# Collaborative Driving Mode of Sustainable Marketing and Supply Chain Management Supported by Metaverse Technology

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**Abstract:** This study aims to explore the relationship between sustainable marketing and supply chain management (SCM) under the background of metaverse technology to realize the sustainable development of enterprises. Firstly, this study deeply studies the influence of metaverse technology on sustainable marketing strategy from the theoretical level. Secondly, it deeply discusses the integration of digital transformation and sustainable development in SCM. Finally, this study implements a collaborative driving model of sustainable marketing and SCM supported by metaverse. By designing and analyzing the questionnaire on the sustainable performance of enterprises, it is found that SCM, cooperation with customers, investment recovery, sustainable marketing, R&D and design, production, and manufacturing have a significant positive influence on the sustainable performance of enterprises ($p<0.01$). In addition, the distribution and retail in sustainable marketing negatively impact the sustainable performance of enterprises, and the standardization coefficient is -0.225 ($p<0.05$). These research results emphasize the importance of sustainable marketing and SCM, which jointly promote enterprises to achieve sustainable performance, and ultimately provide valuable practical guidance for building a sustainable digital economy and contribute to collaborative optimization in enterprise engineering.

## 1 Introduction

With the swift progress of information technology, the digital economy has become the primary engine driving global economic growth. As an emerging concept in the digital era, the metaverse tightly integrates virtual and real worlds, offering unprecedented digital opportunities for businesses (De Franceschi, 2022; Hassan, Khan, Ashraf & Sheikh, 2023; Mancuso et al., 2023; Sivasankar, 2022). In the past decades, although the project engineering of marketing and supply chain management (SCM) has changed from the traditional marketing and supply chain model to the digital and sustainable model, its engineering process still faces many challenges such as market uncertainty, limited resources, and environmental sustainability (Brychko et al., 2023; Beškovnik, 2023). Metaverse, as a virtual digital world, integrates technologies such as virtual reality (VR), augmented reality (AR), artificial intelligence (AI), and blockchain, providing people with an immersive digital experience space. In this new digital world, enterprises and consumers can interact, cooperate, and communicate in a new way, which gives strong support for enterprises to explore new markets, enhance customer experience, and optimize supply chain engineering (Cao et al., 2023; Filipova, 2023; Kshetri, 2022). Consequently, under the rapid development trend of digital technology, using metaverse technology to optimize sustainable marketing and SCM engineering becomes very important.

Metaverse, as one of the emerging digital technologies, affects the business and operation of the company in many ways when applied to company marketing and SCM (Dolgui & Ivanov, 2022). In terms of interactive experience, the metaverse enables consumers and employees to interact and experience in a new way, making it more personalized and immersive, thus attracting more customers and improving brand loyalty. In terms of display and sales, metaverse can be used for virtual display of products and services, so that consumers can experience effects in a virtual environment. Companies can set up virtual stores or exhibition halls in the metaverse to provide more vivid and attractive shopping experiences. Regarding SCM and logistics, metaverse technology realizes real-time monitoring and management of logistics operations by optimizing SCM (Periyasami & Periyasamy, 2022). Virtual logistics and supply chain simulation can help companies better predict demand, reduce inventory costs, and improve delivery efficiency (Chang et al., 2022). Thus, metaverse technology can profoundly change the

company's business and operation mode, and furnish new opportunities for enterprise sustainable marketing and supply chain innovation and growth.

The core goal of this study is to deeply explore the complex and critical relationship between sustainable marketing and SCM under the background of metaverse to promote the sustainable development of project engineering in enterprises. The innovation of this study lies in the in-depth analysis of sustainable marketing strategies and SCM trends supported by metaverse technology, exploring how these trends affect the strategic decision-making and operation practice of enterprise project engineering and constructing a comprehensive, collaborative driving model to integrate sustainable marketing and SCM engineering organically. Through empirical research, the effectiveness of this model is evaluated, which provides a practical and operable guide for the optimization of enterprise project engineering to realize the sustainable development of enterprise project engineering and win-win economic benefits. The contribution of this study is that it provides innovative sustainable development strategies and experiences for enterprise project engineering in the digital age and promotes its economic and social benefits. Meanwhile, by establishing a sustainable digital economy in the era of the metaverse, enterprises can find a harmonious balance between economic prosperity and social responsibility and make substantial contributions to future sustainable development.

The overall organizational structure of this study is as follows. Section 1 introduces the relevant background and motivation of enterprise sustainable marketing and supply chain engineering optimization; Section 2 presents related work; Section 3 describes in detail the relevant contents of implementing a collaborative driving model of sustainable marketing and SCM supported by metaverse; Section 4 conducts empirical evaluation and analyzes the results. Section 5 summarizes and discusses the research findings and significance and puts forward the limitations and prospects of this study.

## 2 Literature Review

### 2.1 Application status of a metaverse in enterprise sustainable marketing

As an emerging concept in the digital economy era, the metaverse combines the virtual and real worlds, bringing new digital opportunities for enterprises. With the widespread adoption of the sustainable development concept, sustainable marketing strategies have become a crucial topic for corporate growth. Sheth and Parvatiyar proposed a framework to achieve sustainable consumption by promoting enterprise marketing strategies and government interventions. The objective of emphasizing four enterprise marketing strategies and four types of government interventions is to achieve sustainable marketing and establish a sustainable society (Sheth & Parvatiyar, 2021). Herman developed a comprehensive analytical model combining the Stimulus-Organism-Response theory and the Technology Acceptance Model. Through structural equation modeling analysis of a sample of 300 employees in the catering industry, they discovered that green marketing orientation and entrepreneurship positively impacted the adoption of big data applications (Herman, 2022). Chen et al. introduced a scientific method to test the quality parameters of marketing communication channels to determine their relationship with green competitive levels. The results indicated that page loading speed, failure rate, image, and remarketing activities were significant parameters related to marketing channel quality (Chen et al., 2021). In the metaverse era, sustainable marketing practice goes beyond traditional methods, as digital technology provides businesses with broader paths for sustainable development (Calandra et al., 2023; Del Giudice et al., 2022).

Hastuti et al. believed that the metaverse was a virtual 3D space that expanded marketing channels and increased sales possibilities through the metaverse (Hastuti, Sanjaya & Koeswoyo, 2022). Kaur et al. achieved sustainability through digitization and introduced innovative infrastructure, involving providing strategic information to achieve customer satisfaction for target customers, developing digital infrastructure to obtain real-time feedback on products and services, and predicting customer behavior to create personalized information or services. This also includes using business analysis to enhance the quality of products or services and developing effective simulations to monitor, test, and plan product improvements based on consumer and market needs (Kaur, Singh, Gehlot, Priyadarshi & Twala, 2022). Cheah et al. investigated the potential advantages or disadvantages that the metaverse may bring to digital marketing and advertising, brands, services, supply chain and logistics, ethics and sustainability, diversity and inclusivity, and consumer health (Cheah & Shimul, 2023). Allam et al. argued that the metaverse may redefine urban design activities and service provision to improve urban efficiency, responsibility, and quality performance (Allam, Sharifi, Bibri, Jones & Krogstie, 2022).

### 2.2 Application status of a metaverse in the digital development of SCM engineering

SCM has also encountered opportunities for digital transformation in the metaverse context. Guo et al. delved into the role and impact of Industry 4.0 information and digital technologies within agile supply chain strategies. They discovered that these digital technologies could heighten the agility of supply chains in perceiving and responding to market changes and customer demands (Guo, Chen, Li, Li & Lu, 2022). Luo et al. investigated the

reasons, approaches, and effects of digital technology adoption in manufacturing enterprises at the supply chain level. Through a literature review, they identified the primary driving factors for manufacturing enterprises to embrace digital technologies and proposed a new adoption process model (Luo, Yimamu, Li, Wu, Irfan & Hao, 2023). Taking the application of digital reverse supply chains in asbestos waste management as an example, Qian et al. explored the roles and effects of blockchain and the Internet of Things (IoT) on supply chain performance. The research results demonstrated that integrating and combining blockchain and IoT could achieve a robust digital reverse supply chain (Qian, Gao & Chen, 2023). Digital technologies enable more intelligent SCM. The utilization of IoT technology and AI algorithms can achieve real-time monitoring of supply chain operations, improve logistics efficiency, reduce resource and energy consumption, and provide robust support for sustainable development (Centobelli et al., 2022; Pakseresht, Ahmadi Kaliji & Xhakollari, 2022; Liu et al., 2023). Trivedi and Negi (2023) discussed the application and benefits of metaverse in SCM. They used case studies to analyze the actual application of several enterprises in the metaverse. It was found that metaverse technology could improve the visibility, collaboration, and real-time monitoring of the supply chain, thus enhancing the efficiency and responsiveness of the supply chain. The results denoted that the metaverse had great potential in SCM and could bring practical benefits to enterprises (Trivedi & Negi, 2023).

Queiroz et al. provided detailed insights into the metaverse's potential, opportunities, and challenges for operational and SCM communities. They found significant similarities and differences between organizations that adopted metaverse technology and those that did not (Queiroz, Wamba, Pereira & Jabbour, 2023). The main results of Chen et al.'s research indicated that performance expectations, promotion conditions, and establishing initial trust with supply chain partners could drive behavioral intentions towards the adoption of the metaverse, thereby improving the resilience of the supply chain. Sensory feedback was identified as an important feature of the metaverse and had a critical impact on adoption behavior. In addition, sensory feedback had an auxiliary partial mediating effect between establishing initial trust and behavioral intention of supply chain partners, and a comprehensive mediating effect between establishing initial trust and behavioral expectation of supply chain partners (Chen, Ye & Huang, 2023). De Giovanni analyzed the sustainability of adopting metaverse technology, with a particular focus on the potential side effects of digital transformation (De Giovanni, 2023). Jamshidi et al. introduced Meta Metaverse to enhance immersive experiences and create realistic digital twins in multiple fields (Jamshidi, Dehghaniyan Serej, Jamshidi & Moztarzadeh, 2023). Rathole mentioned that the main goal of the digital fashion industry was to achieve sustainability through the use of digital tools and to achieve real-world impact while optimizing operations, production, and physical products (Rathole, 2023).

## 2.3 Research Gaps

The above scholars have conducted in-depth research on the emerging concepts of metaverse technology in the digital economy era, combined with the concept of sustainable development, and explored the potential opportunities and challenges of applying metaverse technology in enterprises and SCM. They focus on the role of technologies such as digitization, AI, and big data in achieving sustainability and improving enterprise competitiveness. Although past research has highlighted the importance of sustainability and digital technologies in businesses and supply chains, there are still some shortcomings in the face of the new paradigm introduced by metaverse technologies. For example, some studies have focused too much on one aspect of the metaverse, digitization, and sustainability, lacking a holistic perspective and paying less attention to their potential negative impacts and sustainability challenges. In addition, some studies have shortcomings in the theoretical framework, failing to deeply analyze the complex relationship between the metaverse, digitization, and sustainability, and lacking in-depth theoretical support, which limits the in-depth understanding of the research topic. Furthermore, some studies lack a thorough analysis of the integration of metaverse and AI in marketing in the fashion industry, as well as an in-depth understanding of the potential impact of the practical application of digital technologies in SCM. However, few scholars combine sustainable marketing with SCM. Moreover, as a new technology, the metaverse is rarely applied in enterprise project engineering. The advantage of metaverse technology is that it provides a new digital opportunity and can create broader possibilities in sustainable marketing and SCM. These deficiencies provide research motivation for this study to fill these knowledge gaps and delve deeper into the role of metaverse technology in sustainable marketing and SCM. A review of past research has discovered that there are research flaws in applying metaverse technology in the emerging concepts of the digital economy era. Given the novelty of metaverse technology, in-depth research on its impact on enterprises and supply chains is crucial for promoting the development of the digital economy and achieving sustainable development goals. Therefore, this study introduces metaverse technology, applies this technology to the engineering process optimization of the organic combination of marketing and SCM, and constructs a collaborative driving model. Taking fast fashion clothing enterprises as the object, this study makes an empirical analysis through a questionnaire to explore the impact of collaborative driving of sustainable marketing and SCM on the sustainable development of enterprise project engineering.

## 3 Research Methodology

### 3.1 Analysis of Sustainable Marketing Strategies and SCM in the Metaverse Context

The metaverse stands out a significant characteristic of the digital economy era. Within the metaverse context, digital technology can enhance the marketing and supply chain efficiency of enterprises, optimize resource allocation, reduce resource waste and environmental impact, thus promoting sustainable development and overall performance improvement of enterprises (Far & Rad, 2022; Lv et al., 2022; Aldea, 2023). Sustainable marketing is a strategic approach for enterprises that involves considering social and environmental impacts in their economic activities (Hanaysha et al., 2022; Ziółkowska, 2021). SCM encompasses a series of activities that coordinate and optimize the flow of resources, information, and funds from suppliers to end-users when delivering products or services. In the context of sustainable development, SCM not only focuses on efficiency and cost but also emphasizes the impact on the environment and society (Choudhury, Behl, Sheorey & Pal, 2021; Helo & Hao, 2022; Richey et al., 2022). Figure 1 illustrates the specific elements of sustainable marketing strategies and SCM for enterprises.
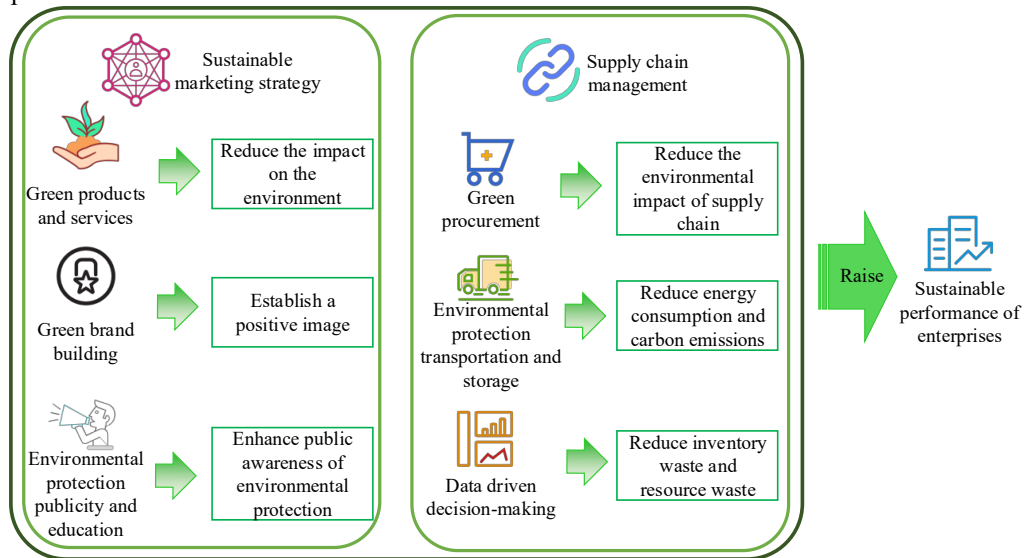


Figure 1. Specific elements of sustainable marketing strategies and SCM for enterprises

Figure 1 presents how the sustainable marketing strategy is centered on promoting and providing green products and services that meet environmental and social responsibility requirements. It promotes the idea of a green brand image, emphasizes corporate social responsibility and environmental actions, and establishes a positive image through public welfare activities and social contributions (Claro & Esteves, 2021; Fatma, Khan, Kumar & Shrivastava, 2022; Kuzior, Arefieva, Poberezhna & Ihumentsev, 2022). The SCM strategy involves the green transformation of the procurement process. By selecting environmentally friendly raw materials and suppliers, the supply chain's environmental impact is reduced, and the importance of data is emphasized (Shekarian, Ijadi, Zare & Majava, 2022; Rejeb, Rejeb, Keogh & Zailani, 2022); Kurdi, Alzoubi, Akour & Alshurideh, 2022; Di Maria, De Marchi & Galeazzo, 2022). IoT technology and intelligent algorithms are adopted to monitor supply chain links in real-time, improve logistics transportation efficiency, and reduce environmental impact. By collecting and integrating supply chain operational data for analysis and mining, enterprises can better understand the status of the supply chain, make accurate production and inventory decisions, and reduce inventory and resource waste (Sadeghi, Mahmoudi, Deng & Luo, 2023; Ricardianto et al., 2022; Burke, Zhang & Wang, 2023). These aspects combine in a synergistic driving paradigm enabled by digital technology to promote resource sharing and efficient allocation, ultimately improving organizational sustainability.

### 3.2 Design and management of supply chain networks in the metaverse context

Against the backdrop of the metaverse, the seamless integration of sustainable marketing strategies with SCM presents an innovative approach to optimize the design and management of supply chain networks. This synergy-driven model elevates the level of sustainable development within enterprises and injects new impetus into supply chains' efficiency, transparency, and environmental responsibility. Initially, metaverse technologies introduce a pioneering approach to visualizing and managing supply chain networks. Leveraging VR or AR, enterprises can digitally represent various links within the supply chain in a virtual space (Awan & Sroufe, 2022). This visualization method empowers enterprises to gain deeper insights into logistics processes, inventory status,

and product flow, enabling more accurate decision-making and planning to optimize supply chain network design and management. Moreover, within the metaverse landscape, it integrates VR, AR, AI and blockchain, which brings new possibilities for SCM. Smart contracts ensure the automated execution of transactions and contracts between partners, thereby enhancing transparency and efficiency. Blockchain technology establishes trust mechanisms within the supply chain, ensuring data authenticity and security (Fosso Wamba, Kala Kamdjoug, Epie Bawack & Keogh, 2020; Dwivedi & Paul, 2022). This not only improves information flow within the supply chain but also enables the tracking of product lifecycles for sustainable management. The metaverse era also underscores the significance of cross-sector collaborative innovation in optimizing supply chains. Metaverse platforms serve as catalysts for cross-industry collaboration among diverse businesses and sectors. Through collaboration, enterprises can collectively optimize environmental impacts within the supply chain, share resources and experiences, and achieve more efficient resource utilization. For instance, manufacturers can collaborate with logistics companies, retailers, and environmental organizations to explore innovative solutions for reducing environmental burdens.

Furthermore, virtual supply chain experiments have emerged as a potent tool within the metaverse paradigm. The establishment of virtual supply chain experiment platforms enables enterprises to simulate diverse supply chain strategies and scenarios, foreseeing their potential impact on sustainable performance (Ramzan, Ali, Ishfaq & Javaid, 2022). This virtual experimentation approach empowers enterprises to try various decisions with lower risk, furnishing more targeted guidance for supply chain network design and management. Lastly, data-driven supply chain optimization emerges as a significant trend in the metaverse era. Big data analytics, AI, and machine learning (ML) can harvest rich data from the metaverse and use it to supply chain network architecture, forecasting, and decision-making (Núñez-Merino, Maqueira-Marín, Moyano-Fuentes & Martínez-Jurado, 2020; Najjar, Alsurakji, El-Qanni & Nour, 2023).

To sum up, the synergy-driven strategy of integrating sustainable marketing tactics with SCM in the metaverse environment presents unprecedented opportunities to enhance supply chain network design and management. Enterprises can achieve more effective and sustainable supply chain operations, laying the path for future sustainable development, leveraging techniques such as VR, smart contracts, blockchain technology, cross-sector collaborative innovation, virtual supply chain experiments, and data-driven approaches. This synergy-driven methodology has a prominent impact on the industry's overall sustainability while also enhancing the competitiveness of businesses.

**3.3 Analysis of the construction of collaborative driving mode of sustainable marketing and** SCM **supported by metaverse**

Metaverse technology is a digital technology that combines the virtual and real world, establishing a cutting-edge platform for enterprises to interact, communicate, and cooperate. This study formulates a collaborative driving model of sustainable marketing and SCM supported by metaverse, encompassing vital components such as data sharing, real-time collaboration, virtual simulation, and other elements.

Data sharing is one of the core elements of the model. In the metaverse, enterprises share various types of data, including sales data, supply chain data, market data, environmental data, and more. These data can be shared and accessed in real-time in a virtual and online environment. Various departments within the enterprise and external partners can upload, update, and share data through the metaverse platform, ensuring real-time responsiveness to market fluctuations and demands. Real-time collaboration serves as another pivotal element, facilitating immediate cooperation and interaction between different departments and teams. This helps to improve communication, teamwork, and problem-solving. In the metaverse, employees and partners can engage in real-time through virtual meeting rooms and immersive virtual environments, enabling document editing, idea exchange, and joint problem resolution irrespective of geographical constraints. Virtual simulation is to simulate and imitate the situations, scenes, and operations of the real world in the metaverse. This proves invaluable for testing new strategies, products, or supply chain solutions. Enterprises can leverage virtual simulation tools to establish simulation environments, such as testing novel logistics schemes in the supply chain or simulating different sales strategies in the market. These simulations can help enterprises to better predict the results and make decisions.

Certainly, within the metaverse, an abundance of data and information becomes available for thorough data analysis and decision support. This includes the analysis of market trends, supply chain efficiency, and sustainable performance. Enterprises can employ data analysis tools and AI algorithms to analyze the data collected in the metaverse. These analyses can help enterprises make more informed decisions to optimize product design, refine marketing strategy, and enhance SCM.

Therefore, the components of this collaborative driving model, bolstered by metaverse technology, enable enterprises to realize real-time data sharing, collaboration, simulation, analysis, and feedback to help them better manage sustainable marketing and supply chains, thus elevating sustainable performance. This model expedites the decision-making process, improves products and services, aligns more effectively with market demand, and

minimizes the waste of resources, thus promoting the sustainable development of enterprises and making the synergy between sustainable marketing and SCM.

Simultaneously, with the support of metaverse technology, by constructing a synergistic driving model of sustainable marketing and SCM, enterprises can enhance operational efficiency, curtail costs, address consumer demands for environmentally friendly products, and fortify their competitiveness and sustainable development capabilities (Tzachor, Sabri, Richards, Rajabifard & Acuto, 2022; Kelleci, A., & Yıldız, 2021; Khan, Piprani & Yu, 2022). The dependent variable used to calculate enterprise sustainable development is business sustainability performance. This metric encapsulates a company's comprehensive performance in achieving long-term sustainable development in economic, social, and environmental dimensions while maintaining balance and coordination among these three aspects (Richnák, P., & Gubová, 2021; Skrynkovskyy et al., 2022; Virmani, Saxena & Raut, 2022). Figure 2 exhibits the proposed theoretical model for the synergistic driving of sustainable marketing and SCM that influence enterprise sustainable development.
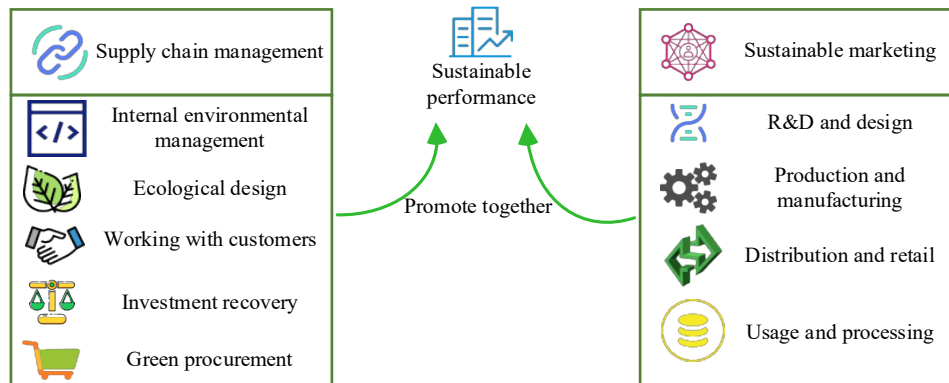


Figure 2. Factors model influencing enterprise sustainable performance

Figure 2 portrays that enterprise SCM and sustainable marketing collectively influence enterprise sustainable performance. On the one hand, SCM is a critical strategy that remarkably impacts the environmental and economic performance of the enterprise. Green practices like reducing waste and maximizing resource use can lessen environmental impact. Additionally, through internal environmental management (IEM) and cooperation with suppliers, green procurement (GP) and the development of environmentally friendly materials are encouraged, further promoting the sustainable performance of the enterprise. On the other hand, concerning enterprise sustainable marketing, explicit product factors influence customers' purchasing intentions, behaviors, and satisfaction, consequently affecting the enterprise's sustainable performance. These factors cover research and development and design (RDD), production and manufacturing (PM), distribution and retail (DR), and usage and processing (UP) (Alshurideh et al., 2022; Ávila-Gutiérrez, Suarez-Fernandez de Miranda & Aguayo-González, 2022; Saqib & Zhang, 2021).

## 4 Results and discussion

### 4.1 Empirical research and data collection

To verify the effect of the collaborative driving model of sustainable marketing and SCM supported by metaverse, this model is analyzed by a questionnaire. Among them, the most obvious characteristics of a fast fashion brand are fast and fashionable, which can quickly launch new products and respond quickly to market changes. It is an efficient sales method for mainstream consumers. Hence, fast fashion brands have their mature business models and marketing strategies. In this study, the research objective is to understand the sustainable marketing and SCM collaborative driving model of fast fashion brands in Guangzhou under the support of the metaverse. young and middle-aged consumers are chosen as they may be the main audience for mainstream fast fashion brands. This is in line with the characteristics of fast fashion brands pursuing fashion and efficient sales. By conducting street interviews in bustling commercial areas, the diversity and breadth of the samples are ensured to cover different populations. When conducting street interviews in the field, a random selection method is used to ensure the randomness of the samples. At each location, passersby are randomly selected for interviews. The survey consists of two types of questionnaires.

One is the questionnaire targeting consumers about enterprise sustainable marketing strategies. Besides the product impact factors scale, the questionnaire encompasses questions about consumer purchasing frequency, motivations, and other related aspects. The survey mainly targets young and middle-aged consumers and is conducted through street interviews in relatively bustling commercial areas of the surveyed cities. A total of 400 questionnaires were distributed in this survey. Random selection ensured that each respondent had an equal chance

of being included in the sample. After checking and sorting out the collected questionnaires, 18 invalid questionnaires were excluded, leaving 382 valid questionnaires.

The other type of questionnaire is targeted at mid to senior-level managers within the companies and focuses on SCM. With the help of recommendations from friends, the surveys are given to fast-fashion apparel companies that have implemented SCM-related activities. Limitations on the company's nature and positions are among the constraints and restrictions set through the questionnaire platform to ensure both the quantity and quality of the surveys. The questionnaire can only be completed by individuals who meet the requirements. In the design of the SCM questionnaire, based on the views of Kerdpitak and Fonseca et al. (Kerdpitak, 2022; Fonseca et al., 2023), the topics of SCM from the perspectives of internal environmental management (IEM), ecological design (ED), work with customers (WWC), investment recovery (IR) and GP are developed. Based on the viewpoint of Khan et al. (Khan & Ali, 2022), enterprises' sustainable performance is designed from the point of economic achievement, environmental performance, and social performance. Overall, 210 questionnaires were distributed, and after excluding incomplete or short-time filled questionnaires, 195 valid questionnaires were obtained. Cronbach's alpha coefficient was used to evaluate the questionnaire's internal consistency and ensure the data's reliability. In this study, Cronbach's alpha coefficient of the questionnaire on enterprise sustainable marketing strategy was 0.939 and that of the SCM questionnaire was 0.961, indicating good credibility. In addition, the normal distribution of the sample size of 382 questionnaires on enterprise sustainable marketing strategy and 195 questionnaires on SCM was consistent (Chernozhukov, Chetverikov & Koike, 2023).

Table 1 presents the questionnaire scales, using the Likert scale to measure the items, with responses ranging from 1.

Table 1 Questionnaire design

| Questionnaire | Structural variable | Observable variable | Measurement indexes |
|---|---|---|---|
| Sustainable Marketing Questionnaire | Explicit influencing factors of products | RDD | Zero waste, durability, disassembly and assembly, multi-purpose, no dyeing or less dyeing |
| | | PM | Minimize waste, zero pollution from dyeing, and maximize material resource utilization |
| | | DR | Fully utilize the logistics industry, promote after-sales repair services, and carry out paid recycling |
| | | UP | Low-energy washing and drying, self-production and reuse, leasing, donation, sharing, and recycling |
| | Purchase intention | Requirement validate | Demand satisfaction of fast-fashion clothing features, such as fashion and quality |
| | Purchasing behavior | Behavioral traits | Be cautious in choosing sustainable clothing |
| | Satisfaction | Confirmation of expectations | Purchased fast-fashion clothes can meet expectations. |
| | | Perceived usefulness | Satisfaction with the use of purchased fast-fashion clothes |
| | | Continuance intention | Willingness to continue buying fast-fashion clothes in the future |
| SCM questionnaire | SCM | IEM | Cooperation between different departments of this company in improving the environment |
| | | ED | The product's design reflects the recyclability of materials, focusing on minimizing waste. |
| | | WWC | Implement green packaging and clean production, and reduce energy consumption during product transportation. |
| | | IR | Establish a dedicated recycling department to recycle waste products and materials and sell waste materials, used materials, and excess asset equipment. |
| | | GP | Conduct environmental audits of the supplier's internal environment to achieve environmental goals. |
| | Enterprise sustainable performance | Economic performance | Reduction of material procurement and energy consumption costs and significant profit growth |
| | | Environmental performance | Reduction of emissions of exhaust gas, waste, toxic and hazardous materials, and removal of the frequency of environmental accidents |

| | | Social performance | Reduction of environmental impacts and risks, improvement of employees' occupational health and safety, and enhancement of the company's social reputation |
|---|---|---|---|

## 4.2 Performance Evaluation

Figure 3 indicates the basic situation of consumers participating in the sustainable marketing questionnaire survey. Only the sample attributes with the highest proportion are selected here.
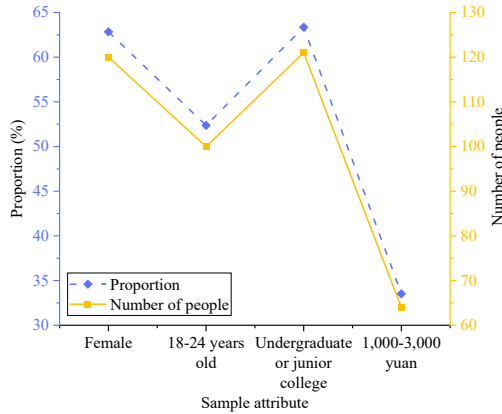


Figure 3. The basic situation of the sample

Figure 3 draws that in terms of gender ratio, women account for 62.83% of the surveyed population, which is relatively high. This indicates that the number of women in this sample is obviously more than that of men. Regarding age distribution, the proportion of people aged 18-24 is 52.36%, which is a considerable proportion, indicating that there are more young people in this sample. In education, the proportion of people with undergraduate or junior college education is 63.35%. This exhibits that most people in this sample are highly educated. In the aspect of monthly income, about 33.51% of people earn between 1,000 and 3,000 yuan. This means that in these consumer groups, a considerable number of people have a medium monthly income.

Figure 4 demonstrates the frequency and motivation of sample purchases of fast-fashion clothes.
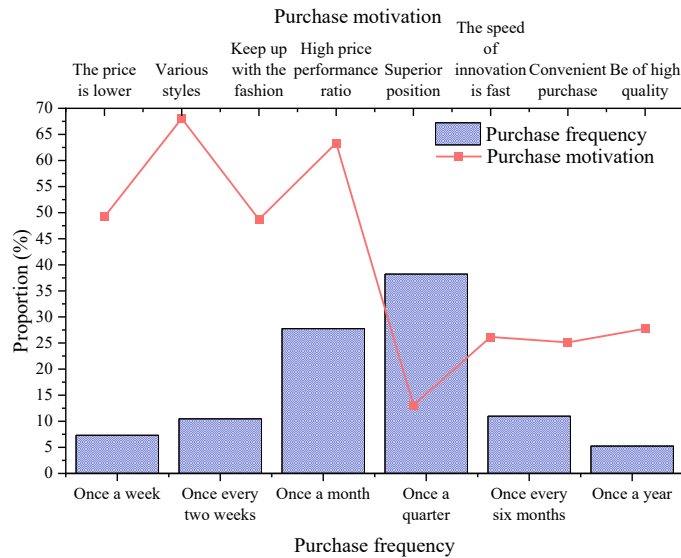


Figure 4. Sample purchase frequency and motivation statistics

In Figure 4, the distribution of purchase frequency in the sample is widespread. Over 38.22% of consumers make purchases once a quarter, followed by once a month (27.75%) and once every two weeks (10.47%). Regarding purchase motivations, the predominant factors are "various styles" (68.06%) and "high price performance" (63.35%), emphasizing that diversity and cost-effectiveness are pivotal considerations for buyers in this sample. Other important purchase motivations include "low price" (49.21%) and "pursuing fashion" (48.69%). Some individuals prioritize factors like "quality" (27.75%), "convenient purchase" (25.13%), and "fast

innovation" (26.18%) when purchasing products. The least prominent factor is the superior position, accounting for only 13.09%. This indicates that consumers' purchasing behavior for fast-fashion clothing is characterized by relatively short cycles, likely due to the fast pace of product updates. A rapid supply chain is a key element of success for fast-fashion brands. Furthermore, affordability and variety stimulate consumers' desire to purchase fast-fashion clothing.

In sustainable marketing, a correlation analysis is conducted for various variables. The results are displayed in Figure 5.
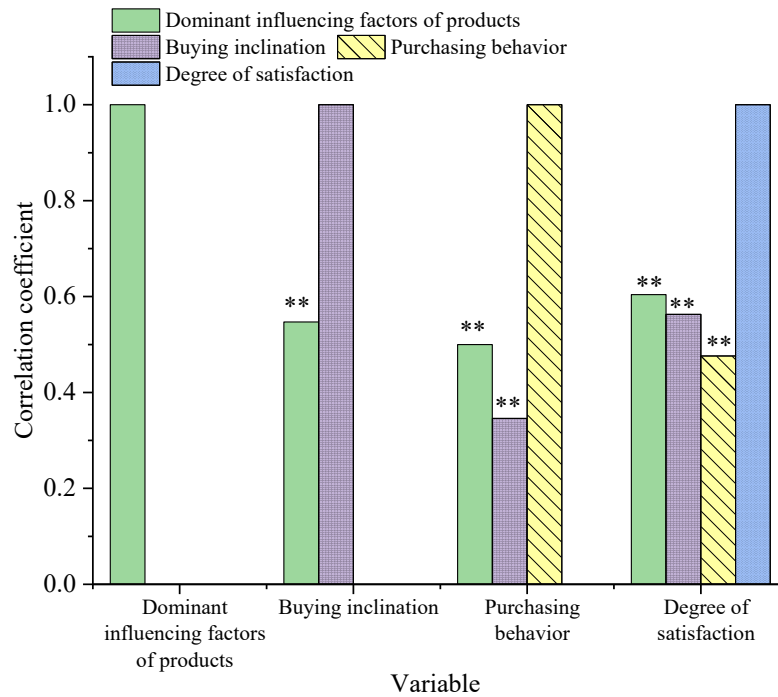


Figure 5. Variable correlation analysis of sustainable marketing (**: $p<0.01$)

Figure 5 suggests that the p-values for the correlations between purchase intention, purchase behavior, satisfaction, and product impact factors are all $<0.01$, indicating a positive and significant relationship between them. The p-values between purchase intention and purchase behavior as well as between purchase behavior and satisfaction are $<0.01$, illustrating a positive correlation among the three variables. The explicit influencing factors of the product, such as RDD and PM, positively influence consumers' purchase intention and behavior, thus affecting their satisfaction.

Figure 6 displays the fundamental demographics of the individuals participating in the questionnaire survey for SCM. The sample attribute with the highest proportion is selected.
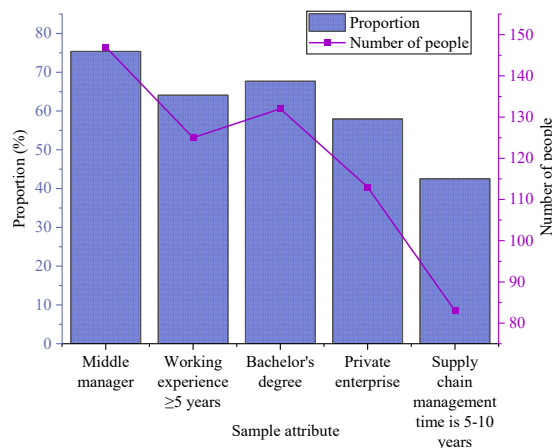


Figure 6. Basic information of enterprise personnel sample

Figure 6 reveals that the survey participants mainly consist of mid-level managers in the companies, with most holding a bachelor's degree or above and having 5 years or more of work experience. The usefulness of the questionnaire replies is increased since these people grasp professional knowledge more thoroughly and are more familiar with implementing green initiatives within the business. In terms of SCM performance, 42.56% of the organizations fell within the 5–10 year range, indicating recent advancements in the field.

The correlation between SCM and enterprise sustainable performance is analyzed based on the results. The findings are depicted in Figure 7.
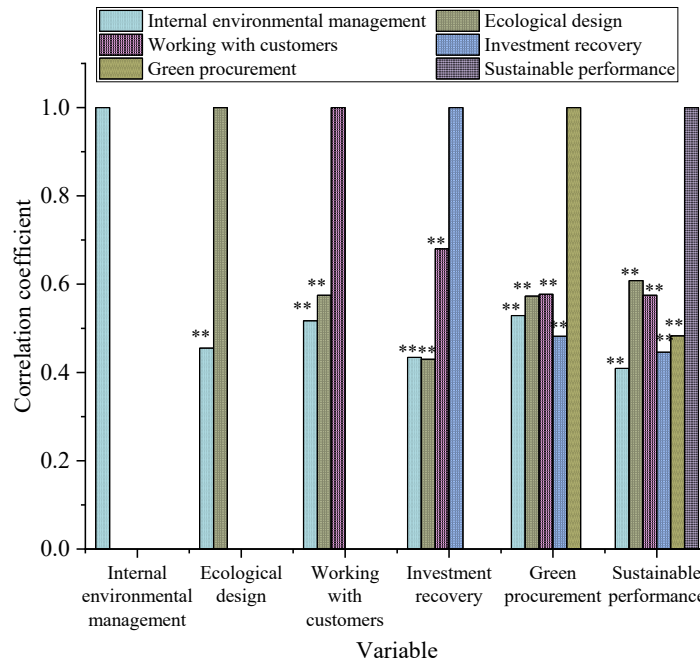


Figure 7. Correlation analysis between SCM and enterprise sustainable performance (**: p<0.01)

Figure 7 denotes the correlation results among all variables. Among them, notable positive correlations emerge, specifically IEM and ED, cooperation with customers, IR, GP, and sustainable performance (p<0.01). A robust positive correlation is evident between cooperation with customers and ED, IR, GP, and sustainable performance (p<0.01). Simultaneously, the correlation between sustainable performance and other factors remains positive, with the highest correlation coefficient observed with WWC at 0.852, signifying a close and statistically significant relationship between them (p<0.01).

Finally, based on the Analysis of Moment Structures (AMOS) 24.0 calculations for model fit, the path coefficient of sustainable marketing and SCM for enterprise sustainable performance is obtained. The results are portrayed in Figure 8.
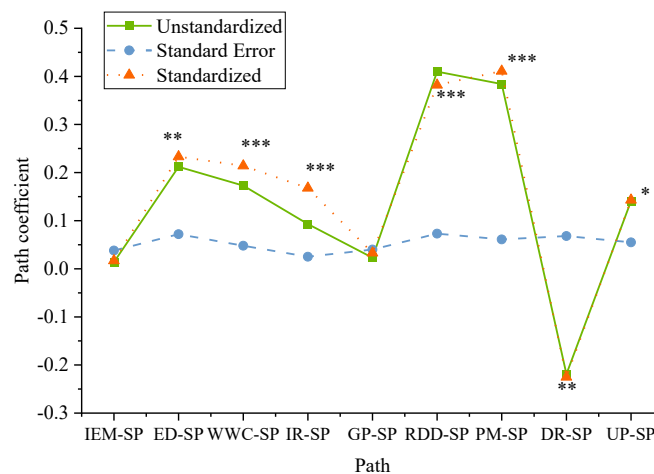


Figure 8. Path coefficient of sustainable marketing and SCM on enterprise sustainable performance (***: p<0.001, **: p<0.01, *: p<0.05)

Figure 8 indicates that WWC, IR, RDD, and PM exert significant positive impacts on enterprise sustainable performance (p<0.001). Additionally, ED and UP also positively influence enterprise sustainable performance (p<0.01). However, IEM and GP do not significantly impact enterprise sustainable performance (p>0.05). However, DR in sustainable marketing has a reverse effect on enterprise sustainable performance, with a standardized coefficient of -0.225 (p<0.05). This underscores that the degree of interaction between various sustainable management factors is helpful for enterprises to formulate more effective sustainable management strategies and decisions, ultimately enhancing the sustainable performance of enterprises.

**4.3 Discussion**

An in-depth analysis of the empirical findings presented above demonstrates that this extensive consumer survey focusing on fast fashion brands reveals the individuals' distinct demographic profiles. Specifically, the respondents exhibit characteristics of being younger in terms of gender, age, education level, and monthly income, with a prevalent lower income level. It is helpful to understand the audience more deeply through comprehensive demographic information, which is consistent with the view of Rahman & Nguyen-Viet(2023). Further delving into the correlation between buying behavior, motivation, and various factors shows that consumers' buying behavior of fast fashion clothes has a relatively short period, which may be due to the rapid product update. The swift and efficient supply chain emerges as a pivotal factor contributing to the success of fast fashion brands. Hence, an effective understanding of the audience's consumer behavior and preferences can support the actual purchase motivation data.

At the enterprise level, an analysis of performance results reveals a significant positive correlation between IEM and ED, cooperation with customers, IR, GP, and sustainable performance. Meanwhile, DR in sustainable marketing has a negative impact on the sustainable performance of enterprises. This underscores the degree of interaction between different sustainable management factors in the collaborative driving mode of sustainable marketing and SCM facilitated by metaverse. The integration of metaverse technology aids enterprises in formulating sustainable management strategies and decisions more effectively and expeditiously, corroborating with findings by Hopkins (2022).

Furthermore, this study is compared with other similar research. Fu et al. conducted empirical research on industrial enterprises through unstructured interviews and questionnaires, analyzing the relationship between sustainable SCM and enterprise performance. They found that effective sustainable SCM implementation notably improved enterprises' operational and financial performance (Fu et al., 2022). Li and Yan constructed a moderated mediation model based on the Porter hypothesis to explore the impact mechanism of green SCM on enterprise sustainable performance from the perspectives of green innovation and signal transmission. The results indicated that green SCM significantly positively affected sustainable performance. Moreover, the mediating impact of green innovation and the moderating effect of green subsidies were also significant (Li & Yan, 2021). Shibli et al. employed the partial least squares structural equation modeling to construct a model. They aimed to investigate the mediating role of enterprise marketing in the relationship between green marketing, green management, dynamic capabilities, and sustainable performance in the organic agricultural sector in Malaysia. The results highlighted the complete mediating role of enterprise marketing in the model. The direct relationship between green management and sustainable performance in the organic agricultural sector was insignificant (Shibli et al., 2021). In conclusion, SCM and sustainable marketing jointly drive enterprise sustainable performance and promote sustainable development.

Through a comparative study of digital technology on sustainable marketing and SCM, Casciani et al. emphasized the impact of digital technology on supply chains, business models, and sustainable innovation. The analysis showed that the adoption of digital technology provided digital opportunities for traditional fashion supply chain models and depicted the innovative changes that were occurring in the fashion industry in terms of processes, products, and services (Casciani, Chkanikova & Pal, 2022). By analyzing the application of digital technology in the fashion industry, this study described the innovative changes that were taking place in the fashion industry in terms of products, services, and processes. Both focused on the opportunities presented by digital technologies for the digital transformation of the fashion industry. Tan et al. explored the relationship between blockchain technology and ethical marketing in the sharing economy and proposed a shift in the logic of ethical marketing, emphasizing the principles of stakeholder capitalism (Tan & Salo, 2023). The results of this study showed a positive correlation between various variables in sustainable marketing, revealing how these factors affect the sustainable performance of enterprises. Chen et al. explored the role of the metaverse in tourism marketing. It revealed the factors that drove the development of metaverse tourism, including planning and management, economic, socio-cultural, and technological factors, as well as perception and acceptance, while the obstacles were mainly from government, industry, tourists, local communities, and educational institutions (Chen, Chan, Xu, Law & Zhang, 2023). This study analyzed the impact of digital transformation on the fashion industry and explored the impact of digital technology on the supply chain, business models, and sustainable innovation of the fashion industry. Both highlighted the transformation of digital technology in the industry. Joy et al. focused

on how leading luxury brands are integrating emerging technologies, involving blockchain, non-homogenous tokens, AI, ML, and VR, to reshape brand image, innovate consumer experiences, and influence consumer behavior (Joy, Zhu, Peña & Brouard, 2022). By studying the impact of digital fashion and metaverse on the fashion industry, this study also dealt with the impact of emerging technologies on brand image, consumer experience, and consumer behavior. Both focused on the impact of digital technology on luxury brands and the fashion industry. Overall, previous research by scholars and the results of this study confirmed each other, providing various theoretical and empirical support for the fashion industry in the digital fashion and metaverse era.

## 5 Conclusion

In the context of the Chinese market, this study emphasizes the impact of sustainable marketing and SCM on the sustainable performance of enterprises supported by metaverse technology. The research focuses on the fast fashion clothing industry, product RDD and PM have a significant positive impact on the sustainable performance of enterprises, while UP has a negative impact on sustainable performance. In the aspect of SCM, WWC and IR have a significant positive influence on the sustainable performance of enterprises, and ED also has a positive influence on sustainable performance. In the aspect of collaborative-driven sustainable development, the introduction of the metaverse makes it possible to integrate the concept of sustainable development and digital technology, optimize product design and supply chain operation, and strengthen green SCM, all of which provide new ways and opportunities for enterprises to achieve sustainable development. These findings emphasize that the application of digital technology can promote a harmonious balance between the economic benefits and social benefits of enterprises in the metaverse era. Based on the actual background of the Chinese market, this study emphasizes that the application of digital technology can promote enterprises to achieve a harmonious balance between economic and social interests in the era of the metaverse. In China, the world's largest market, digital transformation is of great significance for the sustainable operation of enterprises. Enterprises are encouraged to find a balance between digital technology and sustainable development to meet the growing market demand while maintaining a positive impact on the environment and society. This balance helps enterprises achieve long-term success in the Chinese market and achieve sustainable development goals in the digital age.

However, this study has some limitations and there are many future research directions to explore. This study mainly conducts in-depth research on the impact of metaverse technology on sustainable marketing strategies from a theoretical perspective but does not provide a detailed examination of the technical challenges and implementation challenges that may be encountered in practical applications. There may be some subjective biases when designing and analyzing the questionnaire. Meanwhile, the results obtained from the questionnaire may be influenced by factors such as sample selection and regional differences, lacking global or cross-industry universality. Although it has been found that distribution and retail in sustainable marketing negatively impact enterprises' sustainability performance, specific reasons and how to improve them have not been elaborated. Future research should further investigate the specific application scenarios of metaverse technology in various industries, especially practical cases in sustainable marketing and SCM. It is necessary to study how to overcome the negative impact of distribution and retail on the sustainability performance of enterprises, and how these links can better utilize metaverse technology to improve efficiency and sustainability. There is a need to consider conducting more extensive and in-depth empirical research, such as large-scale cross-border and cross-industry surveys, to increase the universality and accuracy of research results. Conduct more in-depth theoretical research on the mechanism of the role of metaverse technology in sustainable marketing and SCM, including potential technical risks, economic costs, social benefits, etc. The action mechanism of metaverse technology in sustainable marketing and SCM is studied in more depth, encompassing potential technical risks, economic costs, social benefits, etc. Overall, this study provides valuable insights into how metaverse technology is driving corporate sustainability. However, further research is still needed to refine and apply the model in practice.

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**Appendix 1**

Dear consumer friends, hello:

Thank you for taking part in our questionnaire. Please read the following carefully before you fill in the questionnaire. This survey is only used for academic research, and there is no right or wrong answer to your questions. Meanwhile, your answers are completely confidential. Your participation is completely voluntary. You can skip it if you don't want to answer some questions. If you have any questions or need further information, you can contact us anytime. We may take up about 20 minutes of your time, and we hope you will give us your cooperation and support.

Please note that your filling in the questionnaire will be regarded as your informed consent. Your participation will be of great significance to our research. Thank you again for your participation.

Basic information

1. Gender:

A. Male; B.Female

2. Age:

A. 18-24; B. 25-34; C. 35-44; D. 45-54; E. Not less than 55

3. Education:

A. Never been to school; B. Primary school; C. Junior high school; D. High school or secondary school; E. Universitiy; F. Undergraduate; G. Master's degree or above

4. Work before retirement:

A. National cadre; B. Employees of enterprises and institutions; C. Teacher; D. Self-employed person; E. Other

Income situation

5. Monthly income (yuan):

A. Less than 1000; B. 1000-3000; C. 3000-5000; D. 5000-7000; E.7000 or above

| | Item | Completely disagree | Disagree | General | Agree | Completely agree |
|---|---|---|---|---|---|---|
| Sustainable marketing questionnaire | 6. Zero waste, durability, disassembly, multi-purpose, no dyeing or less dyeing. | | | | | |
| | 7. Minimize waste, dyeing zero pollution, maximize the use of material resources. | | | | | |
| | 8. Make full use of the logistics industry, promote after-sales maintenance services and carry out paid recycling. | | | | | |
| | 9. Low-energy washing and drying, self-production and reuse, leasing, donation, sharing and recycling. | | | | | |
| | 10. The demand meets the characteristics of fast fashion clothing, such as fashion and quality. | | | | | |
| | 11. Carefully choose sustainable clothing. | | | | | |
| | 12. The fast fashion clothes purchased can meet the expectations. | | | | | |
| | 13. Satisfaction with the use of the fast fashion clothes purchased. | | | | | |
| | 14. Will continue to buy fast fashion clothes in the future. | | | | | |

| | | | | | | |
|---|---|---|---|---|---|---|
| SCM questionnaire | 15. Different departments of the company have cooperated in improving the environment. | | | | | |
| | 16. The design of this product reflects the recyclability of materials, with an emphasis on minimizing waste. | | | | | |
| | 17. Green packaging and clean production were implemented, reducing energy consumption during product transportation. | | | | | |
| | 18. A special recycling department has been established to recycle waste products and materials and sell waste materials, used materials, and redundant assets and equipment. | | | | | |
| | 19. Conduct an environmental audit on the internal environment of the supplier to achieve the environmental objectives. | | | | | |
| | 20. The cost of material procurement and energy consumption has been reduced, and the profit has increased substantially. | | | | | |
| | 21. Reduce the emissions of waste gas, waste, toxic and harmful substances, and reduce the occurrence of environmental accidents. | | | | | |
| | 22. Reduce environmental impact and risks, improve employees' occupational health and safety, and enhance the company's social reputation. | | | | | |