Networked Organizations (CNOs).
Since the very first time I have had to design my earlier research project, the topic has been related to PLM supporting the Product Development process in Fashion companies. I have tried my best to be coherent with this topic along the way, to provide consistent results and insights for both academics and practitioners.
According to Saunders et al. (2009), business and management research projects can be placed on a continuum, basing on their purpose and context: at one extreme of the continuum is "pure research", undertaken to provide results for the academic community; at the opposite extreme there is "applied research", addressing issues of immediate relevance to managers, very similar to consultancy. This research can be defined as an applied research, due to its business-oriented purpose and its context, which is a merge of enterprises and university.
The central issue of this research is to improve and streamline the product development process in Fashion SC through the most appropriate ICT in the field, which is PLM. The Fashion industry considers product development as its core value added task: concept, prototyping, sampling, fitting and other specific activities shape the success of the collection, the image of the brand and its competitive advantage.
This First Chapter will also introduce, in the next sections, the goals and the background for the thesis.

Originality

One of the hardest challenge when writing articles, proceedings and this thesis has been to explain the originality of the research topic. My question has always been the following: is this study original enough for all the enlightened people that are going to read it? I think that a wise PhD student is conscious of his limits, of the

fact that what is original in his mind, could be obvious in the one of his supervisor, for example.
Therefore, my attempt, after three years, is to explain the points that, generally, make this research one-of-a-kind.
First and foremost, the sector that I have investigated is definitely underexplored in the existing literature. More often, researches in the SC and Operations fields concern automotive, aerospace and mechanical companies.
Fashion and Luxury firms have their own specificities in terms of processes, projects, data management and ICTs. Their product is not comparable to a commodity, neither to a fully customised item. Hence, we can say that the product development analysis in Fashion companies is a newness for academics.
Another originality point is the process-oriented approach adopted to analyse these companies and their requirements. From data management to the identification of relevant Key Performance Indicators (KPIs), processes and tasks have always been taken into account.
Finally, the last original contribution is in terms of methodology. This study is a mixture of different methods, evaluated in a long timescale, derived from the opportunity to experience and describe all the stages of a PLM initiative. Hence, the entire product lifecycle has been analysed, trying to implement initiatives enhancing it, according to a framework.

Research objectives

The main objectives of this research project are:

- To describe the "extended PLM" introduction, management and integration within Fashion companies
- To identify the issues in process and data management within Fashion companies
- To determine the extent to which Fashion companies are able to match their organization with a PLM initiative
- To identify the gap between the theoretical PLM initiative and the practical implementation, highlighting issues and variables involved
- To describe common features in PLM implementation basing on the analysis of Fashion companies and other Luxury industries (Food and Furniture)

Research Questions

The following research questions (RQs) will guide the overall thesis:

1. What is the role of the Product Development process in respect to the entire Fashion SC?
2. How information and data are managed throughout the Product Development process?
3. What are the performance measures enabling to monitor and control Product Development in the Fashion industry?
4. Which are the initiatives that a Fashion company may evaluate to improve the Product Development process?
5. What is the role of PLM, in its strategic meaning, in Fashion companies?
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9. In comparison to the Fashion industry, what is the role of PLM in other Luxury industries?

Research design

The philosophy that has inspired this thesis, from the ontological and epistemological viewpoints, has been the Pragmatism (Saunders et al., 2009): the central role of the research questions, the combined use of observable phenomena and subjective meanings to provide acceptable knowledge and the importance of both quantitative and qualitative methods, are evident.
The research approach has been, above all, inductive because it is based on studies carried out in several contexts and, because of the lack of studies concerning product development in the Fashion industry, the ambition has been to understand these settings and build or reinforce theory.
In thinking about the RQs, I have identified two main purposes of this research: exploratory, wishing to clarify the characteristics of a particular context through search of the literature and interviews, and explanatory, trying to establish relationships between variables, collecting quantitative and qualitative data.
With the aim to reach the objectives of this thesis and to answer the RQs, I have designed a research framework. It has allowed me to have a comprehensive view of the overall research and to better guide the readers to approach the manuscript. In this section, I describe the story that I am going to tell you in more detail in the following sections.
Some stories are fascinating because of their chaotic side, because you never know what you can expect from the next page. This story is not that fascinating maybe. As most of the scientific thesis, it has a defined structure and clear goals. The

interesting point is that at this stage everything is unknown, so the reader may have the exciting opportunity to discover.
First of all, this research has a scope: Product Development in the Fashion industry. This is for sure related to many other aspects that will be examined throughout the research:

- The Fashion SC, including process and information management and the related KPIs
- The improvement initiatives for the product development process, with a special focus on PLM, as a strategic approach and as a software
- Product development in other Luxury industries (Food, Furniture, Automotive, etc.). The analysis has been limited to the Luxury market segment because of the similar strategies and of the commonalities in business process management

In Figure 1, the research framework is illustrated and the above mentioned points are highlighted.
Concerning product development in the Fashion industry, I have examined strategies, processes and products (RQ1), i.e. the foundations of an enterprise playing in this sector. I have also investigated information and data management (RQ2), as key elements to support processes and strategies. The main performance measures supporting product development are also identified (RQ3).
Then, I have analysed the initiatives supporting the product development process: business process improvement (RQ4) and PLM (RQ5) are examined as methods and projects producing benefits and drawbacks for the Fashion industry. The characteristics of a complete PLM project are as well discussed, throughout planning, implementation and adoption stages (RQ6 and RQ7).
Finally, a cross-industry analysis is performed, focusing on the two sectors belonging to the Luxury market segments that are closer to Fashion: Food and Furniture. The literature review (Aiello et al., 2015) and economic newspapers (Il Sole 24 Ore) have demonstrated that these sectors are driving Made in Italy to its success: the 3Fs (Fashion, Food, Furniture) have the highest growth potential, which has been evaluated through economic and marketing parameters. Comparisons concerning process and information management have been performed (RQ8) together with the approach to PLM initiatives (RQ9).
The cross-industry analysis is still preliminary, qualitative and exploratory; it constitutes just the starting point of a dedicated research.

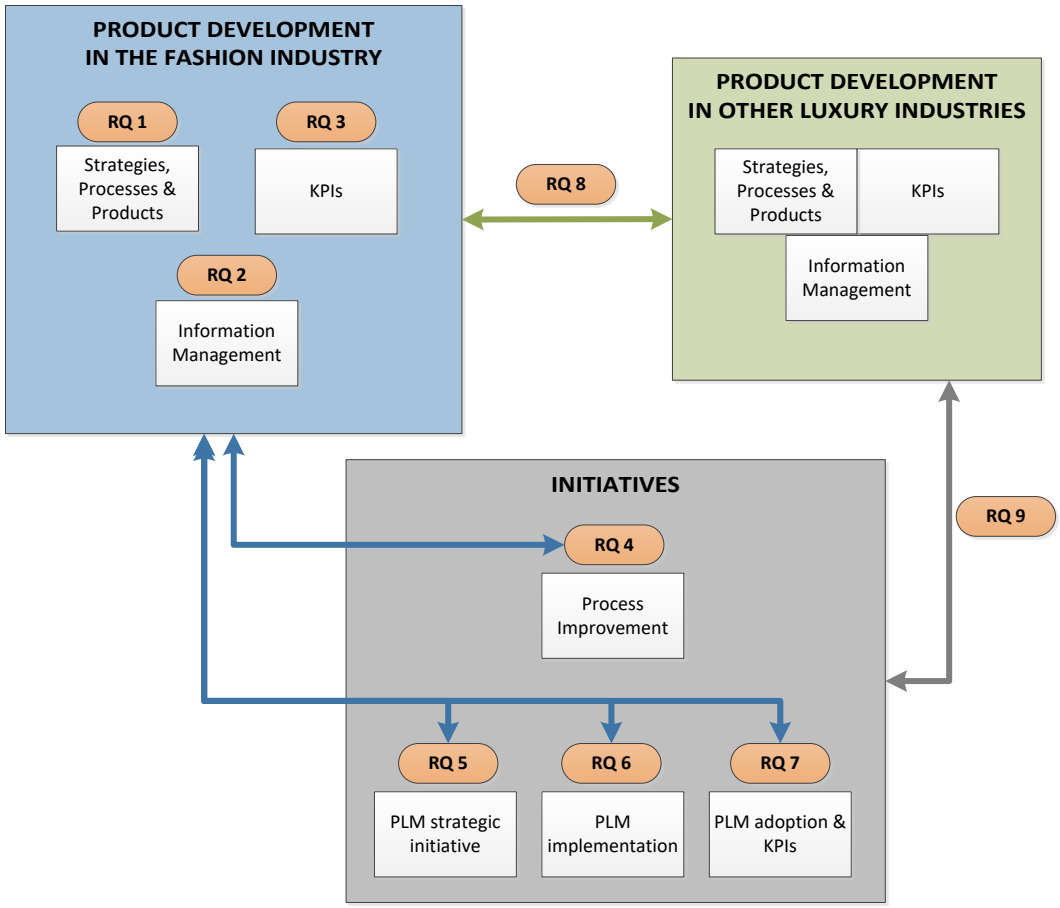

Figure 1 - Research framework

Moreover, the structure of the present manuscript (Figure 2) is organized as follows.

A literature review, deriving from the research objectives and questions, describes the results gathered from the theoretical viewpoint: these are related to the aspects illustrated in Figure 1.

Then, in order to fill the research gap and to fully answer the RQs, the case study strategy, that has supported the analysis from the methodological point of view, is discussed.

The answers to the RQs and the related analytical examination of the results is presented in the fourth chapter.

The thesis concludes reviewing and remarking all the research objectives, results and future steps.

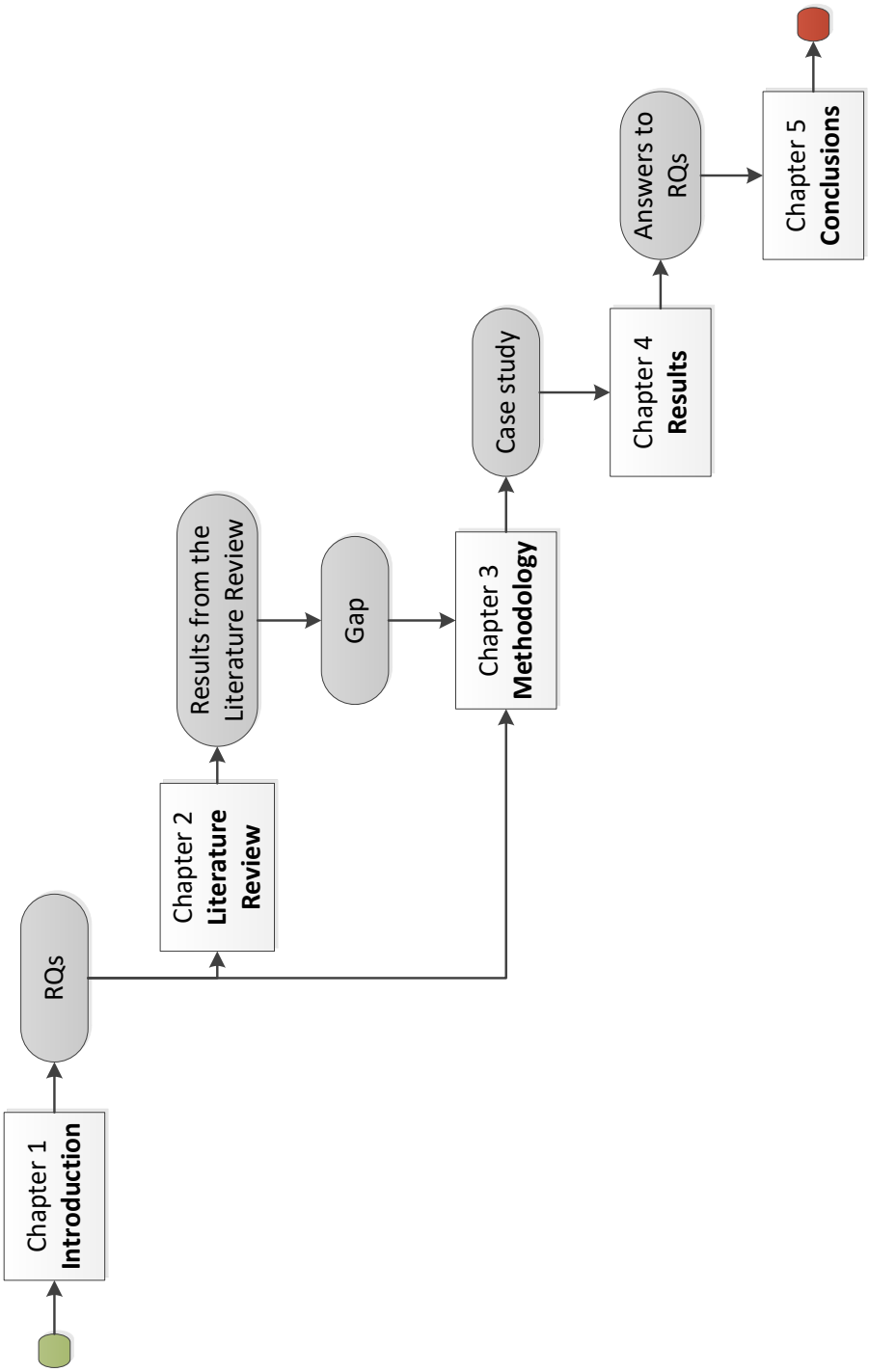

Figure 2 - Structure of this thesis

Background: the Fashion industry

The Fashion industry has always been recognised as the kingdom of creativity, good taste and luxury. What often takes second place is the way these features are managed and balanced. Fashion companies currently embody an important slice of the worldwide economy and they are facing lots of challenges to improve their competitiveness. A demand for innovation is currently affecting the whole supply chain, from product development, through PLM platforms, Digital Printing and 3D software, to retailing, thanks to the 'digital revolution', IoT (Internet of Things), Industry 4.0, Artificial Intelligence and Augmented Reality.
In this scenario, product development represents a weakness due to the longer lead times required to deliver fashion products to customers (Bhardwaj and Fairhurst, 2010). The product specification changes during the development process, for example deriving from late perception of fashion trends, even if buyers and stylists have already spent much time on range development (Tyler et al., 2006). These factors impact on supply chain flexibility and Fashion companies are increasingly trying to be proactive, leveraging on innovation and empowerment from information technologies (IT).
Managing fashion products is challenging, not only for creative and stylists, but also for SC managers (d'Avolio et al., 2015a). Customers are more and more demanding high product variety and innovative products (Caniato et al., 2013), and competition in the Fashion industry is centred on the ability to react timely to changes in customers desires.
Four elements are marking the Fashion industry (Terzani, 2007) in respect to the other productive systems:

- Supply chain structure: it involves many tasks, actors, relationships and a need for coordination emerges. In Italy we have two main Fashion SCs: the upstream Textile/Apparel SC and the downstream Leather goods/Shoes SC. This thesis will focus on the downstream SC.
- Subcontracting: core business processes (as product development) are retained in-house, while less value-added tasks (as manufacturing techniques) are outsourced to subcontractors. Subcontracting ensures high quality standards, low costs and high flexibility. On the other hand, dependencies and commercial pressures may occur. This phenomenon could let to greater risk and the need for more supervision and clarity of information shared with supply-chain partners.
- Collection timing: timeframes are tight because the collection overview at showrooms and the merchandise delivery to stores cannot be postponed.
- Sales channels: directly operated stores (DOS) are the most common, first of all for luxury brands. They guarantee brand identity, customer care and quality of the service. Several drawbacks are typical in these cases: the

company has to bear high fixed costs and to invest capitals. Other management issues are due to the fact that stores represent many small companies geographically distant.

Therefore, Fashion companies have to balance the need to reduce lead times of the collections, while minimizing stocks and the obsolescence risk. In this context, being able to manage the SC, e.g., by achieving partnership between all the SC players, is becoming a strategic imperative in the Fashion industry. These represent highly ambitious objectives, given the key characteristics of the fashion product (Chrstopher et al., 2004): short lifecycles, high volatility (the demand for these products is rarely stable or linear), low predictability and high impulse purchasing.
To be able to cope with such challenges, Fashion companies have to make the SC more flexible, by changing the way they manage their processes.
Flexible SCs are able to adapt effectively to disruptions in supply and changes in demand whilst maintaining customer service levels (Stevenson and Spring, 2007). Moreover, increasing collaboration, both inside and among SC partners, is often seen as a powerful instrument in achieving effective and efficient SC management (de Leeuw and Fransoo, 2009), as well as higher SC agility (van Hoek et al., 2001).

Product categories and Business Units

Products, in the Fashion industry, are characterised by several specificities.
A Stock Keeping Unit (SKU) identifies a product stored in a warehouse or in a sales location: it is a code that allows to track an item basing on its model, colour and size.
Moreover, a product may have different variants: these will be variations of basic working products. Options are additions to a basic working product (Stark, 2015).
A model is a simpler representation of something else; it can be built quicker than the product itself.
The product development in the Fashion industry may involve different product categories (e.g. apparel, shoes, leather goods, metal hardware) managed by different Business units (BUs) with different requirements (d'Avolio et al., 2015b).
Apparel products require several fitting sessions throughout the set of product status, from prototyping, to sampling and pre-production. Moreover, the modelling task is crucial. While in the sampling phase the article is developed in the base size, when the collection is approved for production, a size range is needed. Engineering notes and fittings increase more and more in the production phase.
Shoes products do not need special fitting sessions during prototyping and sampling because sizes have been tested for years. The focal point is on the product structure (i.e. the parts of the shoe), materials and quality controls.
Leather goods, such as bags and other accessories, are not prone to any fitting session. On the other hand, materials and semi finished products need to be

selected and codified with consequences on Bill Of Material (BOM) revisions and on the time to develop the product.
Fashion companies also manage metal hardware components, e.g. through galvanization processes. First of all, a technical assessment is required, then an assembly test is provided and finally the components are aesthetically evaluated. Supplier selection and quality control are the most critical tasks.

Fast fashion vs. Luxury brands

Product development in the Fashion industry is also affected by the market positioning of the brand. From fast fashion to luxury companies, different critical success factors (CSFs) and processes acquire relevance.
Time-to-market (TTM) is the main CSF for fast fashion companies: their challenge is to select suppliers that are able to respect the agreed lead time, besides the costs. The purchasing BU plays an important role because it is in charge to secure alliances with strategic suppliers, to control their activity and to negotiate costs. Due to the target margin that fast fashion companies define, they always try to minimize costs, even if the supplier is located far away and they can lose control on quality. The effort is to reduce the transportations time to and from the factory. Moreover, a fast fashion company may decide to buy raw materials and then to ship these to a factory or to outsource the entire production process. In the first case, lead time is longer because supplier and manufacturer have different needs: the raw material supplier has its own lead time to produce leather or fabrics; then, the manufacturer may require the complete set of materials before starting to produce, thus he has to wait the arrival of the most time consuming item.
Outsourcing the entire production process, exposes the company to a higher risk in terms of quality but lead time is surely reduced.
SC issues are often softened thanks to a product development aligned to customer needs and streamlined through the reduction of approval processes.
Luxury companies compete mainly on quality and, secondly, on timing. Quality is the evidence of the handcrafted tradition beyond the company and has to be ensured throughout the value chain processes. Suppliers are located in surroundings so that the company can have major control on their outputs and lead time. The reason of their proximity is not guided by the "cost" driver, but they have been selected for their skills and the quality of products they supply. Outsourcing is not per se a competitive advantage or disadvantage, but just a cost/effectiveness tool, as long as the control over the whole logistic process remains closely managed by the company.
Product development is the core process: stylists play for time in designing different prototypes of the same product and the shift to sample and production status are slow, to ensure that all the product's features are premium.

The Luxury industries

The luxury market segment includes different industries in its aura of high quality and price: apparel, leather goods, furniture, food, hotels, automotive, nautical and so on. According to a statistic carried out in 2015 by the journal "Il Sole 24 ore", the Italian excellence is ascribable to the three Fs: food, fashion and furniture. These sectors have the highest growth potential, which has been evaluated through economic and marketing parameters.
Resilience - i.e. the ability of organizations to anticipate, respond and adapt to incremental change and sudden disruptions in order to survive and prosper - authenticity and product excellence are allowing the 3 Fs to be competitive and inter-nationally recognized.
Hence, these sectors are not simply producing and selling premium food, fashion and furniture products, but they also belong the luxury market segment, which gives specific undertones on the way these products are perceived by the market and on the way enterprises are organized.
When innovative companies want to improve their new product success rates, one of the first and also most important step is to redesign and to reorganize the product development processes and structures. This redesign activity aims at understanding the CSFs that make the difference between winning and losing in new products.
Brun and Castelli (2013) identify the following CSFs for luxury companies:

- premium quality in all the products in the line and along the whole SC
- heritage of craftsmanship
- exclusivity
- uniqueness
- emotional appeal of the products
- global reputation of the brand
- recognizable style and design
- association with a country of origin
- creation of a lifestyle

In many cases, luxury companies are not simply limiting their offer to premium products, but they are more and more trying to combine also luxury experiences, so that the imprint of the brand is enriched and eternalised.
In the particular cases of Fashion, Food and Furniture companies, product development represents the core process around whom need for innovation and market pressure are revolving. It is considered the domain of creativity, style, ideas where the most value added tasks take place, in particular in the sectors analysed. Consumers' needs, merchandise planning, margin settings and production constraints are merged and balanced to develop a set of products (i.e. a collection,

for fashion and furniture companies) that is aligned with the definition of luxury and ensures long-term competitiveness. Moreover, product development in Fashion, Food and Furniture industries is emphasizing the importance of craftsmanship and tailor-made products.

These sectors are also managing "made-to-measure" (MTM) products: MTM represents a business model that is translated in several peculiarities in terms of process management and has to be properly integrated within the overall strategy. The interfaces with design, manufacturing and customer care have to be planned and managed with the objective to deliver a unique premium product to a consumer that is trusting to the brand and has decided to invest time and money in the name of a loyalty.

The different "shades" of product development may slow it down, therefore losing control over timing is a typical issue.

ICTs are supporting product development in the Fashion, Food and Furniture industries since at least a decade. CAD (Computer Aided Design), PLM platforms, creative suites, 3D printing and scanning are helping 3 Fs companies to best manage all the information related to prototyping, sampling and testing.

CHAPTER 2 – LITERATURE REVIEW

It's always with curiosity, hope and magnificence that a young person, a worker, a farmer who has got a taste for reading, decide to open a new book.

We wish our books to be always opened in such a way

(Italo Calvino, Una pietra sopra)

One of the first thing that I have learned during my PhD is the importance of reading. Often the majority of ideas we have in our mind has been already developed, formalized and written; and someone has even used the best words in their best order to do this.
Hence, before approaching to write anything, I think it is important to read as much as possible what other authors have written. A big issue may occur when reading lots of contributions: it is so simple to get lost. Methodology, in this sense, is very helpful because guides the author to conduct a literature review, establishing the scope, the purpose and possible directions.
This thesis collects the papers that I have produced in the last three years, focusing on the different topics of my research project. Consequently, the literature review has been conducted according to the themes illustrated in Figure 1 and developed in different periods. In this thesis, I have tried to recap all the results from the literature analysis and then to detail the different topics.
The biggest effort has been to find papers concerning the particular Fashion SC, because of the sectorial attitude of this thesis.
The first step during the literature analysis has been to plan a methodology ensuring to locate relevant and up-to-date contributions.
The literature search strategy and the main results are described in the following sections.

Literature search strategy

The subject areas related to this research are engineering, computer science and operations, while the business sectors are Fashion/Retail/Leather Goods. I have selected the most recent publications (last 20 years), without any constraint in terms of geographical area.
The keywords and phrases that I have used are: Product Development Fashion, Fashion Business Processes, Process improvement fashion, Product Lifecycle Management, PLM fashion, Luxury industry, PLM luxury.
These keywords have been searched within search engines (most of all Google Scholar and Scopus). I have had also the opportunity to access to the Polimoda library, which houses the most significant collection of publications on the international Fashion industry in Italy.
Books, papers, proceedings and specialized magazines have been carefully read and recorded. I am used to classify the evaluated literature in order to organize the research and decide which are the most relevant contributions to be cited. The analysis allows me to perform statistics basing on several fields: authors, title, journal, year of publication, methodology adopted, industry focus and keyword. The methodology reports tools or procedure for identifying, delimitating, and gathering the relevant literature. I have attributed to the papers the following three

methodologies (Saunders et al., 2009): case study, survey and grounded theory (explorative and theory-building studies). Regarding the industry focus, four main typologies have been identified: a "general" field, that refers to dissertations about the topic without any industry-specific observation; "fashion" and "manufacturing" industries represent two fields related, respectively, to the apparel, leather goods and footwear industry and to the manufacturing area; "SMEs" is devoted to the increasing importance of Small and Medium Enterprises.
The classification of the papers has been proposed in Table 1. I have analysed and considered as relevant 46 contributions: the large part of these researches has been performed through case studies. The keyword that has allowed finding more results has been "PLM", even if these are more focused on the manufacturing industry. Whereas, the topics involving PLM and PD in the Fashion industry are still a niche in literature.

Table 1 - Literature classification

ID	1st Author	Title	Journal	Year	Methodology	Industry	KW
1	Caniato	Internationalisation and outsourcing of operations and product development in the Fashion industry	Production Planning & Control	2015	Case Study	Fashion	Product Development Fashion
2	Caniato	Integrating international fashion retail into new product development	Int. J .Production Economics	2014	Case Study	Fashion	Product Development Fashion
3	Christopher	Creating agile supply chains in the fashion industry	International Journal of Retail & Distribution Management	2004	Grounded theory	Fashion	Product Development Fashion
4	Christopher	The Agile Supply Chain : Competing in Volatile Markets	Industrial Marketing Management	2000	Grounded theory	General	Product Development Fashion
5	Doyle	Supplier management in fast moving fashion retailing	Journal of Fashion Marketing and Management	2006	Case Study	Fashion	Product Development Fashion
6	Goworek	An investigation into product development processes for UK fashion retailers: A multiple case study	Journal of Fashion Marketing and Management	2010	Case Study	Fashion	Product Development Fashion
7	Jang	Apparel product development: measures of apparel product success and failure	Journal of Fashion Marketing and Management	2005	Case Study	Fashion	Product Development Fashion
8	Simatupang	Supply chain coordination in a fashion firm	Supply Chain Management: An International Journal	2004	Case Study	Fashion	Product Development Fashion
9	Tyler	Supply chain influences on new product development in fashion clothing	Journal of Fashion Marketing and Management	2006	Case Study	Fashion	Product Development Fashion
10	Osterwalder	Clarifying Business Models: Origins, Present, and Future of the Concept	Communications of AIS	2005	Grounded theory	General	Process improvement fashion

11	Trkman	The critical success factors of business process management	International Journal of Information Management	2010	Case Study	General	Process improvement fashion
12	Caro	Fast Fashion: Business Model Overview and Research Opportunities	Retail Supply Chain Management: Quantitative Models and Empirical Studies	2014	Survey	Fashion	Fashion Business Processes
13	Shafer	The power of business models	Business Horizons	2005	Grounded theory	General	Fashion Business Processes
14	Brun	Contract design and supply chain management in the luxury jewellery industry	International Journal of Retail & Distribution Management	2012	Case Study	Fashion	Luxury industry
15	Brun	Supply chain strategy in the fashion industry: Developing a portfolio model depending on product, retail channel and brand	Int. J .Production Economics	2008	Case Study	Fashion	Luxury industry
16	Brun	Logistics and supply chain management in luxury fashion retail: Empirical investigation of Italian firms	Int. J .Production Economics	2008	Case Study	Fashion	Luxury industry
17	Brun	The nature of luxury: a consumer perspective	International Journal of Retail & Distribution Management	2013	Grounded theory	Fashion	Luxury industry
18	Caniato	Supply chain management in the luxury industry: A first classification of companies and their strategies	Int. J .Production Economics	2011	Case Study	Fashion	Luxury industry
19	Christopher	Developing Market Specific Supply Chain Strategies	The International Journal of Logistics Management	2002	Grounded theory	General	Luxury industry
20	Kapferer	The artification of luxury: From artisans to artists	Business Horizons	2014	Grounded theory	Fashion	Luxury industry
21	Tynan	Co-creating value for luxury brands	Journal of Business Research	2010	Case Study	Fashion	Luxury industry
22	Yousnadj	Integration of environmental assessment in a PLM context: a case study in luxury industry	IFIP Advances in Information and Communication Technology	2014	Case Study	Fashion	PLM luxury

23	Ameri	Product Lifecycle Management: Closing the Knowledge Loops	Computer-Aided Design & Applications	2005	Grounded theory	Manufacturing	Product Lifecycle Management
24	Gecevska	Product lifecycle management through innovative and competitive business environment	Journal of Industrial Engineering and Management	2010	Grounded theory	Manufacturing	Product Lifecycle Management
25	Hines	Towards lean product lifecycle management	Journal of Manufacturing Technology Management	2006	Case Study	Manufacturing	Product Lifecycle Management
26	Rachuri	Information sharing and exchange in the context of product lifecycle management: Role of standards	Computer-Aided Design	2008	Grounded theory	Manufacturing	Product Lifecycle Management
27	Ball	Lightweight product lifecycle information management for small enterprises	International Journal of Product Lifecycle Management	2011	Grounded theory	SMEs	Product Lifecycle Management
28	Bokinge	PLM implementation guidelines – relevance and application in practice: a discussion of findings from a retrospective case study	International Journal of Product Lifecycle Management	2012	Case Study	Manufacturing	Product Lifecycle Management
29	Chen	Developing new products with knowledge management methods and process development management in a network	Computers in Industry	2008	Grounded theory	General	Product Lifecycle Management
30	Garetti	Organisational change and knowledge management in PLM implementation	International Journal of Product Lifecycle Management	2005	Case Study	Manufacturing	Product Lifecycle Management
31	Hans	Improving Reverse Logistics Processes Using Item-level Product Lifecycle Management	International Journal of Product Lifecycle Management	2010	Case Study	Manufacturing	Product Lifecycle Management
32	Le Duigou	Generic PLM system for SMEs: Application to an equipment manufacturer	International Journal of Product Lifecycle Management	2012	Case Study	Manufacturing	Product Lifecycle Management

33	Pol	Implementation of collaborative design processes into PLM systems	International Journal of Product Lifecycle Management	2008	Case Study	SMEs	Product Lifecycle Management
34	Segonds	PLM and architectural rehabilitation: a framework to improve collaboration in the early stages of design	International Journal of Product Lifecycle Management	2012	Case Study	Manufacturing	Product Lifecycle Management
35	Segonds	PLM and design education: a collaborative experiment on a mechanical device	International Conference on Product Lifecycle Management	2011	Case Study	Manufacturing	Product Lifecycle Management
36	Subrahmanian	Product lifecycle management support: a challenge in supporting product design and manufacturing in a networked economy	International Conference on Product Lifecycle Management	2005	Grounded theory	Manufacturing	Product Lifecycle Management
37	Terzi	Product lifecycle management – from its history to its new role	International Journal of Product Lifecycle Management	2010	Grounded theory	Manufacturing	Product Lifecycle Management
38	Verhagen	A critical review of Knowledge-Based Engineering: An identification of research challenges	Advanced Engineering Informatics	2012	Grounded theory	General	Product Lifecycle Management
39	Batenburg	PLM roadmap: stepwise PLM implementation based on the concepts of maturity and alignment	International Journal of Product Lifecycle Management	2006	Grounded theory	Manufacturing	Product Lifecycle Management
40	Silventoinen	Towards future PLM maturity assessment dimensions	International Conference on Product Lifecycle Management	2011	Grounded theory	General	Product Lifecycle Management
41	Vezzetti	A benchmarking framework for product lifecycle management (PLM) maturity models	International Journal of Advanced Manufacturing Technology	2014	Grounded theory	General	Product Lifecycle Management
42	D'Amico	Product Lifecycle Management as a Tool to Create Value in the Retailers System	International Journal of Engineering Business Management Special Issue on Innovations in Retailers Industry	2013	Grounded theory	Fashion	PLM fashion

43	Kaur	Computer-aided Product Life Management (PLM) :An Indispensable Tool for Retailers and Apparel Industry	Journal of the Textile Association	2011	Grounded theory	Fashion	PLM fashion
44	Segonds	Early stages of apparel design: how to define collaborative needs for PLM and fashion?	International Journal of Fashion Design, Technology and Education	2014	Case Study	Fashion	PLM fashion
45	Vezzetti	Supporting product development in the textile industry through the use of a product lifecycle management approach: a preliminary set of guidelines	International Journal of Advanced Manufacturing Technology	2015	Case Study	Fashion	PLM fashion
46	d'Avolio	Improving new product development in the fashion industry through product lifecycle management: a descriptive analysis.	International Journal of Fashion Design, Technology and Education	2015	Grounded theory	Fashion	PLM fashion

In Figure 3, I have reported the trend of the analysed papers, basing on the year of publishing and on the industry focus. What strikes one immediately, is that literature about PLM implementations in the manufacturing field is concentrated in the first part of the decade, making way for the more recent contributions in the Fashion industry.
More and more PLM implementation projects are growing within the Fashion industry, thanks to the increasing number of industry-specific tools and to a customized approach to their deployment.

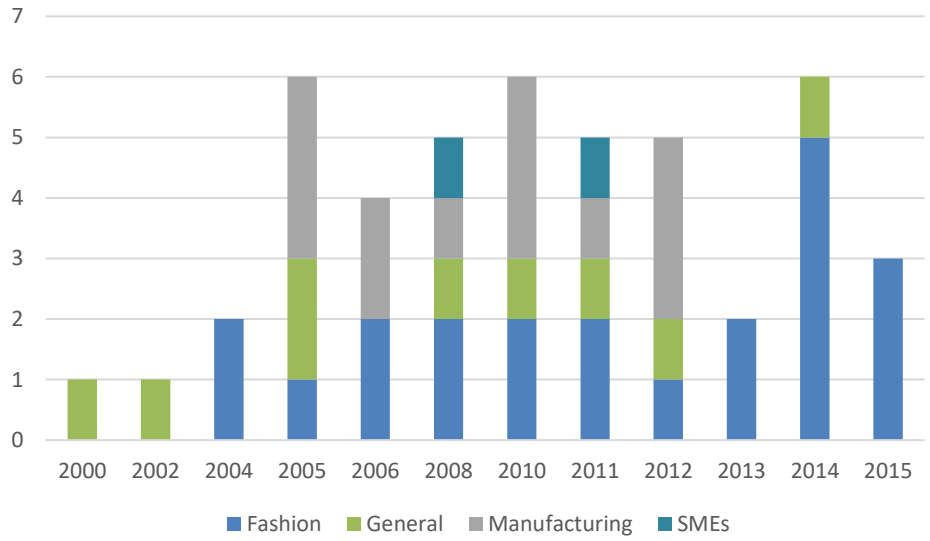

Figure 3 - Trend of the analysed papers

This search strategy has been adopted each time I have answered a RQ described in the previous Chapter. The objective has been to achieve an overall comprehension of the topic and to show how the existing literature defines and analyses the aspects that will be debated.
Once papers have been selected and classified, I have identified different macro-areas allowing me to answer (often just in part) the RQs. Therefore, in the following sections, I illustrate the main results from the literature review, concerning these themes:

- Product Development features in the Fashion industry
- Information Management in the Fashion industry
- Initiatives improving business processes in the Fashion industry
- PLM in the Fashion industry
- Process and data management in Luxury industries

Results from the literature review

Product Development features in the Fashion industry

The Fashion industry has been classified in several ways and it has been analysed from different viewpoints. Saviolo and Testa (2005) propose a distinction between different market segments: from mass market, to bridge, diffusion, prêt-à-porter and high fashion, price, excellence level and quality tend to increase.
Easey (2009) has shifted his focus on the fashion product, distinguishing between classics, fashion and fads: classics are timeless items, fashions change from one season to another and fads are eccentric products with a real short shelf-life.
Since the year 2000, competition in the high street segment has evolved from price based towards fast response to constantly changing fashion trends and fluctuating consumer demands within a single season. This fast-moving environment has continually added pressure for Fashion companies to compete on their ability to deliver 'newness' and 'refreshed look' in products. In such a context, increasing the frequency and 'newness' of fashion collections has become crucial for the survival of many Fashion companies (Tran et al., 2011).
The product development (PD) process represents a set of tasks carried out in the initial part of the fashion SC.
Bandinelli et al. (2013) have depicted PD as a comprehensive process composed of the following tasks: design, modelling/prototyping, detailed engineering, material sourcing, production and distribution.
In particular, during the engineering phase, the Bill of Material is created and the raw material purchase order is quickly submitted. Moreover, the decision as to what item has to be produced can change very rapidly during the period when fashion shows take place.
The duration of the sourcing phase can change from two weeks up to two and a half months, depending on the duration of the commercial launch, which generally takes place at the same time, in conjunction with the fashion shows and fairs (e.g. the Pitti Florence fair, Milan and Paris fashion weeks, etc.). At the beginning of the sourcing phase, a provisional and generic order of raw material is submitted to the suppliers, while confirmation of the raw material quantity is given at the end of this phase, with a maximum gap of 20–30% from the provisional phase.
During this very short period, as soon as the number of sold units is known for the current season, the company board has to decide which products will be produced and which not; accordingly, the raw materials to be ordered and which need to be defined. The production phase usually lasts three to four months and starts when material sourcing is completed.

Tran et al. (2011) have investigated the role of innovation intermediaries within the PD process in Fashion markets. The research distinguishes five main tasks characterising the PD process in the apparel industry: planning, concept development, detailed design, testing and production ramp-up. The planning stage is when fashion trends are identified, market segments are defined, the SC strategy is devised and various design options and textile innovations are assessed.
Once the planning is set, the next stage of PD process is concept development. During this stage, the Fashion company is concerned with activities related to identifying lead users, best designers and competitors. It also needs to investigate fashion and design concepts together with material development, such as trims, colours, coating, silhouettes and samples. Detailed design stage is considered to be a critical stage of the PD process by many Fashion companies. It entails many critical processes such as developing plans for design options for variety, setting pricing strategy, defining modular design templates, choosing materials, defining baseline sketch and measurements, identifying key suppliers and deciding on material development.
After the detailed design, the new garment models need to go through the testing stage. It includes the following processes: testing prototypes, translating sketches to pattern, creating 3D visualisation for virtual settings, generating physical photos, developing promotional materials, preparing for launch, refining quality control and verifying that material development conforms to specifications. The final PD stage is production ramp-up. This is when Fashion companies evaluate the production output and send early promotional items and collections to the stores.
Tyler et al. (2006) have described the apparel product development in the UK and identified factors constraining company activities and competitiveness. The major part of product development in the textile and clothing industry appears characterised by functional independence. Each participant contributes to the process sequentially. This practice results in excessive costs, rework in production associated with late stage design changes and also longer lead times.
Stark (2015) has underlined the new opportunities allowing the product development process to be the most value-added one in the Fashion SC:

- Globalisation, due to the increasing number of customers
- New technologies offering new products (smart products, RFID, Cloud, 3D…)
- Social/environmental opportunities
- Human resource opportunities: new hired people grown up in a digital world.

The contributions found in literature are mostly addressing the topic of the Fashion SC, with some concern to the PD process. Industry-specific strategies, CSFs, business models are underexplored and issues in managing the activities carried out during the PD process are not detailed for each product category.

Information Management in the Fashion industry

Information management is a broad topic that is still not set in an industry-specific frame. From this viewpoint, literature is very poor; hence, one of the aim of the next section is to fill this gap.
Nevertheless, many cross-industry analyses allow to overview the topic and to prepare the ground for further detailed investigations.
According to Bhatt (2001), information is as an organized set of data, while data are considered as raw facts and knowledge is perceived as meaningful information.
Product data are the definition of a product: they represent all the knowledge and the know-how about the product.
A data model is a representation, usually a diagram, of the data in a particular environment. There are different types of data model (conceptual, logical, physical, entity-relationship) and different related diagram as well (data flow, class diagram and state diagram).
The main issues that are related to information management in any industry are (Stark, 2015):

- Access to product data has to be provided to people when they need it. Different users want to see different views of product data.
- Product data are valuable and confidential
- Documents are often annotated informally and are lost forever
- Each business department develops its own jargon. This may be misunderstood by other departments

Management has a crucial role in controlling product data: it has to make sure that product data are of high quality, complete, secure, available to users when they need it and reusable.

Initiatives improving business processes in the Fashion industry

A business process describes how the company wants to work on a particular activity (Stark, 2015). It defines the tasks that people will do to achieve a business objective. Business processes are often industry-specific, product-specific and company-specific.
Business Process Management (BPM) is an overall approach to the improvement of a company's business processes. It includes process mapping, process modelling and process measurement.
Huang and Mak (1998) have defined Business Process Re-engineering (BPR) as a transformation approach that allows to rationalize the product development process, resulting in better product design decisions.

BPR aims at simplifying, eliminating and redesigning business processes for greater efficiency and cost reduction. It is able to determine where and how to improve the processes and it is adopted in different industries to map all the activities throughout the entire value chain (Dale et al., 2001). It is a knowledge intensive activity which requires a strong interoperation between all its participants.
The literature review has provided general purpose contributions related to the initiatives improving business processes (Trkman, 2010, Osterwalder et al., 2005). The effectiveness of specific projects supporting the product development process in Fashion companies, as the identification of process-oriented KPIs, the importance of business process modelling and the lean approach are still not examined in the existing literature (d'Avolio et al., 2015d).

PLM in the Fashion industry

PLM features

PLM is able to manage all the data concerning a product, and all the internal and external actors involved in the development of this product (Le Duigou et al., 2012). It has marked the transition from a departmental approach in product development, when each department defined its own activities independently of the other functions, to a collaborative and holistic approach.
The literature review of PLM includes a wide range of papers from the research area. D'Avolio et al. (2015c) identify four understandings of PLM. It can be defined as a:

- Strategic business approach
- Software integrating other design and SC tools
- Knowledge management system
- Culture generating solution

PLM is a strategic business approach that consistently manages all lifecycle stages of a product, commencing from market requirements through the disposal and the recycling (Chen et al., 2008). However, successful execution of new product development must be implemented in most stages of PLM including market requirement, product concept, detailed design, process plan, production and so on. PLM, in simple terms, is a business methodology and strategy for creating a product-centric environment. Rooted in Computer Aided Design (CAD) and Product Data Management (PDM) systems, PLM is aimed at connecting various product stakeholders over the entire lifecycle of the product, from concept to disposal.

As a technology solution, it establishes a set of tools and technologies that provide a shared platform for collaboration among product stakeholders and streamlines the flow of information along all the stages of the product lifecycle. But, what makes PLM distinct from many other technology solutions is not its state-of-the–art tools but the establishment of a sustainable corporate strategy (Ameri and Dutta, 2005).

From the ICT point of view, PLM can be defined as the "connective tissue" that allows the connection of design software to production and supply chain management software, taking into account the dispersed nature of the extended and collaborative enterprise (Garetti et al., 2005, Terzi et al., 2010). The value chain of product development is supported by the following software tools: CAD (Computer Aided Design), CAPP (Computer Aided process Planning) and CAPE (Computer Aided Production Engineering). The manufacturing chain management process is underpinned by tools as MRP (Material Requirement Planning), APS (Advanced Planning and Scheduling) and MES (Manufacturing Execution System). The integration paths of these tools started several years ago: PDM is the management tool connecting CAD, CAPP and CAPE in the design area. In the production management area, the ERP (Enterprise Resource Planning) is the umbrella, bringing together MRP, APS and MES (and much more). More recently, CRM (Customer Relationship Management) allowed linking of customer-related data to production management and product reengineering, encapsulated in ERP and PLM software suites for their execution and engineering contents respectively.

In this context, the PLM approach can be considered as a trend toward a full integration of all the software tools taking part in design and operational activities during a product lifecycle. Therefore, from a software point of view, PLM can be considered as data and document management tools, that is to say an enlargement of the PDM approach: local and remote collaboration tools based on collaboration; software infrastructures allowing interoperability among different software tools, mainly between the engineering software and the production and supply chain management one.

PLM is also a culture generating solution, which can give the company a unique competitive advantage through its institutionalization. It pervades the whole organization and therefore, its social and cultural aspect is as important as its technological side.

Given these definitions of PLM, multiple case study analyses in the Fashion industry, concerning PLM, have been conducted. The aim has been to evaluate the impact of PLM implementation projects within one or more companies, including the effects on organisation, management, product development and supply chain strategies.

PLM implementation

The most complete contribution aiming at identifying PLM implementation guidelines is attributable to Bokinge and Malmqvist (2012). The authors describe in detail each step of a PLM implementation project in a manufacturing company and evaluate the application of existing PLM implementation guidelines.
Unfortunately, none of the researches analysed have been conducted in the Fashion industry: best practices for PLM implementation derive from case studies or model-based researches that have been validated in the manufacturing/ aerospace/ computer science industries (d'Avolio et al., 2016b).
Literature about PLM implementation in the Fashion industry is devoted to a general description of industry-specific functionalities.
As stated by D'Amico et al. (2013), a PLM platform, which would work in the Fashion industry, should include the following elements contributing to the effective management of the entire product lifecycle: product data management, product structure management, configuration management, change management tracking, workflow management, catalogue library, supply chain management.
For rapid and intelligent working, PLM software is implemented in almost every well automated and growing Fashion industry (Kaur and Sharma, 2011). More creative and rapid response to all seasonal apparels can be achieved with the software.
Another analysis has concerned frameworks for PLM implementation, even if they were not validated in Fashion companies. Reference models and data management are the most common topics. Hovmøller and Tambo (2014) discuss the data dimension of fashion retailing deepening data-model development, master data management and the impact of this on business progress. It is the only one contribution about the Fashion industry, but the focus is on data management more than PLM deployment. Another industry-specific study is provided by Laroche et al. (2015): the authors describe an extended PLM for heritage objects and they identify a proper reference model. The automotive industry has been analysed by Matsokis and Kiritsis (2010): an ontology model of a product data and knowledge management semantic object model for PLM has been developed.
Coming to the frameworks for PLM implementation, two contributions are considered as relevant and have inspired the framework that will be presented in the Results Chapter:

- The first one is a process-oriented framework to support effective PLM implementation (Schuh et al., 2008): processes and PLM functions are linked and benefits coming from PLM implementation are acknowledged. The authors detail the steps to implement PLM, listing several reference models that fit the machinery industry.

- The other contribution is focused on PLM systems for SMEs (Le Duigou et al., 2011, 2012). Their studies aim at proposing a modelling framework to facilitate the implementation of PLM systems in SMEs through the identification of processes and data models. The research approach is based on four steps: identifying needs, modelling the processes to realize the identified needs, extraction of the Business Objects (BO), automation.

This analysis has been particularly useful because it has allowed to recognise how other industries and, consequently, different types of processes and dissimilar data models have been framed and managed in the last decade. Nevertheless, it has shown that these frameworks are not completely generalizable and representative of business processes and information management in the Fashion industry. Indeed, the amount of product data needed to define a part or component varies widely from a product to another (for example, a fashion product includes just a little part of the components of a car, but with a different degree of complexity).
These reasons have led to a deeper analysis, conducted through proper case studies, allowing to generalize results at least within the companies belonging to the sector.

PLM performance measures

Alemanni et al. (2008) propose a solution, based on KPI method, for evaluating the benefits introduced by the adoption of a PLM tool in a manufacturing company. The study sheds some light on the need to identify a set of significant indicators that could synthesize the companies' approach to PLM.
The literature analysis has not allowed to gather information about PD and PLM performance measures in the Fashion industry.
In order to reach this goal and to fill the literature gap, several case studies have been conducted (d'Avolio et al., 2016a).

PLM maturity models

PLM maturity models have been so far developed with a general-purpose intent (d'Avolio et al., 2015b).
Batenburg et al. (2006) have described a PLM framework based on the two concepts of PLM maturity and business/IT alignment. The framework helps companies to define a clear focus for their PLM activities, that is a certain maturity level, and to take into account the alignment of the different business dimensions (strategy and policy, monitoring and control, organization and processes, people and culture and information technology).

A benchmarking between PLM maturity models is provided by Vezzetti et al. (2014). The authors have tested different models, concluding that Batenburg's result is a complete model from every front.
Literature review suggested that adopting Batenburg's model to assess PLM maturity in the Fashion industry might be a starting point to analyse PLM implementation and to customize the framework for industry-specific needs.

Process and data management in Luxury industries

Literature is lacking of contributions about PD in the luxury market segment and, in particular, in Fashion, Food and Furniture industries.
Many studies investigate how ICTs support the PD process by helping to improve companies' critical factors and the corresponding performances (Urwin and Young, 2014; Wu et al., 2014; Arsenyan and Büyüközkan, 2016, MacCormack et al., 2001).
The greatest contribution from literature concerns the CSFs for luxury companies (Brun & Castelli, 2013, Heine, 2010, Walley et al., 2013), that I have already mentioned in the previous Chapter. Whereas, just few authors have dealt with the need for alignment between business strategy and information systems in luxury companies (Oh & Pinsonneault, 2007, Siguaw et al., 2000).
Concerning the topic of MTM, no relevant contributions have been found. Indeed, MTM is a niche within specific industries and an examination of processes and information is still missing.
The use of PLM platforms allows Food companies to provide different benefits, including: higher efficiency and productivity, increased product quality, reduced errors, greater profitability in PD and ensured regulatory compliance. In this concern, several contributions dealing with themes related to the different phases of the product life cycle, (Beginning of Life (BOL), Middle of Life (MOL) and End of Life (EOL)) have been found in the scientific literature (Kiritsis et al., 2003).
The level of knowledge of the PLM platform is still low in Luxury Food and Furniture sectors, from the literature point of view. The major part of the publications is actually based on analyses conducted by consulting societies and specialized magazines. The lack of papers about PD process and PLM functionalities in Luxury Food and Furniture industries has triggered a deeper investigation into several companies.

CHAPTER 3 – METHODOLOGY

For scientists, not knowing is exciting.

It's an opportunity to discover; the more that is unknown, the greater the opportunity

(Philip Tetlock and Dan Gardner, Superforecasting)

From my point of view, methodology is the rationale behind words, writings and actions. It means doing something with a high degree of consciousness, so that if someone is going to ask you "why?" you will have at least one reason, one clear and defined answer. In other words, it is a comfort-zone for academics and practitioners. Perhaps you are not sure about your results: maybe they are not enough generalizable or they might require a deeper analysis; but you have done your best to be coherent with your objective and to be loyal with your audience.
The interesting point with methodology is that you have the chance to state *how* you think, more than *what* you think.
In reading many papers during these years, I have found literature about methods very insightful. However, I think that a major experience and a huge amount of wisdom is required to contribute to such a relevant topic. Therefore, honestly, I still haven't written anything about new methods for Operations management.
Nevertheless, in this Chapter, I describe the methodology adopted to conduct the projects in which I have been involved, according to the existing taxonomies.

Research strategy

With the aim to fill the literature review gap and to ask the RQs, a research strategy has been designed.
I have adopted the case study research, that has allowed to analyse the Fashion SC and to identify links between variables related to organization, processes and information management (d'Avolio et al., 2015a). In fact, case research is considered as one of the most powerful research method in operations management (Voss et al., 2002). It is a strategy which involves an empirical investigation of a particular contemporary phenomenon within its real life context, using multiple sources of evidence (Saunders et al., 2009). It is normally used to gain a more in-depth understanding of the research, often in an effort to answer "how" and "why" questions (Yin, 1984).
The case study has been used, first of all, for exploration purposes and then also with a theory-building attempt. The RQs described in Chapter 1 and the research framework represented in Figure 1 have been defined in order to have a prior view of the constructs to be studied and their relationships. Of course, as in many case study analyses, RQs evolved over time and constructs have been modified and developed during the course of the research.
The aim of this manuscript is indeed to reinforce the structure of the research framework and provide answers to the RQs that are straightforward and lined up with academic and entrepreneurial goals.
Multiple-case sampling was used to increase confidence in the findings and support their external validity (Miles & Huberman, 1984). I have also conducted single-case study analyses in order to assess particular settings and to achieve an in-depth

observation. In Table 2, I have linked each topic from the research framework to its respective methodology, the number of cases involved and the project duration. Analysing the research framework, the reader understands that several topics are tightly connected and in order to effectively answer the RQs, a greater depth is required. Hence, overviewing the overall researches conducted over these years and downstream of each case study analysis, I can define this research as a merge of single case studies, conducted in a wide time window (almost 24 months), and multiple case studies, carried out in 3-8 months. Single case studies in this research are meant as in-depth cases: they have been conducted within a company in a long time horizon and then replicated in other companies showing same needs (this is the reason why in Table 2 a single case study is associated to more than one case). The use of multiple cases is due to the need to establish whether the findings of the first case occur in other cases and, as a consequence, the willingness to generalise from these findings.

According to Eisenhardt (1989) a number between 4 and 10 cases usually works well in these researches, so the considered sample is sufficient to give an accurate account. Having experienced multiple case studies, I run across the so-called "theoretical saturation": concepts and the related linkages have been verified, and it seemed that no additional data were needed.

The organizations I have examined have always given me the chance to analyse several departments and business units, so that embedded case studies have been performed. Cases have also been longitudinal: because of the evolving nature of the Fashion industry and its relationship with ICTs, each setting has been analysed currently and along its development in order to provide a realistic perspective.

Data interpretation has been inductive: once data were collected, then were analysed to see how filling the literature gap, generalizing or defining company-specific behaviours.

Ultimately, methodology has been particularly useful to ensure the alignment between research framework, RQs, data collection, analysis, results and conclusions.

Table 2 - From research framework to sampling

RQs	**Topic**	**Methodology**	**N° of cases**	**Duration (months)**
RQ1	PD & SC: Strategies, Processes & Products	Multiple case study	7	3-6
RQ2	PD information management	Multiple case study	7	3-6
RQ3	PD KPIs	Multiple case study	7	3-6
RQ4	PD Process improvement	Single case study	3	6-12
RQ5	PLM strategic initiative	Multiple case study	7	6
RQ6	PLM implementation	Single case study	2	6-24

RQ7	PLM adoption & KPIs	Single case study	2	6-12
RQ8	Luxury industries: PD and data management	Single case study	3	6
RQ9	Luxury industries: PLM	Multiple case study	12	8

Techniques and procedures

The case study analysis gives the opportunity to perform triangulation, providing stronger substantiation of constructs and hypotheses. It refers to the use of different data collection techniques within one study, both quantitative and qualitative. In fact, structured, semi-structured, unstructured interviews, surveys, interactions, observations and archival sources have been combined.
In addition to the choice of multiple data collection techniques, also analysis procedures have often been merged, quantifying qualitative data and qualifying quantitative data. Hence, a mixed-model has been adopted (Saunders et al., 2009).
From the population of Fashion companies, I have selected a sample that was representative of the strategies and features typical of the sector. It can be defined as a non-probability, purposive and homogeneous sampling: I have selected cases that were particularly informative and I focused on a particular sub-group, sharing similarities, trying to achieve more depth. In order to be included in the sample, the firms considered must have had some key features:

- Having at least a business unit in Italy
- Having an international profile
- Playing in different market segments
- Being established in the fashion business for several years.

Fortunately, Tuscany is hosting lots of firms specialized in leather goods, accessories and apparel. This background has allowed me to experience a wide range of business practices and to collect data for my PhD thesis.
Interviews have represented the primary contact with these companies. At a very first stage, I have had the chance to understand which could be the business areas and issues to focus on. Then, depending on the purpose of the project, I have also designed and administered questionnaires, always accomplished by interactions, personal observation and review of archival sources.
Standardised interviews were used to collect quantitative data or to perform benchmarking between the cases, basing on key variables or drivers (the main questionnaires that have been administered are reported in the Appendices Chapter).
Moreover, one-to-one, face-to-face interviews and group interviews were adopted to gather qualitative data, to probe some topics and to understand the meaning that interviewees ascribe to various phenomena.

The funnel model (Voss et al., 2002), starting with broad and open-ended questions and followed by detailed questions, has been used in most of the projects in order to investigate the context variables, the competitive setting and the general features of the companies with the aim to deepen a particular topic. Each meeting lasted from one hour to eight hours, depending on the number of interviews and on the scope of the specific case.
The different topics analysed required different knowledge, skills and expertise: CIOs, Operations Managers, Buying teams, PD Managers, CFOs and SC Managers have been involved. I needed to analyse dissimilar viewpoints within the same organization and often simultaneously. Then, these multiple perspectives have also allowed me to reduce the risk of subjectivity and bias.
I have conducted all the cases as a single investigator, apart for the Food company that has been interviewed by a colleague of mine, involved in a PhD project in the sector.
The construct validity, i.e. the extent to which we establish correct operational measures for the concepts being studied (Voss et al., 2002), has been ensured using multiple sources of evidence, often sharing the same business model and strategy.
The internal validity, i.e. the extent to which we can establish a causal relationships whereby certain conditions are shown to lead to other conditions, has been controlled thanks to the deep analyses and to the long-time horizons.
The external validity, i.e. knowing whether a study's finding can be generalised beyond the immediate case study, has been checked through the use of multiple cases and through cross-industry analyses. Moreover, comparisons of emergent concepts with existing literature have always been performed in order to check similarities or conflicts.
Reliability, i.e. the extent to which a study's operations can be repeated, with the same results, has required a particular concern. Several validation meetings have allowed to review the analysis with the stakeholder, to fine-tune the main results and finally to validate them.
Each meeting has been documented through proper minutes, summarizing participants, process, data management and issues (see Appendix 1).
With the aim to finalize an effective coding, fragmented data have been grouped into sub-categories, basing on particular drivers (e.g. CSFs, main product and outsourced activities). Then, data were put together in new ways (axial coding) and finally core categories have been selected (selective coding). This process has allowed to never get lost among the high number of information (often paper-based) provided by the companies and to value them correctly.
Finally, two types of analyses, within case and cross-case patterns, have been provided in order to completely overview the sample and its features.

The Fashion companies

The research involved a sample of ten companies, internationally recognized and facing the challenge of competing globally. Table 3 shows the sample's key features in terms of:

- Firm size, considering revenues and number of employees
- Industry or sector
- Main products or core business
- Market segment, according to the price-based classification defined by Saviolo & Testa (2005)
- Outsourced activities within the overall SC
- Main distribution channel
- Interviewees

The eight Fashion companies are large firms, whereas the Luxury Furniture enterprise is small and the Luxury Food enterprise has a medium size.
The core business in four cases is leather goods, then we have two cases that are selling above all ready-to-wear, one case of childrenswear and another of outerwear.
Case 9 sells furniture and decorative accessories, while case 10 produces pasta.
The cases range from the luxury market segment to prêt-à-porter and diffusion.
Since we are examining the downstream SC, it is taken for granted that all the companies interviewed buy raw materials (skins, fabrics, metal hardware, accessories…) from proper suppliers, playing in the upstream SC. Apart from material sourcing, three Fashion companies conduct in-house the entire range of business processes (design, product development, engineering, production, distribution, sales and after-sales). These companies pay a particular attention to the quality of their products, so it is definitely their main CSF.
Cases 1, 3, 8 and 9 conduct all the supply chain processes internally, while in the other cases production is outsourced to suppliers located in Italy and in Europe.
The most part of the cases has selected the Retail channel to sell their products: controlling distribution, sales and merchandise assortment is crucial, the more the company is managing luxury products. The case 7 is an exception: its product are mostly available in corners located in big Wholesale chains. Coming to the case study conducted in the Food industry, as always happens in this sector, distribution and selling are outsourced to providers that locate products on supermarket shelves or in luxury food Wholesale stores.
Each case has allowed to "discover" different settings, practices and specificities. Depending on the objective of the project, it has involved the Product Development team, Operations, Purchase and Information Technology offices. Even if several interviews and interactions required the expertise of users or

process owners, I have always asked a validation to their supervisor (CIO, COO, PD Manager) so that results were checked from the operational and strategic viewpoints.

Table 3 - Sample's features

Cases	**Firm Size**	**Industry**	**Main Products**	**Market segment**	**Outsourced activities**	**Main distribution channel**	**Interviewees**
Case 1	Large	Fashion	Leather Goods, Shoes, Ready to wear	Luxury	None	Retail	CIO, Supply Chain Manager
Case 2	Large	Fashion	Shoes, Leather Goods	Luxury	Production	Retail	CIO, Supply Chain Manager
Case 3	Large	Fashion	Leather Goods, Shoes, Ready to wear	Luxury	None	Retail	CIO, Supply Chain Manager
Case 4	Large	Fashion	Leather Goods	Prêt-à-porter	Production	Retail	CIO, Supply Chain Manager
Case 5	Large	Fashion	Ready to Wear	Prêt-à-porter	Production	Retail	CIO, Supply Chain Manager
Case 6	Large	Fashion	Childrenswear	Diffusion	Sourcing, Production	Retail	CIO, Operations Manager, Buying team, PD Manager
Case 7	Large	Fashion	Outerwear	Prêt-à-porter	Production	Wholesale	CIO, Operations Manager, Buying team, PD Manager
Case 8	Large	Fashion	Ready to Wear	Luxury	None	Retail	CIO, Supply Chain Manager
Case 9	Small	Furniture	Furniture	Luxury	None	Retail	COO, CFO, PD Manager
Case 10	Medium	Food	Pasta	Luxury	Distribution	Wholesale	PD Manager

Cases description

A within cases analysis has allowed to become familiar with each case as a standalone entity, in order to define unique patterns of each case before generalising across cases. Hereafter, each company has been described basing on the features summarized in Table 3.

Case 1

Case 1 is an Italian high fashion brand, best known for its leather goods, which are sold worldwide, and its men's and women's ready-to-wear. Founded in the 1960s, its headquarters are in Italy and Switzerland. The brand is now a part of a famous multinational group. Distribution of products is global, encompassing Europe, Asia, Australia, South America, and North America.
The company strongly believes in product quality and craftsmanship is one of its biggest values. Two main collections are developed and accompanied with an early-fall and a cruise. Carry over products rule the overall assortment: three iconic handbags are proposed since the brand origins, in different colours and sizes.
The brand has to manage lots of activities, all conducted in-house, and takes care of each single material adopted.
Because of its international profile, the company is investing a lot in innovation and on process improvement, in order to reduce non value-added tasks and focus on its mission.
A dedicate IT department is managing all the projects related to PLM and ERP, their integration and implementation. In particular, PLM has been implemented since 5 years and, over time, more and more departments and users have been involved. The primary pilot project was developed for the shoes business unit, then extended to ready-to-wear, leather goods and currently also to their furniture department.

Case 2

The company's expertise is in leather goods, including bags, shoes and small leather products. Collections are refreshed twice a year, for the Spring/Summer (SS) and Autumn/Winter (AW) events; other sub-events may exist, corresponding with Cruise, Catwalk, Pre-fall and Special collections. Like many high-fashion companies, it manages a huge number of carry-over products, which are proposed over the years, often in different colours, but with the same model and materials. There is also another, more fashionable, part of their production that is refreshed each season or is tailor-made for celebrities.

The company designs almost eight thousand pairs of shoes in a year (not all of which are of course approved for sale), with almost eighteen thousand colourways. The company's headquarter is in London, the warehouses are based in Switzerland and SC is managed in Florence. A network of specialized factories is in charge to produce their products: the company is able to coordinate its suppliers, managing product development and outsourcing the manufacturing process.
The company has decided to replace a PDM solution with an industry-specific PLM solution and has implemented it since 4 years. All the business units, suppliers apart, are using this software massively.

Case 3

Founded in the 1960s, the company has been considered one of the world's most prominent fashion houses and it is known for its modern and iconic pieces. Today the brand markets a broad range of women's and men's ready-to-wear products, leather goods, shoes, beauty and jewellery. Its flagship stores are famous all over the world.
The company has been internationally recognised for the focus of its creative director on ready-to-wear and also for the high quality leather goods. In Tuscany, the brand manages its shoes and bags business units. Four main collections (spring, summer, fall and winter) are internally developed each year. The company belongs to the same multinational group of Case 1, so they are completely aligned in terms of promoting and improving innovation.
The PLM solution has been implemented a year later than Case 1, but also in this company the project nowadays concerns all the business units.

Case 4

Case 4 is an Italian company that features products ranging from handbags and shoes to accessories. Its headquarter is located in Bologna, and highly-operative and fully structured regional headquarters are present also in New York, Hong Kong and Tokyo. Product Development and Operations are conducted in Tuscany and a reliable network of near-shore suppliers is producing their merchandise. The product price is lower than the cases described above, but the focus on quality is high as well.
The brand is more and more trying to streamline its processes in order to increase its reactiveness on the market. The company's strategy is a trade-off between the importance of time to market and quality.
Four main collections are developed each year. Carry over products are proposed with different colours and material variation, so that the customer can perceive the closeness to new trends and to quality at the same time.

A PLM solution has been implemented since 3 years and it is fully adopted in all the business units.

Case 5

The company belongs to an Italian fashion group, with an international profile, including 35 labels. It markets up-market ready-to-wear clothing and its headquarter is in Emilia Romagna. The group manages more than two thousand stores in 90 countries.
The brand is very famous for style and design of its cloths and coats. Accessories and shoes are also part of their collection, but with a secondary role, most of all to enrich garments and to create a total look for demanding customers.
Four main collection are developed within a year. The price range is lower than the traditional luxury companies, so that it is serving the prêt-à-porter market segment.
Production is the only process that the company is outsourcing, whereas style is their core business.
After a long-lasting experience with a custom PDM solution, the company is analysing several PLM software, from different vendors, in order to select the one that fits its needs, also as part of a fashion group.

Case 6

The company was founded in the 1950s and now still maintains a strong family imprint. It has been originally founded as a small textile factory and transformed over the years into the Italian leader of children's wear, thanks to important brands.
In order to create each collection, the company organizes an articulated production cycle lasting a whole year. During the creative phase, mood and colours are decided considering the fashion trends, designers team ideas, trade guide and brands image.
Modellers transform the designers' sketches into paper-patterns to create the first sampled garment. Production is outsourced in many departments around the world and these are controlled during the whole manufacturing cycle.
The distribution strategy is based on several international and national channels which coexist in synergy. Advanced IT and Logistic systems allow the company to coordinate all these channels.
Every season about 1.700 styles are realized, leading to a total production of 8 millions garments a year. Several collection are developed in order to refresh merchandise in stores and to satisfy the needs of the low-end market segment.
The company is evaluating to implement a PLM solution, after a four-years' experience with a legacy PDM solution. Another option that the company is considering is to upgrade the existing PDM to its latest release, with the aim to benefit from the extended PDM functionalities.

Case 7

The company markets jackets for men, women and children. Proudly Italian, the brand thinks globally and is already present in the most prestigious shop-windows and locations of international shopping.
The main focus of the brand is to coordinate its complex supply chain, where delicate main materials, as furs and down, are supplied from European countries and then assembled with other accessories. Product development and material purchasing are conducted internally. Production is outsourced to Far East countries, so one of the main challenges is to coordinate distant suppliers and to accelerate the distribution process.
The two main collections are composed, most of all, of carry over products, in few variations. Innovative materials and techniques to improve the padding performances are often introduced, so that the customer can appreciate the product quality. This means that the company's strategy is leveraging on innovation and time-to-market.
A PDM solution is effectively supporting the product development process. It is properly integrated with the ERP software. The company is currently trying to improve process management more than information management.

Case 8

The company is an Italian luxury fashion house that makes men's clothing and accessories. As one of the biggest global producers of fine fabrics, it has been active in promoting improvements in wool production around the world.
The merchandise range includes fabrics, suits, neckties, knitwear, shirts, accessories and sportswear. Today the company has more than 500 stores (almost 300 of which are directly operated).
All the business process are managed in-house, including production, because of the need to ensure quality at each level of the supply chain. Style and product development are actually the most time-expensive tasks, hence the company is performing a software selection with the aim to implement a PLM solution. This project is involving all the product lines. An integration with ERP and creative suites, already adopted by the company, is expected.
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Case 9

This case is set in a small family-based company in Florence, famous for its long-standing tradition of craftsmanship that uses ancient artistry techniques and practices to make true works of art.

Born in 1867, the company has long been recognised a leader in the luxury home furnishing sector and an ambassador of Italian luxury and lifestyle.
The company is specialised in creating one-of-a-kind, custom-made statement pieces embodying both a classic aesthetic and contemporary spirit. The use of colourful stones in the production of decorative objects has been popular in Italy since the Renaissance, where the work of precious stones was flourishing in Florence under the influence of the Medici family.
Many particular materials as amethyst, rock crystal, tiger eye, malachite, jasper and lapis lazuli are mastered every day to satisfy the dreamy needs of customers from all over the world. Even if the headquarter is based in Florence, almost 15 owned boutiques sell internationally their products.
The company's core business is product development but the internal galvanising process and the other operations conducted internally have to be more and more accelerated in order to deliver the final product in a timely manner.
An ERP is currently implemented and business process improvement projects are planned in order to ensure an increasing competitiveness in the market.

Case 10

This company produces quality pasta since 1789. It is innovating many of its internal processes in its production facilities, to transform the best durum wheats into the best possible pasta.
The great part of its business is based on testing and developing new product ranges and to find several market niches to satisfy the consumers' needs. Once they produce and pack the finished products, the distribution process is outsourced to the Wholesale channel, which is also in charge to the selling activity.
The company is trying to reduce time-to-market and, to this aim, several improvement projects are scheduled. Identifying KPIs to measure and control internal and external processes and evaluating industry-specific PLM solutions are actually the main objectives.

Cross-case patterns

Listing and analysing the features of individual case studies have been the first steps to examine data. The next step has been the search for cross-case patterns, with the aim to enhance also the generalisability of conclusions drawn from cases (Voss et al., 2002). The sample is homogeneous and all the cases share predefined characteristics. Table 3 highlights several commonalities and differences between the cases, in terms of firm size, main products, market segment, outsourced activities, distribution channel and industry.
In Figure 4, in addition, I have designed a positioning map, based on two variables that represent the main CSFs for Fashion companies:

- The importance of quality: along the vertical axis the importance of product quality decreases from the top to the downward side.
- The importance of TTM: along the horizontal axis the importance of TTM increases from the left to the right side. A high importance of TTM means that companies are trying to speed up the processes and to compress the collection schedule.

The decision to use this kind of map is related to the high degree of completeness achievable: the two variables are crucial and perfectly representative of the strategies adopted by the companies.
As can be seen in the figure, the four quadrants are all covered and analysed: this explains the effort to include, within the sample, companies homogeneous in terms of industry requirements and, in the meanwhile, owning specific trade-offs in defining their strategies.
The CSFs represented in the following figure are intended in their qualitative meaning: there is no metric in the horizonal and vertical axes. The positioning map is not aiming at measuring some degree of performance; it just frames the companies in a given trade-off between timing and quality strategies.
Cases 2 and 10, the first selling leather goods and the second pasta, are leveraging on high quality standards and are trying to be more reactive in the market, fastening activities within the supply chain and introducing new products within their main collections.
Case 6 is representative of those companies who belong to the low-end market segment and have to be definitely reactive to meet the customers' expectations. Quality is secondary, because the company is trying to reduce costs, outsourcing production to cheap labour countries.
Cases 4, 5 and 7 are selling prêt-à-porter products: quality is higher than case 6, but lower than luxury companies. These companies are focusing on basic items, consolidated throughout the years, with a low degree of newness. They often pay attention to innovative materials, which give their products a special appeal to the customers.

In the end, cases 1, 3, 8 and 9 are luxury companies that strongly believe in quality: their products are "Made in Italy" with craftsmanship techniques. These companies are trying to deliver uniqueness and exclusivity: they set a high price, take advantage from high margins and target to the highest market segment. All these factors lead to the choice to sell basic products or a limited number of newness.

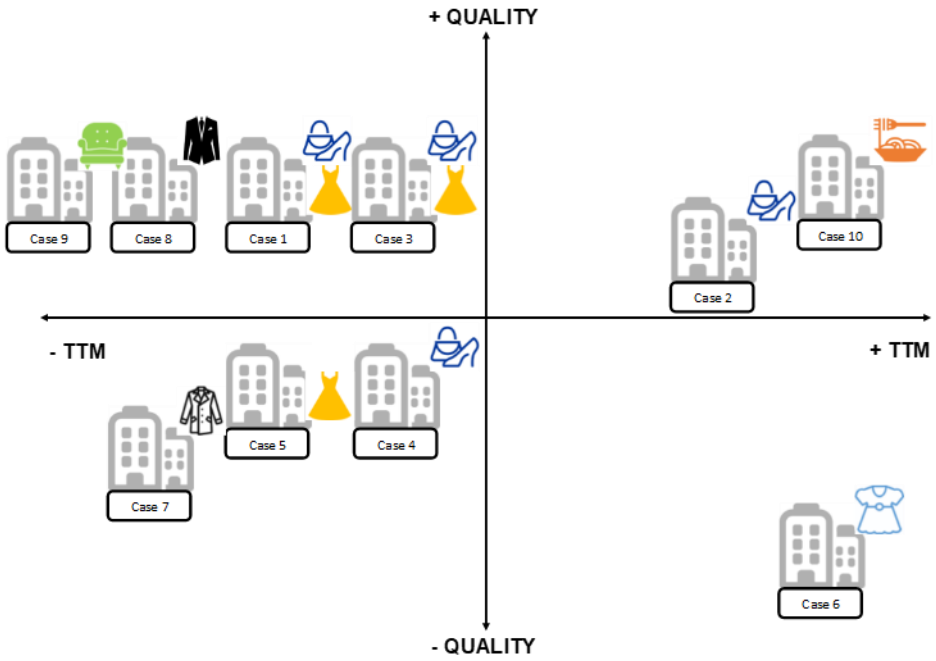

Figure 4 - Positioning map of the cases

CHAPTER 4 – RESULTS

The fox knows many things, but the hedgehog knows one big thing

(Archilocus)

This Chapter has been designed with the aim to fully achieve the objective of this thesis and to answer the RQs. From the research framework, thanks to the literature review and to the case study analyses, over the years, I have gradually reached a wider awareness of the Fashion industry.
The analysis of the entire SC, of its single process, the focus on product development and data management have constituted the earliest step. My idea was to understand strategies, processes, information and product features, as the foundations of any further analysis.
Then, I have deepened the topic of process improvement and PLM, as strategies supporting the Product Development process. I have experienced also the other side of these initiatives, i.e. the ICT-based one, in which a software has to be deployed, integrated with other tools, maintained, upgraded and controlled in terms of performances.
The final step to reach the research objective has been to perform a cross-industry analysis. The sectorial investigation has demonstrated that the product development process has its own specificities in Fashion, but that these might be common to other industries with similar business models. To this aim, two sectors were examined, Food and Furniture, in their Luxury "shade": commonalities and differences between the sectors in terms of product development, information management and PLM requirements were highlighted.
For each topic and for each answer to the RQs, findings are equipped with brief interpretation of facts, then thoroughly discussed and summarised in the next Chapter.

RQ1: Product Development and Supply Chain Management in the Fashion industry

As depicted in the research framework of Figure 1, we are going to analyse product development features in the Fashion industry, focusing on strategies, processes and products.

Strategies

According to Porter (2008), two main strategies are adopted by any company in order to meet its objectives: the "cost leadership" and the "differentiation" ones. Other key strategies are the "niche", "trend-leader" and "trend-follower": these are very common in the Fashion industry where trends rule the overall environment.
In reality, the strategies of many companies do not fall nicely into one of the above categories. For instance, all the luxury companies within the sample described in the previous Chapter (cases 1, 2, 3, 8, 9, 10) are trend-leaders, but also adopt the

niche and the differentiation strategies. Whereas, cases 4, 5, 6, and 7 are trend-followers, and use also cost-leadership and niche strategies.
Therefore, the discriminating factor between the cases is more related to the market segment and to the CSFs that, as we have already seen, could be the importance of quality or TTM.
In order to achieve competitive advantage, the strategy has to be completed with the identification of a business model, describing how the pieces of a business fit together.
Perhaps one of the most famous business models within the sector is Fast Fashion: it combines supply chain agility to respond quickly, and constant product introductions to attract variety-seeking/fashion-conscious customers. Case 6 is the only company in the sample that is adopting this business model.
The traditional business model within the Fashion industry, adopted by cases 1, 2, 3, 4, 5, 7, 8 and 9, is Made-To-Order (MTO): these companies periodically collect orders from the sales channel and then let the production started, basing on quantities and ranges defined during order-entry.
Another industry-specific business model is Made-To-Measure (MTM) that has shifted mass customization to the simpler needs for individualism, personalization and product uniqueness. This business model is more typical of luxury companies that believe in their handcrafted tradition. Cases 1, 2, 3, 8 and 9 adopt this model to differ from competitors and to offer a particular product to their customers. Hence, the MTM model is combined and harmonized with MTO.
The case 10, which belongs to the food industry, is adopting a Made To Stock (MTS) business model: it produces large amounts of pasta in stock and deliver batches basing on the Wholesale constraints.
In Figure 5, I have added several information to the positioning map illustrated in the previous Chapter: price levels and merchandise strategies have been included.
The upper right quadrant is composed of companies (cases 2 and 10) paying huge attention to TTM and product quality: these are selling high-price products and are introducing many capsule collections in addition to the traditional scheduling (SS and FW).
The lower right quadrant is composed of a company (case 6) belonging to the low-end market segment, that is leveraging on TTM while overlooking the importance of quality. This company can benefit from the cheap labour cost and sells low-price products. Collections are frequently refreshed because of the need to follow the changing trends and to satisfy many different customers. The idea is to produce many product variations, relying on quantity more than on quality.
The lower left quadrant includes companies (cases 4, 5 and 7) that are selling medium-low price products through basic collections. Their aim is to behave like luxury companies, following their trends and providing classic assortments of merchandise, but with a lower quality. Hence, these are targeting to a customer that is sensitive to price and in the meanwhile is willing to choose classic items.

The upper left quadrant is composed of luxury companies (cases 1, 3, 8 and 9) leveraging on high quality standards and exclusive products. Prices are definitely high and collections are limited to two main assortments per year. These strategies survive since decades in the luxury market segment and represent its competitive edge, so that became distinctive traits of its companies.

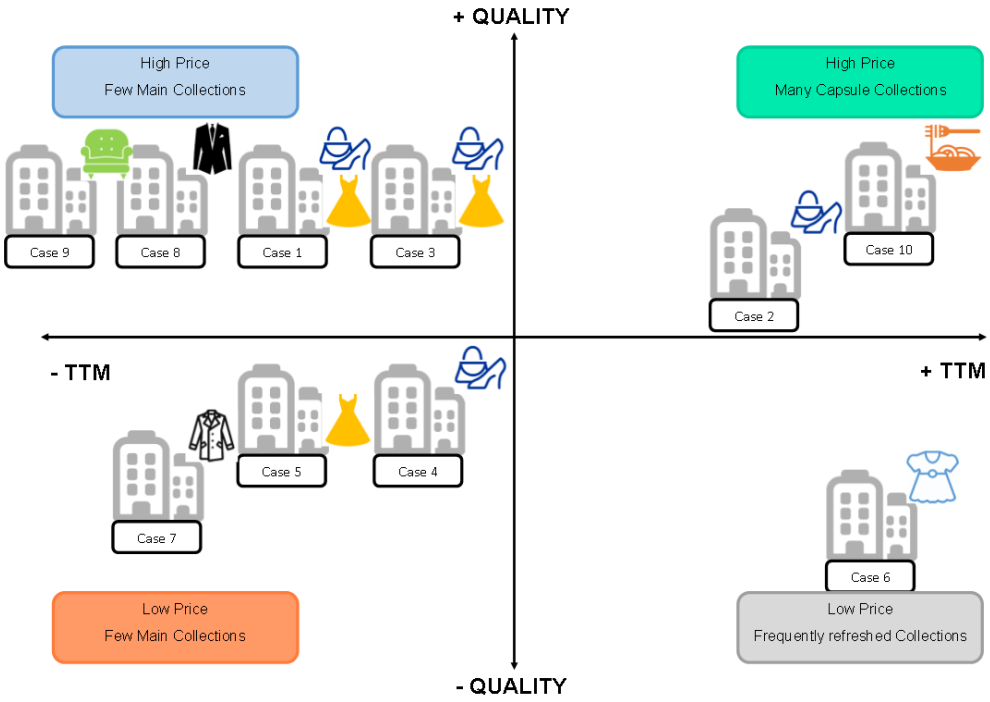

Figure 5 - Positioning map of the companies' strategies

Processes

Multiple case study analyses have allowed to understand which are the key processes characterising Product Development in the Fashion SC. Each company in the sample is different from another in terms of process management. In Figure 6, I have depicted the business process map of a company that performs all the business processes in-house, collaborating with a typical finished product factory and with material suppliers. The focus has been on product development, from design to production. The remaining processes (distribution, sales and after-sales) are not considered for the scope of this study.

The business process map for a company that is conducting the entire set of processes in-house is simplified in comparison to the figure below because less players are involved; hence, the tasks are more or less the same (business-specific activities are typical of Fashion SCs).
The figure illustrates, in addition to the main tasks, the product progress stages: prototyping, sampling and production. As a matter of fact, there is not a specific milestone that triggers the transition from a stage to the next. These stages are rather product states defined with the aim to identify a workflow within product development in Fashion companies.
During Collection Planning, the entire collection is developed according to budget constraints and market needs analyses. Then, with the Collection Briefing task, the merchandising team defines how many new and carry-over products have to be developed, also identifying the collection models, themes, colours, embroideries, moulds and structures. The main activities are: merchandise strategy definition, economic and financial planning, marketing analysis, historical data analysis and trend analysis.
Once the collection targets have been recognised, the product development team is able to design the products, following the merchandising recommendations: a sketch of the article in its earliest stage is made. The product is still a sketch and, as decisions are taken about its main materials and suppliers, it is developed and manufactured. The prototype is subject to fitting tests by the product development team and, during Merchandising meetings, several modifications related to accessories placement and to the general product appeal may be suggested. While the supplier produces a new prototype, information about the product are recorded.
More and more details about the product are available, since product development is progressing to the sampling stage; the BOM lists the entire range of coloured materials, by product colour and size. If new materials or new colourways are developed, they have to be checked with material suppliers and then properly encoded. The company asks a supplier to manufacture the product in its sampling stage and negotiates costs. The Bill Of Labour (BOL), as part of any cost, defines the operation breakdown along with all materials. The Editing meeting represents the last chance for the merchandising team to modify the product before presenting the collection to the sales agents, during the showroom stage. The product information are updated, including all the information required to engineer and manufacture it, such as BOM, BOL, technical sheets, composition details and packaging information.
During the Collection show, the merchandising team is in charge of collecting feedback and orders from the sales channel: a collection book summarises the items within the new collection. The main activities carried out are: managing commercial offices, selecting agents, collection overview, presentation to the salesforce in showroom and order entry.

Finally, production is planned and vendor allocation is ensured in order to distribute the volumes and the assortment to the factories. Bulk orders are then sent to the factories, that are going to perform the Production process.

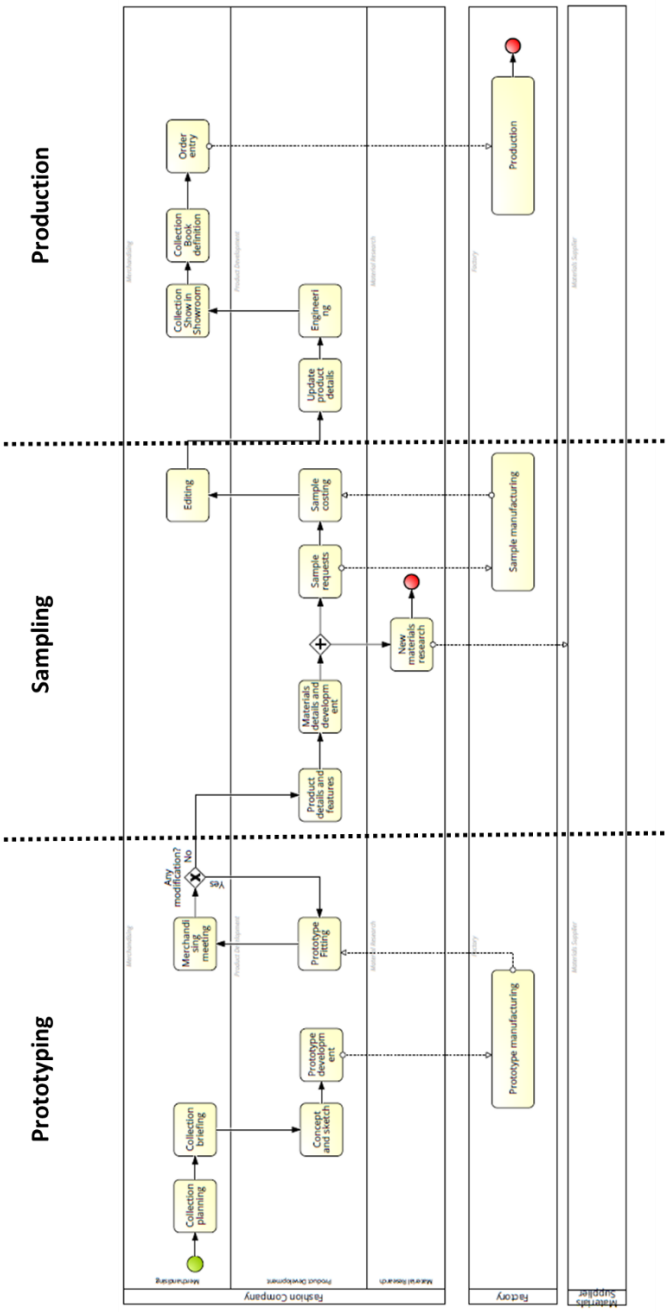

Figure 6 - Business process model of a Fashion company

Products

Multiple case study analyses have allowed to understand the Fashion product features, for data modelling purposes and in its technical/engineering meaning.
In fact, a generic fashion product can be decomposed in several sub-parts (Figure 7), with the aim to attribute specific information and to figure out the data model required to better represent it.
The theme is the set of main coloured materials within a product. Different items may share the same theme, in any collection or season.
The product shape is designed by pattern makers and represents the model of the shoe, of the bag or the clothing. Also a shape can be attributed to different products in different collections.
For product development purposes, the product ID is represented by the Style: it is a code that merges information about the theme, the shape and the colour. The Style uniquely identifies a product within a collection. A Style may have different attributes: it can be a new product, a carry over, or a variation of a carry over. Carry over Styles are typically used in different collections.
For distribution and selling purposes, the product ID is represented by the Stock Keeping Unit (SKU): it is a code that includes information about the theme, the shape, the colour and the size. It has a higher level of detail (i.e. the size within a size range) because, when a product has to be stocked within warehouses, it needs a unique identifier allowing to be distinguished also from other products with the same colour but with different sizes.

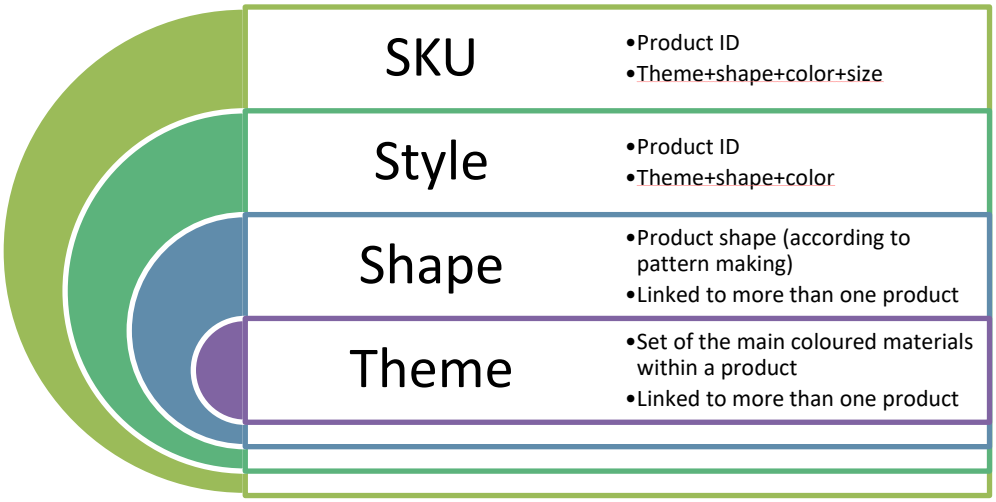

Figure 7 - Fashion product IDs and sub-parts

Once we have defined a generic fashion product and its coding, we can analyse which are its physical components, from the technical/engineering viewpoint. This structure is important for process management, because entails the analysis of tasks involved in the production of the finished good, and for information management, in terms of data related to all the components and BOM by size and colour.
During the case study analyses (cases 1, 2 and 3), the engineering department shed some light on the "anatomy" of the shoes (Figure 8). Depending on the viewpoint (brand, leather factories, accessories factories, shoe or sole factories), a higher or lower level of detail is required to describe the shoe structure. From the perspective of a brand that outsources production to local factories, shoes are composed of:

- the upper, that is the entire part of the shoe that covers the foot;
- the lining, improving comfort and helping increase the lifespan of the shoe;
- the insole, i.e. a layer of material that sits inside the shoe;
- the sole, that sits below the wearer's foot;
- the heel, raising the rear of the shoe in relation to the front;
- the heel tip, that is the part of the heel that comes in contact with the ground;
- accessories, such as sequins, metal hardware and embroideries.

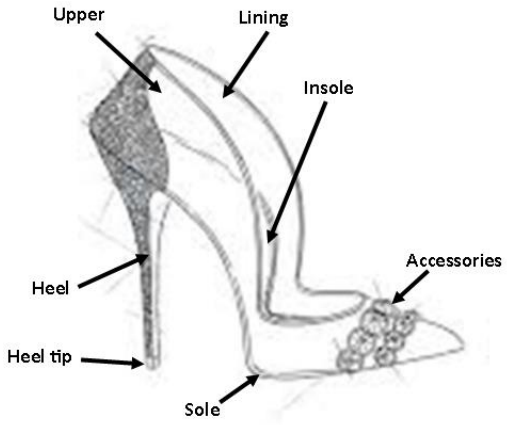

Figure 8 - Key elements of a shoe

This analysis allows understanding the basic parts of a product, that could be an indicator of what we can expect in terms of information management, for example. As the Fashion industry is full of different items and the degree of standardization

is very low, the product complexity should not be deduced simply from the number of its parts.
Thanks to the multiple case study analyses, I concluded that product complexity in the Fashion industry, for all the product categories (not just for shoes) is ascribable to the following elements:

- Seasonality: unlike the automotive industry, the fashion product is highly seasonal, with a very short lifecycle.
- Product typology: a collection representing the product range may contain carry-over and new products. Even carry-over items are not as standardised as in a machinery industry; colours and accessories might change from one season to another.
- Product versioning: each product progresses through three main stages (prototyping, sampling and production). The same product is developed more times with consequent proliferation of physical items and related information.
- Manufacturing techniques: several processing methods require long lead times and the related information are mainly paper-based.
- Presence of semi-finished goods: a part of the finished product might need to be manufactured aside, with special techniques not always performed in the same factory. This means also a longer LT.
- Degree of craftsmanship/automation to manufacture the product: the more handcrafted processes are involved, the higher the probability to lose control over lead times and TTM.

According to this definition of Fashion product complexity, counting the rows within a BOM or the products parts is too simplistic.
In order to analyse product and process complexity, interviews, interactions and business process maps have demonstrated to be more effective and enlightening criteria.

RQ2: PD information management

An important issue within the Product Development process is managing product data. Many tools supporting the Product Development process exist and have a wide diffusion within companies belonging to different industries: Office Automation (Spreadsheet, Word processing, etc.), ERP, Material Requirements Planning (MRP), PDM/PLM, CAD 2D, CAD 3D, Digital Mock-Up (DMU), Computer Aided Styling (CAS), Computer Aided Engineering (CAE), Finite Element Analysis Method (FEA/FEM), Knowledge Based Engineering (KBE) and Design Automation, Computer Aided Manufacturing (CAM), Customer

Relationship Management (CRM), Supplier Relationship Management (SRM), Computerized Maintenance Management System (CMMS), Lifecycle Analysis Software (LCA).
Just a little part of these tools is used in the analysed companies and they are Office Automation, ERP, MRP and the recent PLM solutions. The handcrafted tradition of the firms' products limits the opportunities offered by CAD software, but also SRM and CRM solutions' importance is not still acknowledged. Whereas, one of the most important drivers that has triggered the adoption of PLM is the need to provide a repository of product data and to overview the product choices.
Once the Fashion industry has been analysed in terms of processes, information management and data have been examined.
To this aim, the core result from the case study analyses has been a map of the information exchanged within the companies.
The Enterprise Architecture Diagram allows to have a comprehensive view of the relationships between ICTs and of the information they produce, both as input and as output. This model has been particularly useful, during business process analysis in improvement or PLM initiatives, to draw the AS IS situation, before PLM, and the TO BE, towards PLM.

Before PLM

During the multiple case studies carried out over the years, the companies have recognised that the structure of information they were managing could be improved and which were the integration required to ensure data exchange between different tools involved in the same business process. In Figure 9 the AS IS situation, from a case study analysis, concerning ICTs and data management has demonstrated that many information stored in shared folders were dispersed and never updated: multiple versions (duplicated, incorrect, never used and without-owner data) grew every day. Examples of this, are reports and information aggregated by season, collection, gender and department, such as fitting notes, collection books, materials development, packaging information, business calendar and margin settings.
Furthermore, an ERP solution was the master data software for supplier information and orders. It was interfaced with PDM through a layer, which also provided alerts and notifications to users. Supplier data were sent to PDM, allowing the correct association between a product and its supplier. PDM then managed product data, cost sheets and BOMs through a workflow including the prototyping, sampling and production phases. The layer also ensured communication between the PDM solution and the MRP; BOM placements, expressing the material requirements for each product, were sent to ERP to guarantee material supply. Finally, ERP was interfaced with MRP and bulk orders were daily transmitted.

This way, the MRP solution received information about the products to be ordered from ERP and the materials required to manufacture those products from PDM.

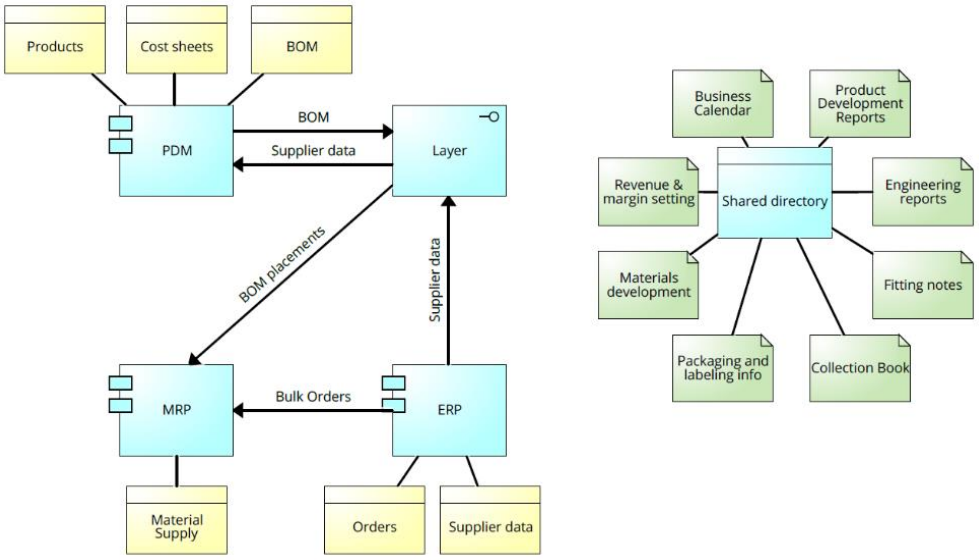

Figure 9 - Enterprise Architecture Diagram before PLM

Several issues related to the current state of process and data management were underlined after the interviews. Each department behaved independently of the others and thus produced information that was not completely clear to the entire company, slowing down the process flow and generating non-value-added activities. Documents were lost and often contained sketchy notes. Versioning and data duplication were continual problems.
In cases 5, 6, 7 and 8, a lot of effort and investments were made to customise the PDM solution, trying to adapt it to business needs and to ensure data reliability.

Towards PLM

The project team, in all the above-cited cases adopting a PDM, understood that business processes were becoming more and more information-intensive and that the implementation of a PLM solution might support all the information-driven processes. Process and product data improvement leads to cross-functional and standard business processes and to the fixing of the problems encountered in data management throughout the product lifecycle: data are digital and stored in a database, information exchange is redesigned, quality of data is enhanced and these are reused by many of the organisational entities within the company.

The future state of data management was designed, identifying the main business objects that the PLM solution should include in accordance with the business requirements. From the AS IS diagram shown in Figure 9, the current information managed in PDM and its links were identified. The business requirements were considered, trying to enhance the current state of information management and moving to an integrated approach where a PLM solution is able to support the entire product development process.
Hence, the needs in terms of information management in PLM which arose during the interviews are hereafter described and grouped by the main processes they are related to:

- Collection Planning: collection represents the "concept" phase in Fashion companies, because a set of products is planned and designed in the face of a market launch. Planning is the earliest stage in product development, when decisions about revenues and margin settings are taken; calendar and milestones are scheduled to achieve the business goals. To these ends, PLM should provide a module related to merchandise planning and calendar management.
- Collection Development: the collection has to be populated with new and carry-over products. Information about materials, colours and products should be stored, controlled and updated in PLM. Moreover, sizes, themes, models, BOM and colouring rules (procedures to massively link a theme to several products) should be managed within PLM.
  PLM should also include a workflow function that allows us to manage prototyping, sampling and production states of product development. Progressing from prototyping to sampling and production, the product acquires more and more definitive information such as details, composition, sketches, and fitting notes.
  Another requirement is to mass print the different sheets generated during this process, through proper data packages.
- Costing and Sourcing: the request is to store and manage cost information and sheets in PLM. Quotes, BOL, supplier libraries and product launches to suppliers (information sent to suppliers to guide and support prototypes and sample manufacturing) have to be included.
- Engineering: PLM should also enable users to add information within reports. Examples are all the reports produced during technical analyses and engineering activities.
- Quality control: quality tests on products and materials have to be tracked. Appropriate sheets analysing product compliance with quality standards are required.
- Operations management: the process owners working in different business departments should have different privileges and views of the system.

Roles and user access profiles have to ensure that each department is able to manage and edit a particular set of data.

Table 4 recaps the business needs, grouped by business process, and the PLM BO. This way, I have tried to line up business processes, information and ICTs.

Table 4 - From Business needs to PLM Business Objects

Business Process	**Business Requirement**	**PLM Business Objects**
Collection Planning	Merchandise Plan	Business Planning
	Business Calendar	Calendar
Collection Development	Product details	Product
	Material details	Material
	Colours library	Colourways
	Sizes library	Size range
	Themes library	Theme
	Models library	Shape
	BOM management	BOM
	Colouring rules	Product Theme Colour
	Images management	Images container
	Fitting notes	Data Sheet
	Composition and care labels management	Composition and care labels
	Data package management	Data Package
	Prototyping/Sampling/Production versioning	Product State
Costing & Sourcing	Supplier library	Factories
	Quote details	Supplier quote
	Cost sheet	Cost sheet
	Product launch to suppliers	Supplier Request
	Bill Of Labour	Operations
Engineering	Information grouped by season	Hierarchy Item, Season
	Information grouped by collection	Hierarchy Item, Collection
	Information grouped by gender	Hierarchy Item, Gender
	Information grouped by department	Hierarchy Item, Department
Quality Control	Quality assurance tests	Test Run
Operations management	Users access profiles and roles	Users

Moreover, the TO BE Enterprise Architecture Diagram, for the same company analysed in Figure 9, is shown in Figure 10. A description of the main business objects is provided hereafter, overlooking the more focused analysis related to the attributes within each BO and the relationships between BOs. A further level of detail, for example using a UML class diagram, was not provided in addition to this analysis because the company was also evaluating an off-the-shelf PLM solution. In this case, the PLM vendor has already designed a data model that fits the needs of a generic Fashion company.

The PLM solution is designed to replace the current PDM software, ensuring the storage and management of the entire set of product data. It receives all the information about suppliers and factories from ERP, which remains master data for orders and supplier information. BOM header details are sent to ERP, while BOM placements are sent to MRP, collecting information for material supply. Proper interfaces between PLM and ERP and PLM and MRP are designed in order to ensure data exchange, avoiding using the layer described in the previous section.

The PLM software has to contain a module dedicated to the calendar and business planning, so that all the milestones and deadlines related to Collection Planning are manageable. For reporting reasons, a hierarchical data model could be useful, which allows browsing of all the items within a season (e.g. spring-summer), a collection (e.g. cruise), a gender (e.g. woman) and a department (e.g. shoes).

Of course, product details need a specific business object, containing all its information, such as the related colours, sizes, shape, theme, BOMs, labels and data packages; this is the most complex BO because it must include several attributes belonging to the other business objects. The product may also progress through time in different states, so the Product State BO allows tracing of the different versions of the finished product, from prototyping to production. The Shape and the Theme BOs include all the models and all the themes in development, which are then linked to a product.

In particular, a colouring rule is required, so colourways, themes and products should be linked in a specific BO, i.e. Product Theme Colour. Composition and care labels are associated to the product specification and an appropriate BO is useful for addressing all the attributes required by the company.

Another essential BO is the one related to Material; it ensures that colours, sizes, sheets and suppliers can be attributed to a material. The BOM business object put together the information from the Product BO with that from the Material BO; the BOM header specifies the product features, while the placements include the coloured materials composing the product. Data Sheets and Cost Sheets allow different templates to be designed, which manage general product and materials information and costs. The Data Package BO ensures that all the data sheets can be merged and sent to suppliers or process owners.

The Test Run BO helps to define quality assurance tests to evaluate product quality, performance and mechanical testing on a product, and to eliminate quality issues.

In addition, it specifies standards to which third party testing facilities must adhere. Libraries for size ranges, colours and factories are managed in the Size range, Colourways and Factories BO and might be associated with both products and materials. The Factory BO, in particular, includes those attributes imported from ERP that are also located in PLM to manage the sourcing process. In addition, in PLM, supplier quotes and requests have to be handled through appropriate BOs. Other general-purpose business objects have to be managed, such as images and user access profiles and roles.

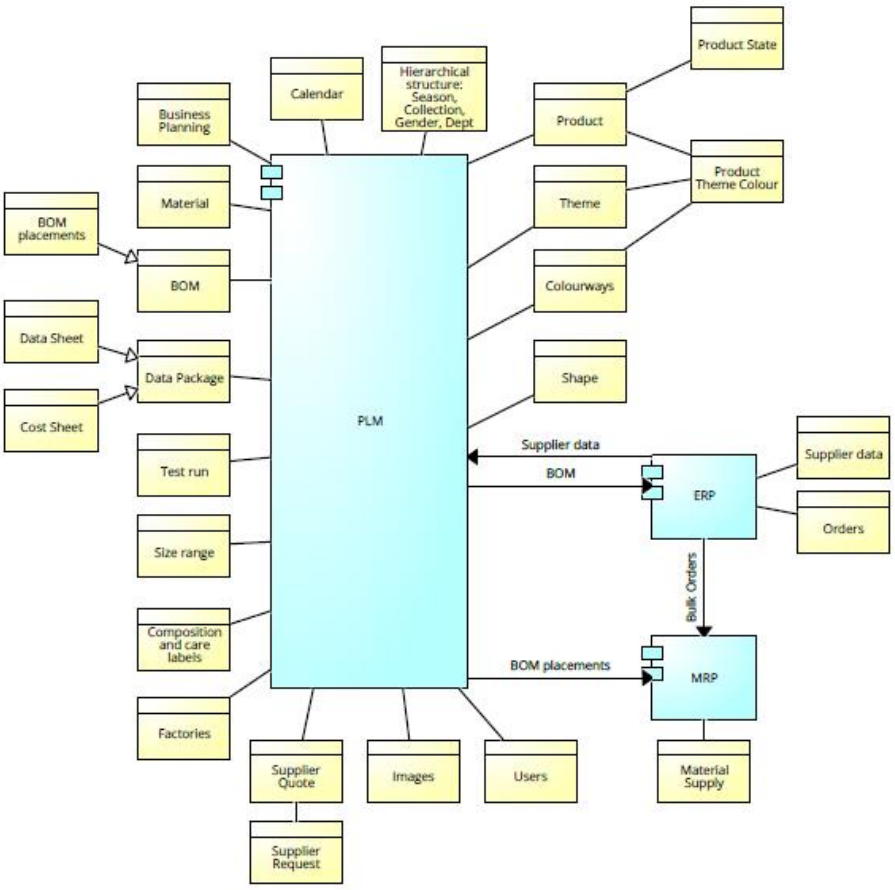

Figure 10 - Enterprise Architecture Diagram towards PLM

RQ3: PD KPIs

With the aim to finalize the examination of product development within the Fashion SC, I have tried to identify the performance measures that are supporting the industry strategy.
The administration of a questionnaire (see Appendix 2) has allowed to list the main product development KPIs:

- Human resources (FTE) - Design
- Human resources (FTE) - Product Development
- Human resources (FTE) - Modeling
- Human resources (FTE) - Prototyping
- Prototypes annual cost (K€)
- Samples annual cost (K€)
- Number of fabrics (FW)
- Number of fabrics (SS)
- Number of colours (FW)
- Number of colours (SS)
- Number of sampled styles
- Number of produced styles
- Prototype Cost / Production Cost (%)
- Sample Cost / Production Cost (%)
- Fitting costs/ Production cost
- Compliance with Marketing Brief (Planned models/Final models) (%)
- Compliance with the product engineering schedule (time to encode products /scheduled time to encode products) (FW)
- Compliance with the product engineering schedule (time to encode products /scheduled time to encode products) (SS)
- Number of fitting sessions (FW)
- Number of fitting sessions (SS)
- Product typology (Carry over-New styles) (%)

The most adopted KPIs are related to the evaluation of resources and costs (prototype, sample and production costs). Moreover, the number of colours developed in different seasons (Fall-Winter and Spring-Summer) and the number of sampled and produced styles are the most important metrics for the companies interviewed. These KPIs are monitored by the Finance, Product Development and Merchandising departments, through Business Intelligence (BI) solutions or PDM and PLM software.

Approaches to Performance Measurement

Basing on the analysis of the metrics used to support the processes along the entire SC, conducted through interviews, a process-oriented framework for performance measurement (PM) in the Fashion industry is illustrated in Figure 11: it is a model categorizing the emphasis that a Fashion company puts in PM according to its needs.
The framework identifies six approaches to PM: financial, product-oriented, production-oriented, behavioural, distribution-oriented and a merge of these i.e. the holistic approach.

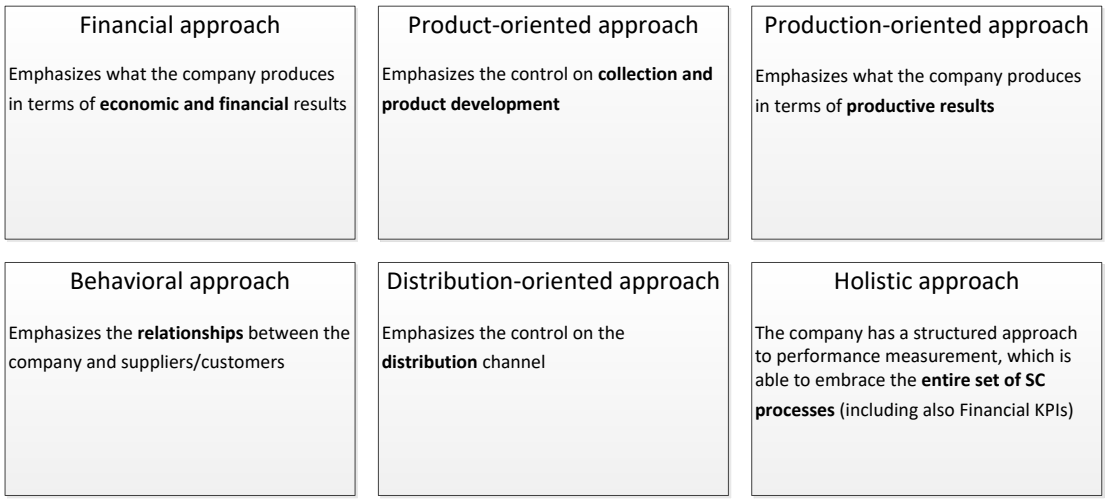

Figure 11 - A process-oriented framework for PM in the Fashion industry

I have also investigated the rationale behind a particular PM approach, from the Fashion companies' perspective. Four main drivers emerge:

- Process KPIs. During the interviews, the companies have outlined the most adopted KPIs, which have been associated to a typical business process. Hence, a process KPI describes the focus area of the company.
- In-house activities. The decision about outsource or retain in-house a process defines the boundaries of the performance measurement process: a company is able to monitor, control and trace the inputs and the outputs of in-house activities. Whereas, suppliers are unwilling to share their information, the more they are far from the main company and not vertically integrated.
- Firm's size. The companies' size helps to understand if a consolidated approach to performance measurement is essential or not: a big firm can't forget to monitor all the processes in every direction and width, but a

smaller company can easily monitor financial indicators without losing control on the overall set of processes.

- Fashion market segment. If a Fashion company belongs to the luxury market segment, its choices in terms of product quality, craftsmanship and exclusivity would influence the way in which business processes are managed and controlled. On the other hand, fast fashion companies need to reduce time-to-market and will focus on the relationship with suppliers and on distribution KPIs.

Best practices for PM

The current state of PM in the Fashion industry has triggered a further analysis with the objective to recognise the best practices to measure process KPIs in a holistic way.
Questionnaires, interviews and comparisons with the general-purpose literature have supported the examination of the gap between the various approaches used by the companies in the sample and the holistic one.
Therefore, four main points might be considered when selecting a set of process-oriented performance measures for Fashion companies:

1. Business strategy and positioning
2. Processes, bottlenecks and value-added activities
3. Balanced metrics
4. Attitude and commitment to PM

Concerning the business strategy, lots of important information and guidelines for tactical and operative decisions are included, such as sourcing strategies and market positioning. Sourcing KPIs will be important for companies that outsource production, while Production KPIs will be crucial for companies retaining in-house the production process. The Fashion market segment and the critical success factors also address the choice of proper KPIs: the focus may be on the product, on the distribution channel or on the retail process.
Each supply chain is composed of several processes and some of them are particularly critical. A retail company will hopefully monitor Product Development, Sourcing, Production, Distribution and Retail KPIs, while a wholesale company will control Financial and Distribution KPIs.
Moreover, the bottlenecks within the supply chain might be taken into account: identifying the issues within a process and measure them is essential for continuous improvement, especially for manufacturing companies. Process-oriented KPIs should not be seen as static measures, but one of the goal for a complex industry, as fashion, should be to compare KPIs at different stages in

order to identify value added and not value added tasks. For instance, comparing the number of sampled styles and the number of produced styles may allow a Fashion company to quantify how many models have been uselessly sampled, that means wasting time during the sampling process. Similarly, comparing the number of sampled styles with the amount of sales to the final customer, a company identifies, in a funnel perspective (see Figure 12), the wasting time during the entire product development process. The rationale behind the funnel is that the number of styles decreases with the time (according to the collection timeline), due to the core tasks of fashion supply chain and to the approval stages: considering the style as the ensemble of model and colour, just a little part of the sampled styles are then approved for sales.

Another point concerns the metrics per se. A balance between quantitative/qualitative measures, resources/output/ flexibility/innovativeness KPIs and general purpose/industry-specific metrics is required to assess in a holist way the Fashion supply chains.

Finally, to measure their processes in a holistic way, Fashion companies need a cultural attitude and commitment to PM. Different business units, resources and many suppliers often represent obstacles to meet a shared unique objective. PM should permeate the entire firm and be part of the overall business strategy in order to fully exploit a process-oriented approach in the Fashion industry.

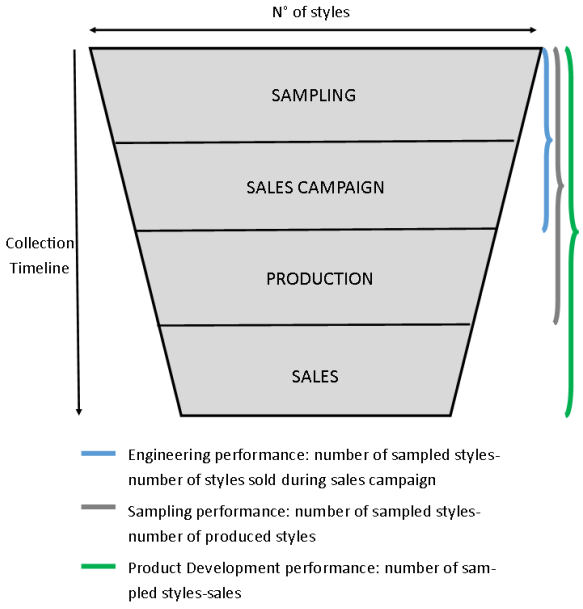

Figure 12 - Measuring process performance in a funnel perspective

Summarizing the main approaches to PM from the case study analyses, three perspectives (Figure 13) emerge. The smaller Fashion companies may have a financial focus, measuring above all governance KPIs.
Other companies may focus on a single process (as product development, sourcing, distribution, production or retailing) because it reflects the firm's internal needs and it is aligned with the business strategy.
In the best case, Fashion companies adopting a process-oriented approach to PM prefer a holistic method, measuring proper KPIs within each business unit and for each core activity.

Figure 13 - Perspectives to PM for Fashion companies

RQ4: PD process improvement

In three cases (2, 6 and 7) I have participated to projects concerning the PD process improvement. These were aiming at enhancing both process and information management.
The answer to the fourth RQ is therefore the result of process improvement projects. I am going to explain in detail an in-depth case study (case 6).
The analysis begun with meetings where process owners explained the process strategy, the timescales and who was included. I have organized proper meetings to define the AS IS. All ideas were welcome and people were involved so that they would feel part of the change process.
In order to communicate process evolution to the stakeholders (internal and partners), the following tools have been used: notice boards, email, group meetings, weekly progress and alerts.
Twenty-four interviews were conducted, lasting between one and three hours each. The interviewees were selected basing on a previous analysis of the Organizational Breakdown Structure (OBS): modelers, product responsible and graphic designers are divided per brand, line and gender; while buyers are divided per suppliers'

geographical area. Marketing and Production officers have been included in the interviews for their impact on Product Development. Three meetings have involved also the ICT team, in order to have a comprehensive idea of the solutions implemented.
Before presenting the deliverables to the top management, the map of the AS IS processes was shared with the managers of product, modeling/prototyping, purchase and ICT departments. This early validation has ensured a fine-tuning of the process model.
After the AS IS final validation, the project focused on underlining issues and future opportunities: a presentation has been designed to summarize these points and the methodology used.
The proposal was then examined by the top management, that has given a feedback to finalize the TO BE model. The project team has finally requested a validation of the TO BE model and proposed a plan to select the PLM solution that was better fitting the business requirements.
In the figure below, a timeline of the project is represented aiming at define the described steps.
A synthesis activity was undertaken in order to compare the project findings with the existing literature.

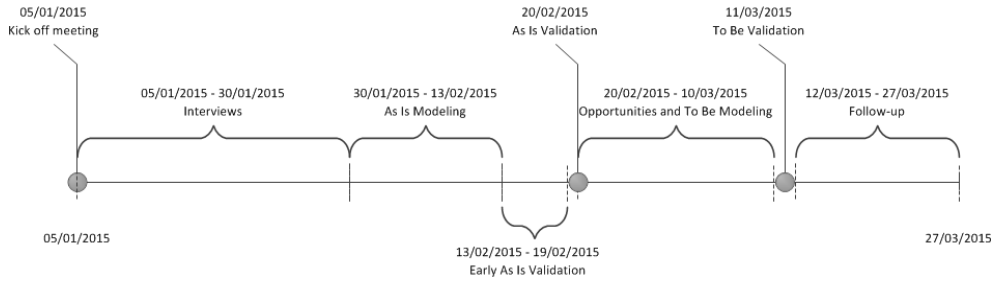

Figure 14 - A project timeline for PD process improvement

In this particular case, during the project, two main directions of improvement were identified:

- Extension of the PDM functionalities
- Implementation of a new PLM solution

The first enhancement allows reusing the current system with its customizations and has a low impact on the users, who are already skilled on the tool functionalities.
On the other hand, the current PDM solution is in phase-out and will need massive interventions to improve its adoption, without covering the entire set of functional requirements if compared to more up-to-date solutions.

The second enhancement proposed could satisfy all the functional and process requirements and constitutes a valuable state-of-the-art solution. The main drawbacks when introducing a new tool as PLM, are related to the huge investment required (for licences and customizations) and to the criticalities in training key users on a new technology.

The in-depth case study has allowed a wider understanding of the optimization areas for fast fashion business processes and of the challenges that a company playing in this market has to face.

As the firm is a leader of childrenswear, one of its important issue is the size range, varying from 0 to 13 years. The apparel industry has in and of itself the characteristic to be critical in terms of fitting and size development. Moreover, managing apparel for children adds several issues for modelers, who have to be skilled to develop sizes for newborns and children, with very different fitting requirements. Consequently, lots of time is spent in modeling and engineering a single article and lots of fitting sessions are essential. Plotters, cutting machines and 2D CAD are useful tools to support this complex process.

There are too many paper-based activities (i.e. materials tests and lab dips, fitting notes for samples and production, etc...), so it is more and more difficult to share documents and communicate in a timely manner with suppliers, trading companies, sales agents, distribution channels. Therefore, data digitization may solve several issues.

The costing activity is poor within the design phase. In particular, planning and tracking of actual vs. target costs for each product and of collection costs, are overlooked.

The abuse of spreadsheets and shared directories characterizes this case study: sketches and silhouettes are stored in shared directories, with consequent issues in managing versioning and retrieving data. Moreover, enterprise systems are updated later, mostly to feed the ERP. Each department collects and processes data in local systems and the consequence is that there are diverging versions of the same data. Many activities (briefing, line planning, style, books and catalogues) are not managed by enterprise systems. Moreover, due the existing spreadsheet-based reporting systems, each office needs to retrieve and elaborate several times the same information to produce customized reports, statistics, and line sheets.

To some people, process re-engineering is an issue, so it is important to involve people and the entire SC, providing a cultural adjustment. People initially will resist change: change is a journey that will require time. Moreover, improvements are on going, so change provides incremental benefits.

The cases conducted to analyse process improvement, have demonstrated that it is for sure involving also information management. Moreover, it often triggers a PLM initiative because PLM is tight to process re-engineering and maturity.

RQ5: PLM strategic initiative

PLM is not just a tool supporting product development and an efficient knowledge management system, it is also a strategic approach ensuring competitive advantage. Adopting PLM can help foster a climate of continuous improvement, through standardization and enhancement of business processes.
PLM has originated and developed within the manufacturing industry, well known for its standardized products, proposed year by year, with high predictability. The production environment is Make to Stock, i.e. products are manufactured for stock based on demand forecasts. This environment characterized by well defined processes and role, has improved the product lifecycle management giving the opportunity to manage all its phases, including beginning of life (BOL), middle-of-life (MOL) and end of life (EOL) (Terzi et al., 2010). PLM has been integrated, over the time, with design tools, such as CAD/CAM, and ERP, for orders management. PLM has found fertile ground in manufacturing companies, having already learned the lean approach and having internalized the need for continuous improvement. The product development process is managed mainly by engineers, skilled to use ICTs, who have successfully embraced innovation.
The present research deals with PLM deployment in the Fashion industry, considering it as a technology solution and as a business strategy improving knowledge management, collaboration and inter-functional coordination, reducing the time to develop products and time-to market.
The acronym "PLM" suggests immediately the link with the product, thus it is essential to consider the differences between a Fashion product and a standardized item: we are analysing customized or premium products, with high impulse purchasing and low predictability. The production environment is Make to Order, i.e. manufacturing is performed when demand is confirmed. These dissimilarities have also impacts on business processes, data and enabling technologies.
Therefore, the reason why the research is focused on the Fashion industry is due to the product's features that trigger a completely different approach to PLM, in all its meanings.
We have already analysed the "P" of the PLM acronym and its emphasis on product data. The "L" refers to the term "lifecycle" which is unique within the Fashion industry: it is particularly short (may last up to six months) and, depending on the merchandise considered (leather goods, shoes, apparel, etc…) and to the market segment (luxury, prêt-à-porter, diffusion, bridge, mass), might become even shorter. Just the BOL is managed, because PLM copes all the processes from design to production and it is not integrated with tools related to the MOL or EOL. Finally, the "M" of management is devoted to consider strategic, tactical and operative goals and issues. Managing operative level in the Fashion industry is critical because people involved in product development are not used to adopt IT

system, so they have to be properly trained. Given this resistance, the top management also faces difficulties when performing change management.
Experiencing PLM on a practical field, through multiple case study analyses, I have recognised that it is usually approached as an enterprise system, one of those solutions that a company has to implement because many competitors have already taken this decision and invested huge amounts of money.
What often eludes the top management is the strategic role of PLM within a Fashion company in supporting its core process, i.e. product development.
A PLM strategic initiative starts aligning the business strategy with the PLM purpose. It has to be intended not simply as a piece of software, but as an ideology. The researches have demonstrated that before implementing a PLM solution, roles, responsibilities and business processes have to be identified and mapped.
PLM projects ask for a huge commitment of top management, super-users, key-users and consultants in order to achieve both the tactical and the strategic goals. Executives have to provide regular input and have to guide the project. A successful PLM project has the full support of executive level sponsorship, who will take critical decisions.
It is important to evaluate the challenges to face and to estimate the return on investment. Medium and long-term objectives related to the initiatives have to be set and several activities to achieve these goals have to be identified.
In order to meet the overall strategies, the impact on resources has to be assessed. The human resources involved in the product development process are used to manage all the information concerning materials, prototypes, samples and products through spreadsheets. A workflow management is difficult to arrange because of the lack of proper approach and tools. As a result, tracing data, measuring performance and matching the needs of different headquarters within the product development process, appears not sustainable.
An aspect that has to be highlighted is that, in comparison to other industries, within the Fashion companies, product engineering is not carried out by engineers: fashion designers and stylists play an important role during the product development process but their skills are not so much related to managing data through information systems. Their attitude to inventiveness and inspiration is the reason why they show resistance to standardized practices and tools.
It is very important to educate the team, which should be led and advised by PLM experts. The IT department has to be involved within the entire project and it has to be appropriately educated. The business and the IT team have to work together to ensure that the PLM implementation is achieving its challenges.
Each department of the company has to be represented and involved within the project. A team leader is also required; he is a single person that has many capabilities: keep the project on time, meet the milestone, respect the budget, be aware of the project scope and objectives, balance many different viewpoints and responsibilities.

It is essential to maintain the same PLM team throughout the PLM project. The whole PLM team should have a full understanding of the project and the business objectives.
Moreover, creating a PLM strategy document is useful to make the process understandable and manageable. Key drivers to determine if the project will be successful or not and proper KPIs should be identified as well.
Planning at this stage is very important to minimise disruptions. The business must understand the demands that a PLM implementation can place on resources and, consequently, must develop and communicate an iterative plan of the ICTs included in the PLM project (as ERP, BI and so on).
Communication is needed to achieve success: it has to invest the whole extended SC, including partners, no matter which the size is. It will concern also architecture and infrastructure, checking the specification of all the hardware (the server, the capacity) and its cost.
Change management is crucial because allows to manage people through the transformation process. A PLM project brings massive change to a company. Change involves all tasks that require modification, process improvements and elimination of all the technologies. Resistance to change is not the ideal scenario to afford for a PLM project, so it has to be managed during and after the PLM project. The main activities related to change management are: develop training, engage teams, share the details, make sure that each user will personally enjoy the PLM-related benefits.
The cases analysed required 3-4 months to establish the PLM strategy.

PLM benefits

Implementing PLM technologies enables several qualitative benefits: these have been highlighted by the companies interviewed. I have proposed a list of the possible advantages, gathered from the literature review, which have been validated and developed in detail.
Four main categories of benefits have been identified (see Figure 15): process, data, cost and communication improvements.
Analysing processes, their benefits are related to the reduction of time to develop products, with important effects on quality, efficiency and effectiveness. PLM has also a positive impact on the manufacturing process, ensuring automation, reducing stocks, WIP and improving information sharing with suppliers. Planning, reporting and decision-making are also improved thanks to a data repository that is always available.
PLM technologies also enhance data management, reducing the time to search information, to update and review data. Versioning is dramatically reduced, as PLM is a collaborative tool, and visibility is higher. Moreover, master data are provided, concerning product code, seasons, colours, employees country, suppliers. Master

data is the base of a PLM project: managing data is a challenge for every solution, as much the information the business holds. Recoding product may create confusion, so it is very important to define master and cleaned data. A centralised database create a new mind-set for the organization.
Product costs are reduced, together with interaction and collaboration costs.
Distributed organizations, who are typically allocated offshore, can share the same data in real time. The availability of accurate and reliable product data allows information to be not fragmented and to avoid isolation.
Adopting PLM technologies allows Fashion companies to be more reactive to consumer needs leveraging one of the most important critical success factors, that is TTM. Moreover, the firms' flexibility may be improved through a reduction of lead times, inventories and product development times.
The driving forces to achieve better management of product data are business reasons, as the need to improve productivity and to respond more flexibly to customers. PLM platforms help companies to improve their competitive edge, for instance providing the right information at the right time, amongst many other quantifiable benefits.

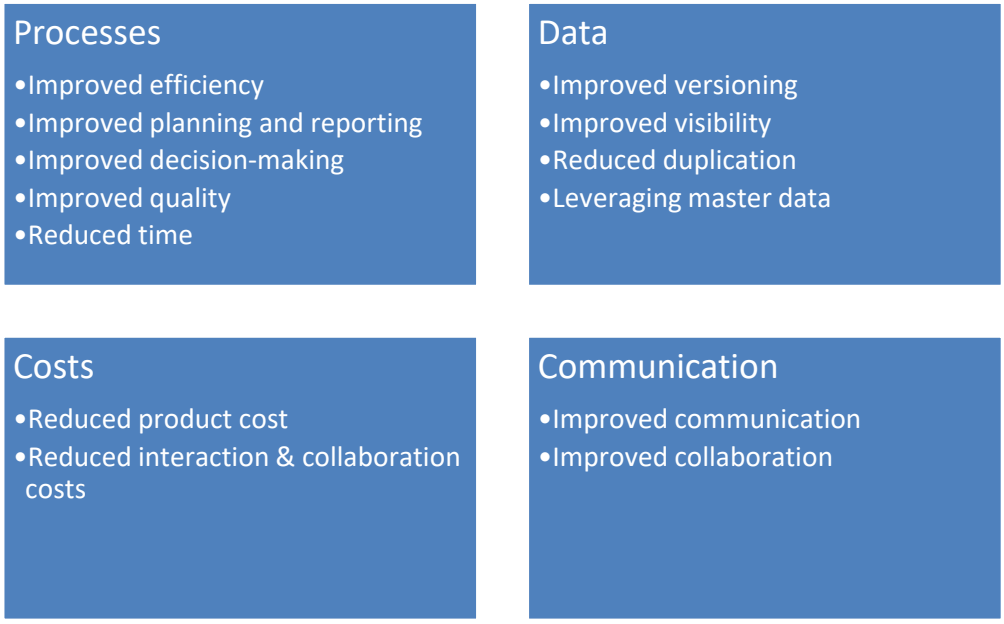

Figure 15 - Key benefits of PLM

RQ6: PLM implementation project

In the previous section, PLM has been described in its strategic role. The aim of this section is to provide a complete overview of PLM as an enterprise solution supporting product development in Fashion companies.
The main results collected by direct observations in two Fashion companies (cases 1 and 2) are reported. I actively participated to the implementation of industry-specific PLM solutions and I have had the opportunity to experience the entire software deployment.
A complete PLM project can be divided into three main steps: planning, implementation and adoption. The following sub-sections develop each step, providing best practices and in-depth analyses.

Planning

In order to effectively plan the PLM implementation, in cases 1 and 2, I have worked with the IT team and I have finalized an industry-specific framework supporting this phase of analysis. The literature review constituted a basis for customising the framework to specifically fit the Fashion companies' complexity, that is due to:

- Product complexity: In the previous sections, we have already analysed product complexity. Here we recap the points that are more influencing a PLM deployment.
  Unlike the automotive industry, the Fashion product is highly seasonal, with a very short lifecycle. Then, a collection representing the product range may contain carry-over and new products. Even carry-over items are not as standardised as in a machinery industry; colours and accessories might change from one season to another. Moreover, each product progresses through three main stages (prototyping, sampling and production) and a data model cannot overlook this product feature.
- Process complexity: the tendency of Fashion companies to outsource production entails many players and many viewpoints being involved in the overall objective to generate value. Different supply chains (the company one and the suppliers' ones) have to be harmonised and integrated. Another factor of process complexity is timing; this continuously puts stress on all the activities. Each delay has to be recuperated in the following stages in order to ensure the product is in the right place, in the desired quantities, at the right moment.

The framework for PLM implementation in Fashion companies is shown in Figure 16: it illustrates how the framework from literature has to be adapted basing on the particular features of the sector. Its four phases are hereafter described:

- Identify business issues and needs. This phase is carried out by interviewing the business stakeholders that are asking for an integrated approach to product development. All the issues related to process and data management are evaluated and the actual and potential needs are considered. The project goals have to be clearly defined in order to avoid analysing problems and requirements that are not related to the PLM implementation. All the data gathered from interviews is then collected and categorised; at this point, bottlenecks, improvement areas and critical tasks emerge. The process owners may also suggest focusing on a particular family of products that they would especially like to analyse. Requirements are listed and classified according to their priority. Moreover, a description specifies each single need in order to facilitate the consequent modelling activity.
  Even if this phase is also mentioned in the existing literature, it is closely linked to the product and process complexities, which are typical of Fashion companies.
- Model process and data. During this phase, the business processes and the information exchanged are modelled. Business Process Model and Notation (BPMN) is often used to display the main tasks and their owners. A further level of detail is provided by the Enterprise Architecture Diagram, modelling also the information systems and the most important data they manage. This way, the current (AS IS) model is created. Combining these different models helps to understand how information is managed through product development and how the different enterprise systems are currently interfaced to respect the business needs.
  The literature review listed several reference models to support this phase, but they are far from the fashion business model, its specific tasks and the importance of suppliers as an integral part of the overall value chain.
- Identify PLM Business Objects. Once the AS IS model is completed, the project team is able to focus on the future (TO BE) configuration of processes, information systems and data. This phase further develops the previous one, detailing the requirements in terms of data models that the PLM platform should have.
  Lots of peculiarities characterise the data model of a PLM for the Fashion industry. Hence, even if this phase has been reported in the literature review, the product and process complexities require a specific data model.
- Conduct a scenario analysis to select the PLM solution. All the previous phases are now decisive for identifying the possible choices for PLM implementation: building a custom PLM solution or buying an off-the-shelf one. There are several drivers influencing this phase, and these are mostly related to the specific business requirements. The examination assumes thorough knowledge of the industry-specific PLM solutions and

a relationship with the main vendors, making it necessary to get some demo versions or press releases describing the software capabilities and functions. A cost-benefit analysis is also useful to qualitatively compare the choices. This phase is especially industry-specific, because all the requirements are transformed into criteria for selecting the right PLM software. Its deployment has to be as agile as possible, complying with the time scheduling established in the business calendar.

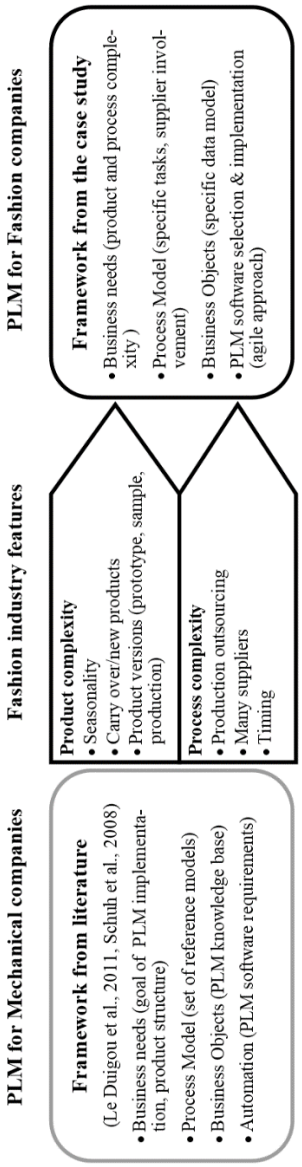

Figure 16 - Framework for PLM implementation

Let's analyse the practical deployment of this framework in the two cases.
First of all, the project scope was identified: it involved all the activities from the product development to the production processes. Business requirements were classified according to their priority (very important, important and nice to have) and typology (new requirement or already managed in PDM). Since a change in information management may affect the way activities are carried out, each need was marked if it required a process change and more information was then provided.
The companies decided to focus firstly on a particular family of products, i.e. women's shoes, as a pilot project.
The main improvement area for these companies was the introduction of a PLM solution, given all the benefits related to its implementation: reduction of TTM and product-related costs; the chance to maximise product value and increase control over it. The two cases precisely required enablement of collaboration across the supply chain, reuse of product knowledge, and transparency about what is happening throughout the product lifecycle.
In the section "Towards PLM" we have already analysed the first three phases of the framework and described the main business requirements, process and information mapping and which are the main BOs needed.
At this stage, the Fashion companies identified what they already manage and what needs to be managed. The missing step concerns the way of filling the gap, i.e. selecting an appropriate PLM solution. The already-known best practices supporting the selection process (Stark, 2015) are applicable also to Fashion companies: know thyself (the reasons for the project and the company's current situation), and know your partners. The point that this research would like to stress concerns the drivers influencing the choice of a PLM solution for the Fashion industry.
Two main decisions could be taken:

- Ask a provider to build a tailor-made PLM solution
- Buy an existing one from a PLM vendor. The choice of buying a PLM software may in turn include different scenarios, according to a short list of system vendors. The companies evaluated three vendors, which is an exhaustive number for taking a decision, given the current PLM spread in the Fashion industry.

The four scenarios (buy from vendor 1, buy from vendor 2, buy from vendor 3 and build) were qualitatively described along with their strengths and weaknesses. Then, each scenario was assessed according to the template illustrated in Table 5. The project team administered a questionnaire to the vendors (see Table 5) and attended a demo of the PLM solution for performing the evaluation.
The main assessment areas concern the vendor and the PLM platform provided; the aim is to confirm their quality and reliability. Within an assessment area, several

drivers and KPIs were identified, with the respective parameters. The last column includes the best conceivable parameter, according to a joint evaluation by the business and the project team. For each KPI, the authors specified its type: industry-specific KPIs allowed a PLM evaluation that better fits the Fashion sector, while cross-industry KPIs could be adopted by a generic company. It is nonetheless true that both types of KPIs proved to be crucial for a qualitative analysis.
Concerning the vendor area, the industry focus was evaluated, considering whether the solution provided is general-purpose or specific to the Fashion industry. A general-purpose software is not always capable of fulfilling the business requirements in terms of functions, and often too many customisations are needed. Industry presence was included as one of the core drivers for assessing the PLM vendor, because it is representative of how many Fashion companies (including competitors) are adopting that PLM solution to improve product development. When a vendor is developing most of his PLM to fit the Fashion industry, this means that he has a high understanding of sector needs and peculiarities. The level of support explains how the vendor decides to manage user support; a direct support is more streamlined, allowing quicker fixing of problems. A vendor may choose to deploy a PLM with different methodologies (agile, waterfall and hybrids) but the one that best fits Fashion companies is the agile approach; close collaboration with users is crucial to ensure complete achievement of the business requirements. Finally, a feedback from the demo version of the PLM platform provided by the vendor allows to finalise an evaluation (through a five- point Likert scale) of how the vendor approaches the business needs.
Coming to the analysis of the PLM solution, the first goal was to understand how many of the company's needs match the Out-Of-The-Box (OOTB) PLM functionalities. The more the needs are covered, the more satisfied the firm is in terms of product lifecycle management. The capacity of the PLM platforms to be interfaced with the existing ICTs is also evaluated; in the best case scenario, applications can be interfaced as in Figure 10, without adding layers or specific tools to ease information exchange. Two crucial performances related to PLM are also PLM flexibility (i.e. the ability to adapt to possible or future changes in business requirements) and its scalability (i.e. the capacity to increase its performance to accommodate resource growth). Because the Fashion industry involves creative designers in product development, it is also important to evaluate the user interface and the ease of use in a PLM assessment; users are familiar with sketches and tools that are highly flexible and capable of supporting their imagination, so that a PLM has to be appealing and suit their abilities. Moreover, the number of releases provided by the PLM vendor is evaluated and a minimum of one release per year is considered enough to review the existing functionalities and fix errors and bugs. In order to install the PLM, the vendor may ask to respect several best practices in terms of database and hardware configuration. Consequently, the company might

have to adapt to these requirements, investing a lot; minimizing its effort is particularly important.
The evaluation was more or less positive, depending on how close the results were to the best case (as specified in the last column of Table 5).
Once the qualitative assessment was completed, it was useful to map scenarios in a cost-benefit diagram. Benefits are based on the above evaluation and on software "build vs. buy" considerations; in particular, an off-the-shelf PLM cannot meet specific business requirements (such as particular reports or collaboration needs) and are more rigid in terms of data model. On the other hand, building proprietary software takes a great deal of time to complete successfully, while good canned software is already available. Costs include several items: implementation, maintenance, organisation, release upgrade and custom configuration.
These analyses have allowed to effectively select a partner and then to perform the PLM implementation.
The planning stage so far described lasted about six months.

Table 5 - PLM vendor assessment criteria

Assessment area	**Drivers & KPIs**	**Type of KPI**	**Assessment parameters**	**Best case**
Vendor	Industry focus	Industry specific	Industry-specific/General purpose	Industry-specific
	Industry presence	Industry specific	Number of customers belonging to the fashion industry over the total	> 65%
	Level of support	Cross industry	Direct support from the vendor/Support from a third part/No support	Direct support from the vendor
	PLM deployment	Cross industry	Agile/Waterfall/ Mix	Agile
	Demo feedback	Cross industry	Very Good/ Good/ Acceptable/ Poor/ Very Poor	Very Good
PLM Platform	PLM functional requirements	Industry specific	Percentage of requirements fulfilled by OOTB functionalities	>=80%
	Data exchange requirements	Cross industry	Very Good/ Good/ Acceptable/ Poor/ Very Poor	Very Good

	PLM flexibility	Cross industry	Very High/ Above Average/ Average/ Below Average/ Very Low	Very High
	PLM scalability	Cross industry	Very High/ Above Average/ Average/ Below Average/ Very Low	Very High
	User Interface	Industry specific	Very Good/ Good/ Acceptable/ Poor/ Very Poor	Very Good
	Ease of use	Industry specific	Very Easy/ Easy/ Acceptable/ Difficult/ Very difficult	Very Easy
	Number of upgraded releases per year	Cross industry	Number of releases provided by the PLM vendor	>=1
	Business compliance with PLM hardware requirements	Cross industry	No investments required/ Low investment required/ High investment required	No investments required

Implementation

Implementing PLM in the Fashion industry is not only a matter of industry-specific solutions, but often business-specific ones are required to satisfy the needs of a single enterprise. The PLM vendor and the system integrator are asked to match the PLM solution with the firm's needs. Before starting the implementation step, the vendor has to perform the following tasks to a successful PLM project:

- Speaking the enterprise's language: coding is crucial and master data too (a finished product could be named a product, an article, an option, an aspect…).
- Matching the solution functionalities with the business processes: several PLM functions could be managed in-depth and other ones could be useless.
- Providing an integration to the existing enterprise solutions, such as ERP and CAD software or replace previous PDM modules.

Implementing a PLM software means also to ensure a proper project management. It includes several work packages; each of these is characterized by several steps and milestones, which have to be completed to move to the next ones.

In Table 6 I have summarized the main work packages involved within a project, the tasks and an estimation of their durations.
Project management has its own lifecycle, which begins with kick-off meetings, includes other blocking tasks aiming at organizing the overall PLM initiative and comprises all the strategic roles within the company.
The PLM vendor needs also to plan a technical deployment, analysing the architecture of the system and the needs in terms of application servers to be used throughout the different phases of the project. In particular, three different application environments are identified: a mirror environment to have a first look at the system's capabilities; a test environment where the users firstly experience the PLM and conduct several trials; a production environment, which is the definitive one after the go-live activity.
A PLM project implementation lasts from twelve to eighteen months, but several variables could take over. Often the different viewpoint of business, consultants and vendor slow down the normal flow of activities. Communication issues or, simply, underestimations of the tasks difficulty represent other causes of delay.
Basing on the requirements of the company, the other work packages may include different items such as the hierarchy definition, material management, style management, sample management, product sourcing and order entry.
Basically, the vendor collects all the requirements, provides data bulk load, configure the system with OOTB functionalities, introduce customizations if required and asks a validation by the users, through User Acceptance Tests (UAT).
A company needs some degree of configuration and a little bit of customization. There is a difference between configuration and customization.
Customization is a programming job aiming at introduce custom-made functionalities and it is carried out by the vendor. While, configuration is carried out by the business resources who understand the functionalities already existing inside the application. Customization has to be reported and planned along the way. There are also SC partner requirements that have to be taken into account.
Fashion companies often try to find a trade-off between customizations and OOTB functionalities. The challenges with customizations are cost and upgrades. Whereas, OOTB pre-configured platforms are based on best practices. More and more the PLM vendors are proposing a new wave of self-configuration more like Apps.
Once validated, the PLM vendor consultants prepare a handbook and carry on the training. Going live is the most critical task within this process and it is followed by the post go-live support.
In parallel to the issuing of the other work packages, the PLM project includes also an integration activity with the existing ERP, in order to ensure an alignment of the business processes and their data management.

Within the analysed case studies, Style Management has been the "core" work package, due to its impact on the business practices and to its relevance for the business.

Table 6 - Managing a PLM project

Work packages	Tasks	Duration (months)
Project management	Kick off, weekly meeting, steering committee, project closure	18
Technical Deployment	Design architecture, install Mirror, Test, Development and Production Servers	4
Hierarchy definition	Validation of To Be Product Hierarchy structure for PLM	3
Material Management	Component structure, Configuration of Material To Be process, Training, Bulk Load, Validation, Go-Live, Post Go-Live support	4
Style Management	Requirements analysis, Training, Bulk Load, Validation, Go-Live, Post Go-Live support	6
Sample Management	Requirements analysis, Training, Bulk Load, Validation, Go-Live, Post Go-Live support	3
Material & Product Sourcing	Requirements analysis, Training, Bulk Load, Validation, Go-Live, Post Go-Live support	5
Order entry	Requirements analysis, Configuration and revision, Training, Go-Live, Post Go-Live support	6
ERP integration	Flow analysis, Interface mapping & test, Go-live	6

With the IT team, we checked that the solution, the configuration and customization were correct and met the requirements defined by the organization. We have also verified the interoperability with other applications used by the company and if the project met the requirements in terms of return on investment.

RQ7: PLM adoption

During the adoption stage, Fashion companies experience PLM, monitor and control its performance and decide which will be the further projects improving product development.

Hereafter I have detailed the analysis of PLM KPIs. Then a comparison between the guidelines from literature and the ones from case studies is performed. Finally, the analysis about PLM concludes with the definition of a framework assessing the PLM maturity.

PLM KPIs

A PLM platform has to be reliable in order to allow users to develop collections and to produce measurable benefits. In this section, the capability of performance measures to address and sustain the product development through PLM, is discussed. KPIs are usually identified during the planning stage, then refined and measured during the adoption stage.
According to the case study analyses, I have assessed KPIs basing on two drivers (see Table 7, Table 8, Table 9, Table 10 and Table 11):

- The category they belong to: time, cost, quality, flexibility and infrastructure KPIs. The majority of PLM KPIs are time-based measures, because one of the main challenges in PLM implementation is the reduction of time-to-market and time to develop products.
- The process they are related to: data management, data configuration, printing, import/export configuration. PLM solutions allow to manage data from the user interface (create styles, colours, materials. etc.) or to configure data in proper settings (define templates, attributes, behaviours on copy, validation rules, etc.).

Other IT solutions and layers could be interfaced to PLM, as printing layers, ERP, and MRP. Since PLM is master data for PD, an import/export job scheduling is available through stored procedures or proper tables.
During business meetings, the following KPIs have been identified and validated, explaining their general meaning and background.
Time measures are mainly related to actions taken by users in day-by-day data management, developing styles and materials. The latter two represent the core BOs for a Fashion PLM solutions. Users usually manage properties within single BOs or aggregated information in table views, including data of more departments (shoes, bags, accessories, etc.) and more collections. One of the key features of a flexible PLM is the opportunity to introduce expressions calculating costs or ensuring data validation: the elapsed processing time may vary depending on the number of objects involved and on the complexity of the expression. Users also need to export data from PLM and to send it to suppliers: data packages, BOMs, quotes reports have to be printed in pdf files. The performances of the printing process have been also included because sending product information to factories is fundamental for companies which outsource production, as long as printing

massive data (e.g. all the BOMs by collection) may take long times. Export batches are the protagonists of data exchange with business enterprise tools. They are scheduled through proper jobs and have to be as fast as possible to ensure data updates and real time collaboration. Other information are imported in PLM, as material codes, and their availability is also remarkable.
Cost measures refers to issues noticed by users, that could be bugs or simple needs for training, requiring an application maintenance service. Costs related to the upgraded release and to an additional customization should be taken into account.
Quality measures represent authentic drivers to select a business specific PLM, given the enterprise architecture structure. The number of aggregated data to be exported to ERP and the frequency of export are strictly dependent on the business environment needs: from four times to once in a day, a company should need to export all the information of more than two seasons.
Flexibility measures could refer to the capability of PLM to support the majority of business processes linked to products. When agile deployment is feasible, the PLM vendor is also able to introduce proper changes to the present configuration and this is a measure of flexibility too.
Finally, infrastructure measures could be seen from the business viewpoint or from the PLM vendor perspective. In the first case, the business needs to understand if it is compliant to PLM platform requirements and hardware configuration. In the second case, the PLM has to guarantee an adequate number of OOTB business objects and several upgrades, at least for bug fixing reasons.

Table 7 - PLM Time KPIs

KPI ID	**PLM KPIs**	**Description**	**Process**
PLM-1	Time to create/copy a style/material	Average time to create a new style/material or a carry over	Data management
PLM-2	Time to create a new BOM	Average time to create a new BOM	Data management
PLM-3	Time to create/copy a new BOM item	Average time to create a new BOM item	Data management
PLM-4	Time to create a colour library	Average time to create a seasonal colour library	Data management
PLM-5	Time to issue a supplier request	Average time to send to suppliers a technical sheet containing information for product prototyping/sampling	Data management
PLM-6	Time to massively issue supplier requests	Average time to send to suppliers more technical sheets	Data management

		containing information for products prototyping/sampling	
PLM-7	Time to load aggregated information in table views	Average time required to display information related to more styles in a table view	Data management
PLM-8	Processing time for costs calculations	Average elapsed processing time to execute an expression related to cost calculation	Data management
PLM-9	Time to print a table view	Average time to print the information contained in a table view	Printing
PLM-10	Time to print a set of BOMs	Average time to print the information contained in a BOM	Printing
PLM-11	Time to print Data Packages	Average time to generate and print a Data Package containing more sheets	Printing
PLM-12	Time to export the report of BOM items to ERP	Average time to run the scheduled export batch containing information about styles and the related materials	Import/Export configuration
PLM-13	Time to export the report of supplier quotes to ERP	Average time to run the scheduled export batch containing information about styles and the related quotes	Import/Export configuration
PLM-14	Time to import style/material/suppliers codes from PDM	Average time to run the scheduled import job containing information about styles/materials/suppliers	Import/Export configuration
PLM-15	Time to download reports imported in PLM	Average time to download a single report imported into PLM	Import/Export configuration

Table 8 - PLM Cost KPIs

KPI ID	**PLM KPIs**	**Description**	**Process**
PLM-16	Number of PLM incidents (monthly)	Average number of system issues noticed by users	Data management
PLM-17	Cost to implement a customization	Average cost to implement medium-high customization based on business requirements	Data configuration

PLM-18	Data searching time	Refers to the capability of the user interface to be simple and friendly	Data management
PLM-19	Cost to upgrade release version	Average cost to upgrade the system to the new release	Data configuration

Table 9 - PLM Quality KPIs

KPI ID	**PLM KPIs**	**Description**	**Process**
PLM-20	Number of seasonal data to be exported to ERP	Average number of data exportable to ERP related to a season (including several collections and styles)	Import/Export configuration
PLM-21	Frequency of master data export to ERP	Average frequency of master data export from PLM to ERP	Import/Export configuration
PLM-22	Loop monitoring & controlling	Availability of a tool to control and remove potential loops	Data configuration
PLM-23	PLM platform scalability	Refers to the PLM capability to increase its performance to accommodate the resources growth	Data configuration
PLM-24	Information tracking	Refers to the PLM capability to allow product information traceability and history	Data configuration

Table 10 - PLM Flexibility KPIs

KPI ID	**PLM KPIs**	**Description**	**Process**
PLM-25	Number of user profiles	Average number of users configurable in PLM	Data configuration
PLM-26	PLM footprint in the fashion company	Percentage of business processes supported by PLM	Data management
PLM-27	PLM platform flexibility	Refers to the PLM ability to adapt to possible or future changes in business requirements	Data configuration

Table 11 - PLM Infrastructure KPIs

KPI ID	PLM KPIs	Description	Process
PLM-28	Number of upgraded releases per two-year period	Number of releases provided by the PLM vendor	Data configuration
PLM-29	Business compliance to PLM software requirements	Considers client system requirements	Data configuration
PLM-30	Business compliance to PLM hardware requirements	Considers database and application server hardware configuration	Data configuration
PLM-31	Number of OOTB Business Objects	Average number of Business Objects implemented out-of-the-box in PLM	Data configuration

The case studies related to PLM performance measures are particularly meaningful because through the listed KPIs it is possible to finalize an all-embracing PLM assessment and, in detail, to compare:

- Different PLM solutions
- Different versions of the same PLM solution
- Data management before/after PLM
- Different configurations of the same PLM solution (in different companies).

While time KPIs are more industry-specific, the remaining are generic performance measures that could be monitored in any PLM project.
The companies interviewed have demonstrated how strategic business alignment, process-based PLM design and reduction of customizations are critical success factors for Fashion firms implementing a PLM solution.
One of the main improvement initiatives consists in changing the way to work and PLM enables this change. To better perform, a company has to focus on process enhancement and then on system change, avoiding to customize the solution to support old processes.
Software customizations entail an effort in terms of costs and time; then PLM is also more expensive to maintain and less flexible for future integrations. Choosing OOTB configuration is one of the right ways to improve the overall set of PLM performances.

Guidelines for PLM projects

During the second year of my PhD I focused on implementation and post-implementation projects in Fashion companies. Downstream to these experiences I have tried to recap the best practices in PLM planning, implementation and adoption.
Hence, in this section, a comparison between results from literature review and outcomes achieved through interviews and the direct contacts with cases 1 and 2 is provided.
In Table 12, Table 13 and Table 14, guidelines from practice and from literature (Bokinge and Malmqvist, 2012) are grouped by project step (planning, implementation and adoption). The "Application (1)" and "Application (2)" columns refer to the applications of the guidelines from practice and from theory at the cases respectively analysed.
Planning is the first phase (Table 12), when the Fashion company and the PLM vendor work together to define a PLM roadmap and to lay the foundations of PLM implementation.
The top management defines strategic business goals, which are translated into operational objectives in the short term. The business decides also the departments that have to be involved: usually a pilot project is performed in one business unit and the others are included later. The business, often supported by consultants, selects the activities related to product development that will be managed in PLM and match current processes with the software functionalities. A gap between the company's requirements and the software capabilities always exist: several requirements will need deeper analyses (high configuration or adoption of other tools) to be satisfied and several PLM functions could be out of the project scope. In the latter case, the business learns from software functionalities improving product development and may decide to implement them in the future. Long-term objectives should not be overlooked: in order to persuade the users that this change in their routine is important, all the benefits related to PLM implementation should be shared and highlighted. In this planning stage, it is also crucial to plan training and adoption with the aim to minimize the project risk.
Application is low in the majority of guidelines: this first stage is often not promoted enough and this is due to the lack of time in project schedule: reconciling different objectives and viewpoints is the most unpredictable cause of delay.

Table 12 - Guidelines for PLM planning step

Guidelines from Practice (1)	**Application (1)**	**Guidelines from Literature (2)**	**Application (2)**
Define strategic business goals	Low	Divide project into sub-projects	Low
Define operational goals	Medium	Plan carefully	Medium
Identify departments to be involved in the implementation	High	Establish a PLM roadmap	Medium
Identify processes to be involved in the implementation	Medium	Carefully estimate the magnitude of change	Low
Map current processes to the features of the selected PLM platform	Low	Align project with PLM strategy	Low
Share the expected benefits	Low	Define benefits for all stakeholders	Low
Identify software functionalities improving product development	Low		
Plan training and adoption	Medium		

The second step is PLM implementation (Table 13). Business requirements could be unique or never tested before, so one of the best practice is to deploy a Test application server to try new customizations. Once the company has identified the gap between its needs in terms of product development and out-of-the box PLM functionalities, a list of the required customizations is provided and efforts and priorities are evaluated: this is a core activity because the PLM vendor has to schedule the implementations. The impact on PLM performance is evaluated each time a new request is analysed with the overall objective to minimise customizations.

The implementation of a requirement should not be simply solved moving into the system consolidated activities, but more effective and efficient ways to manage data should be analysed. Communication with users is fundamental to find a trade-off between business requirements and customizations (with obvious impacts on performances). Once the new request is implemented, it is tested and all the use case are listed and approved. Finally, the PLM vendor produces a handbook that represents the best "how to" for users.

Implementation best practice are more likely to be applied to the business context, because they are decisive and unavoidable within the PLM project.

Table 13 - Guidelines for PLM implementation step

Guidelines from Practice (1)	**Application (1)**	**Guidelines from Literature (2)**	**Application (2)**
Install a Test application server to try customizations	High	Only roll out tried software releases	Low
Identify customization, evaluate the related effort and prioritization	Medium	Establish a coherent PLM architecture	Low
Monitor the impact of customizations on PLM performance	Medium	Follow-up and control project process	Medium
Minimize customizations	Low	Minimize customization	Medium
Propose different and more effective ways to manage data	Low	Improve processes prior to or simultaneously with PLM projects	Low
Define use cases and test them	Medium	Align processes with system capabilities	Medium
Train users and produce proper handbooks	Medium		

The last step is PLM adoption (Table 14): since it has been implemented, users begin to experience issues and benefits. The relationship between process and software change is particular because changing the way we work is usually enabled from the software. Therefore, the best practice is to improve processes and software concurrently with an integrated approach to make sure that process change is aligned with software capabilities.
Once the most important business processes are managed in PLM, the business can focus on those processes that are still not included: several PLM functionalities, that have been overlooked in the first step, should be considered in order to take full advantage of PLM. KPIs and performances related to PLM should be always monitored, ensuring software scalability: information in PLM grows time to time and it has to accommodate this progress. Even if more and more user friendly PLM solutions begin to spread, operators need a support that is crucial in the initial phase and that becomes more manageable according to the learning curve.
PLM, in its software being, is subject to continuous enhancements containing, for instance, bug fixing: companies should benefit from PLM improvements implementing the updated versions. PLM adoption guidelines are not completely applied to the companies interviewed: measuring KPIs and integrate process and

system changes are still difficult to put into practice, while supporting users is perceived as more necessary.
The guidelines from theory, in comparison to the ones from case studies, are more general and less practical, but the goals are quite the same. The applicability for guidelines from literature is lower because it is more difficult to translate them into concrete actions. Perhaps each PLM product should have its own guidelines to be implemented, but I have tried to underline aspects that are common to a generic PLM for the Fashion industry.
Case studies have been conducted in companies adopting the same PLM solution within the same industry. It could be interesting to take into account also other PLM products, supporting fashion and other sectors. A comparison between PLM and other IT projects could be performed in order to generalize results. Then, PLM is an ongoing journey of improvement and connections to a broad list of digital solution platforms and is a never-ending process of improvement.

Table 14 - Guidelines for PLM adoption step

Guidelines from Practice (1)	**Application (1)**	**Guidelines from Literature (2)**	**Application (2)**
Improve processes and PLM concurrently	Low	Be prepared to adjust the plan when business changes	Low
Identify the gap between PLM footprint in the industry and business processes involved in PLM	Low	Use expertise from third parties	Medium
Monitor and control PLM performance	Medium	Ensure management support	Medium
Provide an application maintenance service supporting PLM users	Medium	Educate system users	Low
Consider release upgrade to benefit from software enhancements	Medium		
Measure PLM KPIs	Low		

PLM maturity

With the aim to conclude the analysis of PLM in the Fashion industry, this section examines PLM maturity. Results from literature review have been validated

through five case studies (cases 1, 2, 3, 6 and 8) to empirically evaluate the PLM maturity of Fashion companies, providing industry-specific considerations.
All the interviews and the group discussion were documented by filling out an evaluation form, as well as writing down any comments and answers to open questions.
All respondents were asked to complete the questionnaire to assess their organization according to the PLM framework, as defined by Batenburg et al. (2006). Four maturity levels have been included:

1. PLM on an 'ad-hoc' basis only
2. PLM on departmental level only ('silo' orientation)
3. PLM on the organizational level (cross-departments)
4. PLM on the inter-organizational level (cross supply chain partners).

Taken together, every question was coded as 0 ('no PLM'), 1 ('ad-hoc'), 2 ('departmental'), 3 ('organizational') or 4 ('inter-organizational').
The case studies allowed to reach a wider understanding of the PLM maturity, going beyond the basic assessment and deepening causes and consequences of phenomena.
First of all, I have applied data collected during the case studies to the PLM framework, in order to analyse the status of Fashion companies with respect to implementing PLM.
From the maturity viewpoint, companies are transitioning from the departmental level to the organizational level in PLM implementation. In particular, Case 6 has not yet implemented a PLM solution, but is considering to deploy it in the immediate future: the IT team is defining functional requirements. Case 8 has already selected a PLM solution but the implementation project is still on going and the only department involved is the IT one. Cases 2 and 3 have implemented a PLM solution on the organizational level and Case 1 represents the best practice, sharing to supply chain partners PLM adoption. Figure 17 shows the results of the PLM assessment.

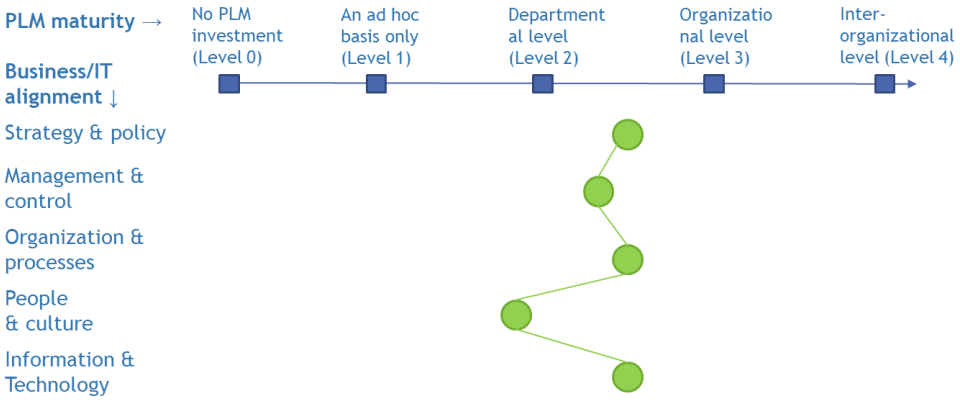

Figure 17 - PLM maturity assessment

Considering the business/IT alignment (Figure 18), the cases interviewed demonstrate a lack in "people and culture" dimension: users are not actively involved in the implementation of PLM software and the concept of PLM is not clearly understood. The industry we are taking into account is composed of users that are not skilled in PLM usage and often consider it as a threat stifling their creativity. Therefore, it is up to the top management to spread the benefits achievable through PLM implementation and to clarify which will be the short-term issues they have to face.
The other dimensions appear to be better developed, depending on the case considered.
We have used this framework mainly as a qualitative assessment, capable to underline areas of improvement and best strategies to perform in further improvement initiatives.

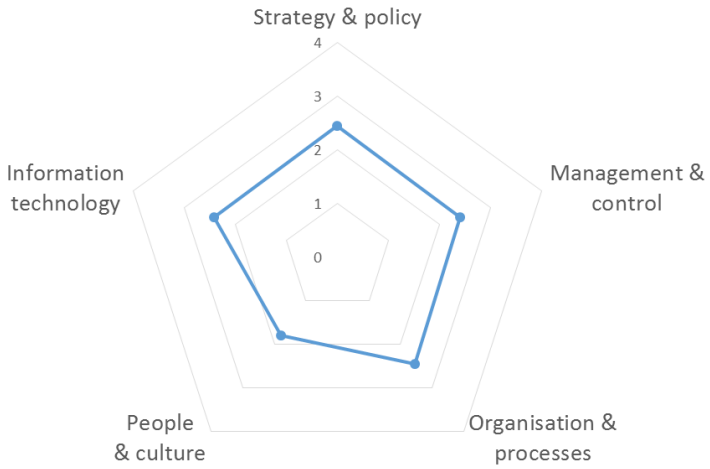

Figure 18 - Business/IT alignment

The second step of the evaluation is represented by the "customization" of the PLM maturity model within the Fashion industry.
Each business case has implemented an ERP solution to manage orders and production data.
Moreover, Fashion companies (especially apparel BU) require CAD systems supporting modelling and product development. What is lacking is an integration of PLM with CAD and ERP that should be considered in order to achieve a full integration with upstream and downstream enterprise solutions.
A modification of the "information technology" dimension is suggested, as highlighted in Table 15. The first item is an information that we already have from the maturity level (PLM usage may vary from 0 to 4). The third item is taken for granted in the cases analysed, because the core objective of PLM is to manage the overall set of product information.
I would like to stress the concept of software integration, explicated in the second item. Given the fact that ERP is always implemented within the cases, we have added an item investigating if the CAD software is used in the company. Then, we have asked if ERP and CAD are integrated with PLM.

Table 15 - Modification of the IT Dimension for the Fashion industry

Original Information Technology Dimension	**New Information Technology Dimension**
PLM software is used in the company	CAD software is used in the company
PLM software is integrated with other information systems	PLM software is integrated with CAD
PLM software includes functionality to manage product configurations	PLM software is integrated with ERP
PLM processes are automated by workflow management functionality	PLM processes are automated by workflow management functionality
PLM software includes functionality to manage documents	PLM software includes functionality to manage documents
A roadmap for the implementation of new PLM software is defined	A roadmap for the implementation of new PLM software is defined
PLM software is based on compatible industry and technological standards	PLM software is based on compatible industry and technological standards
PLM software includes functionality to manage product changes	PLM software includes functionality to manage product changes

Due to the modified dimensions, the result of the assessment is more realistic, getting worse from the IT perspective.
Indeed, sketch, patterns and silhouette are often not supported by CAD solutions and, when the latter are implemented, these are not integrated to PLM. Only the owners of the CAD systems can manipulate the native pattern files, grades and markers so that connecting it to the PLM BOM and Costing module in a dynamic way is very difficult. Most PLM providers will need to take a manual approach to manage this change.
Besides, more common is the integration between PLM and ERP. The case studies examine the Fashion industry, but probably the modification of the IT dimension may fit every industry placing emphasis on design and prototyping.
The evaluation of the maturity level appears improvable: I have observed that a business might not implement any PLM solution, or implementation is still on going in a department, or PLM is implemented and used within the entire organization or, finally, it is shared with partners. However, none of the companies interviewed has an "ad hoc" basis only. PLM investment is usually remarkable: the implementation project will initially involve the IT business unit and then the entire organization, in order to justify the expenditure.

Within the sample I have considered in this thesis, the Fashion companies have decided to adopt a PDM or a PLM solution in order to support their product development process. Moreover, as I have adopted a process-oriented approach along the entire PhD, the evaluation will also take into account process- related considerations (Harrop, 2016).
Hence, according to my experience in conducting multiple case studies, the PLM maturity level in the Fashion industry could be assessed through to the following levels:

1. **Excel-based information management**
   Product development information are managed through spreadsheets and shared folders. This level is typical of SMEs playing in the industry (as factories or suppliers).
2. **PDM**
   Processes are more formalized and documented within a PDM solution
3. **PLM**
   It is used to support all the processes from product development to production and across business units. Processes are fully documented.
4. **Extended PLM**
   Master data and library are extensively used. PLM is interfaced with ERP and/or creative solutions and supports all the activities that are linked to product development.

RQ8: Luxury industries - PD and data management

The objective of this section is to explore PD and the need for ICTs in Fashion, Furniture and Food companies belonging to the luxury market segment. I examined the strategies, the activities, the issues in process management and the most used ICTs tools. Comparing these sectors, I have been able to identify commonalities and differences. With the aim to investigate also improvement areas, several best practices and cross-fertilization are discussed.
The companies involved were cases 2, 9 and 10. All these companies control the major part of their activities and focus their attention on product development, representing the core business process.
My colleague and I have investigated the following topics at a cross-industry level (see Appendix 3):

- CSFs
- PD activities
- Departments involved in PD process
- IT solutions supporting each PD activity

- Issues related to the PD process.

Concerning the CSFs, from the analysis of the interviews emerges that quality is a strategic lever for the three sectors (see Figure 19). In fact, the luxury segment they belong to, force them to reach high quality levels and to invest and focus on quality aspects.
Furthermore, timing is a strategical factor for both Furniture and Fashion companies. They are subjected to the pressure from customers and, in order to be competitive on the market, they have to reduce lead times and time to market.
Other CSFs are secondary and more related to the specific case, than generalizable to the industries we have analysed. Nevertheless, strategies as innovating, being recognised for the brand reputation and for craftsmanship are essential. Thus, as a primary result, the list of CSFs has been validated through the literature and the predominance of quality has been underlined.
The data from the cross-industry analysis, related to processes, departments, ICTs and issues are summarized in the third Appendix.

Figure 19 - CSFs in Fashion, Food and Furniture industries

As a second step to the analysis, we have compared the main activities within product development. Figure 20 illustrates all the common activities: the only task that is typical just of Fashion and Furniture companies is "customer feedback", because they need to present the collection to customers and collect orders.
Manufacturing is performed in different moments: for example, Fashion companies produce prototypes and samples and only when these are approved, production can start; Furniture companies produce directly the finished product; while, in the Food industry, the production stage is forerun by the recipe testing.
Then, depending on the need to sell to a retail channel or directly to the customer, order entry might be managed at the earliest stage of product development or later.
Hence, the analysis has demonstrated that, even if several processes are common, they could be framed in different time windows.

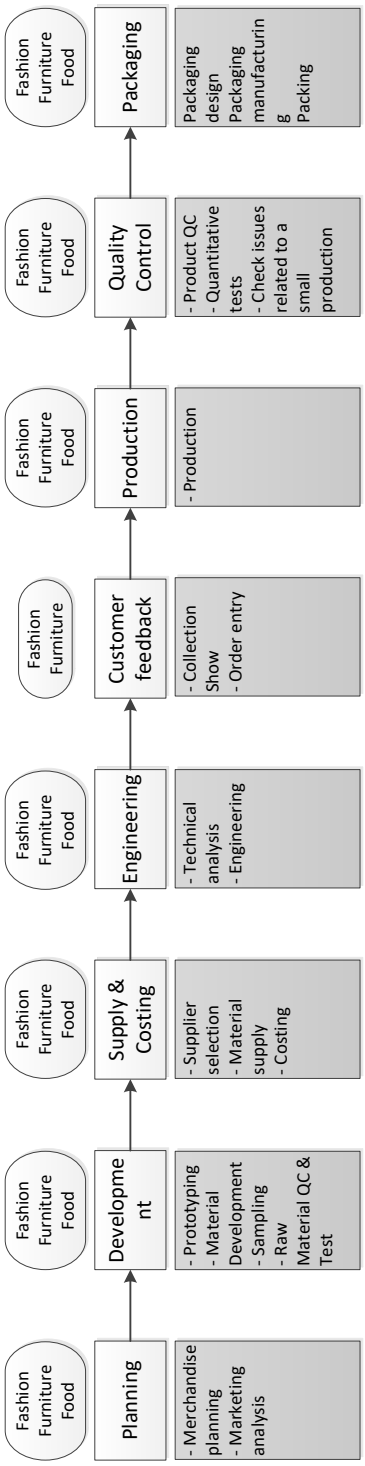

Figure 20 - PD process in Fashion, Food and Furniture industries

Coming to the analysis of the ICTs (see Figure 21), we have noticed that PLM is implemented just from the Fashion company, which also adopts Office automation and creative solutions.
The Food company is not managing product data with an integrated approach, so it simply uses Office automation. CAD and ERP are then used respectively for the upstream and downstream activities within product development.
The Furniture company focuses on orders, hence the core ICT is an extended ERP solution. Product data are stored in spreadsheets within shared folders. 3D and 2D CAD support the design activity.

Figure 21 - ICTs in Fashion, Food and Furniture industries

These different choices in terms of ICTs are due to two main causes:

- The driving force for data management: the product centrality lead Fashion to manage its data in PLM; while, the importance of customer orders in Furniture companies triggers the adoption of an extended ERP.
- The need to innovate through ICTs: several companies prefer to afford on Office automation and renounce to implement PLM because they need a high level of flexibility. Whereas, other companies decide to change their processes and their information jointly, adopting appropriate ICTs, and to invest in innovation.

Coming to the issues analysis, we have noticed that the most critical one faced in process management is related to quality. Controlling whether or not a product gets the target quality is crucial.
Timing is another issue for these companies: it makes them more competitive but also more stressed by the continuous market needs.
Communication and IT issues are more related to the specific cases and less generalizable. For example, the need of ICTs is an issue for the Furniture and Food companies, because they have not yet adopted an integrated approach to data management.
Finally, we have underlined the main improvement areas for the three industries, that also allow to generalize the results. Comparing different industries means, first of all, understanding weaknesses and strengths of each company. Since these firms belong to the luxury market segment, a cross fertilization is possible.

Hence, we have acknowledged the points that might be stressed to be more competitive on the market, that are:

- **PLM**
  The Fashion case teaches that a structured approach to data management allows to streamline product development and to respect the collection scheduling. The other two industries may learn from this point and improve information management, implementing a PLM solution.
- **Product innovation**
  It may be a key to success for luxury companies, that are already famous and stable in terms of craftsmanship. The Food company has learned this lesson, considering innovation one of its main strengths. In fact, product innovation is revealed in the use of new ingredients, associating a meaning to the product itself and customizing it for the referring market segment. The Food company, in order to be competitive, has to be able to understand and satisfy the customer needs. Indeed, the innovation factor adds a plus value to the product itself, allowing Food companies to achieve market success.
- **Change management**
  Change management, finally, is an important lever to be competitive. A company has to proactively change from the existing organizational structure to the future one. Whichever is the innovation to be introduced, change has to be evaluated, analysed and managed. The Furniture company, that is the smallest one, has introduced lots of successful innovation keeping in mind the importance of change management.

RQ9: Luxury industries - PLM

In order to answer this last RQ, multiple case studies have been carried out in Food and Fashion companies. Because of time constraints, we have not had the opportunity to involve also Furniture companies (the one mentioned in the previous section was not implementing any PLM solution).
Nevertheless, five Fashion firms and seven Food firms were involved to investigate similarities and differences between the two sectors, focusing on information management throughout PD and the strategic role of PLM.
Food and Fashion are the two sectors where Italians trust more concerning the "Made in Italy" brand.
At first glance, they appear to be different and distant environments, especially because of product features from the final customer viewpoint. The Fashion industry stresses the not-essential customer needs, i.e. the ones related to the irrational sphere of our mind. On the other hand, the Food industry produces,

more than other sectors, vital items that every customer chooses day-by-day; yet it also delivers more "fashionable" products that clients could do without (in particular processed foods, as chocolate, sweets, jams and so on).
Hence, fashion could be recognisable in all those products that satisfy emotional and temporary needs, including food products. Moreover, analysing both the supply chains from the companies' perspective, they prove to be configured as "market responsive" instead of "physically efficient": their primary purpose is to respond quickly to unpredictable demand.
Other similarities are related to product design and management. Food and Fashion firms deliver innovative products instead of functional ones, characterised by short lifecycles, high contribution margin and high variety. Furthermore, these are also special products instead of standard ones, as suggested by Christopher et al. (2004): they are not stable in demand and include a high level of customisation.
An interesting leitmotiv between Food and Fashion supply chains is that PD represents the core process; in fact, it is always conducted in-house to retain the control over the involved tasks and resources.
In this context, the use of the PLM platform in support of PD process for both the industries could be considered as a key driver of innovation that allows them to be successful in the market.
The two groups of companies, operating in the Food and in the Fashion sectors, have been selected in order to be compared.
The five fashion companies interviewed manage leather goods, shoes and ready to wear products. Two main clusters have been identified: high-end/luxury companies, selling leather goods, prefer to focus on CSFs as quality and innovation and to retain in-house the majority of supply chain processes. They need to achieve innovation also in data management and have implemented an industry-specific PLM solution. The second cluster includes low-end companies, selling outerwear and childrenswear, which are competing on time to market and decide to outsource production to suppliers. They are still not able to manage product information through PLM.
The seven food companies interviewed manage milk and yogurt, pasta and sauces and confectionery products. All the companies interviewed decided to outsource the distribution and sales phases. Moreover, just two companies are using the PLM platform, while the remaining are adopting PDM and ERP. Some of the companies intend to adopt the PLM solution, while others do not even know the meaning of this system and the related benefits.
The selected companies have been contacted and asked for their willingness to be investigated through a case study; the companies analysed have been finally selected among those which indicated their availability for a field investigation.
Interviews and direct contacts with R&D and IT managers have allowed to analyse business processes, with a particular focus on PD and on how information are managed throughout the product lifecycle.

Figure 22 and Figure 23 represent outlines of processes, tasks, PLM functionalities and other software solutions that Food and Fashion companies have validated and approved in a general meaning.
PD and production are the main processes that constitute the beginning of life for Food and Fashion products and that have a relationship to PLM.
Sub-processes are also aligned in Food and Fashion cases: planning, recipe/collection development, prototyping and test, engineering and production are representative of all the companies interviewed.
Information related to PLM functionalities, are based on the cases that are using it: they have implemented the same industry-specific solution, adding several customizations to the out-of-the box configuration
I have already detailed, at the beginning of this Chapter, the flow of activities typical of Fashion companies, the related PLM functionalities and the other software involved: in Figure 22, a recap is provided.

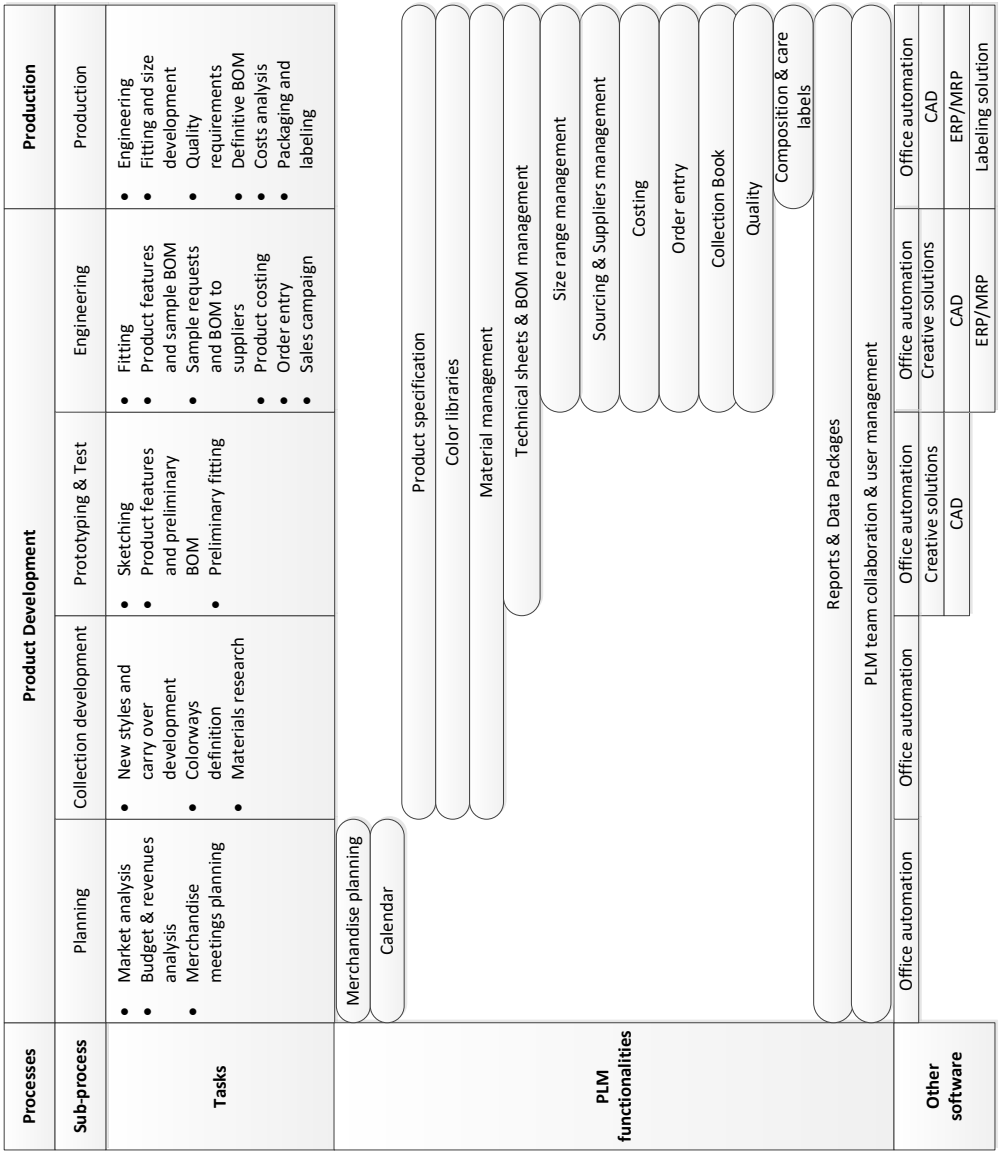

Figure 22 - PLM-related features in Fashion companies

Concerning Food companies, the PD process starts with the phase of planning. The process usually begins with a market analysis, in order to understand the customer needs, the competitor positioning, with different comparisons to industry standards (benchmark) and so on. Once the external factors have been fully defined, the next step is to identify if there are already similar products in the company portfolio. A brainstorming on technical and economics features is conducted in order to identify the product characteristics. Then, a first feasibility

phase has to be developed, in order to evaluate the idea, formulation, equipment, packaging and financial feasibility. When this phase is concluded, a product brief is defined. The PLM functionalities supporting this preliminary phase are: product portfolio and data management (related to the continuous cultivation of product sets by prioritizing and managing PD and retirements), PLM team collaboration (supporting the collaborations between different teams and company functions) and Report specific to the industry (enabling the facilitation, automation, and control of the entire development process).

The second macro-phase that characterize the food PD process is the recipe development. The first activity characterizing this phase is the recipe development. Once the recipe has been developed, this undergoes various evaluation stadiums (usually internal), starting from a laboratory validation, then a pilot plant validation, the industrial plant and finally a legal validation. The PLM modules supporting this phase are: specification management, formula/recipe management and regulatory compliance. Formula and recipe management sustains the recipe development and its management. Specification management allows to capture the descriptions and quantities of ingredients, materials and other content, including process information needed to produce, pack and ship a product. Regulatory compliance enables to identify what regulations, policies and obligations are applicable to the developing product. These functionalities support all the next phases of the process.

If the recipe passes all ratings, then it is possible to move to prototyping & test phase. In this phase, the production of the first prototypes is done observing if the realized products follow all the input specifications. A small batch of product is produced in order to be tasted both internally and externally. After that, the results of the tests will be analysed in order to understand whether changes to the recipe must be done. Therefore, a very important process characterizing this phase is the suppliers' selection. This phase is supported by the following PLM functionalities: Label and artwork management, Costing and Quality. Once the product is fully defined, it is possible to develop labels and artwork for different markets conforming to their preferences and regulations. Furthermore, product quality and costs are measured. These functionalities support the next PD phases, in order to constantly monitor costs and quality factors.

The next macro-phase of the food PD process concerns the engineering stage. The process owner verifies if the production line can handle the new product manufacturing. Different tests are performed, as industrial, quality, transportation and quantity tests. After that, quality tests must be finalized in order to check the quality of the industrialized products. A small number of products is usually produced to check issues related to a small production. Finally, one or more transportation tests have to be done in order to understand how the product reacts to the various conditions during the different transport choices.

Completed the engineering phase, bulk production and product launch are carried out.

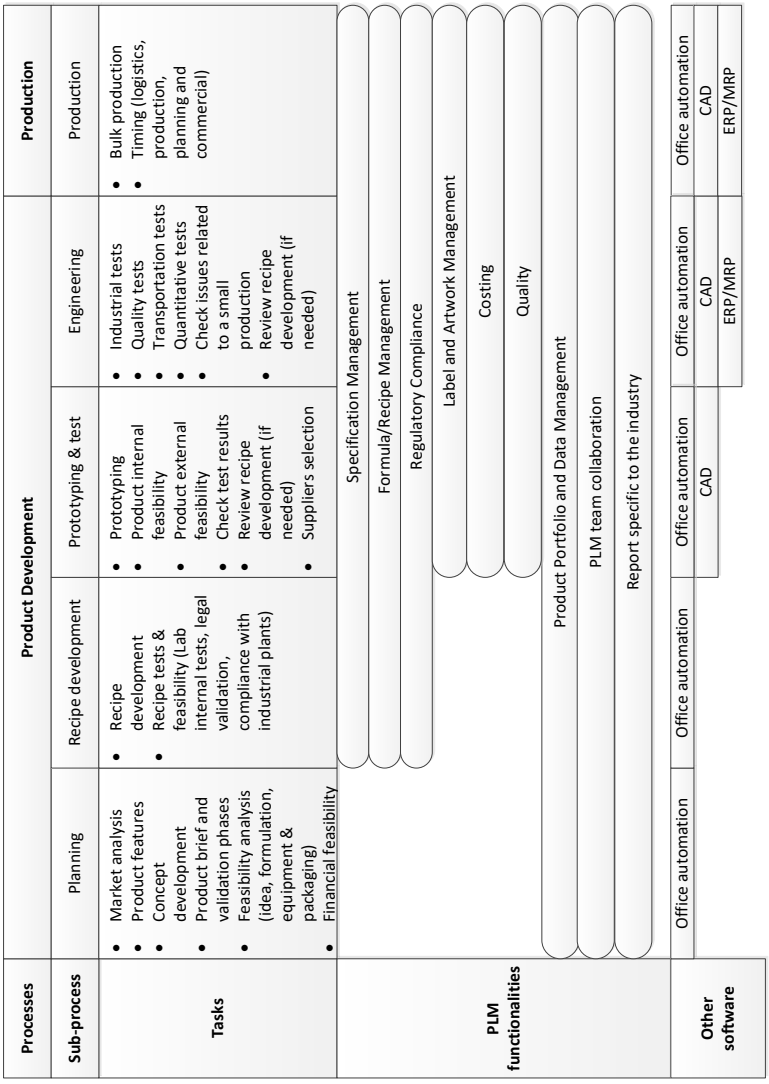

Figure 23 - PLM-related features in Food companies

Given this primary single-setting analysis, then a comparison has been performed. The parallel interviews to Food and Fashion companies allowed to identify several similarities and differences, influencing process and information management. In Table 16 and in Table 17 I have summarised the main results.

Table 16 - Food and Fashion similarities

Similarities	Description
Importance of the PD process	The case study has confirmed the relevance of PD in both the industries. PD is characterized by the same number of phases, assuming also the same meaning for both the sectors
Customer-centric product design	Both the industries recognise the customer central role in the PD process
Importance of product innovation	Fashion companies have demonstrated how innovation is appealing for new consumers. Moreover, the Food sector is focusing heavily on product innovation. It is gradually becoming one of the key factors that characterize successful Food companies
High number of items	Food and Fashion companies manage lots of product variations, due to the high number of colourways, for the Fashion industry, and to different packaging and market-related customizations, for the Food industry
Importance of industry-specific PLM solutions	The cases have demonstrated that a general-purpose PLM solution is not able to fit the needs of Food and Fashion companies. This is the typical situation in which "one size does not fit all". Both the industries require several functionalities that ask for an appropriate data model, provided by a custom solution or an industry-specific PLM, developed by a vendor with a particular focus on the sector

Table 17 - Food and Fashion differences

Differences	Description
Issues related to product obsolescence	Food product lifecycle is highly influenced from obsolescence and expiration dates, while for fashion products, their lifecycle length is just a matter of seasonality and new trends
Issues related to regulatory compliance	PD in Food companies cannot overlook regulatory compliance and market constraints. This is not an issue in the Fashion industry
Differences in the sale channels	Fashion companies need to control the sales channels: the large part is also managing the Retail channel, as brand owners. Food companies sell

	their product to MRC (mass retail channels), losing any control over the sales channel
Differences in data model	The typical fashion item is an SKU, composed of a model, a colour and a size. The same structure is not replicated in the food products, which are characterised by a recipe and the value-added information come from the balancing quantities, more than from the single components
Different customer perception of product design	Even if design is fundamental for both the industries customers directly perceive product design in fashion items while, for the food sector, the appealing design is associated to the packaging, more than to the product itself

CHAPTER 5 – CONCLUSIONS

A book has its own journey to make and should not condemned to being stuck on a shelf

(Paulo Coelho, Like the flowing river)

Working as a consultant and as a PhD student, I spent much time in listening and learning. After these years, the listening moment is still my favourite, because it activates all the creative processes in my mind, merging the speaker's perspective with my mind-set.
However, there comes a time when your audience is expecting something from you. Basically, you are asked to tell you viewpoint, to explain your reasons, to add some kind of value to what has been already done, written, told. A hard and fascinating task!
Hence, at this stage, the reader is going to meet my understanding of the facts and interpretation of results.
This last Chapter collects and recaps all the key-points thoroughly analysed in the previous ones. I have tried to provide a focused viewpoint, allowing the reader to understand each research topic, how it has been developed and the results from the analysis. This has been done for all the research areas depicted in Figure 1.
The research framework, the literature review, the methodology and the results from the case study analyses are not standalone paths of my thesis. There is a leitmotiv within this study, i.e. PLM supporting the PD process in Fashion companies. Hence, the aim of this Chapter is to connect the findings to the main goal of the thesis.
First and foremost, I examine the practical and theoretical implications, trying to highlight the relevance of results from the entrepreneurial and academic perspectives. Research limitations are as well discussed.
The thesis concludes summarizing the main themes of this manuscript, the achievement of the research objective and future steps to improve and finalize the research topic.

Discussion

Practical and theoretical implications

The first implication that these three years have had, can be seen in my personal growth. Contacts with many professionals and academics have allowed me to increase my knowledge about Operations and IT management in the Fashion industry.
More generally, the research activities have led also practical implications. The process-oriented approach, discussed in the previous Chapter, the KPIs study supporting PD and PLM at each stage, the improvement initiatives and the assessment of PLM maturity are examples of analyses conducted on the field, throughout the years.
Sometimes I encountered some problems, that caused issues related to data and time management, in particular:

- Difficulties in retrieving and sharing data because of privacy constraints
- Issues in receiving answers from questionnaires on time to perform proper analyses and to define achievements
- Issues in understanding who was in charge to perform a particular task: roles and responsibilities were often vague
- Issues in project management:
    - Due to timing and tight deadlines during PLM implementation
    - Due to the presence of different stakeholders within the projects (process owners, users, PLM vendor, system integrator, business consultants), that were not sharing the same goal and that had different opinions of a PLM project.
- Issues in change management. Many people were not understanding the need for PLM.
    - Executives had not taken the lead because change management was perceived as time-consuming
    - Users were often "victims of change" because they felt not comfortable with the change in process and data management, entailed by PLM.
      They have often asked for PLM customizations that were basically downgrading the system to an excel-like configuration. Alternatively, they requested a high level of automation (as "I would like a button that allows the team to launch sample requests" and also "The sample requests have to be launched with the same format that we have used so far").

On the other hand, I have never experienced communication barriers with users, process owners, managers and executives. They have always tried their best to explain their requirements and the reasons behind these, allowing me to learn from their expertise, their perspective and their human side.
The research conducted over the years, has also led theoretical implications.
The existing literature and the methodologies available to reach the goal of this thesis, have been studied.
My biggest contribute to theory is in filling the research gap, due to the lack of papers concerning the Fashion product development and SC. Process and data management, KPIs, improvement initiatives, PLM features and projects were underexplored. I have tried to remark the need for an industry-specific analysis, mainly because of product and process complexities, according to the analysis performed in the previous Chapter.
In particular, conducting a PLM project in a Fashion company requires a specific emphasis on collection development, impeding to connect the Fashion SC to another already defined business model and data model. The framework for PLM implementation, depicted in Figure 16, represents the effort to introduce

customised practices and a process-oriented approach to a validated model from literature.
The same approach has been also used to identify KPIs supporting the product development process and PLM adoption.
It is the most original contribute that I would like to provide, given the focus on processes and information management that I have had over the years.
The topics I have debated in this manuscript have been disseminated during Conferences and in several journals.
Apart from the Conferences organized by the University of Florence and other events, intended as integral parts of my PhD (ING-IND 17 Summer School, for instance), I have participated to two main international Conferences, definitely aligned with my research topic:

- International Conference on Product Lifecycle Management (2014-2017). PLM is the core topic and many general and industry-specific researches are presented. A Doctoral Workshop has allowed me to give a presentation, that was summarizing my research as a PhD student, and I have had the opportunity to receive feedbacks to enhance this thesis. Keynote speeches from entrepreneurs and industrials were also organized to merge theory and practice concerning PLM.
- International Workshop on Luxury Retail, Operations and Supply Chain Management (2013-2016). The Luxury SC is the protagonist and many industries are involved, including food, boats, apparel and leather goods.

For each Conference, I have submitted a proceeding that has been reviewed and then approved by the organizers. I have counted a total of 13 proceedings.
Moreover, I have published three articles in several journals. In Appendix 4, the complete list of my contributions to literature is provided.

SC implications

The analysis of product development in the Fashion industry has involved all its relates tasks. From strategic planning to production, everything that was somehow influencing the PD process has been taken into account.
In addition to the product and process features, that we have already examined in the last Chapter (in order to answer RQ1), there are other characteristics that should be highlighted.
Indeed, basing on the product typologies, ascribable to "new product" and "carry over", different needs in terms of order management have been reported. The business model that is ruling the industry is MTO and this means that production starts when orders have already been collected. However, in practice, Fashion

companies try to anticipate some orders to ensure the respect of the business milestones, with the aim to deliver their products in a timely manner.
Hence, carry over products are more likely to be ordered basing on forecasts, according to the MTS manufacturing environment (see Figure 24). These products have been designed in previous collections: information about materials, consumptions and processing techniques are already defined. Moreover, the Fashion company has already identified the factories producing that kind of item.
Whereas, new products are mainly produced basing on the orders actually received when collection is presented to the sales agents. In this case, it is very difficult to forecast the right quantities in terms of finished products and to deduce material consumptions for different colours.
The "shades" between new products and carry over, as carry over variations (different colours or aspects), may be a mixture of MTO and MTS, basing on evaluations from past experiences and on ultimate issues in production management.

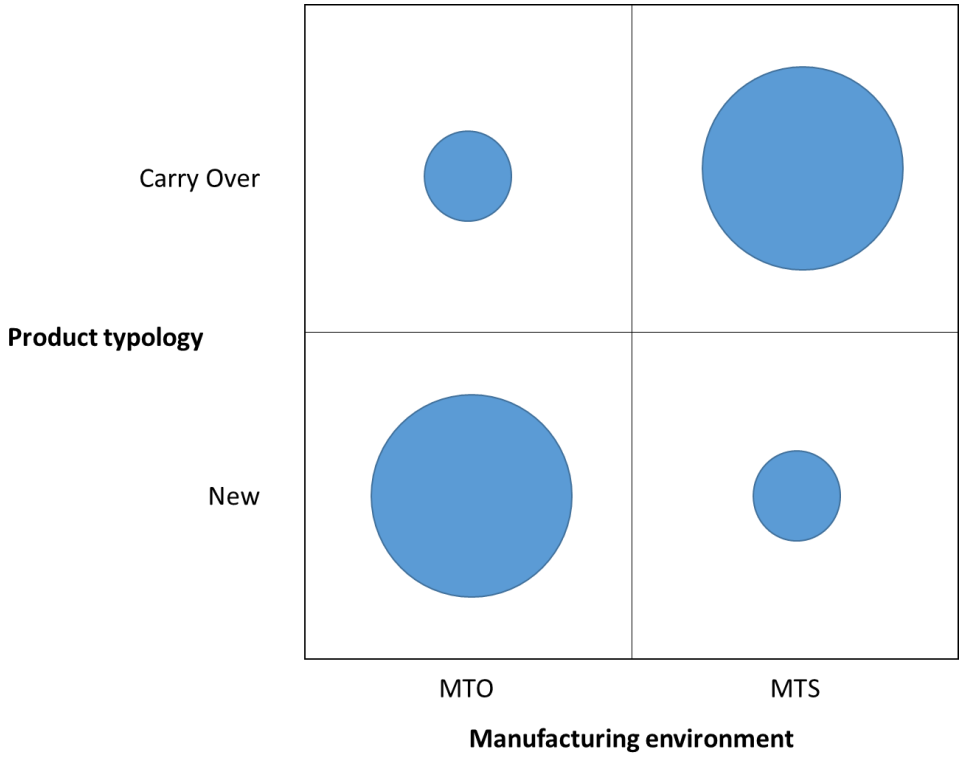

Figure 24 - Product typology vs. Manufacturing environment

Another implication in SC, concerns Make or Buy decisions vs. Product strategies. I have identified four product categories:

- Heritage/Classic: includes premium products with a high handcrafted content. These are icons communicating longevity and the key values of the brand, as part of its heritage. Where and how the products are manufactured and retailed are crucial points.
- Style: includes high quality products with a high creativity content. Design and diversity of materials are the reasons behind the brand success. Customers are sensitive to Made In and Retail channels.
- Innovation: includes innovative products, showing particular performance thanks to new materials and techniques adopted (sportswear and outerwear are typical examples). Customers are willing to buy these products in any channel, because they perceive how a technical innovation may improve their lifestyle.
- Mass: includes cheap products with a mass appeal, that are produced in high volumes. Production is outsourced in developing countries and stock is updated regularly.

Figure 25 shows that high-end companies, selling expensive heritage/classic products, are conducting in-house all the SC processes, including manufacturing (cases 1, 3 and 8). They are trying to combine the traditional MTO strategy with MTM, providing more and more exclusive products.
Cases 2, 4 and 5 are outsourcing their production process to near-shore factories in order to take advantage from external skills and to focus on design/style activities.
Companies leveraging on innovation more than on quality and design, as case 7, supply raw materials from providers in Far East countries, trying to benefit from low costs. Production is then outsourced in European countries. These firms retain internally their know-how, based on the capability to choose particular technologies, tested during product development.
Low-end companies, as case 6, selling cheap products, have to reduce costs in order to ensure low prices to their customers. To this aim, they are buying materials and production to cheap labour countries. These companies place forecast-based orders (MTS) and then assemble the finished product according to the new trends, thanks to Quick Response and to a deep market analysis.
This study suggests that the more a Fashion firms manages premium, classic and expensive products, the higher is the degree of internalization of its processes. Hence, even if the sample is not big enough to perform statistical analyses, it seems that there is a positive correlation between the willingness to adopt a Make Production strategy and the Product strategy to deliver high-end products. As well, firms that are adopting the Buy Production strategy are those that target to the mass market, delivering cheap and highly available products.

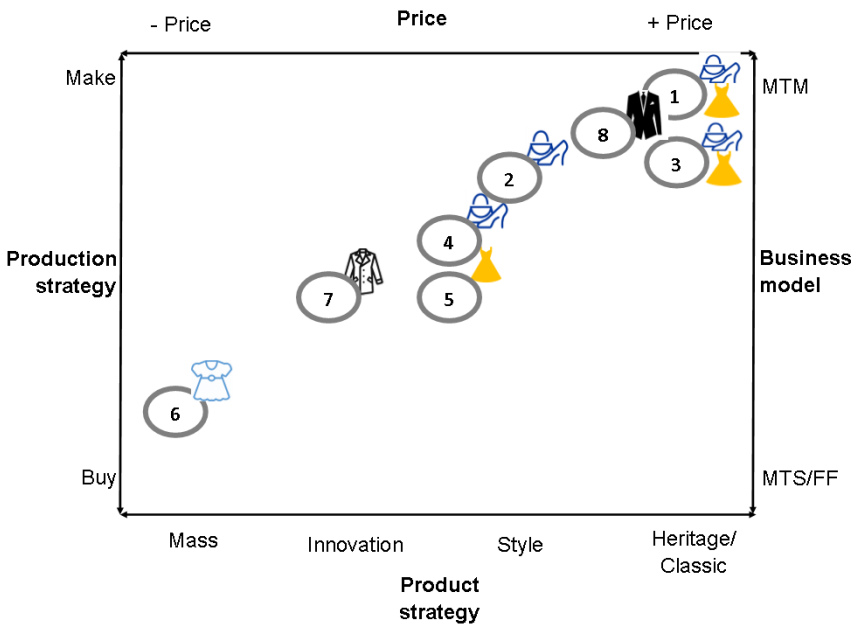

Figure 25 - Production vs. Product strategies

The implications on SC have been bordered to the Production process, so distribution, sales and after sales issues have not been analysed for the following reasons:

- Distribution has not been perceived as a value-added task by the companies interviewed. Logistics partners have to be reactive to ensure the product delivery at the stores. It's all about timing: if delays occur in PD, then the distribution timescale have to be revised and compressed as much as possible. Product development analyses are not affecting from any other perspective this part of the SC.
- Sales features and issues are very relevant in this sector. The Merchandise team is in charge to interface with Sales Manager in order to gather all the information about sales and customer feedbacks. Hence, the sales viewpoint has been already included in the analyses conducted during merchandise planning, that we have analysed as overall business strategy.
- After sales is an emergent process in the Fashion industry and luxury companies are dedicating lots of their efforts to please their loyal customers. Even though after sales activities affect production and operations management, the link with the PD process is still weak.
  I have asked a After Sales Manager (case 2) if the issues he encountered were somehow influencing the choices in terms of collection planning. The answer has been negative, because the Creative Director actually prefers to

take decisions basing on design, new inspiration and customer feedbacks, more than on production issues. Neither Production Managers are considering after sales issues, because their experience with factories and their partnership with several suppliers do really matter in comparison to the rest.

IT implications

The product development implications on IT management in Fashion companies has been widely analysed, underlining the importance of PLM.
The PLM framework, the implementation guidelines and the performance measures identified, complete the overview of such an IT tool and a strategic approach for the Fashion industry.
In this section, I would like to provide an interesting insight concerning the PLM maturity. The latter has been compared to the business and distribution strategies, in order to understand if there is a relation (see Figure 26).
This time, I have considered the overall 10 cases, including also Food and Furniture companies, unlike the analysis conducted in Figure 25, which was more industry-specific.
I identified three drivers:

- PLM maturity. The four levels of PLM maturity (Excel-based, PDM, PLM, Extended PLM) have been already presented and discussed in the previous Chapter.
- Strategy and Business Model. This driver includes strategies based on market segmentation (from Mass to Luxury), on price levels and on behaviours as trend follower or trend leader. According to Figure 25, the business model has been included, so the range from MTS/FF to MTM corresponds to low-end and high-end Fashion enterprises.
- Distribution strategy. This driver figures out the values that inspire the brand when distributing a product to the sales channel. Luxury companies adopt exclusive flagship stores and DOS; low-end companies are massively present in any channel to sell their products (the internet, wholesale, franchising and retail); middle-end companies aim for availability: their products are still expensive but everyone can buy them everywhere and in every moment.

Matching these three variables, as illustrated in Figure 26, we cannot conclude anything about a correlation between the PLM maturity and the market positioning of the company: it is not true that more the firm is high-end and adopts exclusive channels, the higher is its PLM maturity. But this was not the aim of the analysis.
Instead, the picture wants to highlight few key points:

- PLM is a strategic approach that could not be simplified through a mere software implementation. In the figure below, the luxury companies (cases 1, 3, 8 and 9) have taken different decisions in terms of PLM: even if they are all trend leaders, selling exclusive products, often made-to-measure, they can act as great PLM performer, adopting an extend PLM, or they can afford on a basic PDM, or yet rely on traditional spreadsheets. This analysis confirms that the willingness of the business to manage the entire product lifecycle, to build up a proper initiative and to ensure effective project and change management, is decisive.
- Benchmarking with competitors. According to the figure below, companies sharing the same strategies, may move from the present level of PLM maturity to a higher one, because its competitors have already benefit from the effects of a successful PLM implementation. For instance, cases 7 and 5 should learn from case 4; or cases 8 and 9 should learn from case 1 and 3.
- Opportunities for PLM vendors. The figure may help the architects of PLM solutions to identify market niches to address: they can evaluate to point some niches, providing functionalities and deployments that fit their needs, or strategies and marketing actions to encourage these companies to implement PLM extensively. From the vendor perspective, for instance, this analysis can trigger the following questions: which are the alternatives that a Fast Fashion company (as case 6) might have in terms of PLM? Is there any solution supporting its requirements in terms of business model and strategy? How could my PLM solution support its product development process? How could I persuade the company that my PLM solution is enabling it to reach a competitive edge?

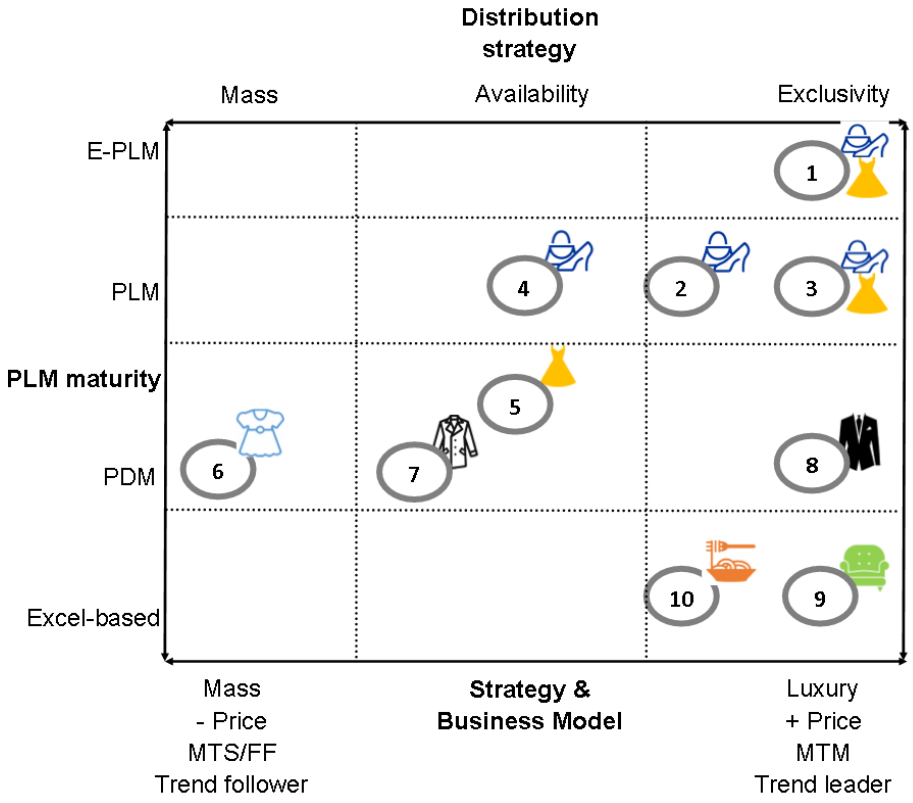

Figure 26 - PLM maturity vs. Business strategy

Other IT implications are more related to the specific projects that have been conducted.

One point concerns the Fashion company organizational structure. In case 2, for example, the company was not managing internally ICTs: an external provider was organizing all the innovation projects and was unaware of the real business needs. This provider, of course, had not a complete awareness of the business processes and so took its decision basing on best practices and on the different viewpoints of business consultants and process owners. Essentially, data and processes were not managed simultaneously, but with different objectives and perspectives. In this case, the PLM project has been particularly hard because of a geographical and planning-oriented distance.

During the other projects, I perceived that the integration between process and data was eased thanks to common factors, which were the internal perspective of both the sides and a common strategy.

The other point concerns the PLM solution. According to an analysis conducted by WhichPLM (Harrop, 2017), the majority of PLM implemented requires a customization. The product that Fashion companies purchase would not have

been usable OOTB. When they do not implement any customizations they did implement with a lot of configurations that allow them to tailor the solutions to their needs and their business requirements.
I confirm, from my poor experience, this trend. Even if the mantra is going OOTB, it is really difficult to get it in Fashion companies. Many business-specific activities, issues, the involvement of suppliers with different needs and different "shades" in their business models, ask for customizations. Hence, the participation of the PLM vendor is crucial and maintenance activities are required.
Fashion runs on a timeless treadmill of translating paper to product, and idea to item (Harrop, 2017).
To truly transform the way these companies design, develop, make, market and sell we need modern-day information architects, professionals who can look at the data flow of product lifecycles and develop methods of integration and interoperability that will underpin the next wave of technical innovation.
Collaboration may not be driven just by technological capabilities but rather by a combination of the right software and the establishment of clear expectations of how PLM will be used not just internally but with suppliers as well.
While PLM vendors have worked hard to make common fields mutually intelligible in English, Chinese and a host of other languages, one of the largest gaps in our ability to communicate with the global supply chain is an inability to communicate what we want to build in the universal engineering language.
The next generation of Fashion creatives are likely to be "born digital", completely divorced from the realities of manufacture. The average designer of tomorrow is likely to be simultaneously more creative than ever before, but also less capable then ever of understanding how to bring that creativity to life at any kind of scale.
Product designers and developers, in every industry, want to make useful, attractive and effective products that make their customers lives better. But they also need the information to flow effectively through the SC and the designs they create must also make a profit for the company. To properly balance both sides of this equation in the modern market the creative teams need to be given the tools and provided with the data to do this from initial concept to the final consumer.

Research limitations

The greatest limitation attributable to this research is about methodology and is due to its generalizability. As I started by saying in the Methodology Chapter, I have conducted, above all, in-depth case studies. For sure, eight cases (considering just those ones belonging to the Fashion industry) are not enough to generalize to the entire sector.
The reader can imagine the constraints that I have had in terms of timescale and business opportunities (not all the Fashion companies are willing to be analysed by academics). This is the reason why I suggest future researches in the field and an

enlargement of the sample. So, for instance, the analyses related to the Food and Furniture industries are just the starting point of further researches.
Another limitation is related to the PLM projects. Since I have experienced just off-the-shelf software, my effort has been to adapt a database architecture, already designed by a software house, to the needs of a Fashion company. Hence, I have not learned how to build custom solutions, starting from user needs and from writing pieces of code. Perhaps this is more fitting the skills of computer scientists, than the ones of an industrial engineer. Nevertheless, I think it would be interesting to perform another kind of analysis and support PLM architects in building customised solutions.
Finally, I have always implemented the same off-the-shelf PLM solution (from the same vendor). It is an industry-specific PLM and many Fashion companies are appreciating its functionalities and the agile deployment that the PLM team is ensuring. Hence, I am not able to compare the specific features of different PLM solutions supporting product development in the Fashion industry. It would have been interesting to test different user interfaces, issues, performance and project features.
I perfectly know that these limitations, both methodological and related to PLM projects, affect the reliability of the results. I hope that further researches will be conducted to fill these gaps. Enfolding literature is still a work in progress goal basing on the previous considerations.

Conclusions

This thesis is the result of my work as a PhD student and as a PLM consultant.
The objective of the researches that I conducted over the years, has been to improve and streamline the PD process in the Fashion SC, through PLM.
In order to clarify the areas of analysis and the relationships in between, I have designed a research framework (Figure 1), illustrating the main topics and the RQs: it is the "fil rouge" within this manuscript.
Before approaching the core part of the study, I have described the background for this research. The Fashion industry is a complex environment, where many actors, tasks and different needs are required to deliver products that are perceived as ephemeral, but that are ruling the great part of international economy. The main industry-related features are described, as the multiple business units referring to Fashion firms, the different market segments and the CSFs. A focus on luxury industries has been provided, because one of the aim of this study is to perform a cross-industry analysis within the Food and the Furniture industries: together with Fashion, the two sectors constitute the 3 Fs leading Made in Italy to its success.
The first step to reach the objective of the study and to answer the RQs has been a literature review. I tried to focus on product development and PLM researches

in the Fashion industry, but I have found a gap because of the lack of industry-specific analyses. Process and data management and initiatives improving product development are described just in general terms. The major part of the contributions from literature concerns PLM. Nevertheless, just few papers are based on analyses conducted in Fashion companies, giving a higher profile to studies in automotive and machinery industries. Coming to the literature devoted to the luxury industries, the main contribution is in terms of strategies and CSFs. Processes, information management and the need for PLM are still underexplored in luxury settings and, of course, also in Food and Furniture companies.
The gap identified in literature and the willingness to answer the RQs, have entailed the development of case study analyses. In the Methodology Chapter, I have described the reasons behind the choice of such a research strategy. The purpose has been both exploratory and explanatory. I have conducted single, in-depth case studies in a wide time window (almost 24 months), and multiple case studies, carried out in 3-8 months. Table 2 summarizes the main research topics and the methodology used to obtain the results. Interviews, interactions, questionnaire administration and archival sources have been mixed to perform triangulation.
I have identified a sample of ten companies, eight of which belonging to the Fashion industry and the remainders to Food and Furniture sectors (see Table 3). A within-case analysis has allowed to describe each single setting and then cross-case patterns have been helpful to compare the cases basing on their main CSFs, namely quality and TTM, in a positioning map (see Figure 4). The major part of the cases belong to the luxury market segment (cases 1, 2, 3, 8, 9 and 10) and is paying huge attention to quality; but I have also analysed middle (cases 4, 5 and 7) and low-end companies (case 6).
Then, I have answered to each RQ, thanks to the previously described methodology. The following conclusions can be remarked:

- The **strategies** that are adopted by Fashion companies have been classified in different ways: trend leader vs. trend follower, price strategies, market strategies (luxury, prêt-à-porter, diffusion, bridge, mass), merchandise strategies (few main collections, many capsule collections and frequently refreshed collections), product strategies (heritage/classic, style, innovation, mass), production strategies (make or buy) and distribution strategies (exclusivity, availability and mass).
  Moreover, the most common **business model** is MTO: the firms wait to collect the great part of orders before to let the production started. Luxury companies are also equipping this business model with MTM, ensuring the customer to meet exclusive and tailor-made products. Whereas, low-end companies are opting for the fast fashion business model, typical of companies that are able to streamline their processes and drastically reduce lead times and TTM.

- The Fashion **products** have to be properly identified and coded. In order to populate the BOMs with a list of materials and also to design a data model fitting the industry-specific needs, the product structure is identified. Product complexity, in Fashion companies, is due to several factors: seasonality, product typology, versioning, manufacturing techniques, presence of semi-finished goods and degree of craftsmanship/automation.
- The main tasks involved in the **PD process** are (RQ1): collection planning, prototyping, sampling, engineering, costing, collection show, order-entry and production. The improvement initiatives (RQ4) leverage on this process to achieve benefits in the overall SC. The use of OBS and business process modelling, allow to overview the process structure, the roles and responsibilities. The current and the future situations can be compared thanks to these maps, in order to have a comprehensive view of the enhancements' impacts.

  Measuring process performance is also crucial within these companies (RQ3). A list of PD KPIs has been provided to monitor and control the related tasks. Moreover, the main approaches to performance measurement in the Fashion SC are summarised in Figure 11 and best practices for PM have been analysed.
- **Information management** (RQ2) has supported the analysis of business processes. ICTs and data produced, as input and output, have been detailed in both the situations, before and towards PLM (see Figure 10). This research has allowed to understand the needs in terms of data model and to recognise the business objects that a PLM solution has to provide in order to satisfy industry-specific needs (see Table 4).
- **PLM** has two basic roles: a strategic one and an operative one.

  The PLM strategic initiative (RQ5) allows Fashion companies to effectively prepare the following implementation, sharing all the achievable benefits, identifying and educating the involved teams, communicating with them and ensuring a proper change management.

  A PLM project, as the operative side of a PLM initiative, can be decomposed in three main phases (RQ6): planning, implementation and adoption. During the planning stage, the Fashion companies decide the boundaries of the project in terms of processes and data and also select an appropriate PLM solution (see Table 5). In order to support this phase, with industry-specific consideration, I have designed a framework and analysed each related step (see Figure 16).

  The implementation phase is the core part of a PLM project, when users, PLM consultants, PLM vendor and managers are involved to configure the software and introduce several customizations. Even though the PLM solutions are ensuring more and more Fashion-oriented functionalities,

some requirements are still business-specific and require the intervention of the PLM vendor.

During the PLM adoption phase, users experience PLM and the IT team controls its performance (RQ7). A list of KPIs, classified basing on several categories (time, cost, quality, flexibility and infrastructure) is provided in Tables 7-11. Moreover, a comparison to the existing literature has been performed, trying to define the main guidelines to plan the PLM project, implement and adopt the solution (see Tables 12-14).

An analysis of the PLM maturity, triggered by the literature review, has allowed to assess the maturity levels and to customize them basing on the experience from the case study. The four maturity levels (Excel-based, PDM, PLM and extended PLM) have been matched with business models and strategies (Figure 26): the map is useful to support Fashion companies in benchmarking with competitors, to find opportunities for PLM vendors (niches for new solutions to be developed) and to underline the strategic role of PLM.

- A cross-industry analysis has been performed in **Food and Furniture companies**, in addition to the **Fashion** ones (RQ8). These companies share the same focus on product quality and consider product development as the most value-added process within their value chains.

  The tasks characterising this process have been analysed (see Figure 20) together with the most adopted ICTs (see Figure 21). An attempt of cross-fertilization has been discussed, with the aim to increase the competitiveness of the sectors.

  Another cross-industry analysis has concerned **PLM implementation in Food and Fashion industries** (RQ9). Processes, tasks, PLM functionalities and other software involved, have been examined in Figures 22 and 23. Similarities and differences have been thoroughly analysed in Tables 16 and 17.

I have also discussed the practical implications of this thesis, underlining the value of the process-oriented approach I have adopted, and the analyses I have conducted over the years.

Theoretical implications address the need to fill the research gap and to highlight industry-specific features, because of product and process complexities.

Since product development is linked with other activities along the SC, I have also discussed the implications on order and production management, basing on the multiple case study analyses (see Figure 25). Moreover, I have added a section related to IT implications, in order to underline the IT perspective and the related issues.

This research is improvable from many viewpoints, but two main elements strikes one immediately: one is related to methodology and the other one to PLM projects. In summary, generalizability can be enhanced, enlarging the sample.

Then, other PLM projects should be examined: PLM implementation through customised solutions and through other off-the-shelf software (I have implemented just one industry-specific PLM solution).

Further research focus

The first recommendation that emerges, lined-up with the conclusions, is to enlarge the sample, considering more cases belonging to the same industry. Other market segments and business models might be analysed in more depth, as FF and MTM. In addition, more companies belonging to Food and Furniture industries may be involved, to increase generalizability and validate the results of this manuscript.
Moreover, experiencing and reporting PLM projects with customised solutions and off-the-shelf software, different from the one already examined, could enhance the value of this thesis.
I would like to stress also new areas of investigation, as future research areas:

- **Lean product development within Fashion companies**
  Lean principles are ruling the Automotive industry and are spreading also in the most organized Fashion companies. Value Stream Mapping (VSM) is starting to be used to monitor and reduce the production lead time.
  Investigating which Fashion companies are more willing to adopt a Lean approach and how, constitute interesting insights.
- **Sustainability**
  Many Fashion companies are using this buzzword just for marketing reasons and it is still difficult to understand how sustainability is practiced within the sector, with clear performance measures for instance. An analysis of the real impact of sustainability on the Fashion SC and on the specific product development process could be considered.
- **Closed-loop PLM** (Beginning, Middle and End-of-Life management).
  Unfortunately, the actual state of PLM solutions (as I have participated to several software selections) allows Fashion companies to manage just the beginning of life (from concept to production). The successive phases related to the middle and the end of life (product use, support and retirement) are still not supported by PLM solutions. The main reason is that building interfaces with downstream IT tools is not easy, given also the youth of these industry-specific solutions. Closing the PLM loop in Fashion companies could be really interesting because merchandise planning might be fostered by after-sales considerations, ensuring a higher proximity to customer needs and increasing profits.
  To this aim, the PLM functional map will also consider 3D, Virtual Design, Digital Printing, Data Intelligence and Augmented Reality.

REFERENCES

Aiello, G. et al. 2015, "An international comparison of "Made in Italy" in the fashion, furniture and food sectors: An observational research study in France, Russia and The United Kingdom", *Journal of Global Fashion Marketing*, 6(2), pp. 136–149.

Alemanni, M. et al. 2008, "Key performance indicators for PLM benefits evaluation: The Alcatel Alenia Space case study", *Computers in Industry*, 59, pp. 833-841.

Ameri, F. and Dutta, D. 2005, "Product Lifecycle Management: Closing the Knowledge Loops", *Computer-Aided Design & Applications*, Vol. 2, No. 5, pp. 577-590.

Arsenyan, J., & Büyüközkan, G. 2016, "An integrated fuzzy approach for information technology planning in collaborative product development", *International Journal of Production Research* (Vol. 54). IFAC.

Ball, A., Ding, L., Patel, M., Mullineux, G. and Matthews, J. 2011, "Lightweight product lifecycle information management for small enterprises", *International Journal of Product Lifecycle Management*, Vol. 5, pp. 21-36.

Bandinelli, R., Rinaldi, R., Rossi, M., & Terzi, S. 2013, "New product development in the fashion industry: An empirical investigation of Italian firms", *International Journal of Engineering Business Management*, 5, 1–9.

Batenburg, R., Helms, R.W. and Versendaal, J. 2006, "PLM roadmap: stepwise PLM implementation based on the concepts of maturity and alignment", *International Journal of Product Lifecycle Management*, Vol. 1, pp. 333-351.

Bhardwaj, V. and Fairhurst, A. 2010, "Fast fashion: response to changes in the fashion industry", *The International Review of Retail, Distribution and Consumer Research*, Vol. 20, No. 1, pp.165–173.

Bhatt, G. D. 2001, "Knowledge management in organizations: examining the interaction between technologies, techniques, and people", *Journal of Knowledge Management*, 5(1): 68-75.

Bokinge, M. and Malmqvist, J. 2012, "PLM implementation guidelines – relevance and application in practice: a discussion of findings from a retrospective case study", *International Journal of Product Lifecycle Management*, Vol. 6, No. 1.

Brun, A., & Castelli, C. 2008, "Supply chain strategy in the fashion industry: Developing a portfolio model depending on product, retail channel and brand", *International Journal of Production Economics*, 116(2), 169-181.

Brun, A., Caniato, F., Caridi, M., Castelli, C., Miragliotta, G., Ronchi, S., ... & Spina, G. 2008, "Logistics and supply chain management in luxury fashion retail: Empirical investigation of Italian firms", *International Journal of Production Economics*, 114(2), 554-570.

Brun, A., & Moretto, A. 2012, "Contract design and supply chain management in the luxury jewellery industry", *International Journal of Retail & Distribution Management*, 40(8), 607-628.

Brun, A. & Castelli, C. 2013, "The nature of luxury: A consumer perspective", *International Journal of Retail & Distribution Management*, vol. 41, no. 11-12, pp. 823-847.

Caniato, F., Caridi, M., Castelli, C., & Golini, R. 2011, "Supply chain management in the luxury industry: a first classification of companies and their strategies", *International Journal of Production Economics*, 133(2), 622-633.

Caniato, F., Caridi, M. and Moretto, A. 2013, "Dynamic capabilities for fashion-luxury supply chain innovation", International Journal of Retail & Distribution Management, Vol. 41 Nos 11/12, pp. 940-960.

Caniato, F., Caridi, M., Moretto, A., Sianesi, A., & Spina, G. 2014, "Integrating international fashion retail into new product development", *International Journal of Production Economics*, 147, 294-306.

Caniato, F., Crippa, L., Pero, M., Sianesi, A., & Spina, G. 2015, "Internationalisation and outsourcing of operations and product development in the fashion industry", *Production Planning & Control*, 26(9), 706-722.

Caro, F., & Martínez-de-Albéniz, V. 2015, "Fast fashion: business model overview and research opportunities", In *Retail Supply Chain Management*. Springer US.

Chen, H. H., Kang, H-Y, Xing, X., Lee, A. H. I. and Tong, Y. 2008, "Developing new products with knowledge management methods and process development management in a network", *Computers in Industry*, Vol. 59, pp. 242–253.

Christopher, M. 2000, "The agile supply chain: competing in volatile markets", *Industrial marketing management*, 29(1), 37-44.

Christopher, M., & Towill, D. R. 2002, "Developing market specific supply chain strategies", *The international journal of logistics management*, 13(1), 1-14.

Christopher, M., Lowson, R. and Peck, H. 2004, "Creating agile supply chains in the fashion industry", *International Journal of Retail & Distribution Management*, Vol. 32 No. 8, pp. 367-376.

Dale, B.G., Elkjaer, M.B.F., van der Wiele, A., Williams, A.R.T. 2001, "Fad, fashion and fit: an examination of quality circles, business process re-engineering and statistical process control", *International Journal of Production Economics,* pp. 137-152.

D'Amico, S., Giustiniano, L., Nenni, M. E. and Pirolo, L. 2013, "Product Lifecycle Management as a Tool to Create Value in the Fashion System", *International Journal of Engineering Business Management*, Vol.5.

d'Avolio, E., Bandinelli, R., Pero, M., Rinaldi, R. 2015a, "Exploring replenishment in the luxury fashion Italian firms: evidence from case studies", *International Journal of Retail & Distribution Management*, Vol. 43 Iss 10/11 pp. 967 – 987.

d'Avolio, E., Bandinelli, R. & Rinaldi, R. 2015b, "Towards PLM maturity assessment in the fashion industry", *Proceedings of the Summer School Francesco Turc*o, pp. 118.

d'Avolio, E., Bandinelli, R. and Rinaldi, R. 2015c "Improving new product development in the fashion industry through product lifecycle management: a descriptive analysis", *International Journal of Fashion Design, Technology and Education*, Vol. 8, No. 2, pp.108–121.

d'Avolio, E., Bandinelli, R., & Rinaldi, R. 2015d, "How Product Development Can Be Improved in Fast Fashion Industry: An Italian Case". In *IFIP International Conference on Product Lifecycle Management* (pp. 718-728). Springer, Cham.

d'Avolio, E., Bandinelli, R., & Rinaldi, R. 2016a, "Product Development and PLM Performance Measures: A Multiple-Case Study in the Fashion Industry". In *IFIP International Conference on Product Lifecycle Management* (pp. 399-410). Springer, Cham.

d'Avolio, E., Bandinelli, R. & Rinaldi, R. 2016b, " PLM implementation and adoption features: From theory to practice in two high fashion companies", *Proceedings of the Summer School Francesco Turco*.

De Leeuw, S. and Fransoo, J. 2009, "Drivers of close supply chain collaboration: one size fits all?", *International Journal of Operations & Production Management*, Vol. 29 No. 7, pp. 720-739.

Doyle, S. A., Moore, C. M., & Morgan, L. 2006, "Supplier management in fast moving fashion retailing", *Journal of Fashion Marketing and Management: An International Journal*, 10(3), 272-281.

Easey, M. 2009, "Fashion marketing", *John Wiley &Sons*. ISBN 978-1-4051-3953-3.

Eisenhardt, K. M., 1989, "Building theories from case study research", *Academy of management review*, 14(4), pp. 532-550.

Garetti, M., Terzi, S., Bertacci, N. and Brianza, M. 2005, "Organizational change and knowledge management in PLM implementation", *International Journal of Product Lifecycle Management*, Vol. 1, No. 1.

Gecevska, V., Chiabert, P., Anisic, Z., Lombardi, F., & Cus, F. 2010, "Product lifecycle management through innovative and competitive business environment", *Journal of Industrial Engineering and Management*, 3(2), 323-336.

Goworek, H. 2010, "An investigation into product development processes for UK fashion retailers: A multiple case study", *Journal of Fashion Marketing and Management: An International Journal,* 14(4), 648-662.

Hans, C., Hribernik, K. A. and Thoben, K.-D. 2010, "Improving Reverse Logistics Processes Using Item-level Product Lifecycle Management", *International Journal of Product Lifecycle Management*, Vol. 4, No. 4, pp. 338-359.

Harrop, M. 2016, "The Internet of Things issue", *WhichPLM Report*, 6th Edition, England.

Heine, K. 2010, "The personality of luxury fashion brands", *Journal of Global Fashion Marketing*, vol. 1, no. 3, pp. 154-163.

Hines, P., Francis, M., & Found, P. 2006, "Towards lean product lifecycle management: a framework for new product development", *Journal of Manufacturing Technology Management*, 17(7), 866-887.

Hovmøller, H., & Tambo, T. 2014, "Fashion Retail Master Data Model and Business Development". In *Proceedings for the 4th Nordic Retail and Wholesale Conference. Nordic Retail and Wholesale Association*.

Huang, G.Q. and Mak, K.L. 1998, "Re-engineering the product development process with "design for X"", *Proceedings of The Institution Of Mechanical Engineers, Part B: Journal Of Engineering Manufacture*, v. 212 n. 4, 259-268.

Jang, N., Dickerson, K. G., & Hawley, J. M. 2005, "Apparel product development: measures of apparel product success and failure", *Journal of Fashion Marketing and Management: An International Journal*, 9(2), 195-206.

Kapferer, J. N. 2014, "The artification of luxury: From artisans to artists", *Business Horizons*, 57(3), 371-380.

Kapferer, J. N. and Michaut, A. 2016, "Pursuing the Concept of Luxury", *Journal of International Marketing Strategy,* pp. 6-23.

Kaur, A. and Sharma, M. 2011, "Computer-aided Product Life Management (PLM): An Indispensable Tool for Fashion and Apparel Industry", *Journal of the Textile Association*, Vol. 72, No. 2, pp. 109-112.

Kiritsis, D., Bufardi, A. and Xirouchakis, P. 2003, "Research issues on product lifecycle management and information tracking using smart embedded systems," *Adv. Eng. Informatics*, vol. 17, no. 3–4, pp. 189–202.

Laroche, F., Bernard, A., & Hervy, B. 2015, "DHRM: A new model for PLM dedicated to product design heritage", *CIRP Annals-Manufacturing Technology*, 64(1), pp. 161-164.

Le Duigou, J., Bernard, A., & Perry, N. 2011, "Framework for product lifecycle management integration in small and medium enterprises networks", *Computer-Aided Design and Applications*, 8(4), pp. 531-544.

Le Duigou, J., Bernard, A., Perry, N. and Delplace, J.-C. 2012, "Generic PLM system for SMEs: Application to an equipment manufacturer", *International Journal of Product Lifecycle Management*, Vol. 6, No. 1, pp. 51-64.

MacCormack, A., Verganti, R., & Iansiti, M. 2001, "Developing products on "internet time": The anatomy of a flexible development process", *Management Science*, 47(1), 133–150.

Matsokis, A., & Kiritsis, D. 2010, "An ontology-based approach for Product Lifecycle Management*", Computers in industry*, 61(8), pp. 787-797.

Miles, M. & Huberman, A.M. 1984, "Qualitative Data Analysis", *Sage Publications*, Beverly Hills, CA.

Oh, W. & Pinsonneault, A. 2007, "On the assessment of the strategic value of information technologies: Conceptual and analytical approaches", *MIS Quarterly: Management Information Systems*, vol. 31, no. 2, pp. 239-265.

Osterwalder, A., Pigneur, Y., & Tucci, C. L. 2005, "Clarifying business models: Origins, present, and future of the concept", *Communications of the association for Information Systems*, 16(1), 1.

Pol, G., Merlo, C., Legardeur, J. and Jared, G. 2008, "Implementation of collaborative design processes into PLM systems", *International Journal of Product Lifecycle Management*, Vol. 3, No. 4, pp. 279-294.

Porter, M. E. 2008, "Competitive advantage: Creating and sustaining superior performance", *Simon and Schuster*.

Rachuri, S., Subrahmanian, E., Bouras, A., Fenves, S. J., Foufou, S., & Sriram, R. D. 2008, "Information sharing and exchange in the context of product lifecycle management: Role of standards", *Computer-Aided Design*, 40(7), 789-800.

Saunders, M. N.K., Thornhill, A., Lewis, P. 2009, "Research Methods for Business Students - 5th Edition", *Pearson Education Limited*, ISBN 978-0-273-71686-0.

Saviolo, S., & Testa, S. 2005, "Le imprese del sistema moda. Il management al servizio della creatività", *Etas Libri*. ISBN 88-453-1303-4.

Schuh, G., Rozenfeld, H., Assmus, D., & Zancul, E. 2008, "Process oriented framework to support PLM implementation", *Computers in industry*, 59(2), pp. 210-218.

Segonds, F. et al. 2011, "PLM and design education: a collaborative experiment on a mechanical device", *8th International Conference on Product Lifecycle Management*. Vol. 11.

Segonds, F., Nelson, J. and Aoussat, A. 2012, "PLM and architectural rehabilitation: a framework to improve collaboration in the early stages of design", *International Journal of Product Lifecycle Management*, pp. 1-19.

Segonds, F., Mantelet, F., Maranzana, N. and Gaillard, S. 2014, "Early stages of apparel design: how to define collaborative needs for PLM and fashion?", *International Journal of Fashion Design*, Technology and Education, Vol.7, Issue 2.

Shafer, S. M., Smith, H. J., & Linder, J. C. 2005, "The power of business models", *Business horizons*, 48(3), 199-207.

Siguaw, J.A., Enz, C.A. & Namasivayam, K. 2000, "Adoption of information technology in U.S. hotels: Strategically driven objectives", *Journal of Travel Research*, vol. 39, no. 2, pp. 192-201.

Silventoinen, A., Pels, H.J., Kärkkäinen, H., Lampela, H. 2011, "Towards future PLM maturity assessment dimensions", *PLM11 - 8th International Conference on Product Lifecycle Management*, pp. 480-492.

Simatupang, T. M., Victoria Sandroto, I., & Hari Lubis, S. B. 2004, "Supply chain coordination in a fashion firm", *Supply Chain Management: An International Journal*, 9(3), 256-268.

Stark, J. 2015, "Product Lifecycle Management: 21st Century Paradigm for Product Realisation", 3rd ed., *Springer International Publishing Switzerland*.

Stevenson, M. and Spring, M. 2007, "Flexibility from a supply chain perspective: definition and review", *International Journal of Operations & Production Management*, Vol. 27 No. 7, pp. 685-713.

Subrahmanian, E., Rachuri, S., Fenves, S. J., Foufou, S. and Sriram, R. D. 2005, "Product lifecycle management support: a challenge in supporting product design and manufacturing in a networked economy", *International Journal of Product Lifecycle Management*, Vol. 1, No. 1, pp. 4-25.

Terzani, S. 2007, "Controllo di gestione nelle imprese di alta moda", *FrancoAngeli,* ISBN 9788846496089.

Terzi, S., Bouras, A., Dutta, D., Garetti, M. and Kiritsis, D. 2010, "Product lifecycle management – from its history to its new role", *International Journal of Product Lifecycle Management*, Vol. 4, No. 4, pp. 360–389.

Tran, Y., Hsuan, J., & Mahnke, V. 2011, "How do innovation intermediaries add value? Insight from new product development in fashion markets", *R&D Management*, 41(1), 89–91.

Trkman, P. 2010, "The critical success factors of business process management", *International journal of information management*, 30(2), 125-134.

Tyler, D., Heeley, J. and Bhamra, T. 2006, "'Supply chain influences on new product development in fashion clothing", *Journal of Fashion Marketing and Management: An International Journal*, Vol. 10, No. 3, pp.316–328.

Tynan, C., McKechnie, S., & Chhuon, C. 2010, "Co-creating value for luxury brands", *Journal of Business Research*, 63(11), 1156-1163.

Urwin, E. N., & Young, R. I. M. 2014, "The reuse of machining knowledge to improve designer awareness through the configuration of knowledge libraries in PLM", *International Journal of Production Research*, 52(2), 595–615.

Van Hoek, R.I., Harrison, A. and Christopher, M. 2001, "Measuring agile capabilities in the supply chain", *International Journal of Operations & Production Management*, Vol. 21 Nos 1/2, pp. 126-147.

Verhagen, W. J.C., Bermell-Garcia, P., van Dijk, R. E.C. and Curran. R. 2012, "A critical review of Knowledge-Based Engineering: An identification of research challenges", *Advanced Engineering Informatics*, Vol. 26, pp. 5–15.

Vezzetti, E., Violante, M.G., Marcolin, F. 2014, "A benchmarking framework for product lifecycle management (PLM) maturity models", *International Journal of Advanced Manufacturing Technology*, Vol.7, pp. 899–918.

Vezzetti, E., Alemanni, M., and Macheda, J. 2015, "Supporting product development in the textile industry through the use of a product lifecycle management approach: a preliminary set of guidelines", *The International Journal of Advanced Manufacturing Technology*, pp. 1-12.

Voss, C., Tsikriktsis, N. and Frohlich, M. 2002, "Case research in operations management", *International journal of operations & production management*, 22(2), pp. 195-219.

Walley, K., Custance, P., Copley, P. & Perry, S. 2013, "The key dimensions of luxury from a UK consumers' perspective", *Marketing Intelligence and Planning*, vol. 31, no. 7, pp. 823-837.

Wu, Z. Y., Ming, X. G., Wang, Y. L., & Wang, L. 2014, "Technology solutions for product lifecycle knowledge management: framework and a case study", *International Journal of Production Research*, 52(21), 6314–6334.

Yin, R.K. 1984, "Case Study Research: Design and Methods", *Sage Publication*, Thousand Oaks, CA.

Yousnadj, D., Jouanne, G., Maranzana, N., Segonds, F., Bouchard, C., & Aoussat, A. 2014, "Integration of environmental assessment in a PLM context: a case study in

luxury industry", In *IFIP International Conference on Product Lifecycle Management*. Springer, Berlin, Heidelberg.

APPENDICES

APPENDIX 1 - MINUTE MEETING TEMPLATE

Date: _____

Process Owner (Surname & First Name): _____

Department	Raw Materials
People	7
IT solutions	Office Automation, PLM
Process	Material development
Product type	Skins and fabrics

Main tasks

Other tasks

Information management

Issues

APPENDIX 2 - PRODUCT DEVELOPMENT AND SUPPLY CHAIN KPIs- QUESTIONNAIRE

INTRODUCTION

Dear,

The aim of this questionnaire is to collect data in order to identify the most adopted performance measures in fashion supply chain. It is the first questionnaire distributed to fashion companies, modelling industry specific key performance indicators (KPIs) and including the link with corporate strategic goals.

Please complete the sections with your data, as it is fundamental in the analysis of the results.

All data collected, in accordance with law 196/2003, will be used only for statistical purposes, to which your business will surely enjoy.

Companies that participate to the survey will be provided with a report in digital format. It will contain the results and the positioning of each company compared to the sample of companies analysed.

PRIVACY

Under Law 196/2003 the information you provide will be used only for statistical purposes in compliance with the privacy law in force.

THANKS FOR YOUR COLLABORATION

Respondent information

Name:……..
Surname:……
Company:……...
Role:……

Supply Chain Performance Measures

1. Background

a) Which of the following activities are manged and controlled by the company? Please check the corresponding box

- ☐ Product Development
- ☐ Purchase (materials)
- ☐ Production
- ☐ Distribution
- ☐ Retail channel
- ☐ Wholesale channel
- ☐ E-commerce channel

b) Please indicate the number of Stock Keeping Units (SKUs) managed by the company

c) Which is the positioning of the brand in the following range?

- ☐ Luxury
- ☐ Diffusion
- ☐ Bridge
- ☐ Mass

2. Importance and utilisation of performance measures

In the following tables, the main industry-specific performance measures are listed basing on the process they support. Please fill-out the tables as specified below:

- In the column "Use" write *Y* if the corresponding KPI is employed within the company or *N* if not

If the Use is=Y, then complete the other fields:

- In the column " Importance " specify the degree of importance of the indicator, according to this scale:
  1. Not important
  2. Low importance
  3. Important
  4. Very important
- In the column "Business Unit owner" write for each measure the BU/Department that is in charge to measure and control the corresponding KPI
- In the column "ICT" write the typology of ICT tool adopted in order to store and monitor the corresponding KPI
- For each process also indicate the additional performance measures (in the " Other " row) typical of your business or your industry, specifying its importance

PRODUCT DEVELOPMENT KPIs	**Use** (Y/N)	**Importance** (1/2/3/4)	**Business Unit Owner** (Product Development/Purchase/Production/Distribution/Finance…)	**ICT** (Office automation/ PDM/PLM/ERP/CRM/BI …)
Human resources (FTE) - Design				
Human resources (FTE) - Product Development				
Human resources (FTE) - Modelling				
Human resources (FTE) - Prototyping				
Prototypes annual cost				
Samples annual cost				
Number of fabrics (FW)				
Number of fabrics (SS)				
Number of colours (FW)				
Number of colours (SS)				
Number of planned models (briefing)				
Number of final models (briefing)				
Prototype Cost/Production Cost				
Sample Cost/Production Cost				
Fitting costs/ Production cost				
Compliance with Marketing Brief (Planned models/Final models)				
Compliance with the product engineering schedule (time to encode products /scheduled time to encode products) (FW)				

Compliance with the product engineering schedule (time to encode products /scheduled time to encode products) (SS)				
Number of fitting sessions (FW)				
Number of fitting sessions (SS)				
Product typology (% carry over and new models)				
Other:				

SOURCING KPIs	**Use** (Y/N)	**Importance** (1/2/3/4)	**Business Unit Owner** (Product Development/Purchase/Production/Distribution/Finance …)	**ICT** (Office automation/ PDM/PLM/ERP/CRM/BI…)
Supplier lead time				
Supplier pricing against market				
Supplier delivery performance				
Ability to respond to demand variations				
Extent of mutual planning cooperation with suppliers				
Satisfaction with supplier relationship				
Satisfaction with knowledge transfer with suppliers				
Information availability				
Information accuracy				
Information timeliness				
Other:				

PRODUCTION KPIs	**Use** (Y/N)	**Importance** (1/2/3/4)	**Business Unit Owner** (Product Development/Purchase/Production/Distribution/Finance …)	**ICT** (Office automation/ PDM/PLM/ERP/CRM/BI…)
Human resources and equipment cost				
Manufacturing Cost				
Manufacturing lead time				
Work in process				
Number of SKU				
Manufacturing flexibility				
Human resources productivity				
Percentage of defects				
Resources utilization				
Capacity utilisation				
Other:				

DISTRIBUTION KPIs	**Use** (Y/N)	**Importance** (1/2/3/4)	**Business Unit Owner** (Product Development/Purchase/Production/Distribution/Finance …)	**ICT** (Office automation/ PDM/PLM/ERP/CRM/BI…)
Inventory cost				
Inventory obsolescence cost				
Total cost of transportation				
Inventory turnover ratio				
Delivery Lead Time				
Customer response time				
Number of on-time deliveries				
Percentage of urgent deliveries				
Percentage of wrong deliveries (in the product typology)				

Number of shipping errors				
Logistics efficiency				
Logistics flexibility				
Other:				

RETAIL KPIs	**Use** (Y/N)	**Importance** (1/2/3/4)	**Business Unit Owner** (Product Development/Purchase/Production/Distribution/Finance …)	**ICT** (Office automation/ PDM/PLM/ERP/CRM/BI…)
Sales				
Number of stockout				
Number of backorder				
Number of lost sales				
Customer satisfaction				
Product substitute percentage				
Sell-through (%)				
Rate of sales in new products				
Level of customer perceived value of product				
Flexibility of service system to meet particular customer needs				
Extent of mutual planning cooperation with retailers				
Other:				

GOVERNANCE KPIs	**Use** (Y/N)	**Importance** (1/2/3/4)	**Business Unit Owner** (Product Development/Purchase/Production/Distribution/Finance …)	**ICT** (Office automation/ PDM/PLM/ERP/CRM/BI…)
ROI				
Profit				
Ebit/ebitda				
Market share				
Fill rate				
Cash-to-cash cycle time (CCNc)				
Accuracy of forecasting techniques				
Forecasting volatility				
Total supply chain management cost				
Number of new products launched				
Number of new supply chain technologies used				
Other:				

3. KPIs and strategies

In your opinion, which benefits are achievable through the identification of proper KPIs?

- ☐ Identification of improvement areas within SC
- ☐ Support to complexity management within SC
- ☐ Alignment of process management with strategic goals
- ☐ Comparison with the main competitors
- ☐ Motivation of the human resources involved in the processes
- ☐ Other:_____
  _____

We have listed some Critic Success Factors (CSFs) to compete in the fashion industry. Which ones are the most important in your company?

☐ Time to Market
☐ Products' quality
☐ Innovation
☐ Costs minimization
☐ Human resources
☐ Craftsmanship
☐ Exclusivity (finished product and raw materials)
☐ Brand reputation
☐ Other:……

Do you think that the employed performance measures are aligned with Critic Success Factors?

4. Critical issues and future actions

Which are the main issues that the company has to face in measuring performances?

☐ Issues in calculating the indicator
☐ Issues in understanding the value of the indicator and translating it into a feedback for the company
☐ Issues in identifying criteria to select indicators for disagreement in BUs
☐ Issues in identifying indicators representing long-term objectives
☐ Issues in updating the indicators whenever the economic environment change
☐ Issues in identifying the most suitable indicators for business units' evaluation
☐ Lack of the organizational and cultural attitude to measure performances

Which actions should be undertaken, in your opinion, in order to improve the performance measurement system?

APPENDIX 3 - DATA FROM CROSS-INDUSTRY ANALYSIS IN LUXURY COMPANIES

FASHION COMPANY				
CSFs	**Process**	**Department**	**IT**	**Issue**
quality	Collection planning	Merchandise	PLM	communication
timing	Prototype design	Product Development	Creative solution	timing
innovation	Prototype development	Product Development	PLM, Creative solution	timing
costs	Prototype manufacturing	Production	Office Automation	quality, timing
heritage of craftsmanship	Prototype fitting	Product Development	PLM, Creative solution	timing

global reputation of the brand	Product details	Product Development	PLM	timing
recognizable style and design	Material development	Material Research	PLM	quality, timing
association with a country of origin	Sample development	Product Development	PLM	timing
creation of a lifestyle	Sample manufacturing	Production	ERP	quality, timing
	Collection review	Merchandise	PLM	communication
	Costing	Costing	PLM	communication
	Technical analysis	Engineering	PLM	timing
	Engineering	Engineering	PLM, Creative solution	timing

	Collection show	Merchandise	PLM, Creative solution	communication
	Order entry	Production	ERP	timing
	Production	Production	ERP	quality, timing

FURNITURE COMPANY				
CSFs	**Process**	**Department**	**IT**	**Issue**
quality	Collection planning/customer acquisition	Sales	Office Automation	Planning, IT
timing	Order entry	Customer Service	Office Automation	communication, IT
heritage of craftsmanship	Prototype design	Product Development	CAD	timing
uniqueness	Prototype development	Product Development	CAD	timing

association with a country of origin	Product details	Product Development	ERP	timing
creation of a lifestyle	Material development	Product Development	CAD	timing
innovation	Material supply	Operations	Office Automation	timing, quality, IT
costs	Material Quality Control	Logistics	ERP	quality
	Material storage	Logistics	ERP	timing
	Costing	Operations	ERP	communication
	Engineering	Operations	CAD, Office Automation	communication
	Packaging design	Product Development	CAD, Office Automation	timing

	Packaging manufacturing	Product Development	Office Automation	timing, quality
	Production	Production	ERP	quality, timing
	Quality control	Operations	ERP	quality
	Packing	Logistics	ERP	timing

FOOD COMPANY				
CSFs	**Process**	**Department**	**IT**	**Issue**
quality	Marketing analysis	Marketing	Office Automation	IT
global reputation of the brand	Product features definition	Marketing/R&D	Office Automation	IT, communication
association with a	Idea feasibility analysis	Marketing/R&D/Finance	Office Automation	IT, communication

country of origin				
exclusivity	Recipe Development	R&D	Office Automation	IT
costs	Recipe test and feasibility	R&D	Office Automation	Quality, IT
innovation	Prototype design	R&D/Operations	CAD	timing
timing	Prototyping development	R&D/Operations	CAD	timing
	Product feasibility	R&D	Office Automation	Quality, IT
	Suppliers selection	Purchasing	ERP	Quality, IT
	Engineering	Operations	Office Automation	timing
	Industrial tests	Operations	ERP	Quality, IT
	Quality tests	R&D/Operations	ERP	Quality, IT

	Transportation tests	Logistics	ERP	Quality, IT
	Quantitative tests	R&D/Operations	ERP	Quality, IT
	Check issues related to a small production	Operations	ERP	Quality, IT
	Production	Operations	ERP	timing

APPENDIX 4 - LIST OF THE AUTHOR'S CONTRIBUTIONS

Proceedings

1. Bandinelli, R., d'Avolio, E., Rossi, M., Terzi, S., & Rinaldi, R. (2014, July). Assessing the Role of Knowledge Management in the New Product Development Process: An Empirical Study. In IFIP International Conference on Product Lifecycle Management (pp. 397-406). Springer, Berlin, Heidelberg.
2. d'Avolio, E., Bandinelli, R., & Rinaldi, R. (2015, October). How Product Development Can Be Improved in Fast Fashion Industry: An Italian Case. In IFIP International Conference on Product Lifecycle Management (pp. 718-728). Springer, Cham.
3. d'Avolio, E., Bandinelli, R., & Rinaldi, R. (2016, July). Product Development and PLM Performance Measures: A Multiple-Case Study in the Fashion Industry. In IFIP International Conference on Product Lifecycle Management (pp. 399-410). Springer, Cham.
4. d'Avolio, E., Pinna, C., Bandinelli, R., Terzi, S., & Rinaldi, R. (2017, July). Analysing Product Development process and PLM features in the Food & Fashion industries. In IFIP International Conference on Product Lifecycle Management.
5. Rinaldi, R., d'Avolio, E., Pero, M., & Bandinelli, R. (2016). How do fashion companies manage performance measurement? Evidence from Italian companies. WIT Transactions on Engineering Sciences, 113, 405-412.
6. Bandinelli, R., d'Avolio, E., & Rinaldi, R. (2014, June). Assessing the maturity of collaborative networks: a case study analysis in the Italian fashion SMEs. In Engineering, Technology and Innovation (ICE), 2014 International ICE Conference on (pp. 1-9). IEEE.
7. d'Avolio, E., Bandinelli, R., & Rinaldi, R. (2013). A comparison between the management of the Open To Buy in the literature and in the Fashion Italian Industry. Proceedings of the Summer School Francesco Turco.
8. d'Avolio, E., Bandinelli, R., & Rinaldi, R. (2014). The need for Product Lifecycle Management (PLM) in the fashion industry: a case study analysis. Proceedings of the Summer School Francesco Turco.
9. d'Avolio, E., Bandinelli, R., & Rinaldi, R. (2015). Towards PLM maturity assessment in the fashion industry. Proceedings of the Summer School Francesco Turco, Issue Industrial Systems Engineering, 118-123.
10. d'Avolio, E., Bandinelli, R., & Rinaldi, R. (2016). PLM implementation and adoption features: from theory to practice in two high fashion companies. Proceedings of the Summer School Francesco Turco.

11. Pinna, C., d'Avolio, E., Bandinelli, R., Terzi, S., & Rinaldi, R. (2017) Product Development KPIs: a case study analysis in Food and Fashion companies. Proceedings of the Summer School Francesco Turco.
12. Bandinelli, R., d'Avolio, E., & Rinaldi, R. (2016). Advanced intermodal freight transportation system for sustainable city logistics: An application in fashion industry. WIT Transactions on Engineering Sciences, 113, 356-363.
13. Shao, J., Taisch, M., Ortega Mier, M. Á., & d'Avolio, E. (2014). Application of the DEMATEL method to identify relations among barriers between green products and consumers.

Journal

1. d'Avolio, E., Bandinelli, R., Pero, M., & Rinaldi, R. (2015). Exploring replenishment in the luxury fashion Italian firms: evidence from case studies. International Journal of Retail & Distribution Management, 43(10/11), 967-987.
2. d'Avolio, E., Bandinelli, R., & Rinaldi, R. (2015). Improving new product development in the fashion industry through product lifecycle management: a descriptive analysis. International Journal of Fashion Design, Technology and Education, 8(2), 108-121.
3. d'Avolio, E., Bandinelli, R., & Rinaldi, R. (2017). A process-oriented framework for PLM implementation in fashion companies. International Journal of Product Lifecycle Management, 10(3), 191-209.