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Artificial Intelligence in the Management of Textile Companies: A Contextual Analysis

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Abstract

The aim of this scientific contribution is to present a contextual analysis of the applications of artificial intelligence in the management and optimization of the textile industry. To achieve this objective, this scientific contribution carries out research in the domains of the Sopas research platform. In this research, the bibliometric and bibliographic analysis tools of this platform are used. In addition, the VOSviewer software is used to generate a term map from text mining. This document focuses on the following lines of results: 1) scientometric analysis of research related to artificial intelligence in the management of textile companies. 2) Main publications related to artificial intelligence in the management of textile companies. 3) A discussion on the application of artificial intelligence in the management of textile companies.

Keywords

Textile Factories, Textile Marketing, Management Strategies, Artificial Intelligence in Decision Making, Bibliometric Analysis, Text Mining, Term Map

1. Introduction

Artificial intelligence (AI) is a field of study and development that focuses on the creation of computer systems and programs capable of performing tasks that require human intelligence. AI is based on the idea of simulating the reasoning, learning, perception and decision-making capacity that humans possess (Vrbka & Rowland, 2020).

Artificial intelligence systems use complex algorithms and mathematical models to process large amounts of data and extract meaningful patterns and insights. These systems can learn from experience and adapt to new situations, allowing them to improve their performance over time (Garg, Aggarwal, Tiwari, & Chat-

terjee, 2021).

There are different approaches and techniques within artificial intelligence, such as machine learning, which allows systems to learn from data without being explicitly programmed, and natural language processing, which allows machines understand and communicate in human language (Bhardwaj & Pathak, 2021).

Artificial intelligence has applications in a wide range of industries and sectors, from medicine and the automotive industry to business management and entertainment. Some examples of AI applications include virtual assistants, recommendation systems, autonomous vehicles, speech recognition, and computer vision (Mehra & Singh, 2021).

As technology advances, artificial intelligence continues to evolve and improve, providing new opportunities and challenges (Bravo Hidalgo & Monteagudo Yanes, 2019). While AI offers significant benefits, it also raises ethical and social questions about issues such as privacy, security and the impact on employment. Ultimately, artificial intelligence has the potential to transform the way we live and work, driving progress and innovation in numerous fields.

Artificial intelligence (AI) has a significant influence on business management in various aspects. Some of the key areas where AI impacts business management are explored below:

Decision Making: AI helps managers and business leaders make more informed decisions. By analyzing large amounts of data and extracting patterns, AI can provide evidence-based insights and recommendations. This allows leaders to evaluate different scenarios and make more strategic and informed decisions (Sahai & Goel, 2021).

Task automation: AI automates repetitive and routine tasks, freeing up employees' time to focus on higher-value activities. Chatbots and virtual assistants are examples of AI that can answer frequently asked questions from customers and provide basic support, reducing the workload of customer service staff (Purthi, 2021). Process optimization: AI can analyze and improve business processes. By applying machine learning algorithms to historical data, AI can identify inefficiencies, bottlenecks, and opportunities for improvement in business operations. This helps companies optimize their performance and increase efficiency in areas such as the supply chain, production and logistics (Bravo, Bennia, Naji, Fellouah, & Báez, 2020).

Personalization and customer experience: AI enables greater personalization in customer interaction. By analyzing customer data, AI can provide personalized recommendations and offers, improving customer experience and increasing satisfaction. Additionally, AI can use natural language processing to understand and respond to customer queries more quickly and accurately (Gusai & Rani, 2021).

Advanced data analytics: AI has the ability to analyze large volumes of data in real time and extract valuable insights. This helps companies identify hidden patterns, market trends, and customer preferences. AI models can predict future

demand, identify risks and opportunities, and provide insights for strategic decision-making (Sanwal, 2021).

Innovation and product development: AI fosters innovation and the development of new products and services. By analyzing market data and customer preferences, AI can help companies identify new opportunities and develop products that fit market needs. Additionally, AI can accelerate the design and development process by performing virtual simulations and testing (Wandmacher, Sturm, Weber, & Kuhn, 2022).

Artificial intelligence (AI) has revolutionized the way companies operate and manage their activities. In the textile industry, AI has proven to be a powerful tool to optimize processes, improve efficiency and increase competitiveness. This analysis will examine the impact of artificial intelligence on the management of textile companies, exploring its applications in areas such as supply chain, production, logistics and data analysis (Naim, 2022).

The objective of this scientific contribution is to present a contextual analysis of the applications of artificial intelligence in the management and optimization of the textile industry. This document contains the following subtitles: First: Scientometric analysis of research related to artificial intelligence in the management of textile companies. Second: Main publications related to artificial intelligence in the management of textile companies. Third: A discussion on the application of artificial intelligence in the management of textile companies.

2. Materials and Methods

The Scopus database was used in this scientific contribution. This is a bibliographic database and citation analysis tool used in academia and research. It is managed by the Elsevier company and focuses mainly on science, technology, medicine and social sciences. Scopus collects information on scientific journal articles, conferences, and patents, providing researchers, academics, and practitioners with access to a wide range of scientific literature. Some of the key features of Scopus include:

- Broad Coverage: Scopus indexes a wide variety of sources, allowing users to access a diverse range of scientific information.
- Citation Analysis: One of the most notable features of Scopus is its ability to perform citation analysis. Users can see who has cited a specific article and analyze citation trends over time.
- Performance Indicators: Scopus provides bibliometric and impact metrics, such as the h-index, which helps evaluate the productivity and influence of a researcher, a journal or an institution.
- Advanced User Interface: The Scopus interface offers advanced search tools and filtering options that make it easy to locate specific information.
- Integration with Reference Management Tools: Scopus integrates with several reference management tools, facilitating the organization and citation of scientific literature.

Researchers and academics use Scopus to find relevant information, perform bibliometric analysis, evaluate journal quality, and measure the impact of their work. However, it is important to note that access to Scopus generally requires an institutional or individual subscription, as it is a commercial service offered by Elsevier.

Using as search criteria, in the aforementioned database, the phrase: "artificial AND intelligence AND in AND textile AND companies", in the title, summary and keywords of the contributions, 49 documents were detected. These documents are divided into articles, conference documents, book chapters, review articles, among others.

In addition, through the Scopus platform and its bibliometric analysis tools, figures were obtained that relate the number of publications by subject area, the number of publications by year, the number of publications by nation and much more information.

On the other hand, in this research the computational tool VOSviewer was also used. This is a software tool used to visualize and analyze bibliometric and scientific networks. This program was developed by Nees Jan van Eck and Ludo Waltman at the Center for Science and Technology Studies at Leiden University in the Netherlands. Its name, VOSviewer, is derived from "Visualization of Similarities viewer". Some of the main features and functions of VOSviewer include:

- Network Visualization: VOSviewer allows you to visualize complex networks of scientific documents, authors, terms or any other entity that can be represented in a network structure.
- Bibliometric Analysis: The tool is especially useful for carrying out bibliometric analysis, which involves the quantitative study of the production and impact of scientific literature.
- Cluster Maps: VOSviewer can generate cluster maps that group similar elements in the network, facilitating the identification of trends, themes and communities in scientific research.
- Custom Colors and Labels: Users can customize the appearance of the maps using different colors and labels to highlight certain aspects of the network.
- Integration with Bibliometric Data Sources: VOSviewer can be used with bibliometric data from sources such as Scopus, Web of Science and other bibliographic data files.
- Exporting Results: The results of the analyses carried out in VOSviewer can be exported for later use in reports or presentations.

VOSviewer is commonly used in academia and research to visually explore relationships between different elements, identify emerging patterns in scientific literature, and assist in data-driven decision making in scientific research and publishing. It is a valuable tool for those who are interested in understanding the structure and dynamics of scientific and bibliometric networks.

Using this tool, the term map figure was created, by indexing keywords. This

text mining analysis was carried out based on the information detected in the Scopus database and with the previously exposed search criteria.

3. Results

3.1. Bibliometrics Analysis of Research Related to Artificial Intelligence in the Management of Textile Companies

Figure 1 shows the percentage distribution of scientific publications detected in the Scopus academic research database. The different types of scientific contributions detected are directly related to research in artificial intelligence in the management of textile companies, from different areas of knowledge. In this figure it is evident that the highest percentage of publications is concentrated in the subject areas: Computer Science, Engineering and Business, People and Accounting. This result shows that research into the applications of artificial intelligence in the management of the textile industry is an excellent niche for future scientific contributions.

In the last 4 years there has been a sustained increase in the number of scientific contributions published in Scopus and related to research in artificial intelligence in the management of textile companies. It is worth highlighting that the applications of artificial intelligence have found many opportunities in the most dissimilar spheres of human activity such as the military industry, cinematography, medical sciences, geography, digital art, Finland, etc. Figure 2 shows how the interest of the international scientific community in the research topic discussed in this document has been growing.

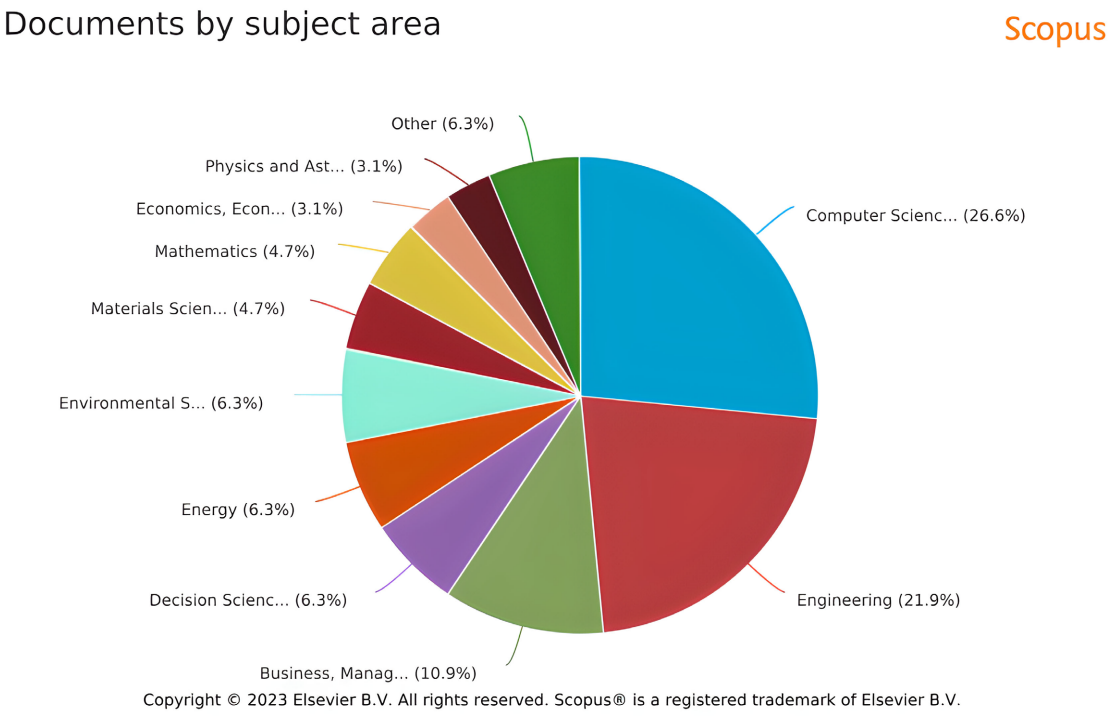

Figure 1. Scientific contributions detected in Scopus, by subject area.

The nations that have placed the greatest number of scientific contributions on the Scopus scientific dissemination platform in this research topic are: Turkey, Portugal, Vietnam, Brazil, Germany, among others. This result shows how emerging economic powers have opted for the application of artificial intelligence in the management of the textile industry (Figure 3).

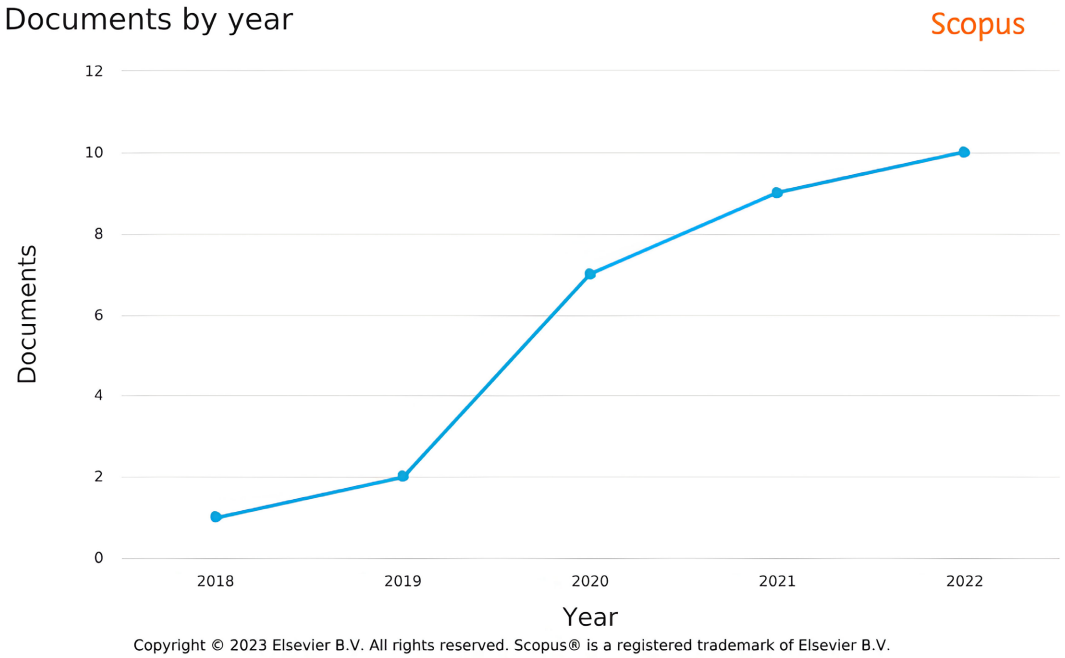

Figure 2. Number of scientific contributions published in Scopus, by year.

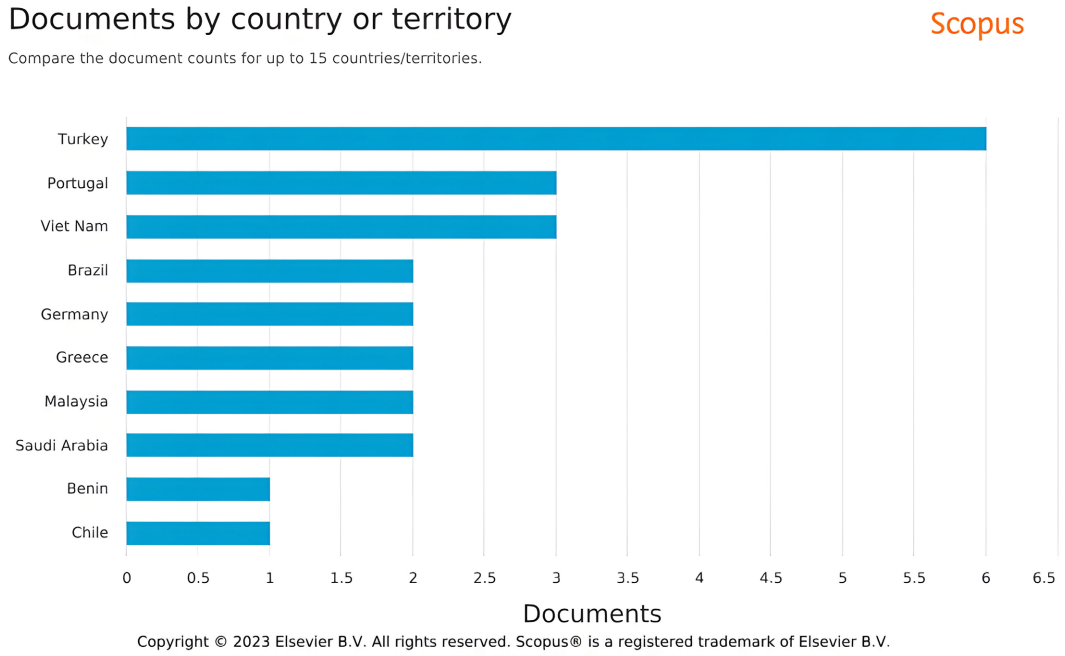

Figure 3. Number of scientific contributions published by countries or regions, in the Scopus database and under the search criteria established in the materials and methods section of this document.

Figure 4 shows the percentage distribution of the different types of documents related to this topic, which have been socialized by the aforementioned Scopus database. 51.7% of the scientific contributions are conference document type, 34.5% are article type document, 10.3% are book chapters and the rest are conference reviews.

The Terms Map shown in Figure 5 is the result of the text mining analysis

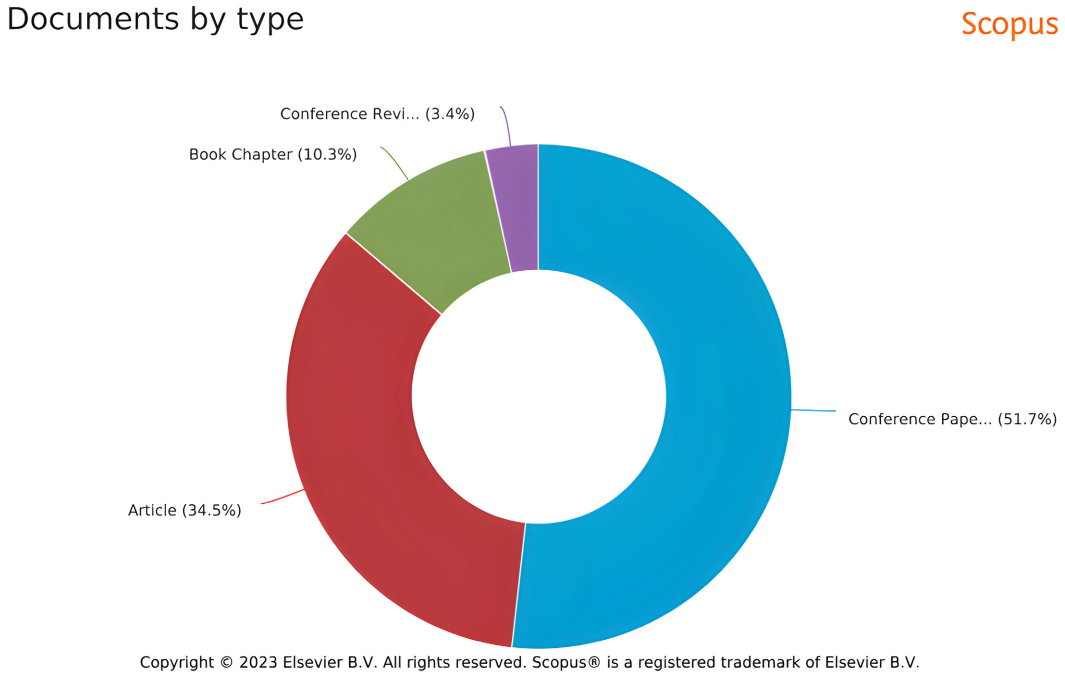

Figure 4. Percentage value for types of documents published in the Scopus database.

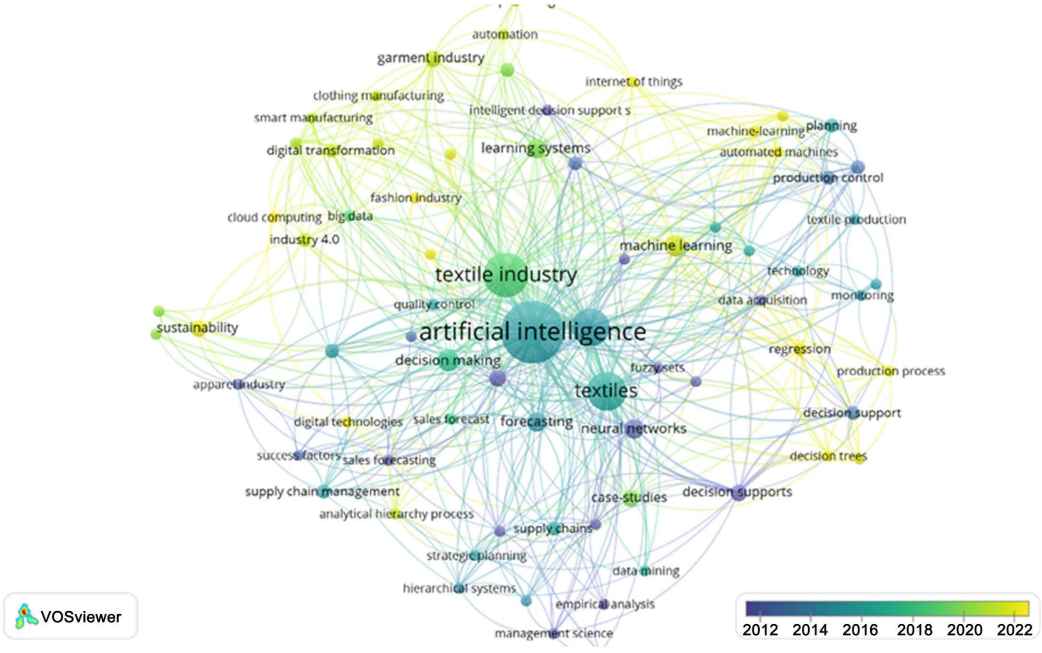

Figure 5. Map of terms by keywords.

carried out with the VOSviewer software on the information extracted from the Scopus research academic directory. In this figure, the color degradation indicates the timeline. The dimensions of the circumferences indicate the intimacy of the co-occurrence of the term. The lines that connect these circles establish the relationship or connection of each term with each other. This **Figure 5** shows that the term "artificial intelligence" is the term with the highest intensity of occurrence, since this criterion is the backbone of this research. The following terms with the greatest incidence are: textile industry, textiles, production control, sustainability, industry 4.0 among others.

3.2. Main Publications Related to Artificial Intelligence in the Management of Textile Companies

Below are some of the scientific contributions most cited by the scientific community, related to the applications of artificial intelligence in the management of companies focused on textile production. These scientific contributions are arranged chronologically, in a way that allows an understanding of the evolution of this line of research over time.

In this paper, an AI (artificial intelligence) approach to the design and control of an integrated maintenance management system is reported. The research work has been done on two levels. At the managerial level the overall maintenance management system is designed by the GRAI method. This system is designed as an integrated system which makes decisions on maintenance activity scheduling and control, taking into consideration not only equipment working conditions but also maintenance cost, product quality, and production efficiency. At the decision support level, a number of intelligent decision support systems (IDSSs) are developed based on Bayesian theory or causal probabilistic networks (CPNs). In this paper, a generic CPN for the maintenance of open-end spinning mills is reported (Tu & Yeung, 1997).

The complexity of current organization systems, and the increase in importance of the realization of internal controls in firms, make it necessary to construct models that automate and facilitate the work of auditors. An intelligent system has been developed to automate the internal control process. This system is composed of two case-based reasoning systems. The objective of the system is to facilitate the process of internal auditing in small and medium firms from the textile sector. The system, analyses the data that characterises each one of the activities carried out by the firm, then determines the state of each activity, calculates the associated risk, detects the erroneous processes, and generates recommendations to improve these processes. As such, the system is a useful tool for the internal auditor in order to make decisions based on the risk generated. Each one of the case-based reasoning systems that integrates the system uses a different problem-solving method in each of the steps of the reasoning cycle: fuzzy clustering during the retrieval phase, a radial basis function network and a multi-criterion discreet method during the reuse phase and a rule-based system for

recommendation generation. The system has been proven successfully in several small and medium companies in the textile sector, located in the northwest of Spain. The accuracy of the technologies employed in the system has been demonstrated by the results obtained over the last two years (Corchado, Borrajo, Pellicer, & Yáñez, 2004).

The supply chain management is a crucial success factor for companies. Due to the specific constraints in the textile-apparel industry, the sourcing and replenishment procedures require the implementation of efficient decision support system. Amongst these systems, sales forecasting models are essential for the optimization of the supply chain management. However, in order to take the right decisions and to decrease the financial risks, it is also recommended to take into account the notions of uncertainty and costs in the forecasting procedure. The proposed system is based on a forecasting system adapted to the constraints of apparel industry, which has been developed in previous work. The performed forecasts are then optimized according to the uncertainty and the purchase and selling prices of each item. This optimization is founded on the Newsboy method. Our system is tested on a real data base relative to an important ready to wear retailer (Sébastien & Pierre, 2005).

An enterprise resource planning system (ERP) is the information backbone of a company that integrates and automates all business operations. It is a critical issue to select the suitable ERP system which meets all the business strategies and the goals of the company. This study presents an approach to select a suitable ERP system for textile industry. Textile companies have some difficulties to implement ERP systems such as variant structure of products, production variety and unqualified human resources. At first, the vision and the strategies of the organization are checked by using balanced scorecard. According to the company's vision, strategies and KPIs, we can prepare a request for proposal. Then ERP packages that do not meet the requirements of the company are eliminated. After strategic management phase, the proposed methodology gives advice before ERP selection. The criteria were determined and then compared according to their importance. The rest ERP system solutions were selected to evaluate. An external evaluation team consisting of ERP consultants was assigned to select one of these solutions according to the predetermined criteria. In this study, the fuzzy analytic hierarchy process, a fuzzy extension of the multi-criteria decision-making technique AHP, was used to compare these ERP system solutions. The methodology was applied for a textile manufacturing company (Cebeci, 2009).

Aiming at the requirement of real-time monitoring of looms and limitations of subsistent monitor systems, a new monitor system based on ZigBee technology for looms was proposed, and then put forward its network structure. The CC2430 chip based on ZigBee technology from TI Company was applied to node controllers which function as data collection and transmission, management of monitoring network, fault alarm and so on. Then the article devised the

circuit schematic for performance data collection, network monitoring node. At the same time pictured the program procedure of master node and data collection node, network protocol and structure of data frame. The result shows that the system has the following characteristics: stable and reliable, anti-jamming, low-power, small-size and low-cost, so this means it can provide the monitoring of looms in textile production with a new technology (Dong & Jia, 2009).

In this paper, a novel systematic method to obtain the most proper organizational safety strategies in a textile company in Iran by utilizing SWOT concept is presented. After finding the SWOT factors DEMATEL method is applied to find inter relations and casual diagram of factors for each four clusters separately. By considering the factor relationship structures, "SO, WO, ST and WT" strategies are obtained. In next step by group fuzzy AHP several criteria to find most proper strategies are weighted. Finally, ELECTRE is utilized to find efficient group of strategies. One of the contributions of this research is to use DEMATEL to obtain importance of each factor in SWOT matrix and considering this importance to determine strategies (Rezaie, Ansarinejad, Nazari-Shirkouhi, Karimi, & Miri-Nargesi, 2010).

In this document, 53 samples were selected from the textile and apparel enterprises listing in Shanghai and Shenzhen stock exchanges. We collected the data of 2007-2009 from CCER and annual reports of the listed companies. With the data, we researched on the influence between growth determinants and other economic indicators, such as size of the firm, profitability, operational capacity, debt-paying ability, and capital structure, by hypothesis test model. Using the "main business income" as the index of the growth of enterprises, the data were processed by statistical software, such as EXCEL, SAS and SPSS. The result shows that if we sort the growth determinants of the enterprises by their influence, we can get size, management and finance capabilities in sequence (Liu & Zhou, 2011).

Problem solving and decision-making are important skills for business and life. Good decision-making requires a mixture of skills: creative development and identification of options, clarity of judgement, firmness of decision, and effective implementation. SWOT analysis is a powerful tool that can help decision makers achieve their goals and objectives. In this study, data obtained through SWOT analysis from a quality department of a textile company were integrated by means of fuzzy multi criterion decision making. The aim of the study was to choose the policy most appropriate for the beneficial development of the quality department (Gürbüz & Pardalos, 2016).

The chapter aims to propose decision support framework for identification of key performance indicators for supply chain performance measurement in textile industry. To meet the objective, hierarchical model is developed including criteria, sub-criteria, alternatives. Proposed decision support system (DSS) is developed with objective as textile supply chain performance measurement with 4 stakeholder value creation perspectives (Financial, Customer, Internal business

processes, Innovation and learning) suggested by balanced scorecard (BSC) as criteria, having 23 sub-criteria (key performance indicators) and 3 supply chain operations (Procurement-Production-Distribution) as alternatives. Structured Delphi method and Minitab 17.0 software for statistical analysis are used for the development of decision support framework. Whereas, for establishing pair wise comparison and analyzing the relative importance of these criteria, sub-criteria and alternative, analytical hierarchy process (AHP) is used. The paper demonstrates the application of decision support system in identifying key performance indicators and analyzing the importance of KPIs towards overall performance of supply chain in textile. The proposed system is put to test at four textile case industries. Case company wise implication as well general implications on textile supply chain performance is presented. Also, managerial implication and limitations are presented. Proposed study presented novel approach in developing DSS for textile supply chain performance measurement, which is very rare one. This DSS will be used for identifying key performance metrics/indicators and also analyzing their importance towards supply chain performance. Use of BSC perspective has given framework wholesome coverage of all stakeholders' consideration. Also, involvement of supply chain cyclic operation added consideration of supply chain partners (Charkha & Jaju, 2020).

The new consumption behaviors and environmental awareness are pushing the textile apparel industry to profound transformations. Co-design and production on demand are two success factors for this paradigm shift but require efficient and practical tools for companies. In this context, the European H2020 FBD_BModel project provides to practitioner a suitable digital platform. More specifically for the supply chain management, efficient and well-known algorithms are implemented in a user-friendly web-based application composed of two modules. The first module aims at selecting suppliers with multi criteria decision making techniques. This is particularly important to deal with a huge variety of products and a large number of small factories with their own features. The second modules proposed a genetic algorithm-based optimization for order scheduling and supplier allocation. In a demand driven strategy, this task is crucial to reach the requirements in terms of cost and lead time. This paper provides a brief description of the methods implemented in the web-based application. A numerical example, based on real data of the industrial partners of the FBD_Bmodel project, shows the results obtained with the proposed solution (Thomassey & Zeng, 2021).

The modern methods offered by the field of artificial intelligence bring an alternative solution to the problems existing in the industry. In this study, it is aimed to make an estimation of cloth waste in a textile company by using machine learning models. Thus, instead of producing with a fixed waste rate, the company evaluates many different parameters affecting the production process and obtains waste rates that vary according to the order. In this way, the company can overcome the problems that may be encountered in terms of both re-

source management and cost with the right amount of production. In the study, four machine learning methods (Support Vector Regressor, Random Forest, Decision Tree Regressor, and Bagging) were used and the results show that bagging gives the highest R2 value and minimum prediction error with 0.86 R2 when compared to other approaches (Atik, Kut, Birant, & Birol, 2022).

The fashion industry is one of the industries that most use natural resources and one of those in the world that most pollutes. This is caused by the excessive and often irrational consumption of textile products. Moreover, most companies in this industry operate in the linear model and despite the incentives to transition to a circular economy model, companies in developing countries face difficulties in finding strategies that are both circular and do not pose risks to their businesses. Thus, whether due to the lack of skills or the structure needed, many companies choose to outsource circular economy strategies to manage fashion waste. However, outsourcing circular decisions are underestimated and arbitrarily taken without any prior analysis of whether these strategies may or may not be outsourced. This can hinder companies' transition to a circular economy due to the lack of circularity of other companies they cooperate with. Hence, the aim of this study was to propose a novel multi-criteria decision model for sorting circular strategies into those that can be outsourced or not in adopters' and incumbents' circular business models supported by a decision support system. Moreover, we compared them in real case studies to identify the main differences between their outsourcing decisions and their impacts on cleaner production for fashion waste management. This comparison resulted in insights that may support circular businesses worldwide to make consistent outsourcing decisions to fashion waste management, which is rarely explored in the literature with empirical evidence (Oliveira Silva & Morais, 2022).

The investments in digital technologies are expected to soon have a major impact on the textile and fashion companies' sustainability and competitiveness. Motivated by these trends empirical research on investments of the fashion and textile companies in ICT technologies-based advancement in the Serbian case was provided in 2022. Representatives of 423 textile and fashion companies were asked about their investments in various digital technologies in the previous three years and their digital transformation status. The research findings show that investments in cloud computing, IT, energy management, automation, robotics, and machine learning technologies have a significant impact on the digital transformation of companies. Most of them reached a medium level of transformation, fewer than a high level, with many textile and fashion companies just defining digital transformation. The contribution of the research findings to the investments in the companies' digital transformation can be seen in the significance of the textile's digital technology implementation, which enables manufacturers and retailers to respond directly to market demand by reducing product lead time and cost, increasing supply chain efficiency and profitability, and promising in terms of ensuring competitive advantage in the risk and chal-

lenging business environment (Špiler et al., 2023).

E-marketing strategies and applications are developing drastically and this has substantial effects on business markets and customer's behavior. Consequently, many firms have presented e-marketing strategies through their electronic web sites so they may associate for all intents and purposes with domestic and global markets. Electronic marketing is perceived as another new development of business practice in organic textile products that are identified with advancement and offering through World Wide Web sites and using other electronic networks. This research paper concentrates on e-marketing applications for organic textile products, and how these computerized applications can strengthen the organizations to make awareness. This paper guides to build the customer's confidence on organic products and also guides the customers to avoid any misconception for green products. E-marketing can possibly educate the consumers regarding significance of environment friendly green products and facilitate the consumers for connecting to internet and other virtual networks to purchase the green products. Nowadays e-marketing is going to become prerequisite of the society; so, organizations are robustly observing these changes to flourish their business. E-marketing is very helpful for the organizations to develop long term relationships with customers, and retaining these loyal customers for their organic textile products on long term basis (Abrar, Safeer, Baig, & Ghafoor, 2016).

4. Discussion

This research detected that the applications of artificial intelligence in the management context of the textile industry are focused on various very specific areas. Next, the aforementioned areas of action of artificial intelligence in the performance of the textile industry are declared and characterized.

- Supply chain optimization:

AI plays a crucial role in optimizing the supply chain of textile companies. Using advanced algorithms, AI can analyze large amounts of data in real time to predict demand, optimize inventory levels, and improve production planning. This allows companies to minimize storage costs, reduce waiting times and avoid shortages or overstocks. Additionally, AI can help identify reliable suppliers and negotiate more favorable contracts, improving the efficiency and quality of textile products.

- Improvement of production and quality:

Artificial intelligence has also been used to improve production and quality in textile companies. AI systems can monitor and control manufacturing processes in real time, detecting anomalies and making automatic adjustments to ensure the quality of the final product. Additionally, machine learning algorithms can analyze large amounts of historical data to identify patterns and trends, enabling better production planning and reduced wait times. This helps companies improve efficiency, reduce production costs, and deliver high-quality products to their customers.

- Efficient logistics and distribution:

AI can play a key role in the logistics and distribution of textile products. By analyzing real-time data, AI can optimize delivery routes, minimize transportation costs, and improve product delivery efficiency. Additionally, AI algorithms can predict and anticipate logistics issues, such as delivery delays or changes in demand, allowing companies to take proactive steps to resolve these issues and minimize their impact on operations. Overall, this leads to a more agile supply chain and higher customer satisfaction.

- Data analysis and decision making:

The amount of data generated in the textile industry is enormous, and AI can help companies extract valuable information and make more informed decisions. Machine learning algorithms can analyze large data sets to identify hidden patterns, market trends, and customer preferences. This helps companies adapt their marketing strategies, develop new products and services, and customize offerings to individual customer needs. Additionally, AI can provide accurate forecasts about future demand, allowing companies to proactively anticipate and respond to market changes.

5. Conclusion

Artificial intelligence has transformed the management of textile companies by providing tools and capabilities that improve efficiency, quality and decision making. From supply chain optimization to improved production, efficient logistics and data analysis, AI offers numerous advantages to textile companies. Those that make the most of this technology can gain a significant competitive advantage by quickly adapting to market changes, improving customer satisfaction, and achieving greater operational efficiency. Ultimately, artificial intelligence has become a key element in managing successful textile companies. This scientific contribution has evidenced a growing interest on the part of the international scientific community in this research topic. This is why the nations have placed the greatest number of scientific contributions on the scientific dissemination platform Scopus, in this research topic, which are: Turkey, Portugal, Vietnam, Brazil, Germany.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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