Agile and Affordable: A Survey of Supply Chain Management Methods in Long Lifecycle Products

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Abstract—**Supply chain management (SCM) is an integrative approach to managing the total flow of the industry from the supplier to the customer. This paper provides a comprehensive survey of the existing models in SCM for long lifecycle products. The paper first defines SCM based on the literature and then summarizes SCM methods in practice for products with longer product design cycles, including the aerospace, shipbuilding, and automobile industries. Further, the reviewed literature is categorized under seven different methods for SCM: the traditional approach, fuzzy approach, closed loop supply chain, economic impact, supplier risk, green approach, and sustainability approach. Based on the seven approaches for SCM, this paper highlights the main factors that were considered and compared between the aerospace, shipbuilding, and automobile industries.**

*Keywords— **Supply Chain Management, Risk, Green Supply Chain, Fuzzy, Closed Loop, Cost, Time, Sustainability***

I. Introduction

Organizations and industries often create and sustain their competitive advantages by developing a strategic and effective supply chain (SC) [1]. Increasing mass production in different industries requires a focus on core activities, which lead to an increased usage of supply chain management (SCM) techniques in practice. This viewpoint has created the challenge of successfully coordinating the entire SCM, from upstream activities such as supply of raw materials and transportation to the plant, to downstream activities such as inventory management and customer service [2].

SCM is a growing concept that integrates multiple approaches to deal with the planning and control of activities involved from the suppliers to the end user [3]. Various activities such as purchasing and supply, logistics and transportation, marketing, organizational behavior and SC network have contributed over the years to SCM literature [2]. With the above activities, there have also been contributions of strategic management, management information systems and operations management to SCM literature [2].

SCM techniques are important for better understanding about the system and communicating information to SC members [2]. Therefore, the basic goal of SCM is to achieve improved customer satisfaction at reduced overall costs [3]. SCM also has links to marketing through its broad perspective on customer service [3]. In today's competitive environment, a customer service orientation can provide a critical advantage. Further, the goal of SCM is extended to integrate the entire channel from supplier to end-user [3]. One key element of managing the SC is to understand how the supply chain network structure is configured. There are three primary aspects of SC network structure [4]: the members of SC, the structural dimensions of the supply chain network and different types of process links across the SC.

To consider SCM and adopt its advantages in companies, there are different approaches and factors depending on the relationships between suppliers and end-users [5]. Firstly, the inventory management factor involves channel-wide management of the stock in inventory [5]. Also, cost is an important factor in SCM. The cost efficiency approach implies a channel-wide evaluation of costs to identify total cost advantages and to reduce economic impact within a SC network [5].

Each member in a SC network expects its membership in the SC to continue their investments in the integrated SCM [5]. Another important aspect in SCM is mutual information sharing and monitoring of each member in SCM [5]. A mutual information sharing approach helps to plan and monitor the processes in the SC network [5].

The objective of this paper is to review and synthesize the existing literature on long time product lifecycle industries, including aerospace, shipbuilding and submarine, and automotive, to help guide managers in choosing appropriate SCM strategies. The paper is organized as follows: Section 2 presents the background of SCM and how it is used in these three industries. Section 3 describes many of the common practices involved in SCM. Section 4 discusses a comparison of the mentioned approaches, and Section 5 summarizes the key takeaways and offers conclusions.

II. Background

In most of the literature, SCM is referred to as a logistics

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network [6]. SCM is the network between a company, its suppliers and customers whose purpose is to produce and distribute a specific product [7]. A supply chain network is the procedure that gets the product to the customer [8]. A SC system contains suppliers, distribution and manufacturing warehouses, retail outlets as well as raw materials, inventory and the specific product [7]. This system helps to create the flow between the suppliers and customers. Atul and Satish define SCM as [9]:

"*A set of approaches utilized to efficiently integrate suppliers, manufacturers, warehouses, and stores, so that merchandise is produced and distributed at the right quantities, to the right locations, and at the right time, in order to minimize system-wide costs while satisfying service level requirements.*"

According to this definition, SCM brings beneficial changes in business scope and progress [10]. Due to the challenges in SCM, applying best practices can improve efficiency for the business and can be beneficial in terms of cost [10,11]. Some of the benefits of SCM are:

- Enhanced information flow and financial flow [10],
- Optimized material and product flow,
- Balance between supply and demand of products,
- Minimized delay in processes,
- Raised business profit level [11],
- Improved inventory system,
- Mitigated risks [12],
- Optimal shipping options [12], and
- Improved communication with suppliers and distributers. [13]

Although there are many advantages of SCM, companies face some challenges as the result of using different SCM methods. It is difficult to find a single perfect model for operating SCM, because most of the research focuses on only a subset of the SCM challenges, which include:

- Matching supply and demand;
- Minimizing system-wide costs and maintaining system-wide services;
- Managing fluctuations in inventory and back-order levels across the supply chain [14];
- Pressures on operational costs due to rising fuel/energy and transportation costs, increasing labor costs, new regulations and rising commodity prices;
- Increasing environmental concerns; and
- Rising complexity due to global supplier networks and extended delivery lead times [15].

To overcome these diverse challenges, different approaches should be considered for SCM according to the characteristics of each industry. This paper discusses available SCM models with references to aerospace, shipbuilding and submarine, and automotive industries, as these are industries with long product design cycles.

Aerospace Industry: Different researchers present studies to overcome the challenges related to managing longer product design cycle SCM. A literature search identified 14 papers that addressed such problems in the aerospace industry. All attributes and datasets reported in these models are information based on products, suppliers, demand and inventory, time based on transportation, order processing lead time, standard production lead time, manufacturing and set-up time, cost related to raw material, transportation, manufacturing and set-up and risks [16,17,18,19,20].

Shipbuilding and Submarine Industry: Aiming to take advantage of global markets, shipbuilding involves shipyards located in different countries [21]. The information flow in shipbuilding industries is often confusing and redundant [22]. It involves many concurrent activities, which raises difficulties in tracking the work flow in this industry. The tasks performed in this industry are mostly dependent on other running tasks such as material delays, which are massive at times [21], raising unique challenges in optimizing SCM in shipbuilding.

Limited research has been published about SCM in this industry compared with the other industries. One reason can be based on the fact that the shipbuilding industry is a step behind in its application of simulation models [14]. In the shipbuilding industry, the main factors taken into consideration during the usage of the models are firm size, product size, intellectual property awareness, customization of the product, communication across different shipyards, total cost analysis, inventory and design and production information [23,24,25].

Automotive Industry: The automotive industry represents the largest industry in terms of economic sectors by revenue [16]. SCM in this industry also plays an important role in terms of customer satisfaction, quality assurance, product variety and process complexity [26]. With the large and sustained demand in this industry, customer requirements have increased at a faster pace than these other industries.

III. Supply Chain in Practice

This section describes the collected papers based on their associated categories, summarized in Table 1.

A. Traditional Approach

The traditional approach in this literature considers simulation-based models with an extension of the Supply Chain Operations Reference (SCOR) model. The SCOR model was developed in 1996 by the Supply Chain Council as a tool different industry could adopt for SCM. The SCOR model is built across five different management processes, namely: plan, source, make, deliver, and return. Simulation-based models with reference to data driven, optimization, lot sizing and scheduling problem (LSSP) and analytic hierarchy process (AHP) are discussed in this section. Different attributes are being used to provide SCM models in different industries. Some models such as simulation-based optimization method [27] and data-driven simulation [17] with the goal of extended enterprises in the aerospace industry were presented. Also, the aspect of maintenance, repair, and overhaul (MRO) was presented [28] to automate, communicate and optimize business information process in this industry. Furthermore, a classification evolutionary

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Table 1: Distribution of research papers

Categories	Industries	Papers	Factors
Traditional Approach	Aerospace	[16] [17] [24][28][29][52]	Product information, demand, order processing lead time, inventory, logistic time
	Automotive	[27] [30]	Operational time, demand, set-up time, order lead time, inventory
	Shipbuilding	[21] [23] [24]	Cost, flexibility, delay time, product and firm size
Fuzzy Logic	Aerospace	-	-
	Automotive	[34] [45] [36]	Quality, greening cost, recycling cost, material features
	Shipbuilding	[24]	Shipyard cost, quality of service, logistics cost, inventory, production flexibility
Closed Loop	Aerospace	[51]	Set-up cost, demand, assembly cost, BOM information, remanufacturing cost
	Automotive	[36]	Material cost, material stock, zip code, load capacity per truck, transport distance
	Shipbuilding	[34]	Cost, demand, Shipyard details, remanufacturing cost, suppliers' information
Economic Impact	Aerospace	[20][37][38]	Material cost, material type, aircraft type, size of firm
	Automotive	[31]	Co2 Emission, cost of material, production cost, weight
	Shipbuilding	-	-
Supplier Risk	Aerospace	[31][50]	Legal risk, budget, controllable and uncontrollable risk
	Automotive	[30][40][42]	Legal risk, procurement, logistics time, lead time, cost
	Shipbuilding	-	-
Green Supply Chain	Aerospace	[44]	Remanufacturing, green purchasing, waste management, green operations
	Automotive	[36] [44][45] [50]	Cost for waste treatment, cost for purchasing materials, delivery improvement, operational cost, pollution control initiatives
	Shipbuilding	[25] [44]	Customer requirements, government regulations, supplier readiness
Sustainability	Aerospace	[47] [48]	Safety, environmental performance, raw materials
	Automotive	[47][49] [50]	Orders, cost, inventory, trust, delivery time
	Shipbuilding	[47]	

scheme (CES) was presented by adding some new SC attributes such as political requirements, outsourcing, SC sourcing, suppliers' risk, product and distribution quality, and delivery time to the existing models [16]. Moreover, an additive manufacturing (AM) model as an extension of SCOR was evaluated to optimize the safety inventory in the aircraft system [29].

While the aerospace industry focuses on SCM simulation models, the automotive industry mostly focuses on improving SC resilience and understanding how to mitigate strategic effects on the system performance [30]. Also, a decision support model [31] is used for supplier selection with an integration of AHP. A hybrid model of mixed-integer linear programming and simulation model [27] reported to deal with LSSP with capacity constraints and uncertain multi-product and multi-period demand.

SCM systems in both the aerospace and automotive industries were modeled based on features like operational time, demand, set-up time, order lead time, inventory, and logistic time, but the approaches are different. In the aerospace industry, Pareto-optimal solutions were tested with different decision-making scenarios based on inventory control policies, order splitting ratios and open/close decisions on facilities [32]. Data-driven simulation was proven to become a useful tool for producing models that can support the design and improvement of SCM operations [13]. The aerospace industry also focuses on web-based models which can help to minimize the stock holding costs [18]. CES model presents changes to SCM to adapt to market realities with the help of new features [16]. Furthermore, using AM models can provide various opportunities for reducing the required safety inventory [29].

The applied methods in the aerospace industry will allow other industries such as the automotive industry to compare SCM behavior after the occurrence of the disturbance under the two SCM resilience design strategies [30]. Supplier selection in SC network gives the decision maker the confidence of the consistency and the robustness throughout the process of supplier selection with the use of AHP and sensitivity analysis [27]. LSSP is resolved by a hybrid model and is adopted to test a local as well as global production strategy of a multi-site manufacturing system of braking equipment for the automotive industry [27].

B. Fuzzy Approach

One extension to the traditional approach is fuzzy logic,

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which is at its core a multi-value logic that allows transitional values such as low/high, good/bad or true/false to be specified. Fuzzy logic was introduced about four decades ago by Lotfi Zadeh [33], who proposed to solve a problem by providing definite conclusions from unclear and uncertain information. Different approaches are integrated with fuzzy logic such as fuzzy rule-based evaluation methodology [33], which aims to have a successful closed loop supply chain in the automotive industry. Fuzzy multiple criteria decision making with an extension of the SCOR model was developed to increase SCM competitive positioning in the shipbuilding industry [23].

Internal management support, green purchasing and ISO 14001 certification are stated to be the most prevalent green SCM practices in the automotive industry [34], while in the shipbuilding industry, shipyard cost was the most important factor [23]. To improve economic performance in the automotive industry, recycling used products was introduced as the major criterion with the help of a visual diagram [35]. The DEMATEL method was used to offer useful insights for managers to improve both economic and environmental performance [34]. Fuzzy rule-based evaluation methodology helped in measuring closed loop supply chain (CLSC) performance periodically based on raw data feed with real time assessment capacity for the automotive industry [43].

Further, the decision-making trial and evaluation laboratory (DEMATEL) method [34,35] as an integration of fuzzy approach was presented to handle the casual relationships and performances between green SCM practices. The DEMATEL method also provides a visual analysis for the Vietnamese automobile manufacturing industry to explore the indicators in green SCM practice implementation [35].

Hybrid models based on the Fuzzy and DEMATEL methods propose that by studying different criteria of GSCP such as economic performance, green purchasing, environmental performance, supplier-customer collaboration, and pollution control initiatives, the increase of cost for purchasing environmentally friendly material was the most influential and significant criterion, while the pollution control initiatives was the most effective criterion [35,36].

C. Closed Loop

Closed-loop supply chain (CLSC) methods arose from traditional SCM due to additional activities such as product recovery, refurbishing or recycling. CLSC network design models are applicable for the context of re-manufacturable, durable products/parts, such as automotive parts, photocopying equipment, ships, and aircraft engines. The automobile industry focuses on end of life vehicle (ELV) treatment using CLSC models, which aim to concentrate on how reverse material flows can be handled regarding reintegration into their genuine supply chains [36]. While the automobile industry focuses on ELV, shipbuilding and aerospace focus more on manufacturing aspects. The CLSC has been applied to study the effect of remanufacturing and transforming scrap in the aerospace industry. The model also determines the quality of components used in forward and reverse flow of SCM. A multi-product CLSC model with the goal to minimize the processing, transportation and fixed location costs by providing effective Benders reformulation was presented for the shipbuilding industry [19].

Despite the huge inventory carrying cost, CLSC models help to increase profits by transforming and remanufacturing scraps in the aerospace industry . CLSC model considered with example of ELV treatment helps to put improved scenarios of reverse logistics planning with examples of automotive industry in Germany [36].

D. Economic Impact

This section discusses the SCM literature with goals to reduce economic impacts using cost or time-based factors. Estimation of released duration or production cost can be generated throughout the product lifecycle using different attributes of the combined information available [37]. It is reported that, there is always a key estimate in any industry, which can directly affect the delivery time if it gets delayed for the customer [38]. To avoid the delay of delivery time, one study applied a Support Vector Machine (SVM) model to predict the manufacturing time of the metallic component required in aerospace industry [38]. The presented SVM model helped with budget planning and predicting accurate lead time. Also, with the help of other components, project managers can generate production schedules which can provide early warnings of delays in the aerospace industry [38]. Another important factor required for SCM is cost estimation while designing a SC. To address this, the Pro-COST model was presented to develop a generalized cost estimation methodology, which can help to estimate the cost for machined parts during the procurement process [37]. The hierarchical approach towards cost estimation in the Pro-Cost model was presented to resolve issues that might occur during the sourcing process. This approach may help in reducing the waste of resources during the sourcing process [37].

E. Suppliers Risk

One important supply chain decision is selecting the right suppliers [31,39,40]. Researchers use different models to track the supplier selection process and mitigate the risk of applying different SCM process. One of these models is the AHP model [31], which ranks available suppliers based on expert opinion and selection of suppliers in an automotive industry [31]. This model helps managers to make better and quicker decisions, considering factors such as price, quality, delivery, and service [31].

Another methodology used for mitigating risk and achieving resilience within the supply chain is to categorize the risks [41]. Five activities were reported to mitigate supplier risk: identifying risks, assessing the risks, plan and implement solutions for risks, conduct failure modes and effect analysis (FMEA) and perform continuous improvements [39].

Another approach to measure, track and analyze suppliers is proposed in the automotive industry to address specific risks related to logistics, politics or inventory [42]. The methodology to measure, track and analyze the supplier was presented to assess, identify and monitor the suppliers and find the specific risk for automobile industry [43]

To achieve supplier risk mitigation, four basic principles are

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presented: resilience should be designed in, collaboration should occur at the highest level in the chain to identify and manage risk, an agile supply chain should be able to react to uncertain environments and a risk management culture should be established within the organization [41]. Also, differentiating different types of risks, foreseen, perceived, controllable and uncontrollable risks, will help in reduction of redundancy with the mitigation process. This can ultimately help in efficient utilization of resources for supplier risk mitigation [36]

F. Green Supply Chain

Green supply chain management (GrSCM) can be defined as the integration of environmental thinking into the traditional approach to SCM with the implementation of several "R's": Reduce, Re-use, Rework, Refurbish, Reclaim, Recycle, Remanufacture, Reverse logistics [44]. Developing countries have started considering rapid usage of GrSCM due to environmental pressures and challenges to improve environmental and economic performance [42,45]. This is an emerging and important approach which can help to reduce environmental issues and ecological impacts of industrial activity without sacrificing cost, reliability, quality or performance [42,45]. In the shipbuilding industry, GrSCM is used based on pollution concerns from cargo shipping activities [25]. The important factors and drivers for the participation of the suppliers in the shipbuilding industry was analyzed by [46] because of the concerns raised.

In the automotive industry, green supply chain practices (GSCP) are being studied and evaluated by different methods such as the simulation method and fuzzy methods integrated with DEMATEL [35,36,40]. The proposed simulation methods aim to evaluate GSCP and assist the decision makers in acquiring in-depth understandings about GrSCM [26].
Using fuzzy and DEMATEL methods, a hybrid model has been proposed to present cause and effect diagrams and find the influence of GSCP for the supply chain system [36]. Similarly, hybrid models investigated the effects of each criterion within GSCP by using different case studies such as the Vietnamese automobile manufacturing industry [35].

Research in the shipbuilding industry reported that supplier readiness, competitive advantage and social responsibility are found to be significant factors after analyzing the important factors of the suppliers [46], while no significant impact was found based on governmental regulations and customer requirements [46]. One interesting case in the automotive industry used a combined simulation model of system dynamics (SD) and discrete event simulation (DES) to improve the consumption of water and energy, reduce waste, and reduce the costs of energy and waste treatment [40].

G. Sustainability

Sustainability in an organization depends on various factors such as size, location, and the number of supply chain attributes involved in the SC network [47]. The three dimensions of a sustainable supply chain management (SSCM) are the environment, economy, and society, which are collectively known as the 'triple bottom line' of sustainability [58]. Review-based models such as a case study of British Aerospace Systems [48] reviewed the key features and necessary drivers for SSCM such as social responsibility, stakeholder pressures, resource depletion, and environmental standards. Other models focused on the evolution of SSCM with the goal of identifying trends, potential agreement in findings and approaches across studies [47]. A collaborative fractal-based SCM framework for the automotive industry was presented to manage trust issues and the reduction of load in production planning [49]. In this framework, relationships between the participants of a SC are modeled as a fractal, and each fractal has a goal model which generates a production plan for its participants on the model. The production planning takes trust value under consideration during the generation of each goal model of fractal in the framework [49]. To validate the developed framework for the automotive industry, simulations were conducted using AutoMod 12.2. The results from the simulations indicated that their framework can be useful for getting precise production plans. [49]

SSCM models focus on the factors that drive sustainability within a SC network that link with the environmental, social and economic performance [47]. According to available studies, factors that lead to increasing economic performance are government legislation, stakeholder pressures, resource depletion, low carbon economy, environmental standards, and social responsibility [48].

Further, due to the growth in social awareness of the environmental impact, inclusion of considering both social and operational costs of CO2 emission helped decision-makers to assist in SCM with the help of presented generic mathematical model [44]. This mathematical model considered a specific set of constraints while analyzing the different scenarios: Material requirement, supplier's capacity limit, production limits of plants and throughput limit [44].

IV. Discussion

In this section, different approaches and factors involved in SCM models are compared. Figure 1 illustrates an overview usage of the different categories of SCM in the reviewed literature.

According to the SCM categories reported in the previous section, CLSC and GrSCM share similar goals in term of usage of remanufacturing and recycling products for the SC network. Interestingly, fuzzy logic was integrated with the GrSCM model to provide better outcome in the practices used in GrSCM. Also, integration of the fuzzy approach and GrSCM was presented in order to increase of cost for purchasing environmentally friendly material which may help to increase the environmental performance. Therefore, green logistics initiatives focus on minimizing greenhouse gasses emissions such as CO2, Methane, and nitrous oxide, which can ultimately help to decrease the economic impact and increase the environmental performance.

SCOR models were introduced as an extension of the traditional approach as well as the fuzzy approach. Using the SCOR method in additive manufacturing [29], it was shown that additive manufacturing is important for the aerospace

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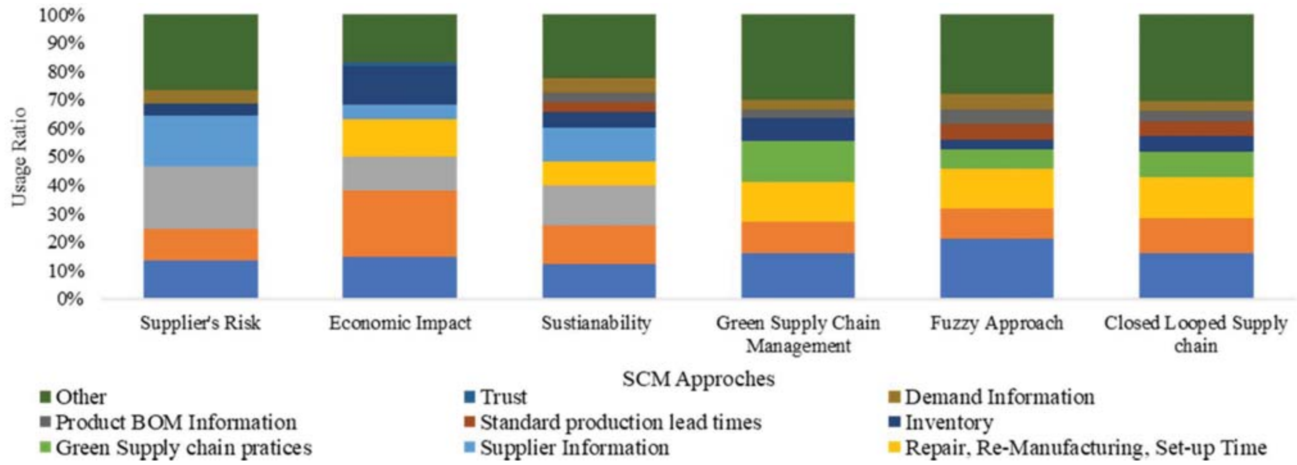

Figure 1: Approaches with percentage of factors used

industry. In the shipbuilding industry, the focus of SCOR with the fuzzy model [43] was to highlight shipyard cost as an important factor.

Further, selection of suppliers is important for monitoring and mitigating supplier risks. SCOR models consider suppliers as the key elements to participate in the SCM and consequently reduce the risk in the system. A well organized and integrated SCOR model can help mitigate the risks in any SC network. Figure 1 presents the introduced categories with the percentage of some factors used in SCM. This visualization is based on the mentioned analyses from the available research papers. Interestingly, there are no similarities between sustainability and GrSCM.

It is reported that improved estimating cost and time methodologies within the supply chain network is an important aspect of SCM. Cost estimating methodology used analogous classification, ratio estimating and parametric testing for the production parts and costing framework. The estimating time methodology used batch size, raw material cost, manufacturing cost and inspection test time to either generate production schedule or predict the lead time of any component.

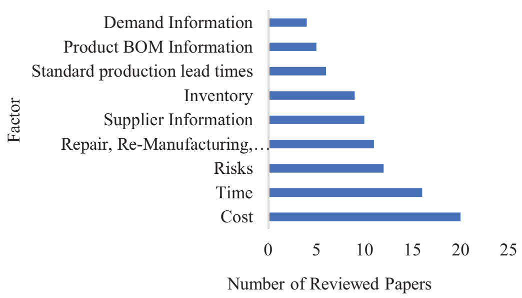

Figure 2: Top factors considered in available papers in SCM models

Figure 2 represents different factors considered for SCM models in different research papers. On one hand, cost was the most common factor used for all approaches. There are different models considering cost for the reduction of economic impact with supply chain network such as fuzzy integrated DEMATEL method for the visual diagram and handling of casual relationships and performances of GrSCM [35,36]. Another category focusing on cost was the GrSCM model which was used to reduce both environmental impact and economic impact [42]. When the social cost rate of CO2 emissions is higher, the emission of CO2 in an apparel manufacturing supply chain network will be lower [50]. Interestingly, location and fuel crisis data were less often considered when presenting the SCM models.

Another key factor that appeared in many of the articles was time. Some models focus on delivery time, which has a direct economic impact, while other models focus on setup time, delay time or operational time. Predicting the manufacturing time before the start of manufacturing with the help of SVMs can provide a buffer time in order to avoid delays [38]. Whereas, considering transportation time, on-time delivery rate and demand response time as factors, an optimization-based model can provide decision, and inventory control policies [27]. Further, considering lead-time of repair, transforming, re-manufacturing and assembly, a mixed-linear programming model can be useful to maximize the profit [51].

Another common factor broadly used in SCM approaches is risk. A multi-criterion scoring procedure is presented to calculate part and suppler risk indices [25]. Those indices will be used in development of a risk assessment and monitoring the supply chain network that allows to identify the trends towards the higher risk levels. Another aspect used for mitigating risk is the methodology which provides a mechanism to minimize conflicting objectives.

Although cost and time are the most common factors considered in the literature, trust factors can be easily integrated into profit or goal models [50]. Trust value of participants in SCM were evaluated in numerical terms and considered in production planning. Numerical terms in production planning helped to generate precise production plans in supply chain network and reducing back-order costs [50]. Also, the concept of modularity was investigated and analyzed within the shipbuilding industry [52]. The relationship of modularity and

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SCM integration was examined, and four contingent variables were concluded: customization, IP awareness, product and firm size and innovativeness. With the help of contingent variables, ten propositions were stated [52]. Moreover, the relationship between the dimensions of supply chain flexibility and firm performance was explored with the help of sample data of Spanish automobile industries [53].

Although there are different approaches used for SCM, there are some points to be considered by companies before implementing a SC network approach [1]:

- Although cost reduction is a prime reason for SCM collaboration, customer satisfaction and service should be considered as well by all SC members.
- Members of the SC network are the key to successful collaborative. Companies often invest money in technology and information flow in the system by forming the right teams for the right tasks.
- People culture, trust and willingness are important among the members of a successful SC network.

In general, SCM can help companies and provide a realistic view of the challenges found in the network [4]. However, there is still much work to be done in the SCM literature. One priority is to research a normative model that can guide members in a network to develop and manage supply chain activities more effectively [4].

V. Conclusion

This paper presents a literature survey of supply chain management models with specific industries that have longer product design cycles. We have considered seven different approaches for presenting existing models: the traditional approach, fuzzy approach, closed loop supply chain, sustainability approach, economic impact, supplier's risk, and green supply chain. The study also highlights the key factors considered in existing models for SCM. Finally, a comparison of the approaches and the corresponding factors was discussed.

References

[1] F. Stanley, M. Gregory and M. Matthew, "Benefits, barriers, and bridges to effective supply chain management".

[2] Paulraj and C. I.J, "Understanding supply chain management: critical research and a theoretical framework," 2007.

[3] Ellram and Lisa, "Supply Chain Management: The industrial organizational perspective," 1990.

[4] L. Douglas, C. Martha and P. Janus, "Supply Chain Management: Implementation Issues and Research Opportuntities".

[5] Ellram, C. Martha and Lisa, "Characteristics of supplly chain management and the implications for purchasing and logistics strategy," 1993.

[6] "SCM-Logistics,"[Online].Available:https://www.michiganstateuniversityonline.com/resources/supply-chain/is-logistics-the-same-as-supply chain-management/#.W3OBJOhKg2w.

[7] "Supply Chain," [Online]. Available: https://www.investopedia.com/terms/s/supplychain.asp.

[8] "Supply Chain defination," [Online]. Available: https://en.wikipedia.org/wiki/Supply_chain.

[9] B. Atul and B. Satish, "Domain of Supply Chain Management- State of Aret", Journal of technology management and innovation, vol. 2, no. 4, 2004.

[10] "Advantages SCM," [Online]. Available: https://solutiondots.com/blog/benefits-of-supply-chain-management/.

[11] "Advantages -2," [Online]. Available: https://www.liaison.com/blog/2017/02/10/benefits-supply-chain-management/.

[12] U. g. Sourcing, "Advantages of SCM," [Online]. Available: https://www.unitedgs.com/blog/global-supply-chain-management/the-advantages-of-supply-chain-management/.

[13] "Advantages - 3," [Online]. Available: http://www.aims.education/supply-chain-blog/advantages-and-benefits-of-supply-chain-management/.

[14] "Challenges," [Online]. Available: https://www.mckinsey.com/business-functions/operations/our-insights/the-challenges-ahead-for-supply-chains-mckinsey-global-survey-results.

[15] "Challenges 2," [Online]. Available: http://blog.rbwlogistics.com/the-5-biggest-supply-chain-challenges/.

[16] Christen, B. James, R. Keith, A. Peter, V. Liz and S. Mark, "A cladistic classification of commercial aerospace supply chain evolution," 2007.

[17] T. James, C. Bing, F. Richard and B. Mike, "Data-driven simulation of the supply-chain—Insights from the aerospace sector," 2007.

[18] M. Michael and C. Ben, "Designing a support system for aerospace maintenance supply chains," 2005.

[19] H. Vesra, C. Mingyuan and F. Liping, "Process planning for closed-loop aerospace manufacturing supply chain and environmental impact reduction".

[20] W. Tim, M. Roger and E. Bruce, "Demand chain management theory: constraints and development from global aerospace supply webs".

[21] M. M and S. J, "Supply chain management in the shipbuilding industry: challenges and perspectives," 2011.

[22] "Shipbuilding," [Online]. Available: http://journals.sagepub.com/doi/abs/10.1177/1475090211406836?journalCode=pima.

[23] P. Margherita, Martin and RobertoCigolin, "Linking product modularity to supply chain integration in the construction and shipbuilding industries".

[24] W.L.Bean, P.M.U.Schmitz, G.n.Engelbrecht, "Adapting the Score Model to Suit The Military : A south African Example"

[25] M.C.J. Caniels, E. Cleophas, J.semeijn, "Implementing Green Supply Chain Practice in an Emprical Investigation in the Shipbuiling Industry", Journal of Maritime Policy and Management, May 2016

[26] "Automobile industry," [Online]. Available: http://www.advantech.com/logistics/case%20studies/39fd76a1-9fc7-4c5f-82d7-ac017d1a1a61/.

[27] D. Hongwei, B. Lyes and X. Xiaolan, "A Simulation-based Optimization Method for Production-distribution Network Design".

[28] M. Michael and C. Ben, "Designing a support system for aerospace maintenance supply chains," 2005.

[29] Moceno and Daniela, " Supply Chain Features of the Aerospace Industry Particular Case Airbus and Boing"

[30] C. Helena, B. Ana, M. Virgínia, A. Susana and M. Cruz, "Supply chain redesign for resilience using simulation," ELSEVIER Computers & Industrial Engineering, pp. 329-341, 2012.

[31] C. Martin and P. Helen, "Bulding the Resilient Supply Chain," The International Journal of Logistics Management Volume 15, Number 2, 2004.

[32] Kuo-JuiWu, Ching-JongLiao, Ming-LangTseng and C. Anthony, "Exploring decisive factors in green supply chain practices under uncertainty".

[33] S. Frank, Z. Moritz and R. Otto, "Modeling reverse logistic tasks within closed-loop supply chains: An example from the automotive industry".

[34] G. Kannan, K. Roohollah and V. Amin, "Intuitionistic fuzzy based DEMATEL method for developing green practices and performances in a green supply chain".

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[35] Kuo-JuiWu, Ching-JongLiao, Ming-LangTseng and C. Anthony, "Exploring decisive factors in green supply chain practices under uncertainty".

[36] Ü. Halit, E. Gopalakrishnan, E. Akçali and Ç. Sila, "Benders Decomposition with Alternative Multiple Cuts for a Multi-Product Closed-Loop Supply Chain Network Design Model," 2006.

[37] P. Watson, R. Curran, A. Murphy and S. Cowan, "Cost Estimation of Machined Parts within an Aerospace Supply Chain".

[38] F.J.de Cos Juez, P.J.García Nieto, J.Martínez Torres, J.Taboada Castro, "Analysis of lead times of metallic components in the aerospace industry through a supported vector machine model," Mathematical and Computer Modelling, 2009.

[39] T. Shih-Chang and H. Shiu-Wan, "A strategic decision-making model considering the social costs of carbon dioxide emissions for sustainable supply chain management".

[40] B. Jennifer, S. Kevin and J. Danny, "Supplier risk assessment and monitoring for the automotive industry," 2007.

[41] S. Pankaj, W. Larry and M. Don, "Methodology to mitigate supplier risk in an aerospace supply chain.," Supply Chain Management: An International Journal, Volume 9 : Number 2, pp. 154-168, 2004.

[42] B. Jennifer, S. Kevin and J. Danny, "Supplier risk assessment and monitoring for the automotive industry," 2007.

[43] S. K. Srivastava, "Green supply-chain management: A state-of-the-art literature review".

[44] L. Ru-Jen, C. Rong-Huei and T.-H. Nguyenc, "Green supply chain management performance in automobile manufacturing industry under uncertainty," International Conference on Asia Pacific Business Innovation & Technology Management, 2011.

[45] M.C.J. Caniels, E. Cleophas, J.semeijn, "Implementing Green Supply Chain Practice in an Emprical Investigation in the Shipbuiling Industry", Journal of Maritime Policy and Management, May 2016

[46] F. Reza, R. Shabnam, D. Tammy and F. Samira, "Competitive supply chain network design: An overview of classifications, models, solution techniques and applications," 2013.

[47] C. Craig and E. Liane, "Sustainable supply chain management: evolution and future directions".

[48] G. Kavitha, Y. Yahaya, M. Ahmed, A. Tijjani and A. Hafsat, "Sustainable supply chain management: A case study of British Aerospace (BAe) Systems".

[49] O. Seungjin, R. Kwangyeol, M. Ilkyeong, C. Hyunbo and J. Mooyoung, "Collaborative fractal-based supply chain management based on a trust model for the automotive industry".

[50] T. Shih-Chang and H. Shiu-Wan, "A strategic decision-making model considering the social costs of carbon dioxide emissions for sustainable supply chain management," 2013.

[51] H. Vesra, C. Mingyuan and F. Liping, "Process planning for closed-loop aerospace manufacturing supply chain and environmental impact reduction".

[52] L. Peng, H. Samuel, M. Abhiram, Z. Heng and H. Liang, "The impact of additive manufacturing in the aircraft spare parts supply chain: supply chain operation reference (scor) model-based analysis," Production Planning & Control: The Management of Operations, 2013.

[53] Pe´rez, M. S. Angel and P. Manuela, "A conceptual model and empirical study in the automotive industry," 2005.

978-1-5386-8396-5/19/$31.00 ©2019 IEEE