Fostering the Garment Industry Competitiveness: *The ICT Contribution*

Sara Cepolina
Università di Genova, Italy
Sara.Cepolina@unige.it

ABSTRACT

The paper addresses a new holistic organization paradigm along the garment value chain, covering the main advanced technology innovation solutions at the aim to foster industry sustainability and competitiveness. The proposed manufacturing system will allow the garment industry to fully satisfy the final customer requirements in terms of functionality, comfort and fashion while increasing industry sustainability and competitiveness through its implications in terms of productivity, time to market and wastes reduction.

The framework and the method developed for garment industry is presented and two ICT based innovative solutions regarding product tracking and virtual prototyping are analysed.

KEYWORDS

Garment Industry	Competitiveness
Sustainability	Supply chain management [SCM]
ICT	Technology innovation
Competitiveness	

EMPIRICAL ARTICLE

PREAMBLE

"… In future, winning companies will be the ones able to connect with consumers and optimise their in-store experience thanks to an integrated business and product planning. The latter should speed-up design and development while integrating sourcing, supply and logistic partners with the aim of improving companies service strategies and create unique flow paths" (Mrs Ern-Stockum - Managing Director, Kurt Salmon).

"… (the) experience has shown that, when suppliers and retailers cooperate, exchange information on stock levels and sales and, more generally, create solid and long-lasting relationships as business partners, both parties can achieve much better results than if they deal with each other merely as suppliers and buyers." (Mr. Massoletti - AEDT Vice-President)

These two considerations emerged during the recent European Apparel and Textile Confederation (EURATEX) annual general assembly well summarize the European industrial approach to the hypercompetition (D'Aveni, 1994) characterizing the garment industry and underline the relevance and the future expectations for ICT technology applications into the garment supply chain.
The garment industry has been subject to different reconfiguration processes to adapt itself to the changing political, environmental, economic and competitive factors. Old economic trends have been added recently by newer globalisation trends which affect deeply the apparel supply chain modifying its configuration and intensifying the industry competitive pressure (Cepolina & Scarsi, 2011). The emerging garment value chain is high disperse and is composed by numerous different players all over the world. In these globally networked organizations, a firm's competitive advantage lies not so much in being "the best", but in its ability to co-create with others and to orchestrate this process of co-creation in the most efficient, effective (Daiser, 2009) and sustainable way. At this aim enterprises have to develop new competencies and capabilities.

Emerging concepts of garments as made-to-measure fashion items or technical clothes like protective equipment, medical appliance, wearable computer etc. require a reconfiguration of the overall customer-vendor relationships, a paradigm change in customer service and customer relationship management with a focus on value-adding product-services and sustainability (Binder, Janicke & Petschow, 2001). In other words new management of product complexity, new attention should be paid to customisation and personalisation taking into account sustainability issues like: resources sparing, environment protection, and cleaner utilisation, waste re-cycling. This situation criticality looks for new policies in the market of products, to lower tangibles spoilage, by value-chain paradigms turned on intangibles. This paper addresses appropriate management concepts building on knowledge and technological tools integrated within a seamless common architecture, purposely developed for benefitting this industry. The proposed framework - the Extended Smart Sustainable Organization (xSSO) – is suggested to become the new networking oriented, integrative framework for the organization of flexible garment manufacturing of the future (Abernathy, Volpe & Weil, 2006).

THEORICAL FRAMEWORK

Smart Organization

The organization is knowledge-driven, internetworked, dynamically adaptive to new organizational forms and practices, learning and able to create and exploit the opportunities offered by the new economy (Abernathy, Volpe & Weil, 2006).

The idea that today all companies are more or less working in networks of various types leads to some implications (Filos & Banahan, 2000). To work effective in communities a company has to change its understanding about its environment: the organization should recognise the value of partner contribution and use it for the wellbeing of the community; the organization should not seek to control its environment but recognise that any such attempt would at best, fail, and at worst, stifle the creativity and imagination necessary to support innovation (Matheson & Matheson, 1998); the organization should realise that trust is a key issue in determining the success of relationships in the digital economy (Camarinha-Matos, Afsarmanesh & Erbe, 2000) and seeks to prove it, in the way it interacts.

To achieve this new understanding, companies need collaborative and networking competencies (Grant, 1996; Lorenzoni & Lipparini, 1999). These competencies can be reached by the evolution of the companies in the field of ICT networking, organizational networking and knowledge networking.

Sustainable Organization

The sustainability is becoming urgent demand. The World Commission for Environment and Development (WCED) clearly stated the new economic paradigms for sustainable development, which meets the needs of the present population without compromising the needs of future generations (Carr, 2001).

Sustainable organization introduces constraints aimed at - lowering material and energy depletion intensity (at production, use and dismissal); - avoiding toxic dispersion and lower pollution; - enhancing using renewable resources and re-using of exhausted tangibles; - increasing the service intensity (by artefacts sharing, by functions dispensing, etc.); - increasing recycling efficiency, with profitability of the new business aiming at the tangibles reverse logistics (from waste, to 'raw' materials); increasing energy efficiency (World Commission on Environment and Development, 1987). Company's competitiveness will turn towards the ability of offering to the customer expected product functions with proper satisfaction and non-renewable resource balance.

xSSO concept is based on research work developed within the Leapfrog European research project. The concept, there developed by the technical and scientific perspectives, is here enriched with the sustainability component and it is faced by the managerial perspective with attention to its implications in terms of firms' competitiveness. Technical aspects are briefly introduced to show system functionalities and any further information can be found in (Walter, Kartsounis & Carosio, 2009).

XSSO FRAMEWORK

The xSSO concept is based on different theories coming from numerous research fields (smart organization, ICT, knowledge management, relationship marketing and cluster analysis, supply chain management and innovation management (Nonaka, 1991; Pilat, 2004; Handfield & Nochols, 1999; Chopra & Meindel, 2003; Shapiro, 2001; Gronros, 1987; Gummeson, 1987; Hakansson, 1979; Kang & Kang, 2009; Gupta, Raj & Wilemon, 1986; Chesbrough, 2003) offering an original, holistic and new integration framework able to support strategic behaviour of enterprises operating in the sector. Each company could query the software and receive different options to improve its competitive positioning. The options could refer to many firm's areas, like: logistics, quality system, supply chain management, networking etc.. The enterprise will adopt and include in its own xSSO the options considered most relevant and coherent with its corporate strategy (Cepolina, 2011).

The application of the xSSO concept is aimed to modernise and transform the garment sector into a flexible knowledge-driven sustainable high-tech industry by:

- ✓ a leap in productivity and cost efficiency in the garment manufacturing process,
- ✓ a radical move towards rapid customised manufacturing,
- ✓ a coherent life cycle sustainability assessment and
- ✓ a paradigm change in customer service and customer relationship management with a focus on value-adding product-services.

The integration of all innovations and new processes/services requires a new holistic organizational paradigm along the value chain, covering efficient life-cycle design (Bendell, 2000), production, use and recovery. Garment development and production have to be done in flexible, dynamically interoperating networks of enterprises (Anderson-Connell, Ulrich, & Brannon, 2002), flexibly adaptive to new emerging production technologies and business models, fully adaptive regarding customized market requirements and new technologies (Mo & Nemes, 2001). The novel manufacturing system has to enable the garment to suit the final customer use in terms of functionality, comfort and fashion effects while increasing productivity and reducing time to market. Much more flexibility and dynamism than currently in the traditional, complicated, resource and waste intensive textile and clothing value chain is required.

This holistic organizational framework with related conceptions, methods and operational tools will allow the garment industry to develop and produce extended garment products in flexible, dynamically interoperating networks of enterprises. It enables an integrated management of existing and new products and processes for garments within new business models of the factory of the future. Moreover the proposed approach has positive implications also by the demand side. In fact, the high and early customer involvement into the design and concept steps allows achieving a high rate of customer satisfaction, minimizing returns of goods and restraining waste (Luttropp & Lagerstedt,1999; Candi, 2006). The consequent cost reductions benefit enterprise and customers as well.

The xSSO framework is the basic framework for modelling organizational networks with the constituting elements and their relationships, the dynamic behaviour in terms of stability, control structures, flexibility, self-adaptivity and robustness properties for the targeted knowledge-based, integrated garment production processes. It refers to suitable visualization and navigation software tools for selecting, designing and operating network instances, also including functionality and sustainability testing structures.

xSSOs are implementing and applying elements of both the dimensions of smartness (knowledge-base) and sustainability (eco-consistency) networked by powerful ICT structures in a trans-disciplinary environment including engineering, economics and social perspectives (Vieira, 2009).

The xSSO application framework consists of the model set the repository and a configurator, whose main aspects are outlined in the next sections, and various implementation sets besides the operational systems. These elements are interacting with the goal to support garment companies enabling the establishment of smart organizations. An overview of the interactions is given in Figure 1, describing the principle sequence of interaction.

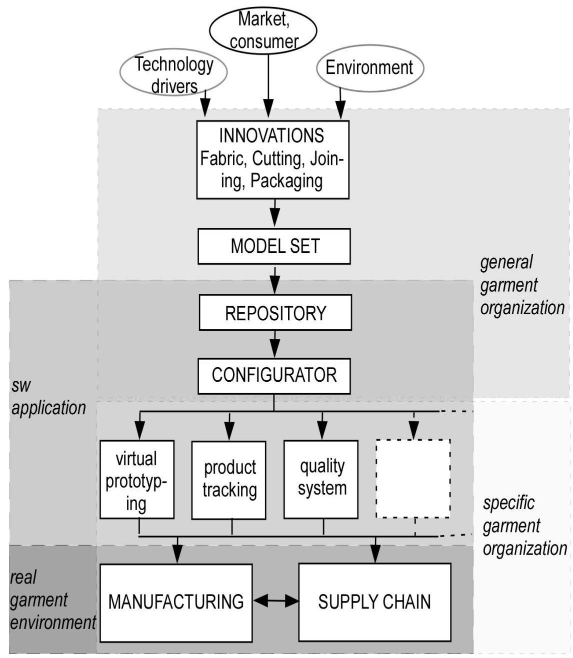


Figure 1: Context of the xSSO framework

MODEL SET

The Model Set is the first step of the research and comprises the analysis of competitive behaviour of firms operating in the garment industry and their abstraction into models. The out coming models refer to all aspects of operational activity in the garment manufacturing and garment supply chain. A set of model types aligned in a concise structure has been developed, based on state-of-the-art frameworks for enterprise and ICT modeling (Porter, 1998). Following the xSSO conception the Model Set allows creating a consistent, comprehensive integrated set of models of enterprise acting in the garment value chain (Nordås, 2004).

The modelling subjects range from representing data to representing conceptions and ideas from organizational aspects to product aspects. The xSSO Model Set supports various levels of abstraction and innovations. It also supports various specific views of an organization. Model types of various levels of abstraction but with the same scope can be combined.

The xSSO Model Set constitutes the comprehensive knowledge about the structural needs of different emerging areas, like new materials, new flexible automation cells, new garment virtual prototyping, in a sustainable organization framework. A model consisting of three layers and views corresponding to respectively the rows and columns in the overview in Figure 2 was implemented.

xSSO	SMART SUSTAINABLE ORGANIZATION		
	Organization view	*Processing View*	*Product view*
Knowledge asset later	Knowledge about organizational Structures	Knowledge about Process and Resources	**Knowledge about Products**
Sustainability layer	Sustainability constrains on organization	Sustainability issues on process and resources	**Sustainability issues on products**
Organization layer	Business model	Business process	**Business service**
ICT layer	**ICT architecture**	**Information flow**	**Product data**

Figure 2: Overview of the xSSO model set

REPOSITORY

The repository is the concretization of the model set activity, cataloguing all the models developed in the previous research's step. Its main objective is to allow data storage and reuse from the Configurator. The repository is specifically designed to store models related to traditional issues and innovative solutions as they are created and developed. These models are then used as basis to start the analysis required to applying these technologies to the actual configuration of the industry, suggesting the areas where a major effort in modifying the status is required.

The model development is, actually, based on GME (General Modelling Environment) that is an open source application, developed by the Institute for Software Integrated Systems of the Vanderbilt University. XML format is the source of information used by the repository.

The design of the repository starts from the xSSO Model Set in order to separate the data structure from the application (GME) that uses it. This choice allows changing the application platform without loss of information or models.

The implemented structure is very simple and do not investigate the intrinsic nature of the component: all objects are similar, only common characteristics are used: the object has a name, a description, some attributes, a position in the diagram and connections with other objects.

Different components have different associated rules and a graphical aspect that differentiate each other. The rules and the graphical aspect refer to a metamodel that is common to all models Rules describe the behaviour of a component, for example how to connect with another component, how many component of each type can be inserted in a model and so on.

The xSSO Repository is a relational database that stores the GME model and collaborates with the Configurator. Also, the xSSO has some simple web interfaces to manage the inserted model, user information and rights. It can be easily connected with web publication tools, like Java servlets or PHP pages, or with remote application through a secure socket.

CONFIGURATOR

The Configurator is a software tool which enables firm to query the repository in an easy to use and user-friendly way. It enables the selection of best suitable innovations for the design and operation of individual enterprise in smart networks. After the selection, in fact, each proposed innovation is visualised together with current situation of the (extended) enterprise. The configurator's outcome is not only a set of possible innovations to improve firm's competitiveness and efficiency but it offers ready to use and customised software.

To improve the usability for the user, the models of the innovations and their relationships are presented graphically. Navigation within these models is possible, based on the relations in and between models.

Navigation is very important for the user to quick find and assesses suitable innovations. Therefore a navigation based on classifications is applied. There should be no restrictions for creating classifications. The classifications suitable for navigations are created as a tree because circular relations between navigations will irritate the user. The classifications should be extendable without the need to change the classification of existing innovations. All data concerning the models are stored in the xSSO Repository and all data necessary for evaluation of models are stored in the xSSO Configurator.

Due to the strict splitting of data and evaluation logic, the Configurator accesses the model data with the help of high-level functions provided by the Repository. For sake of portability these high-level functions are designed to be independent from the technical implementation of the data pool to allow an easy change of the data delivery system. The evaluation logic should also be independent from the Model Set, so that changes to the Model Set do not require a redesign of the evaluation logic but only marginal changes should be needed.

The selected system allows the flexible design of objects which are used for the evaluation logic. Each object has a freely defined set of attributes helping the navigation and allowing, without additional configuration effort, to make a full-text search or an attribute-specific search. Therefore the configuration of the system is mainly focused on creating the necessary objects to realise the classifications, navigation and evaluation logic.

CASE STUDIES

The over outlined xSSO framework allows modelling of and analysis of an existing network for innovation and production, and it let to select and configure appropriate measures in order to improve the integration of activities and actors. ICT technology plays a strategic role supporting the garment supply chain management and networking, allowing integration between different actors along the chain, supporting information-sharing (Kollberg & Dreyer, 2006). ICT plays also an important role in the strengthening and reinforcing the sustainability efforts giving a greener face to the fashion value-chain (Sahni, 2010).

Radio Frequency IDentification technology (RFID), virtual prototyping and design, Computer integrated manufacturing (CIM) as well as vendor managed inventory (VMI) and collaborative planning, forecasting and replenishment (CPFR) are examples of ICT based solutions improving efficiency by sharing information related to matching demand and supply such as short- and long-term production planning, demand forecasting, materials and capacity planning. The first two solutions are stand-alone analysed in the following sections.

PRODUCT TRACKING

1. Technology Background

Product tracking technology is gaining increasing importance due to the globalization process and to the resulting global and complex supply chain's configuration. The markets of the modern world are characterised through an increasing globalisation and rapid technology changes.

This situation asks for ICT technologies and applications which enable the identification of products as single items, of item working resources (e.g. cut, sewing machines), of logistic entities (e.g. transport units, boxes, cartons) by attaching different information (e.g. status values, quality control information, progress messages) to the single items in an inter-firm way. This information has to be readable from different players in the value chain.
To identify goods along the value chain, the RFID technology has been selected, being a contact-less and reliable identification technology (Wang, Tang, Sheng & Wang, 2006).

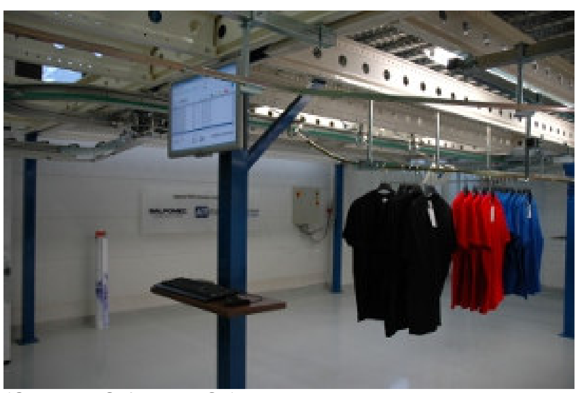
Typical RFID mobile device uses client-server architecture. Because the device runs in a web browser, every computer with an internet connection serves as client. A hand-held RFID scanner can be connected to this computer enabling to collect RFID data from the scanned tags. The data is then transferred via the internet connection to the prototype server instance where it could be processed.

2. Economic implications.

Globalization process results in an increasingly intense competition, as new producers and merchants gain access to previously well limited markets (D'Aveni, 1994). Innovation, the increase of productivity and the optimisation of business processes are keys to survive and prosper in this environment (Porter, 2001).

The RFID system could support companies' competitive challenge supporting garment supply chain integration, offering a quick and transparent order, manufacturing and delivery process to the customers ordering, with positive implications in terms of quality and efficiency. Additional benefits of RFID relate to the production phase in terms of logistics and security, improving available information through the supply chain, and in terms of networking configuration of production, allowing information exchange between commissioning industries and suppliers. The increased reliability given by the RFID traceability properties makes the possibility to match apparel parts (trousers and jackets), realised by different suppliers, much easier then previously.

RFID could, for examples, enhance the process of create and verify the delivery notes. Through scanning of objects tagged with an RFID label it is possible to automatically add and verify the goods that are packed for transportation and automatically assign carton numbers. Compared to other methods this modified process yields the potential to save time and costs, especially for the actors in later steps of the chain, like transportation service providers or customers.



(Courtesy Salpomec Oy)

Figure 3: RFID Based inventory

Customer driven integrated manufacturing tracking systems allow individualized web orders to be processed in 'real-time' and 'tracked' throughout the supply chain. Straight forward CAD/CAM processing technology interlinking web frontend 3D configuration processes and e-shops with backend weavers and manufacturers generates automatically BoL/BoM embedded into the SCM system "TXTChain". Both B2B and B2C tracking tools are available from order input until home delivery, info for the latter the customers can trace in his e-account on the retailers website.

Concerning the sustainability issue, RFID achieves higher efficiency which leads to sustainability through its positive implications in inventory productivity and accuracy and operating efficiency. The technology helps in errors location, in loss prevention, in unnecessary truck deliveries minimization, in cloth life cycle management, in stolen items control and in reduction of customers' trips to store for items that were out of stock during their initial visit. It could works also on the consumer behaviour, raising consumer awareness of the apparel life cycle and communicating how each garment rates in terms of overall sustainability (Treanor, 2011).

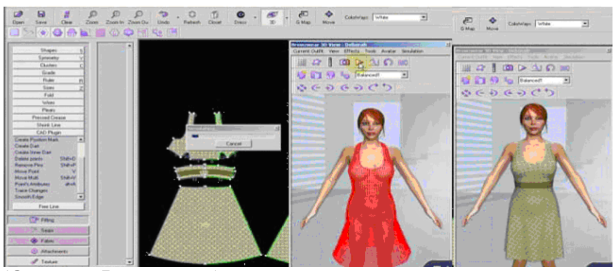
Moreover RFID technology and product tracking solutions are fundamental pillars in the evolution of digital clothing supply chains, from design to retail, that minimize returns and reduce waste.

VIRTUAL PROTOTYPING

1. Technology background

CAD tools have greatly evolved and new techniques and capabilities were introduced allowing the 3D representation of soft material in a dynamic environment. So today the most updated ICT technologies can be applied to the design and evaluation of garment new collection in terms of virtual, instead of physical prototypes in a collaborative manner (Magnenat-Thalmann, 2010; Apeagyei 2010). Design and prototyping are critical activities in order to meet consumers demand, to reduce wastes and to address sustainability issues.
The key innovative concepts are based on ICT technical developments offering a comprehensive methodology for garment design performed directly in 3D, replacing virtual prototypes instead of physical prototypes, contributing to reduce the time-consuming tasks of design and prototyping. Recent CAD processes allow to represent typical body shapes integrating representative female and male morphotypes derived from hierarchical statistical clustering of Anthropometric Survey data or based on specific customer sample data acquired through three-dimensional (3D) body scanners (Zulck, Koruca & Borkircher, 2011).

The development of a web platform enabling e-collaboration between potential users of 3D design and Virtual Prototyping, such as product managers, designers, modelists and sales and marketing personnel in a scenario intended to speed up and enhance creativity and effectiveness represents a further important key opening new challenges to enhance sustainability in clothing supply chain. This platform can be linked to other satellite web-delivered services, such as a fabrics library, a cost estimation module and a real-time animation module, offering visualisation of animated virtual mannequins 'dressed' with the new creations and allowing the customer himself to virtual dress the garment for appreciating its look and for feeling its comfort.



(Courtesy Bronzewear)

Figure 4: Interface of a platform for garment virtual fit testing

2. Economic Implications

Virtual prototyping application has strong economic implication in terms of efficiency improvement and cost reduction as well as in terms of customer satisfaction and customer relationship management (CRM).

The simulation introduction all along the design process and the virtual prototyping allow garment companies to adopt postponement strategy and just in time strategy. This ICT based solutions linked to the e-business make it possible to assembly the final product only when customer has just acquired it. Economic benefits relate to stock and waste reduction, inventory lower costs thanks to lean production adoption, improved quality levels and compressed production cycle time. Furthermore this technology could support the control over the manufacturing and development process of garments, thanks to its easy integration into existing production plant and in the future flexible automation production.

Considering the customer point of view, he is deeply involved since the design and concept phases till to the production and logistic ones (Abecassis-Moedas, 2006). Customers are able to design their personnel ideal garment matching at the same time the hand made comfort and fit evaluation benefits with affordable costs levels and delivery time.

Concerning the sustainability issue, virtual prototyping supports the digitalization process of the garment supply chains, through e-configurators, digital design toolkits, online dressing facilities and the development of "controlled" virtual shopping communities. The digital assessment of fit forms is more accurate in 3D; this has positive effects on sample budgets and therefore means fewer physical samples, lower transport costs, less material use and, above all, time savings. It is a keystone in developing a garment sustainable supply chain, allowing the product to remain in digital form until later in the process. At least in fact it is more sustainable to create and buy a garment in a digital form, because whenever a physical sample is created, waste is introduced into the process.

CONCLUDING REMARKS

The xSSO is a web-based decision support system, enabling visualisation and navigation for identifying, selecting and designing innovative methods and technologies for the garment industrial sector, in order to improve the integration of activities and actors. The interactive overall platform allows to reach a high integration level of the entire supply chain, from the front-end collaborative design toolkit up to manufacturing and e-fulfilment, thanks to ICT technology. The two ICT based solutions analysed show the technology contribution in terms of variety synchronisation from design to production, from sale, delivery and post sale.

By the economic perspective, the xSSO framework allows to minimize stock and its related costs and to achieve important competitive advantages both in terms of cost and diversification advantages. The xSSO is also a Consumer Driven Manufacturing business model which reduces stock wastes and promotes a real sustainable supply chain. These savings result in a win-win situation for all the players involved in the supply chain.

Thanks to ICT and internet application, the process integration of CAD-CAM is accelerated and optimized in a global CDIN (Computer Driven Intelligent Network), where the consumer becomes producer (prosumer), driving the fully integrated supply and manufacturing chain by him or herself.

AKNOWLEDGEMENTS

I would like to acknowledge the research team of the Leapfrog European project for the kind support and collaboration

REFERENCES

i. Abecassis-Moedas C. (2006). Integrating design and retail in the clothing chain: An empirical study of the organisation of design. *International Journal of Operations and Production Management, 26(4)*, 412-428.

ii. Abernathy, F. H., Volpe A. & Weil D. (2006). The future of the apparel and textile industries: prospects and choices for public and private actors. *Environment and Planning, 38(12)*, 2207–32.

iii. Anderson-Connell, L. J., Ulrich, P. V. & Brannon E. L. (2002). A consumer-driven model for mass customization in the apparel market. *Journal of Fashion Marketing and Management, 6(3)*, 240-58.

iv. Apeagyei P.R. (2010). Application of 3D body scanning technology to human measurement for clothing Fit. *International journal of digital content technology and its applications, 4(7)*, 58-67.

v. Bendell J. (2000). *Terms of endearment: business, NGOs and sustainable development.* Sheffield: Greenleaf Publishing Limited.

vi. Binder M., Janicke M., Petschow U. (2001). *Green industrial restructuring: international case studies and theoretical interpretations.* New York: Springer Verlag Press.

vii. Camarinha-Matos L. M., Afsarmanesh H., Erbe H.H. (2000). *Advances in networked enterprises: virtual organisations balanced automation and systems integrations.* Dordrecht: Kluwer Academic Press.

viii. Candi, M. (2006). Design as an Element of Innovation: Evaluating Design Emphasis in Technology-Based Firms. *International Journal of Innovation Management*, 10(4), 351–374.

ix. Carr G. (2001). *The digital enterprise: how to reshape your business for a connected world.* Harvard: Harvard Business School Press.

x. Cepolina S. (2011), Extended Smart Sustainable Organization in Garment industry, in Lather, Saini, Khatri, *Strategies and innovations for sustainable organizations*, McMillan publisher India Ltd

xi. Cepolina S., Scarsi R. (2011), Apparel supply chain management: ICT contribution to networking sustainability and competitiveness, in Bartolo H. et al. *Proceedings of SIM 2011 Sustainable Intelligent Manufacturing*, IST Press Lisbona.

xii. Chesbrough, H. W. (2003). *Open Innovation: The new imperative for creating and profiting from technology.* Boston: Harvard Business School Press

xiii. Chopra S., Meindel P. (2003). *Supply Chain Management: Strategy, Planning, and Operation.* New Jersey: Pearson Prentice Hall Press.

xiv. Daiser R. (2009). *Designing the Smart Organization: how breakthrough corporate learning initiatives, drive strategic change and innovation.* San Francisco: Jossey Bass /Wiley Press.

xv. D'Aveni, R. A. (1994). *Hypercompetition: Managing the Dynamics of Strategic Maneuvering.* New York: The Free Press.

xvi. Filos E., Banahan E. (2000). Will the Organisation Disappear? The Challenges of the new Economy and Future Perspectives. In L. M. Camarinha-Matos, H. H. Afsarmanesh, Rabelo (eds), *E-Business & VirtualEnterprises* (pp. 3-20). Dordrecht: Kluwer Press.

xvii. Grant, R. M. (1996). Prospering in dynamically-competitive environments: Organizational capability as knowledge integration. *Organization Science, 7(4)*, 375-387.

xviii. Gronros C. (1987). Marketing redefined. *Management decision, 28(8)*, 5-9.

xix. Gummeson E. (1987), The new marketing: developing long-term interactive relationships. *Long range planning, 20(4)*, 10-20.

xx. Gupta A. K., Raj S. P. & Wilemon D. (1986). A Model for Studying R&D-Marketing Interface in the Production Innovation Process. *Journal of Marketing*, 50 (April), 7-17.

xxi. Hakansson H. (1979). *Corporate technological behaviour: co-operation and networks.* London: Routledge Press.

xxii. Handfield R. B., Nochols E. L. (1999). *Introduction to Supply Chain Management.* New Jersey: Pearson Prentice Hall Press.

xxiii. Hilger J., (2008). The apparel industry in West Europe. Copenhagen Business School, *Creative Encounters Working Papers, 22.*

xxiv. Kang K., Kang J. (2009). How do firms source external knowledge for innovation? Analysing effects of different knowledge sourcing methods. *International Journal of Innovation management, 13(1)*, 1-8.

xxv. Kollberg M., Dreyer H. (2006). Exploring the impact of ICT on integration in supply chain control: a research model, *www.sintef.se/project/SMARTLOG*

xxvi. Lorenzoni G., Lipparini A. (1999). The leveraging of interfirm relationships as a distinctive organizational capability: a longitudinal study. *Strategic Management Journal, 20(4)*, 317-338.

xxvii. Luttropp C., Lagerstedt J. (1999). Customer benefits in the context of life cycle design. *Eco-Design '99: 1st Intl. Symp. on Environmental Conscious Design and Inverse Manufacturing, Tokyo*: Feb. 1999.

xxviii. Magnenat-Thalmann, N. (2010). *Designing and Animating Patterns and Clothes, Modeling and Simulating Bodies and Garments.* Springer Publisher.

xxix. Mahadevan B. (2000). Business models for internet-based e-commerce: an anatomy. *California Management Review, 1(July)*, 55-69.

xxx. Matheson D., Matheson J. E. (1998). *The smart organization: creating value through strategic R&D.* Cambridge: Harvard Business School Press.

xxxi. Mo J. P. T., Nemes L. (2001). *Global engineering, manufacturing and enterprise networks*. Dordrecht: Kluwer Academic Publishing.

xxxii. Nonaka I. (1991). The knowledge creating company. *Harvard Business Review. 69 (6 Nov-Dec)*, 96–104.

xxxiii. Nordås H. K. (2004). The global textile and clothing industry post the agreement on textiles and clothing. *World Trade Organization discussion Paper, 5*, Geneva, Switzerland.

xxxiv. Pilat, D. (2004). The ICT Productivity Paradox: Insights from Micro Data. *OECD Journal: Economic Studies, 38*, 37-65.

xxxv. Porter M.E. (1998). Clusters and the new economics of competition. *Harvard Business Review, 1(Nov.)*, 77-90.

xxxvi. Porter M.E. (2001). *Competition in global industries*. Harvard: HBS Press Book.

xxxvii. Sahni H. (2010), Towards Sustainable Fashion - Computer Technology Integration for a Green Fashion Value-Chain. *www.fibre2fashion.com*

xxxviii. Shapiro J. F. (2001). *Modeling the Supply Chain*. Pacific Grove, CA: Duxbury Thomson Learning Press.

xxxix. Treanor Z. (2011). Sustainable Apparel: Integrating Global Commerce and Increasing Consumer Awareness.

xl. Vieira V.A. (2009). An extended theoretical model of fashion clothing involvement. *Journal of Fashion Marketing Management, 13(2)*, 179-200.

xli. Walter L., Kartsounis G. A., Carosio S. (2009). *Transforming clothing production into a demand-driven, knowledge-based, high-tech industry*. London: Springer-Verlag Press.

xlii. Wang Z., Tang R., Sheng W., Wang G. (2006). Research on RFID-Based Production Logistics Management Techniques with Application in Garment Industry. *International Technology and Innovation conference 2006*, Hangzhou, China, June 2006.

xliii. World Commission on Environment and Development (1987). *Our Common Future*. Oxford: Oxford University Press.

xliv. Zulch G., Koruca H.I. & Borkircher M. (2011). Simulation-supported change process for product customization – A case study in a garment company, *Computers in Industry*, Vol. 62, 568–577.