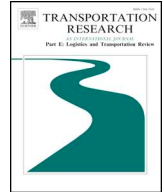




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A United Nations' Sustainable Development Goals perspective for sustainable textile and apparel supply chain management[☆]



Ya-Jun Cai, Tsan-Ming Choi*

Business Division, Institute of Textiles and Clothing, Faculty of Applied Science and Textiles, The Hong Kong Polytechnic University, Hung Hom, Kowloon, Hong Kong

ARTICLE INFO

Keywords:

United Nations' Sustainable Development Goals
Supply chain management
Sustainability
Textile and apparel industry
Review

ABSTRACT

Motivated by United Nations' Sustainable Development Goals (SDGs) and the importance of sustainability, this study examines how the textile and apparel (TA) supply chains can comply with the SDGs. By examining the literature as well as industrial practices, we show that the current sustainable operations in TA industry are far away from realizing the goals of economic growth going hand-in-hand with the social and environmental sustainability. For instance, among the SDGs, the goals of "Responsible Consumption and Production", "Clean Water and Sanitation", and "Climate Action" receive a considerable amount of attention, while goals of "No Poverty", "Reduced Inequalities", "Life below Water" and "Life on Land" have the least attention. Balanced sustainable development actions from the stakeholders' perspective are proposed. Managerial implications and future studies are discussed.

1. Introduction

1.1. Background

Sustainability and green supply chain management are very important for business operations nowadays (Li et al., 2019; Kalkanci and Plambeck, 2020; Li and Wu, 2020; Wu et al., 2020). United Nations' new sustainable development agenda for 2030 has come into force since 2016, which initiates 17 sustainable development goals (SDGs).¹ The SDGs well demonstrate the new objectives of economic, social and environmental developments, such as ending poverty, economic growth, environmental protection and so on. SDGs call for everyone in the world to contribute to the goals, including governments, companies, civil organizations and the public. From the private sector, it is reported that sustainable business can bring up to US\$ 12 trillion in economic opportunities.² Meanwhile, we witness some giant fashion enterprises effectively respond to the United Nations' SDGs. Inditex manages its sustainable supply chain management based on the United Nations' SDGs and tries hard to take actions for every detailed goal.³ For example, Inditex strictly carries out the Code of Conduct and its compliance and evaluates them by auditing, to ensure workers' good health and well-being. H&M indicates that its business must contribute to sustainable development goals as a starting point, with details

[☆] We sincerely thank the editors and reviewers for their kind comments on this paper.

* Corresponding author.

E-mail address: jason.choi@polyu.edu.hk (T.-M. Choi).

¹ <http://www.un.org/sustainabledevelopment/sustainable-development-goals/> [Accessed on 25 March 2019].

² <https://www.un.org/ecosoc/en/node/4965587> [Accessed on 25 March 2019].

³ <https://www.inditex.com/documents/10279/319575/Inditex+Annual+Report+2016/6f8a6f55-ed5b-41f4-b043-6c104a305035> [Accessed on 8 May 2020].

summarized in its “Agenda 2030”⁴. For example, by 2030, H&M will only use recycled or sustainably sourced materials in its products, to ensure responsible production.

The fashion supply chain is a textile and apparel industry specialized supply chain, which is characterized by labor-intensive manufacturing, long value chain and relatively high degree of environmental pollution (Bentahar and Benzidia, 2018; Choi and Cai, 2018; Choi et al., 2019), compared with supply chains in other industries. From the economic and social perspectives, global production takes advantage of low labor costs in developing countries, such as Cambodia, Vietnam, Bangladesh and so on. The factory accident Rana Plaza collapse in Bangladesh⁵ reflects the serious social problems hidden in the TA industry, which also arouse the public awareness on the labors’ rights, their health and safety, their payment, etc. From the environmental perspective, the TA industry brings serious pollution to the environment. Meanwhile, a huge amount of resources (e.g., cotton, linen, wool, etc.), energies (e.g., electricity), and water are consumed. Especially in the dyeing process, the wastewater contains various kinds of toxic chemicals. If not properly handled, the rivers and streams are seriously polluted. For example, “colorful rivers and streams” show up in some towns in the developing countries, where apparel factories are built and most of them do not invest on clean technology for wastewater treatment.⁶ From the statistics of the World Bank, 17% to 20% water pollution from industrial consumption is created by the dyeing and treatment process in the TA industry, and there are 72 toxic chemicals produced by the textile dyeing.⁷ Moreover, fast fashion and fast changing fashion trends have caused a high frequency of consumers’ purchasing, a shortened apparel lifespan, and a large number of post-consuming apparel waste (Dissanayake and Sinha, 2015). Thus, it is really a big challenge for the TA industry to achieve the new objectives of economic, social and environmental developments.

Nowadays, some controversies around fast fashion in terms of sustainability are reported. Since fast fashion has created fast-speed disposal, this directly yields tremendous waste generation and imposes high pressure on the environment. Due to the external pressure, sustainable measures have been taken by fashion brands (Biswas et al., 2018). On sustainable purchasing, “organic cotton” is widely used. For example, sustainable sourcing of cotton occupies 43% of H&M’s total cotton consumption in 2018 and the goal is that all the brands in H&M group will use sustainable raw materials and recycled materials by 2030.⁸ To solve the water pollution problem in the jeans dyeing process, Levi’s launched a “Waterless Dyeing Process” to reduce the water consumption and water pollution in 2016.⁹ Levi’s Eureka Lab has invented a new laser technology to make ripped and washed jeans more eco-efficient in 2018.¹⁰ To protect the animal’s rights, the luxury brand Gucci announced to stop using the genuine leather and fur in 2017.¹¹ The sustainable fashion designer-label brand Stella McCartney insists on using the artificial leather for handbag and shoes making and this type of artificial leather has a high-quality of functionality, which even can compete with the genuine leather. To protect the ocean, the plastics wastes (e.g., PET bottles) have been collected and remanufactured for fashionable clothes and shoes by sustainable fashion companies (e.g., ECOALF). To close the loop, H&M initiates the used apparel collection plan. Uniqlo collects the post-consumer products for donation. Nike recycles the old shoes for new ones. Many other practices can be observed in major well-established international fashion brands.

1.2. Research goal and approach

To this end, this research aims to examine how the TA sector can comply with the SDGs and how the TA industry can become more sustainable. Prior reviews (e.g., O’Rourke, 2014; Ansari and Kant, 2017; Köksal et al., 2017), research (Choi et al., 2019) or discussion papers (e.g., Choi and Li, 2015; Shen et al., 2017) in sustainable fashion supply chain management neither focus on the SDGs, nor comprehensively review the extant literature. Thus, to the best knowledge of us, this is the first paper which systematically examines from the SDGs perspective the fashion¹² supply chain management (FSCM) problems by drilling deeply in the literature. Based on “Triple Bottom Line” (3BL) (Elkington, 1994, 1998),¹³ we classify the 17 SDGs into three categories: social, economic and environmental perspectives (see Table 1.1). The objective of this research is to examine how to make the FSCM well respond to the 17 SDGs by 2030 and make the fashion industry more sustainable and eco-efficient.

This research employs a systematic literature review methodology (Tranfield et al., 2003) to explore the state-of-art literature on the sustainability and supply chain management in the TA sector (see Section 2 for why this method is adopted) and identify the potential contributions to the UN’s 17 SDGs. The results show that the sustainable supply chain management (SSCM) in the TA sector provides a number of sustainable practices. However, sustainable operations contribute unevenly to the developments of the social, economic and environmental sustainability. For instance, the goals of “Responsible Consumption and Production”, “Clean Water and

⁴ <https://about.hm.com/content/dam/hmgroupp/groupsite/documents/en/Digital%20Annual%20Report/2017/Annual%20Report%202017%20Sustainable%20development.pdf> [Accessed on 8 May 2020].

⁵ <http://www.bbc.com/news/world-asia-22476774> [Accessed on 25 March 2019].

⁶ <http://ohsoethical.website/tag/fast-fashion/> [Accessed on 23 April 2020].

⁷ <http://chinawaterrisk.org/resources/analysis-reviews/the-environmental-cost-of-clothes/> [Accessed on 25 March 2019].

⁸ <http://about.hm.com/en/sustainability/sustainable-fashion/materials/cotton.html> [Accessed on 25 March 2019].

⁹ <https://wellmadeclothes.com/articles/LevisMakesItsWaterlessDyeingProcessOpenSourceAndLaunchesSustainableFashionInnovationLab/> [Accessed on 25 March 2019].

¹⁰ <https://nyti.ms/1Orr3ja> [Accessed on 25 March 2019].

¹¹ <http://equilibrium.gucci.com/environment/fur-free/> [Accessed on 23 April 2020].

¹² In this paper, unless otherwise specified, the term “fashion supply chain” and “textile and apparel (TA) supply chain” are used interchangeably.

¹³ “Triple Bottom Line” is a well-established term for sustainability, which emphasizes the “three pillars” on economic, social and environmental sustainability.

Table 1.1
UN's 17 SDGs under three categories.

3BL	Social	Economic	Environmental
SDGs	#1 No Poverty #2 Zero Hunger #3 Good Health and Well-being #4 Quality Education #5 Gender Equality #11 Sustainable Cities and Communities #16 Peace, Justice and Strong Institutions #17 Partnerships for the Goals ^b	#8 Decent Work and Economic Growth #9 Industry Innovation and Infrastructure #10 Reduced Inequalities ^a #12 Responsible Consumption and Production #17 Partnership for the Goals	#6 Clean Water and Sanitation #7 Affordable and Clean Energy #13 Climate Action #14 Life below Water #15 Life on Land #17 Partnership for the Goals

^a The full content of Goal 10 aims to “Reduce inequality within and among countries”, which tends to be economic disparities within and among countries. Thus, we put Goal 10 in the “Economic” column.

^b Goal 17 is “Partnerships for the Goals”, which means collaborations among the social, economic, and environmental perspectives. Thus, we allocate Goal 17 in the three columns.

Sanitation”, and “Climate Action” receive a considerable amount of attention, while goals of “No Poverty”, “Reduced Inequalities”, “Life below Water” and “Life on Land” have the least attention. That means the TA industry is on the track to pursuing the sustainable development. However, it does not well balance the social, economic and environmental benefits. It is far away for the TA sector to realize the goal of economic growth going hand in hand with the social and environmental sustainability. Thus, we ultimately propose the “balanced sustainable development actions” for the sustainable FSCM, to comply with the United Nations’ 17 SDGs by 2030. The proposed strategy is of significant values to the policy maker and stakeholders (fashion designer, manufacturer, retailer, consumer, recycler, NGOs, investor, etc.) in the TA sector.

1.3. Contribution statement

This study contributes to the literature by discovering how sustainable FSCM can comply with the recently established United Nations’ 17 SDGs. To our best understanding, it is the first comprehensive study to link the TA sector with the SDGs. The research gaps are identified. Most importantly, “balanced sustainable development actions” are proposed from the stakeholders’ perspective, which would provide valuable guidelines for the policy maker and stakeholders in the TA industry. Additionally, we provide important implications regarding how various pertinent organizational theories can help to enhance sustainable FSCM. *The list of acronyms (in an alphabetical order) is placed in Appendix (A1).*

2. Research methodology

We adopt a systematic literature review methodology (Tranfield et al., 2003) for collecting and analyzing the target literature on sustainable FSCM. Observe that the systematic review methodology performs the literature searching in an explicit and rigorous algorithm, as opposed to a “heuristic way” (Tranfield et al., 2003). It can help researchers discover the exact state of the field’s development and the future trend (Denyer and Tranfield, 2009) without suffering too much from personal biases in paper selection. To this end, we consider that the systematic review methodology is an appropriate way to explore our topic “SSCM in the TA sector” and reach our “research objective” to generate important managerial insights for improving sustainability and achieving the SDGs. In the following, we present the searching methods and the searching results.

Firstly, we preliminarily identify the keywords. SSCM in the TA industry is not yet well-established. We read a variety of related papers to identify the keywords. After the preliminary reading, we uncover that the following keywords frequently appear in sustainable FSCM related papers: “sustainable fashion (or clothes, or textile and apparel) supply chain management”, “sustainable fashion (or clothes, or textile and apparel) sourcing”, “sustainable fashion (or clothes, or textile and apparel) design”, “sustainable fashion (or clothes, or textile and apparel) production”, “sustainable fashion (or clothes, or textile and apparel) retailing”, “sustainable fashion (or clothes, or textile and apparel) consumption”, “used apparel (or clothes) collection”, “recycling of textile and apparel materials”, etc. The details of the key words and searching results are shown in Appendix (A2).

Secondly, we conduct the keywords searching and analysis. We choose the *Web of Science* as the database to target the SCI or SSCI journal articles. Then we enter the above-mentioned keywords and identify 545 journal papers written in English excluding the conference papers. We search the *Web of Science* published papers for a number of reasons. First, the collected papers have a good academic quality as *Web of Science* journal papers are known to have a high standard. Second, this searching shows important statistics and the trend of publications over time, as well as the popularity of different journals; Third, the searching result comprehensively uncovers the topics and research methods taken by other researchers (Cai and Choi, 2019).

Thirdly, we conduct the paper selection. We check and read the initially identified 545 journal papers and filter out irrelevant articles, so as to acquire the target papers, which are most closely related to our research topic “SSCM in the TA industry”. For the first time, we obtain 172 journal papers. For the second time, we exclude the review papers, discussion papers, and duplicated ones, and filter out 64 papers. Ultimately, we collect 108 journal papers as the target papers for review and the paper selection is completed in May 2019. The selection process is shown in Fig. A1 (see Appendix (A3)).

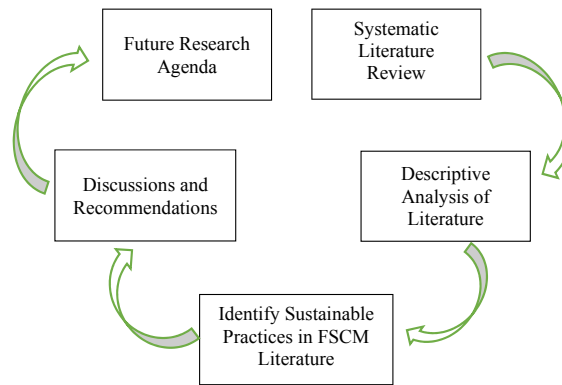


Fig. 2.1. Organization of this research.

The organization of the rest of this study is as follows. Section 3 gives a descriptive analysis of the collected literature. Section 4 matches the identified sustainable operations in sustainable FSCM to comply with the SDGs. Section 5 presents the discussions and recommendations. Finally, Section 6 concludes this research and proposes the future research agenda. Fig. 2.1 depicts the organization of this research.

3. Descriptive analysis of searching results

The searching results show that 108 collected papers related to sustainable FSCM are published from 1998 to 2019. The collected 108 papers are further categorized into more specialized areas, such as sustainable supply chain management¹⁴, forward activities, reverse activities, closed loop supply chain, and life cycle assessment (LCA). Fig. A2 (see Appendix (A3)) shows the proportion of each specialized area. We can see that the publications in the forward activities dominate the other activities, which implies that the forward supply chain management attracts more attention in the extant literature during the past two decades. Meanwhile, “reverse activities” and “closed loop supply chain” are emerging topics for the sustainable FSCM.

In a fashion supply chain, forward activities commonly include design, dyeing, production, logistics and distribution, retailing, and consumption. Reverse activities may involve reuse, remanufacturing, and recycling. Closed loop supply chain contains both the forward and reverse activities. As a remark, LCA as a popular quantitative method, can be used for measuring the closed-loop lifecycle. For the easiness of categorizing the journal papers, we allocate LCA related papers in the closed loop supply chain scope. The details of each category (called “node”) are shown in Appendix (A4). Finally, we review the supply chain activities and identify the sustainable operations in sustainable FSCM as follows.

4. Identify sustainable practices in the FSCM literature

In this section, we first review the relevant FSCM literature in more specialized areas in details. Then, we identify the sustainable practices in each area and summarize them in Tables 4.1–4.8.

4.1. Sustainable fashion supply chain management

The “3BL” based sustainability issues are critical in the TA sector. In this section, we review the papers which study the sustainability issues from the FSCM perspective. Various issues may include information disclosure in sustainability reports (Kim and Kim, 2017; De Brito et al., 2008), corporate social responsibility (CSR) initiatives (Amatulli et al., 2018), fairness, safety and wages for workers (Mair et al., 2018, 2019; Clarke-Sather and Cobb, 2019), carbon emissions (Morgan et al., 2018), sustainable collaborations (Ma et al., 2017), sustainability awareness (Garcia et al., 2019), intelligent forecasting (Choi, 2018) and so on. The extant literature studies these issues from both strategic and operational management perspectives.

From the strategic management perspective, Chi (2011) investigates how to improve the sustainability of supply chain management and identifies that CSR is a critical driver for the sustainability goals in the global fashion supply chains. Dabija et al. (2016) explore the connection between the ethical norms and sustainable development principles in the Romanian garment sector and disclose several measures of ethical principles for the achievement of sustainability. Shi et al. (2017) evaluate the economic performance and environmental impact of investment in sustainability and find that both the manufacturer and retailer can benefit from the sustainable investments. Nagurney and Yu (2012) study the international collaborations of supply networks in the clothing industry from economic, social and environmental perspectives and find that a strong relationship will facilitate the development of sustainability goals. Oelze (2017) studies the enablers and barriers of SSCM and finds that collaborations can facilitate the sustainable

¹⁴ This category contains papers which may include forward activities, reverse activities and others, but do not focus on a concrete supply chain activity. Thus, we put them in the category of “sustainable supply chain management”.

supply chain implementation in the TA sector, such as cross-industrial collaboration and supply chain members' collaboration.

From the operations management (OM) perspective, Na and Na (2015) investigate how Korean textile and fashion companies pursue the sustainability development and find that their main efforts made on the sustainability development are using the eco-friendly materials, product reusing and eco-marketing. Atilgan (2007) studies the eco-labelling applied in the European countries and finds that eco-labelling acts as an important role in addressing the human health and environment issues in the TA sector. Shen (2014) studies the structure of sustainable fashion supply chain by employing a case analysis of a fast fashion brand H&M and finds that H&M is on the track of implementing the sustainable supply chain, but it may give less consideration on the environmental wellbeing. Yang et al. (2017) examine the luxury groups in adopting sustainable supply chains and finds that not all brands actively carry out sustainable practices. The authors propose "sustainable value co-creation mechanisms" to help luxury brands to create sustainable value effectively. Li et al. (2017) study the water usage in China's TA industry and show that the factor of large textile industry scale is the most influential driver for the increasing amount of China's textile industry water usage. Li and Wu (2017) study how the adoption of environmental management systems affect firms' performance on operational efficiency and find that environmental management systems reduce the firms' profits. Based on the above findings, we uncover how "sustainable fashion supply chain management" literature can provide insights to enhance sustainable practices based on 3BL. Table 4.1 shows the details.

Table 4.1
Sustainable practices in sustainable FSCM literature.

Area	3BL	Details
Sustainable Fashion Supply Chain Management	Social Sustainability	-Disclosing the sustainability reports with firm's real actions ^a ; -Executing corporate social responsibility (CSR) is helpful for the sustainability goals.
	Economic Sustainability	-Sustainable investment does good to both the economic and environmental benefits; -Strong international collaborations of supply networks facilitate the development of sustainability goals, such as cross-industrial collaboration and supply chain members' collaboration.
	Environmental Sustainability	-Disclosing the sustainability reports with firm's real actions; -Environmental regulations, international operation standards and sustainability incentives should be provided; -Sustainable investment does good to both the economic and environmental benefits; -Operations like using the eco-friendly materials, product reusing and eco-marketing, are adopted by Korean textile and fashion firms.

^a If one sustainable measure can apply to more than one of the 3BL, we put it in the different 3BL. For instance, "disclosing the sustainability reports with firm's real actions" can help improve both social and environmental sustainability. This categorizing approach applies to all the tables in this section.

4.2. Forward activities across the fashion supply chain

The traditional supply chain management focuses on forward activities management, which contains upstream activities, including sustainable design, sustainable dyeing, sustainable sourcing, sustainable production, and downstream activities, including sustainable retailing and consumption (Chiu et al., 2018; Choi et al., 2017; Choi and Luo, 2019; Kim and Kim, 2017; Choi et al., 2015). We review them as follows.

4.2.1. Sustainable design

Sustainable design means to use more eco-friendly materials, patterns and techniques to design apparel, when comparing with the traditional apparel design (Kozłowski et al., 2018, Jiang et al., 2018, Maldini et al., 2019). The concepts of design for disassembly, design for recycling, and design for environment are also new approaches for sustainable design (Liu et al., 2019). Moon et al. (2013) study the sustainable fashion design skills from the energy-efficient perspective and identify the energy-saving factors for sustainable fashion design. They are the choice of materials, style design and operation controlling. Lewandowska and Kurczewski (2010) explore the eco-design procedure to comply with the guidelines of ISO14062 standard and present the procedure's structure and practice application (Kurczewski and Lewandowska, 2010). The authors find that the formulated eco-design procedure should take into account the functionality, ergonomics, and safety, as well as economic and environmental elements. Wang et al. (2014) study how the clothes pattern transforms into the tent and find that using similar raw materials can achieve the multi-functional design goal and finally yield energy saving. Sanches et al. (2015a, 2015b) compare different eco-friendly materials (organic cotton, lyocell and soybean protein fiber) for sustainable apparel design and reveal that soybean protein fibre fabrics may be the best one to meet the customers' needs, when comparing to the other two. Wang and Shen (2017) analyse the product line of a sustainable fashion brand and find that the sportswear brand Patagonia mostly adopts organic cotton, recycled fabrics, and traceable materials in its eco-design.

Jin Gam et al. (2011) study sustainable apparel design and take men's jacket as an example for design for disassembling. The authors find that the mixed use of natural and synthetic fabrics in apparel design makes end-of-life product management rather difficult. It is an efficient way to avoid using diverse fabrics and sew the similar fabrics together. Laitala et al. (2015) study how to improve clothes design for a long time use and identify four critical factors for clothes disposal. The four levels are product (material and shape), service, systems, and consumer behaviours. Clancy et al. (2015) explore how ecolabels have an impact on sustainable apparel design and find that ecolabels only have a marginal influence on sustainable apparel design. Efforts should be made in

creating guidelines for fashion designers who want to design for sustainability. De Angelis et al. (2017) investigate the consumers' perceptions on green luxury fashion design and recommend a strategy for the luxury fashion company that new green product development should be designed similarly with previous products, because consumers are familiar with the features (e.g. durability) of the brand's past products. Chen et al. (2017) develop a modular design architecture for recyclable apparel systems to respond to the calls for strategic recycling implementation. Guo et al. (2020) study the green product development scheme in fashion apparel. They propose novel insights with both analytically proven results and industrial interviews. Based on the above findings, we conclude how the "sustainable design" literature can generate sustainable practices based on 3BL in Table 4.2.

Table 4.2
Sustainable practices in sustainable design literature.

Area	3BL	Details
Sustainable Design	Social Sustainability	Creating guidelines for fashion designers who want to design for sustainability; -Improve clothes design for a long-time use; -Soybean protein fibre fabrics may be the best one to meet the costumers' needs among three eco-friendly materials, namely the organic cotton, lyocell and soybean protein fibre.
	Economic Sustainability	- Designing for disassembling to avoid mixed use of natural and synthetic fabrics; -Designing for transformation to use similar raw materials; -Developing a modular design architecture for recyclable apparel system.
	Environmental Sustainability	-Eco-design with the guidelines of ISO14062 standard; -Controlling energy-efficient factors: choice of materials, style design and operation controlling; -Using sustainable materials, like organic cotton, recycled fabrics, and traceable materials in eco-design.

4.2.2. Sustainable dyeing

The dyeing process leads to serious pollution problems (e.g., water pollution) in the TA supply chain. For instance, toxic chemicals release, if not well treated, may affect the health of workers as well as the surrounding community. The process involves activities like the choice of dyes (e.g., natural or chemical), dyeing method (e.g., spin-dyeing or conventional dyeing), operations control, etc. Different choices and decisions will affect the sustainability in the dyeing section. Ellams et al. (2014) study sustainable coloration to decrease the environmental impact in the process of dyeing and apply extracts of leaves and barks from eucalyptus trees to the lyocell fabrics. The authors find that the screen printing approach can allow the lyocell fabrics to attain "better fastness" in daily usage. The presented model will help contribute to the development of sustainable coloration. Budeanu et al. (2014) investigate the eco-dyeing by using natural hemp fibre. The authors experiment on three types of hemp fabrics and three types of dye pigments extracted from black tea, red beets, and onion leaves. Finally, the authors reveal that the natural dyes have good coloration performances and suggest widely applying these approaches to the TA sector. Terinte et al. (2014) examine the environmental performance of two types of dyeing methods (spin-dyeing and conventional dyeing). The authors find that the method of spin-dyeing creates less energy usage, less water usage and less carbon emissions and suggest that the adoption of spin-dyeing in the apparel industry would reduce the environmental impact. Parisi et al. (2015) examine the impact of eco-efficient coloration on the environment and compare the new dyeing method with the traditional dyeing process. The authors show that approaches like "enzymatic synthesis" and "plasma pre-treatment" facilitate the sustainable coloration and decrease the use of raw materials, energy, and water. Valley et al. (2019) develop a rapid and efficient extraction method to separate industrial dyes from wastewater. This method is called "coacervate extraction". Based on the above findings, we highlight how the "sustainable dyeing" literature can generate sustainable insights for practices based on 3BL and summarize the results in Table 4.3.

Table 4.3
Sustainable practices in sustainable dyeing literature.

Area	3BL	Details
Sustainable Dyeing	Social Sustainability	/
	Economic Sustainability	-Spin-dyeing creates less energy use, less water use and less carbon emissions than conventional dyeing; - "Enzymatic synthesis and plasma pre-treatment" facilitate the sustainable coloration.
	Environmental Sustainability	-Screen printing approach is environmentally friendly; -Applying natural extracts of leaves and barks from eucalyptus trees to the lyocell fabrics; -Using dye pigments extracted from black tea, red beets, and onion leaves; -Spin-dyeing creates less energy use, less water usage and less carbon emissions than conventional dyeing; -Using "coacervate extraction" method to separate industrial dye from wastewater.

4.2.3. Sustainable sourcing

Sustainable sourcing in the upstream supply chain is rather critical to the apparel manufacturers and retailers (Choi, 2013a; Choi and Cai, 2018). For the OEM manufacturers, they need to prepare the raw materials, including the fabrics and accessories like zippers, buttons, and buckles, etc. For the fashion retailers, they need to select the suitable and reliable suppliers, to place the orders,

and to control the lead time and establish quality assurance. To cooperate with green suppliers is a strategic approach for sustainable sourcing (Eryuruk, 2012; Plambeck and Taylor, 2016; Chen and Lee, 2017; Fang and Cho, 2020). Jiang (2009) studies the supply management under the Supplier Codes of Conduct (SCC) in the global TA operations and finds that cooperation in the buyer's governance will make supplier's performance under SCC more sustainable. Choi (2013b) studies how to optimally select the suppliers in the fashion supply chain under the regulation of environment carbon tax. The author reveals that the carbon emission tax schemes affect the fashion retailer's decision on supplier selection, and a non-linear quadratic carbon taxation form can better promote the local supplier selection.

Winter and Lasch (2016) study the sustainable supplier evaluation problem and examine the sustainability criteria. The social factors are identified as no child labour and forced labour, normal working hours, no discrimination, employment compensation, association freedom, and health and safety guarantees. The environmental criteria include the use of wastewater treatment systems and eco-friendly materials. Jia et al. (2015) study how to effectively select the suppliers which provide the sustainable apparel materials with the consideration of sustainability issues. The authors develop twelve criteria from the social, economic, and environmental perspectives to evaluate the sustainable material suppliers, and propose the approach of "Technique for Order of Preference by Similarity to Ideal Solution" for optimal supplier selection. Sardar et al. (2016) study sustainable outsourcing problems in the apparel supply chain, and find that outsourcing to international markets benefits from cost savings, while local sourcing could obtain flexible capacity. Niu et al. (2017) study sustainable sourcing problems in fashion supply chains under government's regulations. The authors find that there exists a conflict between the sustainability goal and the social welfare maximization. It is suggested that the government should take actions to balance the sustainability and profits. Amindoust and Saghafinia (2017) investigate the supplier selection challenge in the sustainable textile supply chain and propose a "fuzzy inference system" for supplier's evaluation and ranking in terms of sustainability index. Based on the above findings, Table 4.4 shows the related sustainable practices based on 3BL.

Table 4.4
Sustainable practices in sustainable sourcing literature.

Area	3BL	Details
Sustainable Sourcing	Social Sustainability	-Executing Supplier Codes of Conduct (SCC) under the buyer's governance; -Evaluating suppliers under social and environmental criteria; -The government should take actions to balance the sustainability and profits issues in sustainable sourcing.
	Economic Sustainability	-Selecting suppliers with the supply of sustainable materials; -Adopting the approach of "Technique for Order of Preference by Similarity" to ideal solution for optimal supplier selection; -Using a "fuzzy inference system" for supplier's evaluation and ranking in terms of sustainability index; -Outsourcing to international markets could benefits from cost savings, while local sourcing could obtain flexible capacity; -The government should take actions to balance the sustainability and profits issues in sustainable sourcing.
	Environmental Sustainability	-Evaluating suppliers under social and environmental criteria; -Employing the carbon emission tax schemes to reduce the carbon footprints in the sustainable sourcing; -The government should take actions to balance the sustainability and profits issues in sustainable sourcing.

4.2.4. Sustainable production

Production in the TA supply chain creates issues like labours' rights, resources and energy consumption, waste generation and so on. A stream of literature explores sustainable operations in the production process. Pineda-Henson and Culaba (2004) assess the green productivity in sustainable manufacturing to improve the resource efficiency and waste reduction. The authors find that the factors of green productivity are dominated by water usage, energy usage, and land ecotoxicity. Ghazinoory (2005) investigates the clean manufacturing strategy implementing in Iran to promote the industrial sustainable development. The author identifies that the TA industry has the highest priority to implementing cleaner production. Jin Gam et al. (2009) propose a "cradle to cradle apparel design" strategy for the sustainable production to help the practitioners to deal with the sustainability problems in fashion production. The authors uncover that production with the proposed model can achieve good function and colour fastness. Subic et al. (2013) study the environmental performance of sustainable manufacturing by "Capability Assessment Tool". The authors find that energy efficiency action is the general measure adopted by the companies to reduce the carbon emission.

Jordeva et al. (2015) study the situation of apparel cutting waste generated in production in Macedonia and find that most of the textile wastes are disposed by landfill and recycling infrastructure investment is rather low. Druica (2015) studies the sustainable technology development in Romanian apparel companies and finds that white biotechnology can be applied in making clothes with eco-friendly materials to promote the sustainable market. Wickramasinghe and Perera (2016) examine the productivity problem in the TA manufacturing and show that total productive maintenance positively affects manufacturing performances, such as reducing the costs, enhancing the product quality, and so on. Pinheiro and de Francisco (2016) study the situation of the textile solid waste produced in clothing manufacturing in Brazil. The authors suggest reusing the raw materials to promote sustainable practices. Van der Velden and Vogtländer (2017) study the production process in the textile supply chains using the method of social life cycle

assessment (S-LCA). The authors find that five social issues are included in S-LCA: wage criteria, child labour problem, poverty problem, working hours, and safety and health. [Hirscher et al. \(2018\)](#) explore the social manufacturing with the consumer participation and propose two consumer-engaged design strategies: do-it-yourself, do-it-together. The authors find that the proposed approaches can benefit the small scale and local firms. We summarize how “sustainable production” literature can generate insights on sustainable practices based on 3BL in [Table 4.5](#).

Table 4.5

Sustainable practices in sustainable production literature.

Area	3BL	Details
Sustainable Sourcing	Social Sustainability Economic Sustainability	-Combining the social manufacturing with the consumer participation; -The factors of the green productivity are dominated by water usage, energy usage, and land ecotoxicity; -Employing a “cradle to cradle apparel design” strategy for sustainable fashion production; -Making good use of the textile solid waste in clothing manufacturing;-Using social life cycle assessment (S-LCA) for the production process evaluation;
	Environmental Sustainability	-Adopting clean manufacturing strategy for the TA industry; -Taking energy-efficiency action to reduce the carbon emission; -Using white biotechnology for making clothes with eco-friendly materials;

4.2.5. Sustainable retailing and consumption

With the increasing consumers’ awareness of being environmentally friendly and socially responsible, sustainable retailing and consumption is a must in sustainable FSCM to meet the consumers’ new requirements and preferences ([Jacobs et al., 2018](#); [Cai et al., 2019](#)). In the following, we review the generated literature from three aspects: sustainable retailing, consumers’ sustainable consumption, and consumers’ disposal behaviours.

From the retailer’s perspective, [Choi and Chiu \(2012\)](#) study the fashion retailing’s sustainability issues via the “mean-downside-risk” and “mean-variance” models. [Shen and Li \(2015\)](#) study the product return policy in fashion retailing and find that the costs associated with product returns have an impact on the retailing sustainability. [Visser et al. \(2015\)](#) examine how the advertising strategies affect the consumers’ buying behaviours and show that advertising considering the consumers’ benefits and the sustainable factors will promote the best probability of the consumers’ purchasing. [Seebauer et al. \(2016\)](#) investigate the carbon footprint of different product categories in the retailing channels and find that private household consumption should be reduced to decrease carbon emissions. [Manzoor et al. \(2016\)](#) study how the environmental and social concerns affect the consumers’ decision making in resource consumption and find that heterogeneity of consumers and social relationships can help identify which type of social context facilitates sustainable resource consumption.

From the perspective of consumers’ sustainable consumption, [Cox et al. \(2013\)](#) study the UK consumers’ perception on the product lifetime and find that the current market environment forces the consumers to “update products” via purchasing very frequently and the consumers’ environmental consciousness is very low. [Žurga and Forte \(2014\)](#) investigate the sustainable apparel consumption in the Slovenian area. The authors reveal that the percentage of consumers with eco-labelling concept and environmental consciousness is rather small and the consumers can only accept “an extra 10%” higher price for an apparel with eco-labels. The authors argue that there is a need to increase the public’s awareness on sustainable apparel consumption and the confidence in eco-labelling practices to promote sustainable apparel consumption. [Armstrong et al. \(2015\)](#) examine consumers’ perception on apparel with design for environment in Finland and identify the distinctive characteristics between the young and old consumers in which young consumers prefer “clothes exchanges”, while old consumers prefer apparel redesign and repair. [Ciasullo et al. \(2017\)](#) study the Italian consumers’ behaviours on purchasing clothes regarding sustainability. The authors find that sustainable consumption is associated with little importance in consumers’ purchasing decision, and the consumers’ willingness to pay for an eco-friendly apparel is no more than 20% higher than the one for a non-eco-friendly common apparel. [Grappi et al. \(2017\)](#) study how NGO campaigns influence the Italian consumers’ attitudes towards fashion brands and reveal that NGO campaigns affect consumers’ purchasing behaviours, which provides important insights for fashion companies to respond to these kinds of NGO campaigns. [Wei and Jung \(2017\)](#) study the intentions of the Chinese consumers on purchasing the sustainable fashion products and find that face-saving is a critical driver for sustainable fashion consumption. [Tama et al. \(2017\)](#) investigate the university students’ environmental awareness on clothes purchasing in Turkey and find that only 20% of the investigated university students have the awareness of sustainable fashion consumption. Recently, collaborative fashion consumption is popular, which can be regarded as a sustainable consumption approach ([Becker-Leifhold, 2018](#); [Choi and He, 2019](#); [Iran et al., 2019](#)). Due to the current serious environmental problem, the concept of “reduced clothing consumption” can be an effective approach for this issue ([Joanes, 2019](#)).

From the perspective of consumers’ disposal behaviours, [Žurga et al. \(2015\)](#) further investigate the Slovenian consumers’ behaviours in apparel purchasing and disposing. The authors find that the environmental conscious consumers prefer “repair and redecoration” as eco-friendly behaviours and waste apparel are mostly donated in the Slovenia. [Norum \(2017\)](#) examines the U.S. consumers’ disposal choices of clothes in the post-consuming stage and finds that consumers’ decision making in clothes disposal are affected by many factors, including “compensatory choice”, lifetime, garment nature, awareness creating, and assurance providing. [Laitala and Klepp \(2018\)](#) study Norwegian people’s behaviours in using clothes and find that mending and remaking can increase the

lifespan of clothes. However, the sustainable practices are correlated with people's environmental awareness. Table 4.6 presents a summary of how "sustainable retailing and consumption" literature can provide insights to support sustainable practices based on 3BL.

Table 4.6
Sustainable practices in sustainable retailing and consumption literature.

Area	3BL	Details
Sustainable Retailing and Consumption	Social Sustainability	-Considering the consumers' benefits and the sustainable factors in advertising strategies; -Identifying which type of social context facilitates the sustainable resource consumption; -The environmental conscious consumers prefer "repair and redecoration" as eco-friendly behaviours;
	Economic Sustainability	-Using the models of "mean-downside-risk" and "mean-variance" to compare the sustainability levels in the fashion retailing; -Reducing the costs associated with product returns; -Increasing the public's awareness on sustainable apparel consumption and the confidence in eco-labelling practices;
	Environmental Sustainability	-NGO campaigns affect consumers' purchasing behaviours; -Reducing clothes consumption to decrease the carbon emissions; -Advocating collaborative fashion consumption and reduce clothing consumption;

4.3. Reverse and closed-loop fashion supply chains

In this section, we mainly review reverse activities, closed loop supply chain and life cycle assessment (LCA) in the FSCM. Nowadays, reverse activities and closed loop supply chain are popular topics in the TA sector. In this subsection, we focus on reverse activities like reuse, remanufacturing and recycling (Govindan and Soleimani, 2017). Closed-loop supply chain management implies the recycled textile materials can act as raw materials for new products to minimize the solid waste and reduce the environmental burden (Govindan et al., 2015). LCA is an effective tool for the evaluation of environmental impacts from the lifecycle perspective. Thus, we list the subsection of LCA, after discussing "closed-loop supply chain".

4.3.1. Reverse fashion supply chain

Increased consumption of fashion products creates a large amount of post-consuming waste to the planet, which is a worldwide concern. However, reverse FSCM activities can provide opportunities to alleviate this situation (Pinheiro et al., 2019). Reverse FSCM activities may include reuse, remanufacturing, recycling and so on (Kannan et al., 2012; Bukhari et al., 2018; Paras et al., 2018).

From the reuse perspective, Farrant et al. (2010) examine the impact of reusing clothes on the environment and find that reselling the second-hand clothes can reduce the purchasing of new clothes, and reusing clothes can decrease the environment impact. Valverde et al. (2012) study the textile waste management and propose the reuse of waste textile fibres for the heat insulation panels, which can be applied in the construction sector. The authors find that the proposed approach can reduce the environment impact and enhance the energy efficiency. Fortuna and Diyamandoglu (2017a) study the reuse of second-hand clothing through a survey and find that reuse on a local level is dominated, but the internet exchange will expand the second-hand clothing reuse beyond the regional boundaries. Fortuna and Diyamandoglu (2017b) explore carbon emissions in the reuse of second-hand clothing and develop an "integrated solid waste management system", which combines relevant reuse companies, online exchange platforms, and traditional waste management channels. The authors find that the proposed framework can improve the resource efficiency and reduce the environment impact. Trajković et al. (2017) study the reuse of polyester fabrics in the textile industry and propose using them in producing insulation blankets. Paras and Pal (2018) study the clothes reuse in Nordic countries (Denmark, Finland, Iceland, Norway and Sweden) by conducting the Markov chain analysis and find that Denmark reuses the clothes most frequently, while Finland reuses the clothes less frequently. The authors suggest the policy maker to take relevant initiatives to promote the reuse of clothes.

From the remanufacturing and recycling perspective, Dissanayake and Sinha (2015) study the apparel remanufacturing to make the fashion materials circular and reduce the landfill rate. The authors find that there exist barriers in implementing reverse supply chains, and its development needs cooperation and commitments from both the giant fashion retailers and the consumers. Furferi and Governi (2007) study the recycling of colourful wool clothes and attempt to develop a tool for automated classification of recycled wool fibres. The authors develop an artificial neural network tool for classification, which is more accurate than labour classification. Köhler et al. (2011) study the recycling and disposal issues of smart fashion of electronic textiles and find that recycling electronic textiles is challengeable because of the technical constraints that the valuable metals are dispersedly distributed in various types of waste materials. The authors suggest that the product developers should consider the relevant issues at the beginning of product development. Muthu et al. (2012) examine the effect of textile waste recycling on carbon footprints and find that textile waste recycling can directly reduce the carbon footprints, but difficulties and barriers exist in the recycling process. The authors suggest that the fashion designers should have the concept of design for recycling in the preliminary stage to facilitate the end-of-life textile management. Wu et al. (2015) study the effect of textile waste recycling on both the water and carbon footprints and find that recycling contributes to both the reduction of textile waste and the reduction of water usage and carbon footprints. Zamani et al.

(2015) study the effect of textile waste recycling on carbon footprints in Sweden and find that incineration has the largest potential for producing the carbon footprints, while compared with incineration, textile recycling can reduce the carbon footprints and energy usage. De Silva and Byrne (2017) examine the recycling of cotton textiles for regenerated cellulose fibres and find that cotton waste can provide better mechanical properties for regenerated cellulose fibres, than other materials. Based on the above findings, Table 4.7 shows how “reverse activities” literature can generate insights on sustainable practices based on 3BL.

Table 4.7

Sustainable practices in reverse activities literature.

Area	3BL	Details
Reverse Activities	Social Sustainability	-Advocating cooperation and commitments from both the giant fashion retailers and the consumers for the apparel remanufacturing.
	Economic Sustainability	-Reusing “scrap/leftover textile” fibres for the manufacturing of heat insulation panels; and reuse polyester fabric for insulation blankets; -The internet exchange will expand the second-hand clothes reuse beyond the regional boundaries; -Adopting an artificial neural network tool for classification of returned colourful wool clothes; -Considering design for recycling in the design stage to facilitate the ease of end-of-life textile management;
	Environmental Sustainability	-The policy makers should take relevant initiatives to promote the reuse of clothes. -The clothes reuse and recycling can decrease the environment impact; -An “integrated solid waste management system” can combine relevant reuse companies, online exchange platforms, and traditional waste management channels; -The policy makers should take relevant initiatives to promote the reuse of clothes.

4.3.2. Closed-loop fashion supply chain

Closed-loop fashion supply chain (CLSC) management is an effective approach for circular textile and apparel, which creates both economic and environmental values (Ashby, 2018). The research on CLSC attracts more and more attention nowadays. Morana and Seuring (2011) study the CLSC in the TA sector, and propose a management system connecting the society, supply chains, and actors together. The authors show that the proposed “CLSC system” can be successfully implemented and can provide directions for the industrialists and policy makers for strategic decision making. Eryuruk (2012) studies the whole supply chain activities (including design, production, waste management, etc.) in the clothing industry and suggests that the fashion supply chain should take precautions to become environmentally friendly and to make the industry greener. Oh and Jeong (2014) study the profitability and environmental impacts of the CLSC in TA sector. The authors find that recovery activities can enhance the CLSC performance, and technological innovation can enhance the profitability of the CLSC. Hu et al. (2014) study the rental service of fashion products to promote sustainable practices in the fashion industry and reveal that the rental service facilitates environmental sustainability. The development for this new business model still needs the supports of finance and relevant policies. Sanches et al. (2015a, 2015b) examine the properties of knitted fabrics made of recycled fibres in a closed loop material flow and take recycled polyester as an example. The authors show that the fabric made of 80%-polyester/20%- recycled-polyester presents the best properties for maintenance and durability. Telli and Özdil (2015) examine the properties of knitted fabrics made of recycled PET fibres and find that “r-PET fabrics” are cost-saving and eco-friendly, and the producers may benefit a lot from the wide use of “r-PET fibres”. Choi et al. (2018a) explore the used apparel product collection in intimate apparel. The authors propose how the optimal coupon value can be decided to entice consumers to return the used intimate apparel to “close the loop” for the fashion supply chain.

4.3.3. Life cycle assessment (LCA)

LCA can be used to evaluate the environmental and social impacts of textile and apparel from its life cycle perspective (Moazzem et al., 2018; Zamani et al., 2018). Woolridge et al. (2006) study the performance of reuse or recycling of waste textiles by using LCA method from the energy-saving perspective. The authors find that the reuse and recycling of waste textiles can save the energy footprints and reduce the environmental burden, comparing with the use of virgin raw materials. Van der Velden et al. (2014) use LCA method to study the environmental impact of textiles made of various kinds of fabrics: cotton, polyester, nylon, etc. The authors find that the environmental impacts of PET and acryl are the least and knitted fabrics are more environmentally friendly than woven fabrics. Castellani et al. (2015) also examine the environment impact of reuse by employing LCA approach and conduct a case analysis on second-hand shops. The authors reveal that the reuse of second-hand clothes can avoid the most environmental impacts, due to the large volume of reselling and the convenience for reselling, when comparing with other second-hand products. Zhang et al. (2015) examine the environment impact of T-shirts made of cotton in China by adopting LCA method and identify that the use of energy (electricity), chemicals (fertilizer, pesticide and dyes) and water contributes to the total environment impacts, which provides directions for establishing future sustainable operations. Roos et al. (2016) study the sustainability performance of the TA sector in Sweden by using LCA method and find that the most effective approach for reducing the climate impacts is to use the renewable energy. The use of recycled cellulose fibres to replace the cotton fibres can reduce the water consumption. Testa et al. (2017) study how small and medium companies can adopt the sustainable operations in Italy by using LCA method and find that the collaboration among the stakeholders can tackle the barriers and difficulties in the implementation of sustainable practices. Based on the above findings, we conclude how “CLSC” and “LCA” literature can generate insights on sustainable practices based on 3BL. Table 4.8 shows the details.

Table 4.8
Sustainable practices in CLSC and LCA literature.

Area	3BL	Details
Closed-Loop Supply Chain and Life Cycle Assessment	Social Sustainability	- "CLSC system" connects the society, the supply chains and the actors; -The collaboration among the stakeholders can tackle the barriers and difficulties in the implementation of sustainable practices.
	Economic Sustainability	-Technological innovation can enhance the profitability and the environmental performance of the CLSC; -Recycled PET fibres are cost-saving and eco-friendly in a closed loop material flow; -The collaboration among the stakeholders can tackle the barriers and difficulties in the implementation of sustainable practices.
	Environmental Sustainability	-Taking precautions to make the whole fashion supply chain greener; -Technological innovation can enhance the profitability and the environmental performance of the CLSC;-New business model (like rental service of fashion products) facilitates the environmental sustainability; -Recycled PET fibres are cost-saving and eco-friendly in a closed loop material flow; -Using recycled cellulose fibers to replace the cotton fibers can reduce the water consumption; -Knitted fabrics are more environmentally friendly than woven fabrics; -The collaboration among the stakeholders can tackle the barriers and difficulties in the implementation of sustainable practices.

5. Discussions, managerial implications and recommendations

5.1. How sustainable FSCM contributes to SDGs

From Tables 4.1–4.8, we can see the sustainable practices in the sustainable FSCM literature. We endeavour to match them with the 17 SDGs from social, economic, and environmental perspectives respectively¹⁵.

Social Sustainability Perspective: We summarize the possible measures for social sustainability in Table 5.1 (see Appendix A5). We find that to disclose the sustainability and CSR reports, and implement SCC helps increase the transparency of the goals of "Good Health and Well-being", "Quality Education", and "Gender Equality". Especially, for the goal of "Good Health and Well-being", the literature shows that eco-labelling acts as an important role in addressing the human health and environment issues in the TA sector. And it is necessary to create guidelines for fashion designers who want to design for sustainability, e.g., improving clothes design for a long-time use, which can increase consumer welfare. Firms can also combine the social manufacturing with consumer participation, and consider consumers' benefits and the sustainable factors in their advertising strategies. Moreover, CLSC systems could connect the society, the supply chains and the actors, which can be useful to achieving the goal of "Sustainable Cities and Communities". However, we find that few measures are provided for the goals like "No Poverty", "Zero Hunger" and "Peace, Justice and Strong Institutions" in the literature.

Economic Sustainability Perspective: We summarize the possible measures for economic sustainability in Table 5.2 (see Appendix A5). Generally speaking, the literature has provided many constructive and detailed sustainable measures for economic sustainability. Specifically, for the goal of "Decent Work and Economic Growth", sustainable investment, supply chain contracts (Chiu et al. 2011), and "sustainable value co-creation mechanisms" are proved to be helpful to make more benefits. For the goal of "Industry Innovation and Infrastructure", the approach of "Technique for Order of Preference by Similarity" can be regarded as an ideal solution for optimal supplier selection. A "fuzzy inference system" for supplier's evaluation and ranking in terms of sustainability index can also be used. Technological innovation can enhance the profitability and environmental performance of the CLSC. For the goal of "Responsible Consumption and Production", firms can adopt sustainable dyeing approaches like spin-dyeing, enzymatic synthesis and plasma pre-treatment, etc., develop green productivity in water usage, energy usage, and land ecotoxicity, as well as make good use of the textile solid waste in clothing manufacturing. From the circular economy perspective, firms are suggested to employ a "cradle to cradle apparel design" strategy for sustainable fashion production, and use social life cycle assessment (S-LCA) for the production process evaluation. On sustainable consumption, the fashion firms should increase the public's awareness on sustainable apparel consumption and the confidence in eco-labelling practices. Importantly, NGO campaigns can affect consumers' purchasing behaviors. To conclude, from the economic perspective, the goal of "Responsible Consumption and Production" has been addressed on sustainable measures, while the goal of "Reduced Inequalities" is almost ignored. Actually, the economic inequalities of global and regional developments are very serious.

Environmental Sustainability Perspective: We identify the possible measures for environmental sustainability in Table 5.3 (see Appendix A5). The literature shows that environmental regulations, international operation standards, establishment of environmental management systems, sustainability incentives, and sustainable investment are helpful to environmental sustainability. Various operations are proved to be effective, like using eco-friendly materials, product reusing and eco-marketing, eco-design with the guidelines of ISO14062 standard, etc. In particular, in sustainable dyeing, methods like screen printing approach, and using dye

¹⁵ There is a certain degree of subjectivity involved in matching the sustainable practices with the 17 SDGs from social, economic, and environmental perspectives.

Table 5.1
Possible measures for social sustainability.

<i>Possible Measures for Social Sustainability</i>	
Sustainable FSCM	-Disclosing the sustainability reports with firm's real actions; -Executing corporate social responsibility (CSR) is helpful for the sustainability goals.
Sustainable Design	-Creating guidelines for fashion designers who want to design for sustainability; -Improving clothes design for a long-time use; -Soybean protein fibre fabrics may be the best one to meet the costumers' needs among three eco-friendly materials, namely the organic cotton, lyocell and soybean protein fibre.
Sustainable Dyeing	/
Sustainable Sourcing	-Executing Supplier Codes of Conduct (SCC) under the buyer's governance; -Evaluating suppliers under social and environmental criteria; -The government should take actions to balance the sustainability and profits issues in sustainable sourcing.
Sustainable Production	-Combining the social manufacturing with the consumer participation.
Sustainable Retailing and Consumption	-Considering the consumers' benefits and the sustainable factors in advertising strategies; -Identifying which type of social context facilitates the sustainable resource consumption; -The environmental conscious consumers prefer "repair and redecoration" as eco-friendly behaviours.
Reverse Activities	-Advocating cooperation and commitments from both the giant fashion retailers and the consumers for the apparel remanufacturing.
Closed-Loop Supply Chain and Life Cycle Assessment	- "CLSC system" connects the society, the supply chains and the actors; -The collaboration among the stakeholders can tackle the barriers and difficulties in the implementation of sustainable practices.

Table 5.2
Possible measures for economic sustainability.

<i>Possible Measures for economic Sustainability</i>	
Sustainable FSCM	-Sustainable investment is good to both the economic and environmental benefits; -Strong international collaborations of supply networks facilitate the development of sustainability goals, such as cross-industrial collaboration and supply chain members' collaboration.
Sustainable Design	- Design for disassembling to avoid mixed use of natural and synthetic fabrics; -Design for transformation to use similar raw materials; -Developing a modular design architecture for recyclable apparel system.
Sustainable Dyeing	-Spin-dyeing creates less energy use, less water use and less carbon emissions than conventional dyeing; - "Enzymatic synthesis and plasma pre-treatment" facilitate the sustainable coloration.
Sustainable Sourcing	-Selecting suppliers with the supply of sustainable materials; -Adopting the approach of "Technique for Order of Preference by Similarity" to ideal solution for optimal supplier selection; -Using a "fuzzy inference system" for supplier's evaluation and ranking in terms of sustainability index; -Outsourcing to international markets could benefits from cost savings, while local sourcing could obtain flexible capacity; -The government should take actions to balance the sustainability and profits issues in sustainable sourcing.
Sustainable Production	-The factors of the green productivity are dominated by water usage, energy usage, and land ecotoxicity; -Employing a "cradle to cradle apparel design" strategy for sustainable fashion production; -Making a good use of the textile solid waste in clothing manufacturing;-Using social life cycle assessment (S-LCA) for the production process evaluation.
Sustainable Retailing and Consumption	-Using the models of "mean-downside-risk" and "mean-variance" to compare the sustainability levels in the fashion retailing; -Reducing the costs associated with product returns; -Increasing the public's awareness on sustainable apparel consumption and the confidence in eco-labelling practices; -NGO campaigns would affect consumers' purchasing behaviours.
Reverse Activities	-Reusing "scrap/ remaining textile fibres" for the manufacturing of heat insulation panels; and reuse polyester fabric for insulation blankets; -The internet exchange will expand the second-hand clothes reuse beyond the regional boundaries; -Adopting an artificial neural network tool for classification of returned colourful wool clothes; -Considering design for recycling in the design stage to facilitate the ease of end-of-life textile management; -The policy makers should take relevant initiatives to promote the reuse of clothes.
Closed-Loop Supply Chain and Life Cycle Assessment	-Technological innovation can enhance the profitability and the environmental performance of the CLSC; -Recycled PET fibres are cost-saving and eco-friendly in a closed loop material flow; -The collaboration among the stakeholders can tackle the barriers and difficulties in the implementation of sustainable practices.

Table 5.3

Possible measures for environmental sustainability.

<i>Possible Measures for environmental Sustainability</i>	
Sustainable FSCM	<ul style="list-style-type: none"> -Disclosing the sustainability reports with firm's real actions; -Environmental regulations, international operation standards and sustainability incentives should be provided; -Sustainable investment does good to both the economic and environmental benefits; -Operations like using the eco-friendly materials, product reusing and eco-marketing, are adopted by Korean textile and fashion firms.
Sustainable Design	<ul style="list-style-type: none"> -Eco-design with the guidelines of ISO14062 standard; -Controlling energy-efficient factors: choice of materials, style design and operation controlling; -Using sustainable materials, like organic cotton, recycled fabrics, and traceable materials in eco-design.
Sustainable Dyeing	<ul style="list-style-type: none"> -Screen printing approach is environmentally friendly; -Applying natural extracts of leaves and barks from eucalyptus trees to the lyocell fabrics; -Using dye pigments extracted from black tea, red beets, and onion leaves; -Spin-dyeing creates less energy use, less water usage and less carbon emissions than conventional dyeing; -Using "coacervate extraction" method to separate industrial dye from wastewater.
Sustainable Sourcing	<ul style="list-style-type: none"> -Evaluating suppliers under social and environmental criteria; -Employing the carbon emission tax schemes to reduce the carbon footprints in the sustainable sourcing; -The government should take actions to balance the sustainability and profits issues in sustainable sourcing.
Sustainable Production	<ul style="list-style-type: none"> -Adopting clean manufacturing strategy for the TA industry; -Taking energy-efficiency action to reduce the carbon emission; -Using white biotechnology for making clothes with eco-friendly materials.
Sustainable Retailing and Consumption	<ul style="list-style-type: none"> -Reducing clothes consumption to decrease the carbon emissions; -Advocating collaborative fashion consumption and reduce clothing consumption.
Reverse Activities	<ul style="list-style-type: none"> -The clothes reuse and recycling can decrease the environment impact; -An "integrated solid waste management system" can combine relevant reuse companies, online exchange platforms, and traditional waste management channels; -The policy makers should take relevant initiatives to promote the reuse of clothes.
Closed-Loop Supply Chain and Life Cycle Assessment	<ul style="list-style-type: none"> -Taking precautions to make the whole fashion supply chain greener; -Technological innovation can enhance the profitability and the environmental performance of the CLSC; New business model (like rental service of fashion products) facilitates the environmental sustainability; -Recycled PET fibres are cost-saving and eco-friendly in a closed loop material flow; -Using recycled cellulose fibers to replace the cotton fibers can reduce the water consumption; -Knitted fabrics are more environmentally friendly than woven fabrics; -The collaboration among the stakeholders can tackle the barriers and difficulties in the implementation of sustainable practices.

pigments extracted from black tea, red beets, and onion leaves, are environmentally friendly. These findings are important to the industrial practitioners. Moreover, new business models (like rental services of fashion products) would facilitate the environmental sustainability. Specifically, for the goal of "*Clean Water and Sanitation*", it is suggested that standards of water usage and pollutant release in textile printing and dyeing should be made. We can use "coacervate extraction" method to separate industrial dye from wastewater, to avoid water pollution. It is interesting to find that the use of recycled cellulose fibers to replace the cotton fibers can reduce the water consumption. In addition, the reuse and recycling of apparel can decrease the environment impact. For the goal of "*Affordable and Clean Energy*", we should pay attention to the factors of controlling energy-efficient, such as choice of materials, style design and operation controlling. For the goal of "*Climate Action*", the literature shows that the carbon emission tax schemes can reduce the carbon footprints in the sustainable sourcing. Moreover, taking energy-efficient actions and reducing clothes consumption can decrease the carbon emissions. Finally, no sustainable measures are found in the literature for the goals of "*Life below Water*" and "*Life on Land*". To conclude, from the environmental perspective, "*Clean Water and Sanitation*" and "*Climate Action*" receive more sustainable measures, which also reflects that the TA industry creates severe water pollution and carbon footprints. However, "*Life below Water*" and "*Life on Land*" are almost ignored in the literature.

Finally, for the goal of "*Partnerships for the Goals*", it is suggested that the government should take actions to balance the sustainability and profits issues. The collaboration among the stakeholders can tackle the barriers and difficulties in the implementation of sustainable practices. Strong international collaborations of supply networks would facilitate the development of sustainability goals, such as cross-industrial collaboration and supply chain members' collaboration.

5.2. Managerial implications and recommendations

In this section, we propose managerial implications and recommendations from two aspects: one is balanced sustainable development actions and the other is theoretical backup and implications.

Balanced Sustainable Development Actions: Based on the above analyses and results, we find that prior studies in the extant literature regarding SSCM in the TA industry have not considered the balanced socially, economically and environmentally

Table 5.4

A balanced sustainable development actions from the stakeholders' perspective.

Stakeholders	Details of BSDA
The Government	-Considering taxation policies for balancing the social, economic and environmental benefits. -Taking actions for the goals "No Poverty" and "Zero Hunger". -Taking actions for the goal "Reduced Inequalities".
The Fashion Designer	-Having the concept of eco-design, design for recycling or design for environment. -Receiving the training for sustainable design. -Being awarded for the sustainable design.
The Manufacturer	-Being responsible for taking back the post-consuming products. -Being charged more for using virgin materials and should receive tax reduction for using sustainable materials and recycled materials. -Being incentivized for the technology innovation, like adopting clean manufacturing equipment, the waste water treatment systems, etc.
The Retailer	-Inventing new sustainable business models like fashion rental service. -Creating the green image, adopt eco-labelling for advertising, and re-market the used and remanufactured fashion products. -Reducing the carbon emissions in the retailing channel.
The Consumer	-Increasing the awareness of sustainable consumption. -Facilitating the reverse activity of "taking-back" used apparel. -Being responsible for end-of-life apparel management.
The Recycler	-Being given incentives on recycling infrastructure investment. -Creating a profitable business model for used apparel recycling. -Cooperating with the retailer to gain the large-scale economy for recycling.
The NGOs	-Disclosing the timely social and environmental problems to the public. -Pushing the relevant legislation in the TA industry. -Receiving financial support from the government or other supporting funds.
The Investor	-Not only caring about economic performance, but also evaluating firms' social and environmental behaviors in supply chains. -Having patience in the long-term investment in sustainability R&D, such as new materials, new technology, new equipment, etc. -Supporting or granting more opportunities to new start-ups in fashion sustainability.

sustainable developments. In terms of "sustainability" research, most existing studies focus solely on economic and environmental sustainability. That's why sustainable measures are proposed for the economic and environmental aspects than the social aspect. For the United Nations' 17 SDGs, we find that the goals of "Responsible Consumption and Production", "Clean Water and Sanitation", and "Climate Action" receive a considerable amount of attention, while goals of "No Poverty", "Reduced Inequalities", "Life below Water" and "Life on Land" have the least attention. There is no doubt that the balanced development of the social, economic, and environmental sustainability is extremely crucial to the TA industry, which would help achieve the United Nations' 17 SDGs by 2030. Matos and Hall (2007) also show that it is a big challenge for firms to balance the conflicting pressures created by sustainable development. We argue that joint efforts from the policy makers and stakeholders (fashion designers, manufacturers, retailers, consumers, recyclers, NGOs, investors, etc.) should be made to alleviate the unbalanced development situation of SDGs. Thus, we propose the "balanced sustainable development actions" (BSDA) for the TA industry, to comply with the 17 SDGs by 2030. The proposed actions create valuable guidelines for the policy makers and stakeholders in the TA industry. We present the detailed actions in Table 5.4, which could be implemented to achieve the balanced sustainable development.

Theoretical Backup and Implications: In addition, various well-established empirical organizational operations management (OM) theories, such as the transactions cost economics theory, agency theory, institutional theory, etc. can also be used to guide the achievability of sustainable fashion supply chain management (Ketchen and Hult, 2007). In particular, we compare the traditional supply chain management and the SSCM in the TA industry from the perspective of different mainstream empirical organizational OM theories. The comparisons will provide important implications regarding how these organizational OM theories can help to enhance sustainable fashion supply chain management. Table 5.5 shows the details.

6. Concluding remarks and future research agenda

6.1. Summary and major findings

Motivated by the SDGs and sustainable business's huge potential, this paper aims to investigate how the TA sector can achieve the SDGs and how the TA industry can become more sustainable. Based on the well-established "3BL", we classify the UN's 17 SDGs into three categories, namely "social, economic and environmental" perspectives. The key objective of this research is to make the FSCM well respond to the UN's 17 SDGs by 2030 and make the fashion supply chains more sustainable and eco-efficient.

The results of this research show that prior studies in SSCM in the TA sector have extensively examined different sustainable operations. However, in the TA industry, the social, economic and environmental benefits are not well-balanced. Thus, we ultimately propose the "balanced sustainable development actions" for the sustainable FSCM, to comply with the UN's 17 SDGs by 2030. The proposed actions create managerial guidelines for the policy maker and stakeholders (fashion designers, manufacturers, retailers,

Table 5.5
Achieving SSCM in TA industry: Related organizational behavior (OB) theories and implications^a.

Theories	Features of Traditional Supply Chains in TA Industry	Features of Sustainable Supply Chains in TA Industry
Transactions cost economics (TCE) theory Agency theory	Fashion supply chain members focus on costs in making purchasing and production decisions. Interests of different channel agents, in business costs and benefits, are not fully aligned along the fashion supply chain.	Fashion firms should focus on the three bottom lines in making purchasing and production decisions. Interests of different channel agents, in the three pillars, need to be well aligned along the fashion supply chain.
Resource dependence theory	Resources tend to be independent among different fashion supply chain members.	Resources are shared and are mutually dependent in fashion supply chains, in order to attain the sustainable development.
Institutional theory	Rely heavily on successful industrial practices to manage the fashion supply chains.	Seeking breakthroughs and enhance innovations in order to respond to social and environmental pressures in managing fashion supply chains.
Game theory	Free riding might exist, and supply chain members all give their own benefits the top priority.	Mutual dependence and special caring are critically important for people and the planet in establishing a SFSC.
Network theory	Strong ties or weak ties among fashion supply chain members are not strategically formed among linked entities.	Network is strategically configured by aligning the economic, social and environmental goals of the fashion supply chain members.
Strategic choice	Strategic decisions are made from the perspectives of individual fashion supply chain members.	Strategic decisions are made from the fashion supply chain's perspective, based on 3BL.
Resource-based view	Focus on creating economic values through certain critical assets and pertinent capabilities among firms in the fashion supply chain.	Creating economic, social, and environmental benefits through certain precious assets and critical capabilities at the fashion supply chain level.

^a The choices of theories follow [Ketchen and Hult \(2007\)](#) which are now the classic and well-established empirical theories for supply chain and operations management studies.

consumer, recycler, NGOs, investor, etc.) in the TA industry. The main limitation of this research is that we choose the journal papers based on *Web of Science*, for the sake of obtaining high quality papers. Thus, we may miss some papers which also concentrate on the SSCM in the TA industry. Moreover, we do admit that there is a certain degree of subjectivity involved in identifying the possible measures for the SDGs as well as content analyses of the collected papers.

6.2. Future research agenda

We conclude this paper by proposing a future research agenda. To be specific, from the literature review and analyses conducted in this paper, several critical areas are identified as shown below.

Holistic Research Balancing of the Three Pillars: Prior research in the area usually focuses on one particular aspect, e.g., the majority of studies explore economic sustainability first and the other aspects are subsidiary. Thus, this will never be sufficient to yield promising results which can achieve the SDGs. As such, future research should focus more on managing the sustainable operations in the TA sector to balance the social, economic and environmental developments together. More empirical theories are suggested to use in the exploration of balancing the three pillars ([Ketchen and Hult, 2007](#)). A more holistic perspective should be adopted.

Joint Efforts of Stakeholders: To establish a sustainable fashion supply chain, there are various internal and external stakeholders who are involved. How the joint efforts made from the stakeholders could contribute to the progress of achieving SDGs deserves more explorations. This is a challenging topic as the scale and scope of research both require careful planning. Some innovative ideas and novel models need to be built. To be specific, the goal of "Partnerships for the Goals" comes up with new requirements for the TA sector to establish strong international collaborations in the global fashion supply chain setting. Considering the interests of all the related stakeholders is crucially important. Achieving the systems optimality by balancing all these interests is a complex process which requires the establishment of the right framework. The stakeholder theory can be applied for this sake.

Under-Explored Dimensions: Among all the SDGs, not all of them are given an equal emphasis. As a result, we propose that more actions should be taken to realize those SDGs which currently are under-studied in the TA supply chain management literature. For example, there are very little prior studies on the SDGs such as "No Poverty", "Reduced Inequalities", "Life below Water" and "Life on Land". They are hence critical areas which call for more scientific research in the future. Moreover, more attention should be paid to issues such as (i) how to solve the issue of "low wage" in the apparel manufacturing sector in developing countries (e.g., Bangladesh), (ii) how to protect the life below water from the threat of plastic pollution, and (iii) how to keep the biodiversity from climate changes.

Multi-Methodological Research: Most research conducted in the literature on sustainable fashion supply chain management only adopts a single method, e.g., analytical modeling approach with mathematical analyses. However, this is insufficient and will easily fall into the "blind man and an elephant trap". Thus, we propose more research to be conducted using the multi-methodological approach ([Choi et al., 2016](#)). For example, by combining the analytical modeling approach with empirical case studies can provide the needed industrial practices to verify and check for the validity of the research findings in the real world. The use of statistical means to establish real data based mathematical analyses can also be adopted to ensure the analytical models are realistic and fit the real-world setting. As a remark, as many topics in sustainable fashion supply chain management are still in their infant stage, only

qualitative case based exploratory studies have been published. Thus, further explorations using quantitative empirical data as well as theoretical modelling analyses should be conducted to establish the scientifically sound solid theories.

Risk Management: The global economy is challenged by all kinds of disruptions brought by disasters, accidents and diseases. For instance, the recent COVID-19 virus outbreak (Choi, 2020) has created a major challenge to global supply chains, including TA supply chains. There is no doubt that achieving the SDGs involves global efforts and relies heavily on the success of not only local supply chains, but also the global supply chain system. Thus, how to properly manage the operational risk (Arza et al., 2020; Choi et al., 2008, 2020; Zhang et al., 2020) in TA supply chains in order to achieve the SDGs is a crucial issue. Much more research effort should be devoted to this area. The use of big data driven approach (Choi et al. 2018b) to enhance the “sense-and-response” kind of resilient capability of global supply chains will be one pertinent area for further studies.

CRedit authorship contribution statement

Ya-Jun Cai: Conceptualization, Investigation, Methodology, Validation, Formal analysis, Writing - original draft, Writing - review & editing. **Tsan-Ming Choi:** Writing - review & editing, Supervision, Investigation.

Appendix A1. The list of acronyms

Acronyms	Full Forms
3BL	Triple Bottom Line
BSDA	Balanced sustainable development actions
CLSC	Closed loop supply chain
CSR	Corporate social responsibility
FSCM	Fashion supply chain management
LCA	Life cycle assessment
NGO	Non-Governmental Organization
PET	Polyethylene terephthalate
SCC	Supplier Codes of Conduct
SCI	Science Citation Index
SDGs	Sustainable development goals
S-LCA	Social life cycle assessment
SSCI	Social Sciences Citation Index
SSCM	Sustainable supply chain management
TA	Textile and apparel

Appendix A2. The details of key words searching

Key words searching	Paper amount (SCI or SSCI, English, excluding conference papers)	Paper amount (related to textile and apparel industry)	Paper amount (excluding review, discussion, and duplicated papers)
-Sustainable fashion (or clothes, or textile and apparel) supply chain management; -Sustainable fashion (or clothes, or textile and apparel) sourcing (or design, or production, or retailing, or consumption);	349	116	108
-Used apparel (or clothes, or textile) collection; -Second hand apparel (or clothes, or textile); -Reuse (or remanufacturing, or recycling, or recycling technology) of textile and apparel materials; -Recycled material for clothes;	141	34	
-Closed loop supply chain in the textile and apparel industry; -Close the loop in the textile and apparel industry; -Circular textile and apparel industry; -life cycle analysis of clothes (or textile and apparel);	55	22	

Appendix A3. The details of categorizing papers

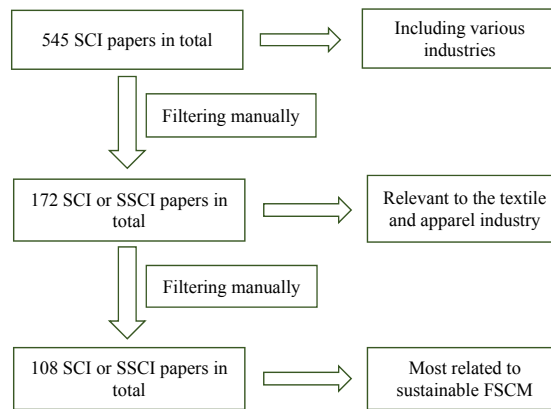


Fig. A1. The target paper selection process.

Appendix A4. The details of paper distribution in supply chain activities

Nodes in the Fashion Supply Chain	Nodes in Details	Paper Amount	References ^a
Sustainable Fashion Supply Chain Management		22	Atilgan (2007), De Brito et al. (2008), Chi (2011), MacCarthy and Jayarathne (2011), Nagurney and Yu (2012), Shen (2014), Na and Na (2015), Dabija et al. (2016), Kim and Kim (2017), Li et al. (2017), Li and Wu (2017), Oelze (2017), Shi et al. (2017), Wang et al. (2017), Yang et al. (2017), Amatulli et al. (2018), Ma et al. (2017), Mair et al. (2018), Morgan et al. (2018), Clarke-Sather and Cobb (2019), Garcia et al. (2019), Mair et al. (2019)
Forward Activities	Sustainable Design	14	Lewandowska and Kurczewski (2010), Kurczewski and Lewandowska (2010), Jin Gam et al. (2011), Moon et al. (2013), Wang et al. (2014), Clancy et al. (2015), Sanches et al. (2015a, 2015b), De Angelis et al. (2017), Laitala et al. (2015), Wang and Shen (2017), Chen et al. (2017), Jiang et al. (2018), Kozlowski et al. (2018), Maldini et al. (2019)
	Sustainable Dyeing	5	Ellams et al. (2014), Budeanu et al. (2014), Parisi (2015), Terinte (2014), Valley et al. (2019)
	Sustainable Sourcing	7	Jiang (2009), Choi (2013b), Jia et al. (2015), Sardar et al. (2016), Winter and Lasch (2016), Amindoust and Saghafinia (2017), Niu et al. (2017)
	Sustainable Production	10	Pineda-Henson and Culaba (2004), Ghazinoory (2005), Jin Gam et al. (2009), Subic et al. (2013), Jordeva et al. (2015), Druica (2015), Wickramasinghe and Perera (2016), Pinheiro and de Francisco (2016), Van der Velden and Vogtländer (2017), Hirscher et al. (2018)
	Sustainable Retailing and Consumption	19	Choi and Chiu (2012), Cox et al. (2013), Žurga and Forte (2014), Armstrong et al. (2015), Shen and Li (2015), Visser et al. (2015), Žurga et al. (2015), Manzoor et al. (2016), Seebauer et al. (2016), Ciasullo et al. (2017), Grappi et al. (2017), Norum (2017), Wei and Jung (2017), Tama et al. (2017), Becker-Leifhold (2018), Jacobs et al. (2018), Laitala and Klepp (2018), Joanes (2019), Iran et al. (2019)
Reverse Activities (including Reuse, Remanufacturing, Recycling, etc.)		16	Furferi and Governi (2007), Farrant et al. (2010), Köhler et al. (2011), Muthu et al. (2012), Valverde et al. (2012), Dissanayake and Sinha (2015), Wu et al. (2015), Zamani et al. (2015), De Silva and Byrne (2017), Fortuna and Diyamandoglu (2017a), Fortuna and Diyamandoglu (2017b), Trajković et al. (2017), Bukhari et al. (2018), Paras and Pal (2018), Paras et al. (2018), Pinheiro et al. (2019)
Closed Loop Supply Chain		7	Morana and Seuring (2011), Eryuruk (2012), Hu et al. (2014), Oh and Jeong (2014), Sanches et al. (2015a, 2015b), Telli and Özdil (2015), Ashby (2018)
LCA (Life Cycle Assessment)		8	Woolridge et al. (2006), Van der Velden et al. (2014), Castellani et al. (2015), Zhang et al. (2015), Roos et al. (2016), Testa et al. (2017), Moazzem et al. (2018), Zamani et al. (2018)

^aThe references are placed in the order following the publication year.

Appendix A5. Possible measures for social, economic, and environmental sustainability

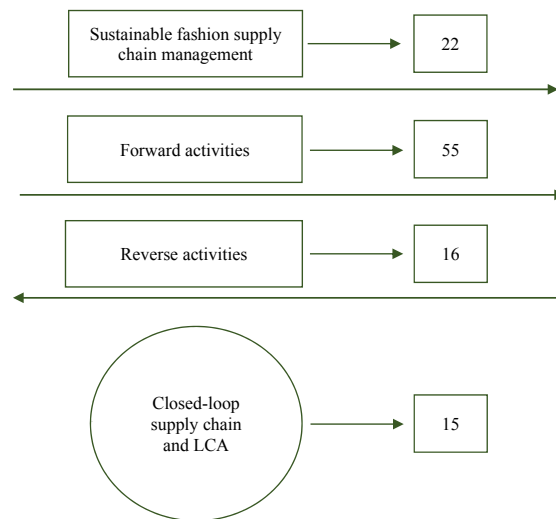


Fig. A2. Further categorizing the 108 sustainable FSCM related papers.

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