Improving new product development in the fashion industry through product lifecycle management: A descriptive analysis

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Improving new product development in the fashion industry through product lifecycle management: a descriptive analysis

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New product development represents a core process within the fashion industry: it is a knowledge-intensive set of tasks that needs to be improved in order to enhance a company's competitive advantage. In this context, through product lifecycle management (PLM) product data are shared amongst the various actors and processes in the different phases of the product lifecycle. A descriptive exploratory research allows the authors to recognise the importance of PLM in the fashion industry, after an in-depth analysis of the existing literature. PLM includes modules supporting many industry-specific processes, reducing time-to-market, lead times and inventory. It is not just a product centric lifecycle-oriented business model, but it also represents a strategic approach that is spreading in the recent years also in a complex industry, as that of fashion.

Keywords: new product development; NPD; product lifecycle management; PLM; fashion supply chain

Introduction

Nowadays the fashion industry is facing lots of competitive issues: the need for a reduction in lead times, for product quality, for innovative materials and design, which have to perfectly fit in with the behaviour of a more and more exigent consumer.

These requirements have several supply chain (SC) implications. First of all fashion SCs have to be agile: agility is a business-wide capability that embraces organisational structures, information systems, logistics processes and, in particular, mind-sets (Christopher, 2000). Specifically, the agile SC is closely connected to end-user trends; it is also 'virtual' because it relies on shared information across all SC partners; it gains flexibility by using the strengths of specialist players and finally it is process aligned.

Fashion SC also requires closer cooperation between the subjects responsible for different processes. This aspect is particularly relevant, referring to the new product development (NPD) that is a dynamic process characterised by a high seasonal demand, due to the seasonal nature of fashion products (Bandinelli, Rinaldi, Rossi, & Terzi, 2013). In fact in this scenario, product development cycles are frequently updated, the degree of outsourcing is substantial and the use of innovation intermediaries is persuasive (Tran, Hsuan, & Mahnke, 2011).

In modern product development, as the complexity and variety of products increase, so does the need for knowledge and expertise for developing products. Co-located and monolithic design teams can no longer efficiently manage the product development effort in its entirety. In order to avoid lengthy product development cycles, higher development costs and quality problems, collaboration across distributed and multidisciplinary design teams has become a necessity (Ameri & Dutta, 2005). Today's knowledge-intensive product development environment requires a computational framework which effectively enables representation and reuse of product knowledge: this is the essence of product lifecycle management (PLM).

In such a context, PLM is a strategic approach to manage design, product data, product manufacture and marketing management. PLM technology promises quicker innovation in terms of creativity and technical design (Kaur & Sharma, 2011). In order to lead a firm to operate efficiently, effectively and innovatively, the PLM is advised for the execution of the NPD (Chen, Kang, Xing, Lee, & Tong, 2008). The PLM tools have been successfully adopted in the aerospace and automotive sectors, and in recent years their use has also been extended to other markets.

The aim of this paper is to analyse the PLM adoption in the fashion industry, highlighting the importance of the NPD process. An overview of the changing trends related to the PLM implementation has been provided to support academics, vendors of the main industry-specific solutions and managers in their PLM-oriented strategy.

This paper is organised as follows: in the second section, a first literature review has been performed in

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order to acknowledge the features of the NPD process in the fashion industry and to what extent other authors have focussed their attention on the usage of PLM. The third section reviews the goal of this study, individuating several research questions and describing the methodology adopted. A discussion of the main outcomes has been carried out in the fourth section, with particular attention to the industry-specific solutions, to the spread of PLM in each sector and to the advantages achievable thanks to this technology. Finally, the fifth section concludes with a summary and recommendations for future works.

Literature background

The fashion industry includes several peculiarities that impede its comparability to other sectors. Christopher, Lowson, and Peck (2004) individuated the key characteristics of the present fashion market: the short product lifecycles, the high volatility of the demand, its low predictability and the high impulse purchasing shown by consumers.

This 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, fashion ones change from one season to another and fads are eccentric products with a real short shelf-life.

In the following sub-sections, the topics of the NPD process in the fashion industry and the adoption of PLM have been widely analysed within the existing literature.

The NPD process in the fashion industry

Since 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). In this scenario, the NPD process represents a set of tasks carried out in the initial part of the fashion SC.

Many authors have performed in-depth analyses of this primary process in different industries, such as Bandinelli et al. (2013), Brown and Eisenhardt (1995), Eisenhardt Chen et al. (2008), Krishnan and Ulrich (2001), Lau, Hui, Ng, and Chan (2006), Parker (2000), Slater, Mohr, and Sengupta (2013), Tran et al. (2011), Tyler, Heeley, and Bhamra (2006), Van Kleef, Van Trijp, and Luning (2005), Zhang (2011) and Segonds, Mantelet, Maranzana, and Gaillard (2014). The focus of the present literature review will be on the fashion industry.

Bandinelli et al. (2013) have depicted NPD as a comprehensive process composed by the following tasks:

(1) design,
(2) modelling/prototyping,
(3) detailed engineering,
(4) material sourcing and
(5) production and distribution.

In particular, during the engineering phase the Bill of Material is created and the raw material purchase order has to be submitted quickly. Moreover, the decision as to what item has to be produced can change very rapidly during the period when fashion shows take place. In some companies, the engineering phase is completed for all the products before the beginning of the fashion fairs, permitting quick management of the sourcing activities, but overloading the engineering staff with activities that probably will not be valued, since the goods that will usually be produced are only a small percentage of all the items presented at the fashion shows.

The duration of the sourcing phase can change from two weeks to 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 need to be defined. The production phase usually lasts three to four months and starts when material sourcing is completed.

A more industry-specific classification has been proposed by Tran et al. (2011): the authors have investigated the role of innovation intermediaries within the NPD process in fashion markets. The research distinguishes five main tasks characterising the NPD process in the apparel industry: planning, concept development, detailed design, testing and production ramp-up. In Figure 1, the processes composing the fashion value chain have been illustrated and each activity has been detailed.

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 NPD process is concept development. During this stage, the fashion

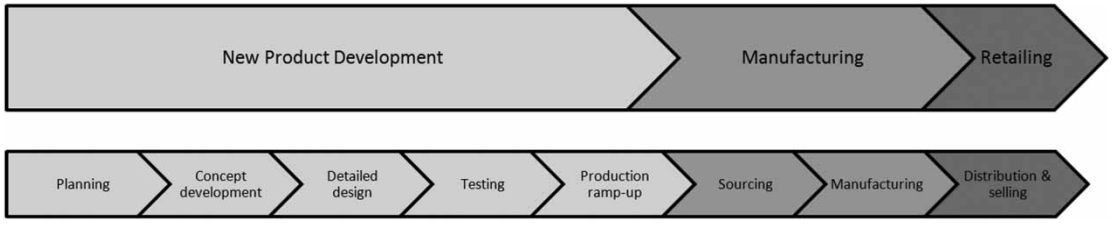

Figure 1. Processes and tasks in the fashion value chain.

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 NPD 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 NPD stage is production ramp-up. This is when the fashion companies evaluate the production output and send early promotional items and collections to the stores.

The existing literature does not just focus on the description of each activity carried out within the NPD processes: the inefficiencies related to this process and the need for collaboration are also stressed.

In particular, 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. Product development represents the major area for improvement. It is clear that timescales are long, there is much wasted effort and that communications between the different functions (design, production, marketing and sales) are poor. Some of the inefficiencies of the product development process emerge, often as a result of communication problems. Several weaknesses are highlighted, as inadequate product development, difficulties in design/production/marketing relationships, geographical separation and lack of customer focus.

Another important contribution to the literature is by Parker (2000), who investigated, through an exploratory research, the issue of collaboration in NPD in the South-African textile and clothing industry. Collaborative NPD is the cooperative relationship between firms aimed at innovation and the development of new products. The author indicates several critical factors in determining the success of a collaborative product development, such as the trust between collaborating partners, the frequent consultation between participants, that there is consultation between marketing and technical personnel and the sharing benefits between collaborators.

The impact of PLM

The growing importance of PLM has been pinpointed by several authors, such as Ameri and Dutta (2005), Ball, Ding, Patel, Mullineux, and Matthews (2011), Bokinge and Malmqvist (2012), Chen et al. (2008), D'Amico, Giustiniano, Nenni, and Pirolo (2013), Garetti, Terzi, Bertacci, and Brianza (2005), Hans, Hribernik, and Thoben (2010), Kaur and Sharma (2011), Kiritsis (2011), Le Duigou, Bernard, Perry, and Delplace (2012), Pol, Merlo, Legardeur, and Jared (2008), Segonds, Maranzana, Véron, and Aoussat (2011), Segonds, Nelson, and Aoussat (2012), Subrahmanian, Rachuri, Fenves, Foufou, and Sriram (2005), Terzi, Bouras, Dutta, Garetti, and Kiritsis (2010), Verhagen, Bermell-Garcia, van Dijk, and Curran (2012) and Zhang (2011).

In order to enhance a company's competitive advantage, the product development and introduction processes need to be improved.

The literature review of PLM includes a wide range of papers from the research area. The authors have established criteria to select the papers analysed: they focused on the most recent papers (2000–2014) that are concerned with four main understandings of PLM. The criteria used to select the papers to analyse were that they should be recent (2000–2014) and concerned with at least one of the following understandings of PLM:

(1) strategic business approach,
(2) software integrating other design and SC tools,
(3) knowledge management system and
(4) 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 NPD 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 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 retirement. 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 life cycle. 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 & Dutta, 2005).

Q2 From the ICT point of view, PLM can be defined as the 'connective tissue' that allows the connection of design software to production and SC management software, taking into account the dispersed nature of the extended and collaborative enterprise (Garetti et al., 2005). The value chain of product development is supported by the following software tools: CAD, CAPP (Computer-Aided process Planning) and CAPE (Computer-Aided Production Engineering). The manufacturing chain management process is underpinned by such tools as material requirement planning (MRP), advanced planning and scheduling (APS) and manufacturing execution system (MES). 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 enterprise resource planning (ERP) is the umbrella, bringing together MRP, APS and MES (and much more). More recently, 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 towards a full integration of all the software tools taking part in design and operational activities during a product life cycle. 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 SC management one.

Q3

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

The social process of knowledge sharing is one of the pillars of PLM culture. New knowledge, meant as an organised combination of meaningful data, emerges as the result of interplay between individual effort and social interactions. Employees' attitude to sharing knowledge is central to the success of knowledge management practices like PLM. PLM, as a corporate strategy, provides a formal framework for aggregations, organisation and dissemination of the intellectual assets of the company and constructs a non-replicable competitive strategy.

PLM knowledge base is not necessarily a physically centralised repository of knowledge, but it is an interconnected network of dispersed knowledge repertories which are virtually unified using IT solutions. PLM, as a knowledge management system, improves the learning capacity of the organisation and, consequently, increases the rate of knowledge accumulation in the corporate knowledge base. This enhances organisational performance through the creation, sharing and use of all types of knowledge that are critical for decision-making.

PLM implementation enables the companies to face both internal and external forces. From the first point of view, PLM improves competitiveness because (Ameri & Dutta, 2005):

- It encourages innovation: innovation relies on creativity and creativity is most likely to happen in open environments which facilitate inclusion of the best ideas. With a knowledge management system in place, product-related knowledge can be systematically shared among knowledge users.
- It provides customer intimacy: to ensure a rich and effective communication, the upstream and downstream flow of information between customers and manufacturer should be as seamless and direct as possible. Customers are valuable sources of knowledge since they are in close contact with the product and their ideas about possible improvements in the product can considerably help the design teams in modifying product features.
- It promotes operations excellence: one way to gain operational excellence is to reduce the waste both in the value chain activities and in the linkages among them. An environment characterised by systematic capture, management and dissemination of knowledge is required.

Coming to the external forces, PLM enables a decisive reaction to (Ameri & Dutta, 2005):

- Globalisation: collaboration of globally dispersed product development teams has become a common practice in most firms. In dispersed environments, knowledge management becomes more difficult

because sources of knowledge are not co-located. The presence of knowledge owners poses more challenges in the PLM initiatives.

- Product complexity: such products have often complex designs which in turn result in the formation of a complex development environment which is characterised by complex information structure and flow.
- Shrinkage in product lifecycle: with shrinkage in the length of product life, the product development process also has to become shorter.
- Push into the SC: major phases of the product life cycle, from conception to retirement, have been characterised by extensive outsourcing. Knowledge dissemination, as one of the core concepts of knowledge management, becomes a vital requirement for integrating suppliers into the design process.
- Environmental issues: due to increasing environmental regulations worldwide, companies are required to identify, evaluate and minimise the environmental impacts of their products over the lifecycle and to take the responsibility of retirement of their products once they become obsolete.

PLM in the fashion industry

Given the four perspectives of PLM listed in the previous section, an investigation of case studies or explorative researches in the fashion industry concerning PLM has 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 or SC strategy. Literature about PLM implementation in the fashion industry is not as rich as the ones dedicated to other sectors. It is devoted to a general description of industry-specific functionalities.

Şen (2008) reports that recently emerging PLM technologies are targeting to improve communications throughout the SC during the product development process. The primary benefit of these new technologies is shortening the concept-to-production cycle time, which is, on average, 26 weeks for the apparel and footwear industry. Moreover, PLM applications in this context allow SC partners to collaborate on product design over the Internet.

As stated by D'Amico et al. (2013), a PLM system, which would work in the fashion industry, should include the following elements contributing to the effective management of the entire product lifecycle:

- PDM;
- product structure management;
- configuration management;
- change management tracking;
- workflow management;
- catalogue library and
- SC management.

Considering the entanglement of such elements, the PLM can be very useful for fashion firms since it can help to handle the complexity by which they are characterised, in terms of:

- supply variability, which refers to the innovation degree of different supply components;
- supply variety, that is the number of products and their components (i.e. models, fabric, size and colour) within a specific collection;
- importance of the service provided by the fashion firm to the retailer: the growing complexity due to the range of supplies has an impact on the production cycle length and, consequently, on the level of the service provided and
- need to reduce lead time.

Cooperation and information sharing between the subjects involved, both inside and outside the production chain, are crucial to the development, manufacturing and distribution processes. Furthermore, a PLM system makes communication simpler for subjects working inside and outside the production chain and reduces the associated costs.

For rapid and intelligent working, PLM software is implemented in almost every well automated and growing fashion industry (Kaur & Sharma, 2011). More creative and rapid response to all seasonal apparels can be achieved with the software. Industry-specific PLM has features like design management, creative design, technical design, colour management and a new PDM module.

Methods

The aim of this study is to analyse the relevance of PLM implementation in the fashion industry through a descriptive exploratory research, based on interviews and other information from websites and industry-specific magazines. More and more PLM implementation projects are growing within the fashion industry, thanks to the increasing number of industry-specific tools and to a customised approach to their deployment. When a company decides to implement a PLM solution, inevitable impacts on business strategy, knowledge management, software integration and cultural aspects will arise. The previous section represented an overview of the existing literature concerning the main topic of this study. A lack in dissertations concerning the PLM adoption by the fashion companies has emerged, constituting the starting point to situate the following research questions:

RQ1: how widely have PLM technologies so far diffused through the fashion industry?
RQ2: what are the main peculiarities related to PLM implementation in the fashion industry?
RQ3: what are the benefits achievable through PLM implementation in the fashion industry?

In order to answer these questions, a precise methodology has been designed. The first step of the research framework has been a literature review concerning the main topic of the research, followed by an explorative research concerning the PLM adoption in the fashion industry. The results of the latter step have been used in order to answer RQ1. Last, a third step of the research framework, based on information collected through interviews, web-sites and specialised magazines, has been made in order to answer RQ2 and RQ3. A graphical representation of the framework is reported in Figure 2.

Regarding the first step, the existing literature has been analysed and classified: several papers have been individuated to introduce the topic and to acknowledge the state of the art of PLM implementation.

A classification has been provided in Table 1, based on the publishing year, the methodology employed and the topic. In addition, a detail of the field considered by the subject of the paper has been specified. The topic states the overall issue or the objectives of the paper and the methodology reports tools or procedure for identifying, delimitating and gathering the relevant literature. In particular, the survey-based researches have been typically exploratory ones and the model-based researches checked were essentially empirical analyses. The 44% of the papers analysed deal with the NPD topic and 60% concern the PLM theme.

Regarding the field, four main typologies have been individuated: a general field, which refers to dissertations about the topic without any industry-specific observation (mostly literature reviews); retailers and manufacturers and others represent two fields related, respectively, to the apparel and footwear industry and to the manufacturing area. The field named SME is devoted to the increasing importance of small and medium enterprises.

The last column is devoted to the description of the understanding of PLM in each paper, according to the four perspectives previously individuated (PLM as a strategic business approach, as a software integrating other design and SC tools, as a knowledge management system and as a culture generating solution).

Then, the reviewed papers have been categorised following the scheme presented in Table 2. For each field of analysis, every paper has been classified according to the methodology adopted and the topic. The number of papers has been reported in brackets per topic per methodology. A primary outcome has to be highlighted: while the NPD topic covers a varied range of methodologies, a large part of the papers about PLM adopts case study researches. This is due to the fact that the case study methodology is more suitable to focus on PLM implementation in one or more companies.

The authors have opted for a descriptive approach to improve generalisability of the results, without focussing on particular cases. Therefore, the second step of this research is represented by an exploratory research with the aim to describe the current state of PLM implementation in the fashion industry and to answer RQ1. Exploratory researches have the objective to gain preliminary insight on a topic and to become more familiar with it. In the preliminary stages, exploratory survey research can help to determine the concepts to be measured in relation to the

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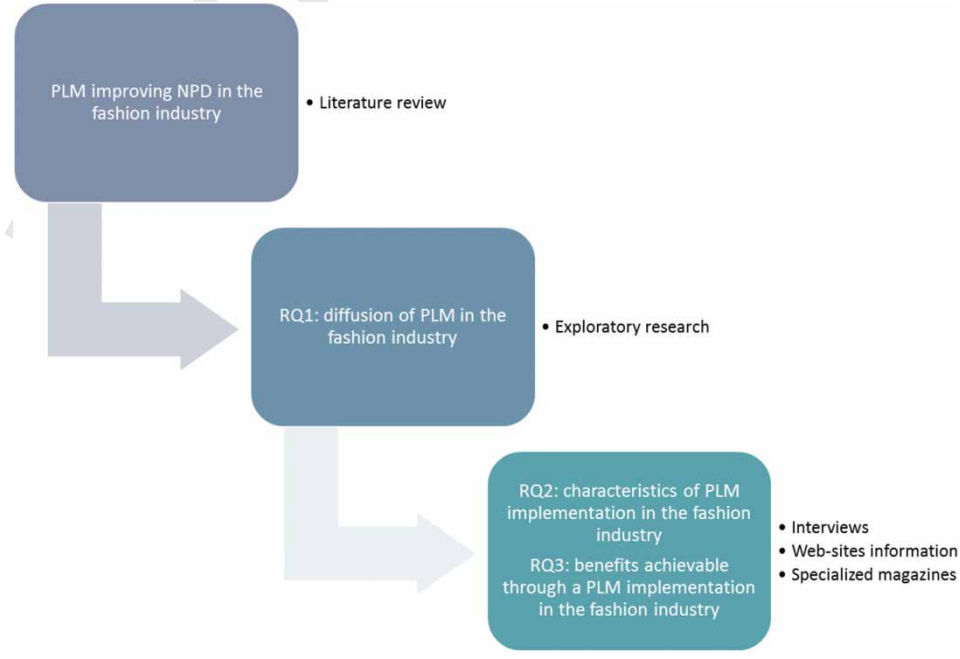

Figure 2. Research approach.

Q5 Table 1. Paper analysed.

First author	Paper name	Year	Employed methodology	Topic	Field	Understanding of PLM
Ameri	Product lifecycle management: Closing the knowledge loops	2005	Empirical analysis	PLM	Manufacturers and others	Strategic business approach, knowledge management system and culture-generating solution
Ball	Lightweight product lifecycle information management for small enterprises	2011	Empirical analysis	PLM	SME	Strategic business approach, software integrating other design and SC tools, knowledge management system
Bandinelli	New product development in the retailers' industry: An empirical investigation of Italian firms	2013	Empirical study	NPD	Retailers	
Bokinge	PLM implementation guidelines – relevance and application in practice: a discussion of findings from a retrospective case study	2012	Case study	PLM	Manufacturers and others	Strategic business approach, software integrating other design and SC tools, knowledge management system
Brown	Product development: past research, present findings and future directions	1995	empirical analysis	NPD	General	
Chen	Developing new products with knowledge management methods and process development management in a network	2008	Empirical analysis	NPD, PLM	General	Strategic business approach, knowledge management system
D'Amico	Product lifecycle management as a tool to create value in the retailers' system	2013	Empirical analysis	PLM	Retailers	Strategic business approach
Garetti	Organisational change and knowledge management in PLM implementation	2005	case Study	PLM	Manufacturers and others	Strategic business approach, software integrating other design and SC tools, knowledge management system
Hans	Improving reverse logistics processes using item-level product lifecycle management	2010	Case study	PLM	Manufacturers and others	Strategic business approach, software integrating other design and SC tools, knowledge management system
Kaur	Computer-aided product life management (PLM): An indispensable tool for retailers and the apparel industry	2011	Literature review	PLM	Retailers	Strategic business approach
Kiritsis	Closed-loop PLM for intelligent products in the era of the internet of things	2011	Empirical analysis	PLM	Manufacturers and others	Strategic business approach, software integrating other design and SC tools, knowledge management system
Krishnan	Product development decisions: A review of the literature	2001	Literature review	NPD	General	
Lau	A new fuzzy approach to improve retailers' product development	2006	Empirical analysis	NPD	General	
Le Duigou	Generic PLM system for SMEs: Application to an equipment manufacturer	2012	Case study	PLM	Manufacturers and others	Strategic business approach, software integrating other design and SC tools, knowledge management system
Parker	Interfirm collaboration and the new product development process	2000	Exploratory research	NPD	Retailers	

(*Continued*).

Table 1. (Continued)

First author	Paper name	Year	Employed methodology	Topic	Field	Understanding of PLM
Pol	Implementation of collaborative design processes into PLM systems	2008	case Study	PLM	SME	Software integrating other design and SC tools, knowledge management system
Segonds	PLM and design education: a collaborative experiment on a mechanical device	2011	case study	PLM	Manufacturers and others	Strategic business approach, Software integrating other design and SC tools, Knowledge management system
Segonds	PLM and architectural rehabilitation: A framework to improve collaboration in the early stages of design	2012	Case study	PLM	Manufacturers and others	Software integrating other design and SC tools, knowledge management system
Segonds	Early stages of apparel design: How to define collaborative needs for PLM and fashion?	2014	Case study	PLM	Retailers	Strategic business approach, software integrating other design and SC tools
Slater	Radical product innovation capability	2013	Empirical analysis	NPD	General	
Subrahmanian	Product lifecycle management support: A challenge in supporting product design and manufacturing in a networked economy	2005	Literature review	PLM	Manufacturers and others	Strategic business approach, software integrating other design and SC tools, knowledge management system
Terzi	Product lifecycle management – from its history to its new role	2010	Empirical analysis	PLM	Manufacturers and others	Strategic business approach, software integrating other design and SC tools, knowledge management system
Tran	How do innovation intermediaries add value? Insight from new product development in retailers' markets	2011	Case study	NPD	Retailers	
Tyler	Supply chain influences on new product development in retailers' clothing	2006	Case study	NPD	Retailers	
Van Kleef	Consumer research in the early stages of new product development: a critical review of methods and techniques	2005	Literature review	NPD	General	
Verhagen	A critical review of knowledge-based engineering: An identification of research challenges	2012	Literature review	PLM	General	Knowledge management system
Zhang	Requirement driven knowledge management system design to support automotive product development	2011	Exploratory research	NPD, PLM	Manufacturers and others	Knowledge management system

Table 2. Summary of the analysed papers.

Field of analysis/ methodology (Number of paper)	Case study	Empirical analysis	Exploratory research	Literature review
General		NPD (3)		NPD(3) **PLM(1)**
Manufacturers and others	**PLM(6)**	**PLM(2)**	NPD(1)	**PLM(1)**
Retailers	NPD(2)	NPD(1) **PLM(1)**	NPD(1)	**PLM(1)**
SME	**PLM(1)**	**PLM(1)**		

phenomenon of interest, how best to measure them and how to discover new facets of the phenomenon under study (Forza, 2002).

This research includes a number of related sub-processes: defining the sample, selecting the methods of data collection, pilot testing, collecting and analysing data.

The sample considered is composed of medium or large companies, established in the fashion industry for several years and having an international profile. Sampling overcomes the difficulties of collecting data from the entire population which can be impossible or prohibitive in terms of time, costs and other human resources. The sample size in exploratory researches has to be sufficient to include the range of the interest phenomena: in the present study a total of 441 companies has been involved.

Data can be collected in a variety of ways, in different settings and from different sources. Personal interviews and mailed questionnaires have been used at this stage. A pre-test questionnaire was submitted to industry experts to prevent the inclusion of some obvious questions and to improve its effectiveness. The authors tried to contact randomly a total of 500 companies and 441 confirmed their availability to respond (the response rate was about 88%). The list of the contacted companies has been identified based on the customers' references suggested by the main PLM vendors. In order to obtain a high number of feedback, the companies were asked to provide simple information:

- the business name;
- the PLM solution the company has implemented and the vendor's name;
- the geographical area where the company operates;
- the market segment the company belongs to and
- the company's core business (apparel, leatherwear, accessories and jewellery).

Moreover, within this sample, only few companies, less than 20, provided more information about their implementation projects. These cases, together with information gathered from websites and specialised magazines, allowed us to acknowledge the peculiarities related to PLM implementation in the fashion industry (RQ2) and the benefits they have achieved (RQ3).

Finally, the outcomes have been analysed and interpreted: the following section aims to discuss the results of the exploratory research.

Discussion

As previously discussed, it is very difficult in the fashion industry to achieve standardisation both in the process and in the product managed: creativity and ideas by fashion designers are translated in a less structured process, a fragmentation of the NPD process and, obviously, the resulting product will not ever be a commodity. In addition, this industry is characterised by different policies that are often district-specific or even company-specific. Information about product definition was no longer in a single location but was dispersed among various agents, each of whom had their own abstraction and conception of the product and its related information. Disintegration between people, information and processes was a major consequence.

This shortcoming triggered the need for a more comprehensive knowledge management solution which addresses all phases of the product life cycle from planning and conception to retirement and includes all stakeholders of the product. In fact, PLM aims at reintegrating the manufacturing organisation by closing all the knowledge loops and positioning the product at the focal point of the whole organisation (Ameri & Dutta, 2005).

The exploratory research has been designed to answer the three research questions, previously described. The information gathered from the literature review, concerning PLM in the fashion industry, are complemented and deepened. Q6

Diffusion of PLM in the fashion industry

The first RQ investigates the spread of PLM technologies in the fashion industry. During the exploratory research, the companies interviewed were classified based on the industry sector they belong to (apparel, leatherwear, accessories and jewellery), on the market segment (Saviolo & Testa, 2005) and on the geographic area.

First, an attribution of each firm to each market segment and industry sector was carried out. As represented in Table 3 a company may be associated with more than one category: it may belong to more than one market segment and industry sector (e.g. a company could sell leatherwear and accessories for the diffusion and bridge sectors). The major part of the sample is composed of apparel and accessories firms, especially belonging to the medium–low price range.

Then, to each company its PLM vendor was attributed: the vendors' names cannot be showed in this study because of privacy reasons but a brief overview of the results may be pinpointed.

Table 3. Sample classification based on industry sector and market segment.

	Apparel	Leatherwear	Accessories	Jewellery
High fashion	3	4	4	0
Prêt-à-porter	48	8	43	24
Diffusion	105	4	89	15
Bridge	172	0	144	15
Mass	132	1	141	5

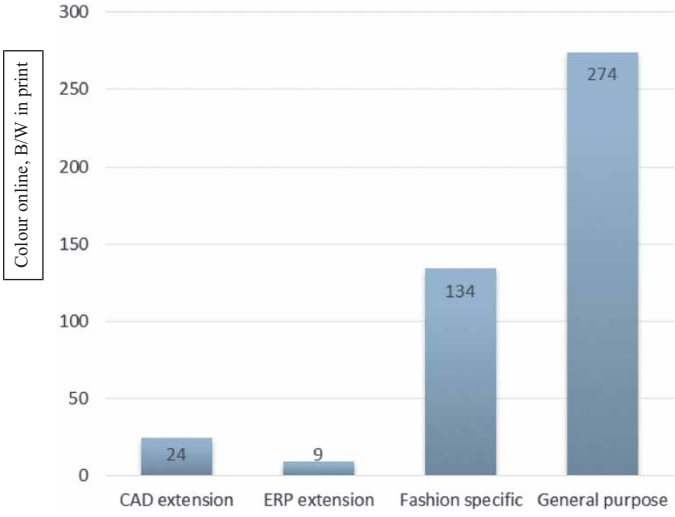

Figure 3. Typology of solution provided by the vendors.

Fundamentally most of the vendors offer a PLM solution from the higher to the lower market segments even if, given the sample's composition, there is a major concern regarding the bridge and mass. PLM vendors provide solutions to each industrial sector, but the jewellery industry is supported by specific PLM solutions and vendors. In this context, considering all the continents, North America (48%) and Europe (38%) seem to be the geographical areas more interested in PLM technologies, followed by Asia (10%), South America (2%) and Oceania (2%).

The exploratory research has also shed some light on the typology of solution provided by the vendors within the companies interviewed (Figure 3): 274 companies, on the total of 441, tend towards general purpose solutions, while 134 prefer fashion-specific tools, customised for their specific needs. Just 33 companies have approached PLM through an extension of the existing CAD or ERP solutions.

The study has revealed that, during the last decade, PLM solutions have been integrated to ERP, but recently an increase in integration to the downstream processes, such as colour management, calendaring, merchandise planning, has begun to emerge. Other forms of integration have been provided in the logistic and retailing area. Therefore, the actual trend seems to be an integration of the entire set of business tools with PLM.

Characteristics of PLM implementation in the fashion industry

In order to answer the second RQ, an in depth-analysis of the main features of PLM implementation in the fashion industry has been provided. Several interviewees have described their approach to PLM, detailing its impact on the business processes.

One of the most important drivers that has triggered the adoption of PLM is the need to refresh collections and to innovate the product choices, given that apparel companies mostly compete on time-to-market (TTM). A complex network of suppliers permits the achievement of product quality and significant agility through the SC. Therefore, the impact of globalisation, the needs for SC integration and knowledge management have to be taken into account.

Nowadays, the fashion industry is showing interest in PLM technologies but, up until a few years ago, a small number of companies adopted them and preferred PDM solutions as an alternative. Other companies were cautious, waiting for the outcomes of the 'pioneer' companies. With the intent to revolutionise the previous policies and to deal with the market transformations, fashion companies are asked to optimise their core business processes, such as design, production planning and control. Thanks to PLM and concurrent engineering, i.e. the parallelisation of tasks within product development, this process may be optimised: indeed many firms implement a sequential NPD process that begins with the research of the right fabric, coming to the design, cutting, sewing and product finishing. For example, difficulties in management of prototypes and samples often occur due to different qualitative opinions, which led to models' proliferation.

The adoption of PLM would improve the capability to manage lots of business processes, including the aspects related to communication and integration within the SC. Communication is fundamental because during the NPD phase, designers and managers have to exchange their information and match their different needs, in order to renovate the collections and respect brand policies.

The fashion companies would be able to manage a standardised seasonal supply, based on timely and correct decisions deriving from precise information.

Many fashion companies still have several uncertainties related to the different features of the NPD process carried out in firms where PLM has been traditionally implemented. This is due to the fact that the fashion product has low engineering content, the manufacturing process is outsourced and the after-sales process is negligible.

PLM technologies are able to support the following core business processes within a fashion company: collection planning and development, creation and sharing of the technical sheet and sourcing (Figure 4).

PLM technologies provide lots of basic functionalities, implementable in each industry. But also industry-specific functionalities have been developed to support the particular requirements related to the fashion context.

In Figure 5 the main PLM functionalities, based on the different macro processes they support, are listed: the slots highlighted in grey represent fashion-specific functionalities, those in white are general purpose.

We have identified three macro-processes supported by PLM: NPD, manufacturing and retailing. The PLM in the fashion industry is still not able to manage the last phases of the product lifecycle, such as after-sales and maintenance. Indeed, fashion companies, based on the product

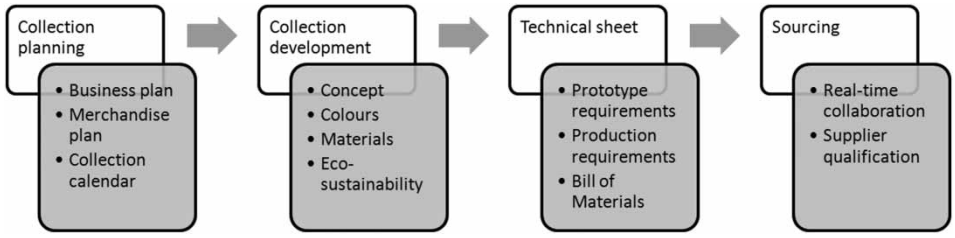

Figure 4. Core processes supported by PLM.

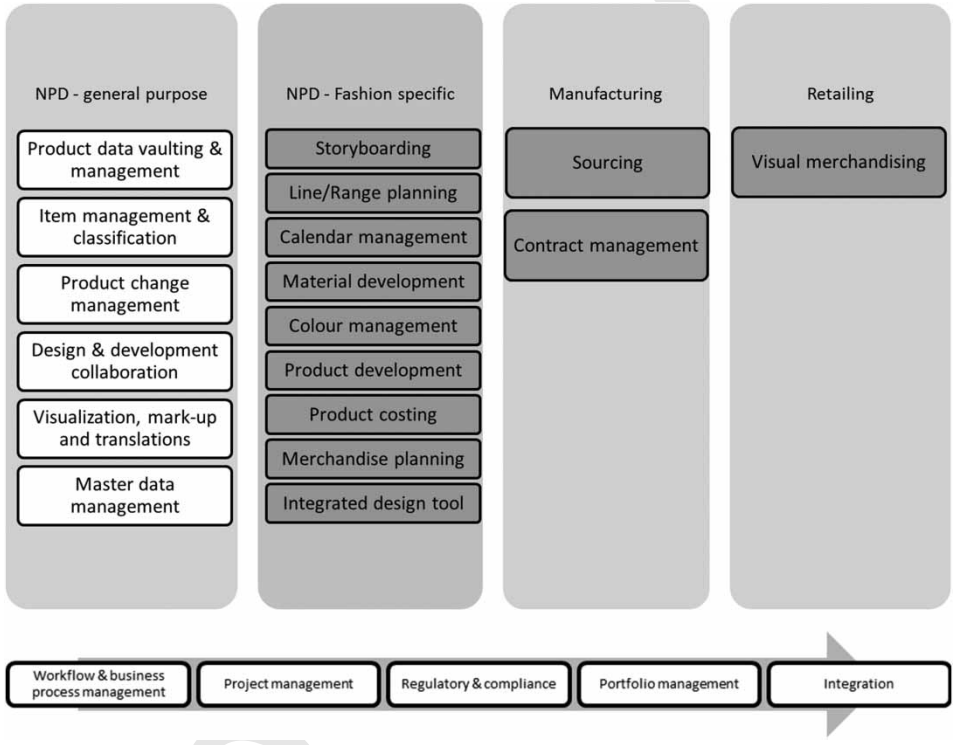

Figure 5. General purpose and industry-specific PLM functionalities.

they sell, prefer to focus on the earliest processes that give up the post-retailing information.

The major part of the PLM functionalities are dedicated to the NPD process. In particular, Product data vaulting and management ensure effective and efficient acquisition, storage and protection of information, allowing the company to easily find data. The item management and classification module is a sort of library which stores information about raw materials and semi-finished and final products. The product change module allows managing each technical modification of the product and allows assessing the impact on the other lifecycle phases. The design and development collaboration permits the roles involved to collaborate during the design process, based on specific views of the product. The visualisation, mark-up and translation module allows the visualisation and the labelling of product data that are usually stored in a proprietary format, in order to share them with all the involved users. The master data management module represents a centralised repository for product data.

Coming to the fashion-specific functionalities that support the NPD process, storyboarding is a module that enables the acquisition and assessment of the trends and product requirements, product ideation management and creation of the updated storyboard to share within and outside the company. The line planning module aims to support assortment planning: the product planners are able to enter the historical sales data in order to achieve an improvement in the planning precision. Calendar management is a tool that allows the collection definition, in terms of styles that have to be created per size and colour. Q7

The material development module allows to track each step related to the material and accessories development, including costing and testing. With colour management it is possible to support the use of industrial standards in order to define seasonal colours and all the associations between colours and materials. The product development module supports the design and product development processes, including design process management, material development, colour management, prototyping, sampling

and product release. Through product costing a company is able to define the cost of the product since the earlier stages of its lifecycle, in order to keep control during each stage. The merchandise planning module helps to identify which products have to be sold, their cost and the assortment. With the aim to favour the product development process, the PLM solution has to support design through ad hoc tools, remaining in the same environment; therefore an integrated design tool is required.

The manufacturing area is supported by the sourcing and contract management modules. They aim to ensure the correct and well-timed sharing of information within the entire product lifecycle and also to improve the supplier collaboration management (selection, auditing, etc.). This way, solid relationships with the suppliers are established, enabling directness within the SC.

In the retailing macro process the visual merchandising module enables the presentation and the advertising of products in the stores.

Finally, PLM includes several general purpose modules not specifically related to a single macro-process. The workflow and business process management module allows the modelling and the execution of business processes. It also includes the documents related to the company's processes and the roles of the players involved. The project management module supports the definition of the work breakdown structure, the resources and tasks management. The regulatory and compliance module ensures that products and materials used are compatible with the rules and regulations of the company's inner and outer parts. Portfolio management introduces wisdom and protocol in the product selection process and in the innovation that the companies would like to pursue. Finally, the integration module enables information sharing from and to other management systems.

The vendors of PLM technologies are trying to make their solutions more flexible, modular and adaptable to industry-specific needs. Therefore, the supply of PLM product for the fashion industry usually consists of:

- general purpose and industry-specific PLM products that are often market leaders and
- products that represent extensions of industry-specific CAD or ERP solutions.

Benefits achievable through PLM implementation

Implementing PLM technologies enables several qualitative benefits (RQ3), which several companies interviewed have reported during the exploratory research. The authors have proposed a list of the possible advantages, gathered from the literature review, which has been validated and developed in detail. A classification of the benefits that the companies have procured is illustrated in Figure 6. In the NPD stage, benefits are related to the reduction of time to develop products, with important effects on quality, efficiency and effectiveness. PLM technologies also improve document management, reducing the time to search information, to update and review data. In the manufacturing process PLM has a positive impact, ensuring automation, reducing stocks, WIP and improving information sharing with suppliers. Moreover, lots of benefits affecting the entire company at a cross-functional level may be achieved, such as reduction in TTM and improvement in managing processes and projects.

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. This information is confirmed by a Gartner study, as shown in Figure 7.

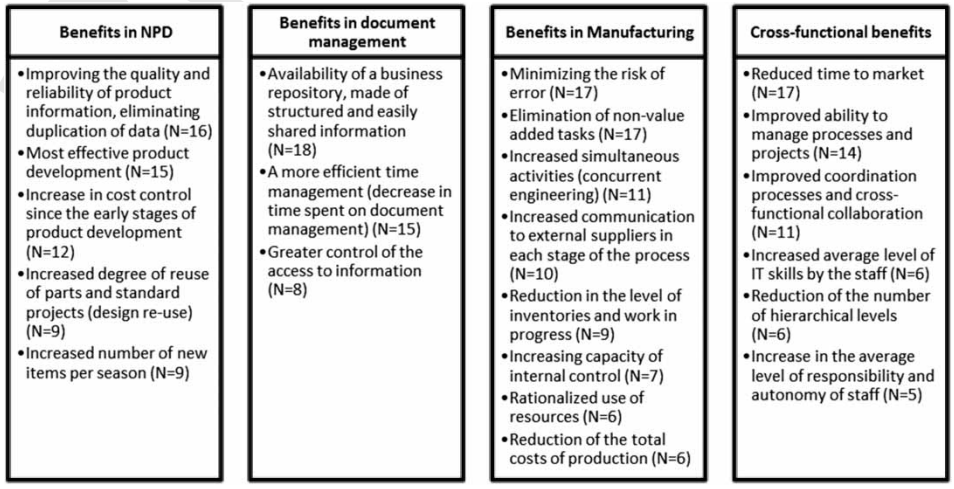

Figure 6. Benefits achievable through PLM (The numbers in parentheses indicate the amount of companies interviewed (*N*) that experienced each benefit).

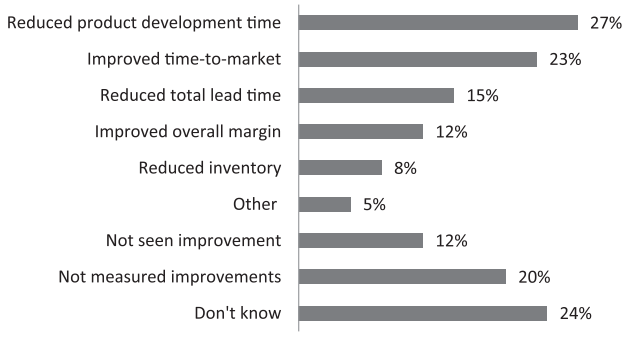

Figure 7. Improvements related to PLM adoption. Source: Suleski and Draper (2012).

Conclusions and future work

The paper has provided an overview of NPD in the fashion industry and PLM adoption. The existing literature illustrates the main features related to the NPD process in the fashion context, describing each single task and its impact on the firms' competitiveness, underlining the need for collaboration.

PLM is a strategic business approach, widely discussed in the last decade, which manages all lifecycle stages of a product, including NPD. It can be seen also as a software integrating other design and SC tools, as a knowledge management system or as a culture ensuring competitive advantage. Just a small part of the literature concerns the topic of PLM in the fashion industry: in order to fill this gap, after an in-depth analysis of the existing papers, a descriptive exploratory research was performed. The goal of the study was to describe the main features of PLM implementation in the fashion industry, considering the spread and benefits achievable.

The discussion of the proposed approach has allowed the authors to answer the following research questions:

RQ1: how widely have PLM technologies so far diffused through the fashion industry?

The exploratory research has revealed that PLM functionalities may support the higher and lower fashion industry market segments. The sample considered has shown a majority of implementations in the apparel and accessories sectors and, in terms of geographical areas, in North America and Europe. The aim of PLM for the fashion industry is to sustain many of the business processes and to ensure integration of the entire range of tools implemented in the company.

RQ2: what are the main peculiarities related to PLM implementation in the fashion industry?

Through PLM, fashion companies are able to manage standardised processes, based on timely and correct decisions deriving from precise information. PLM technologies support several core tasks, such as material and colour management, merchandise planning, product sourcing and visual merchandising. PLM includes modules sustaining the NPD process, but also the functional areas of manufacturing and retailing specific modules. Post-retailing processes (as after-sales and maintenance) are still not managed within PLM because of the fashion product features. PLM operates at a cross-functional level, with modules concerning project management, compliances and integration.

PLM vendors propose a great number of solutions to fashion companies; some of them are general purpose, others are extensions of industry-specific CAD or ERP solutions.

RQ3: what are the benefits achievable through PLM implementation in the fashion industry?

PLM triggers many advantages and improvements noticeable in different functional areas. In fact it is able to shorten the product development process, to ensure greater control of information and also to impact the manufacturing area, reducing inventory and non-value-added tasks. Moreover, cross-functional benefits emerge: first of all the reduction of TTM, a real source of competitive advantage in a fashion company.

In conclusion, a fashion company that would like to reach flexibility and competitiveness should recognise the importance of NPD and to provide PLM solutions supporting business processes.

Future work may consist of case study researches in the fashion context, analysing the NPD management and pros and cons related to the adoption of PLM. Even if middle of life and end of life are not managed throughout PLM, another development should concern its potentials in the latter phases of the product lifecycle: the way the fashion companies decide to manage customer feedbacks, the integration with data provided by RFid technologies and the interface with business intelligence reporting systems could be analysed. Cross-industry comparisons provide an interesting insight to acknowledge, for example, the existing differences between manufacturing and apparel industries. Finally, a research highlighting the different behaviours of PLM implementation in the high fashion and in the mass market, or in different fashion sectors may be carried out.

Disclosure statement

No potential conflict of interest was reported by the authors.

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