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Decision support and intelligent systems in the textile and apparel supply chain: An academic review of research articles

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ABSTRACT

This article provides a comprehensive review of research articles related to the application of decision support and intelligent systems in the textile and apparel supply chains. Data were obtained from 77 articles published from 1994 to 2009 in 35 journals. The articles were categorized according to their applicability into three basic sectors – textile production, apparel manufacture, and distribution/sales. They were further categorized into 16 subsectors based on their operational and management/control processes. A comprehensive list of categorized journal articles identified in this study provides insights and relevant references for both researchers and practitioners on the application of decision support and intelligent systems to various stages of a textile and apparel supply chain. In light of the developed classification framework, we identify gaps in extending the use of the decision support and artificial intelligent systems in the industry and suggest potential and applicable research areas for further consideration in this subject area.

1. Introduction

The increasing trend toward globalization and growing levels of international competition have compelled firms in the textile and apparel industry to build strong and responsive supply chains that will enable efficient and effective operations and to offer customers the best value with a view to achieving market leadership. A supply chain consists of a network of members (generally organizations) formed towards achieve a common aim of converting raw materials into final products and then delivering these products to intermediates and, ultimately, final consumers (Chopra & Meindl, 2007). Such a network is notable for the nature of the relationships among members, which enable information-sharing and add value to products and services by increasing internal coordination (Chandra & Kumar, 2000).

The application of information technology (IT) is a significant enabler of such opportunities. Porter and Millar (1985) argued that IT can create competitive advantages for companies to improve coordination and communication among trading partners, increase the availability of information for intermediaries and customers (e.g., the ability to track or trace products in the chain), and provide added value at various stages along the entire supply chain. Indeed, IT allows supply chains to achieve agility (Gunasekaran & Ngai, 2004); to reduce uncertainty, cycle-time, and inventory (Levary, 2001; Srinivasan, Kekre, & Mukhopadhyay, 1994); and to closely collaborate with networked members (Simchi-Levi, Kaminsky, & Simchi-Levi, 2003). Essentially, IT functions as the central nervous system of the entire network and provides direct benefits to individual members within a given supply chain (Auramo, Kauremaa, & Tanskanen, 2005).

In the textile and apparel industry, globalization is intensifying, with many companies either sourcing components overseas or moving manufacturing to countries with lower labor costs (Jones, 2002). Such a challenge is further complicated by the growing unpredictability of the global fashion market, which leads to rapid changes of customer demand in styles and in quantity. In short, the industry is characterized by unpredictable demand, short product life cycles, quick response times, large product variety, and a volatile, inflexible, and complex supply chain structure (Fischer, 1997). The application of IT introduces flexibility into such a supply chain, especially in terms of quick and accurate responses to meet rapid changes in the fickle market (Stylios, 1996).

When discussing the application of decision support and intelligent systems in this context, it is important to consider the role of IT in amalgamating a supply chain. These systems use data and mathematical models that possess the characteristics of flexibility, adaptability, memory, comprehension, and the ability to manage

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uncertain and constantly changing information (Krishnakumar, 2003). Because of their specific features, they can improve efficiency and effectiveness in supply chain management, particularly within such a competitive environment as the textile and apparel industry. Typically, these systems include several systems developed from the study of artificial intelligence (AI); which are expert systems (ES), genetic algorithms (GA), artificial neural networks (ANN), knowledge-based systems (KBS), and fuzzy-logic systems.

A scan of research review articles in the discipline indicates some studies that focus on the application of IT in various areas. For example, Stephanopoulos and Han (1996) provide an overview of the work done in seven specific areas and a review of intelligent systems in process engineering. Shen, Hao, Yoon, and Norrie (2006) review the application of agent-based systems in intelligent manufacturing. Nonetheless, despite the fact that a number of research studies of the textile and apparel industry and on fashion supply chains have been conducted (Bruce, Daly, & Towers, 2004; Chandra & Kumar, 2000; Romano & Vinelli, 2001; Şen, 2008), no comprehensive review of such applications has yet been conducted. Without that, the understanding of the current situation in the industry regarding the use of these technologies is hindered and will thus affect decisions with regard to research direction, in turn leading to gaps in potential misdirection of research efforts and negative impacts on the future development of the industry.

This study, therefore, aims to provide a systematic and comprehensive review of research articles in order to gain insights into the applications of decision support and intelligent systems in a textile and apparel supply chain. It also aims to develop a classification framework to analyze the extant literature in this subject area to provide a reference for researchers to maximize effort value in future research.

The remaining of this paper is organized as follows. First, we propose a classification scheme for analyzing the structure of a textile and apparel supply chain and for categorizing the articles relating to the applications of decision support and intelligent systems in the industry. Second, we describe the research methodology adopted in conducting the study. Third, we scrutinize those articles in relation to our proposed framework. Fourth, we provide a discussion on the practical implications of applying such systems in the industry and identify potential areas for future research; in particular, we highlight some new AI technologies that have a potential to be used in the textile and apparel industry, for example, mobile technology. Finally, we provide a summary and conclusion to describe the contributions as well as the limitations of the study.

2. A classification framework for textile and apparel supply chains and decision support and intelligent systems

To understand the application of decision support and intelligent systems in the textile and apparel supply chain, we first analyzed the structure of the industry, classifying it into three major sectors: textile production, apparel manufacture, and distribution/sales. We then identified the various decision support and intelligent systems which are applicable to the management of each of these sectors.

2.1. Structure of textile and apparel supply chain

A textile and apparel supply chain incorporates the flow of products, services, money, and information among suppliers, manufacturers, distributors, and retailers (Yi, Ngai, & Moon, 2011). Based on the classification systems considered by Forza and Vinelli (2000), Bralla (2007), and Şen (2008), we divided the textile and apparel supply chain into sectors of textile production, apparel manufacture, and distribution/sales. Furthermore, we analyzed the business practices of each sector in terms of operational processes and management/control processes. Accordingly, 16 subcategories were found (see Fig. 1), which form the basis of the classification framework adopted in this study.

2.1.1. Textile production

Textiles are the basic materials of apparel products (Moon & Ngai, 2010). The operational processes in the sector of textile production involve activities that turn raw materials (e.g., fibers) to finished textile products (e.g., yarns and fabrics). Three main subcategories are included: 'fiber-to-yarn', 'yarn-to-fabric', and 'coloring and finishing'. Fiber-to-yarn involves turning fibers into yarns by spinners, throwsters, and/or texturizers (Şen, 2008), while yarn-to-fabric converts yarns into fabrics or cloths through weaving, knitting, or some forms of nonwoven process. Coloring and finishing are additional processes applied to textile products in order to create special visual and/or tactile effects.

The management/control processes in this sector involve activities that support the production of textile products and can be further classified into 'textile inspection and evaluation' and 'textile production management'. Textile inspection and evaluation comprises all inspections and evaluations during the entire textile production process, including quality inspection, textile property evaluation, and error identification. The main purpose is to ensure that the quality of the finished textile products are up to a level that is agreeable with the clients. Textile production management refers to planning, organizing, monitoring, and controlling production activities like scheduling, line balancing, and shop floor layout as well as the general management of information flow, human resources, organizational behavior, environmental control, cost control, and other management-related activities.

2.1.2. Apparel manufacture

Apparel manufacture encompasses the processes of transforming textile products, such as fabrics and yarns, into finished garments according to specific design requirements. The operational processes in garment manufacturing can be subcategorized into 'product design and development', 'material management', 'garment making', and 'pressing, finishing and packing'. Product design and development involves activities in bringing aesthetic or natural beauty concepts into a garment product and then transforming these concepts into a physical prototype; that is, the first sample (Tate, 2004). Material management refers to the activities of sourcing and purchasing needed materials from suppliers; and then evaluating and processing these materials before cutting and sewing in the later stages. Garment making is the main process in making-up a garment, which includes spreading/cutting, sewing, buttoning/buttonholing, and some other special sewing processes (Bralla, 2007). Pressing, finishing and packing are the final processes undertaken to ensure the finished garments are at the required state for delivery and/or retail.

Management/control processes in this sector can be classified into subcategories of 'garment inspection and evaluation' and 'garment production management'. The former is a process undertaken to ensure that final products delivered to customers are up to an agreed quality standard, which include activities like detecting garment defects (Kuo, Lee, & Tsai, 2003; Yuen, Wong, Qian, Chan, & Fung, 2009), checking sizes (Croyle & Lin, 1996), and assessing seam puckers (Mak & Li, 2007). The latter supports the operations of garment manufacturing, including activities like production scheduling and routing, machine layout, work study, line balancing, and other general management issues.

2.1.3. Distribution/sales

The final stage of a textile and apparel supply chain is distribution/sales, which involves moving the finished garment products