Research on Resource Reuse and Collaborative Governance Innovation of Textile and Apparel Enterprises under the Circular Economy

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Abstract:Against the backdrop of global advancement towards the "Dual Carbon" goals and addressing resource constraints, the textile and apparel industry, as a typical field of high consumption and high emissions, urgently needs to transition towards a circular and sharing economy. This paper takes the resource reuse and collaborative governance innovation of textile and apparel enterprises as its research object, comprehensively employing methods such as literature research and case analysis to deeply analyze the practical pathways of domestic and international enterprises like Bosideng, Icicle, Anta, Adidas, Uniqlo, and Nike. The study reveals that the industry has formed a diverse technological system centered on "physical recycling --- chemical regeneration --- digital empowerment," wherein chemical recycling effectively solves the separation challenge of polyester-cotton blends, and product digital passports provide support for full lifecycle information management. At the governance level, although a multi-stakeholder collaborative mechanism involving "government --- enterprises --- research institutions --- consumers" has been initially constructed, challenges such as fragmented recycling systems, high technological costs, and insufficient internalization of environmental externalities remain. Based on case comparisons, this paper proposes a three-dimensional solution centered on "technological breakthrough --- model reconstruction --- collaborative empowerment," emphasizing cost reduction and efficiency increase through chemical recycling and digitalization, reconstructing production models by implementing the "design for recycling" concept, and improving the multi-stakeholder collaborative governance mechanism. Research indicates that the deep integration of resource reuse and collaborative governance is not only a key pathway to promoting energy conservation and emission reduction in the textile and apparel industry but also a strategic pivot for enterprises to build green competitive advantages and achieve a win-win situation for both environmental and economic benefits. It provides a theoretical basis and practical model for the high-quality and sustainable development of China's textile and apparel industry.

Keywords: Circular and Sharing Economy; Textile and Apparel Enterprises; Resource Reuse; Collaborative Governance; Green Transformation

1. Introduction

The textile and apparel industry is one of the pillar industries of China's national economy and also a key sector for global carbon emissions and resource consumption. Data shows that globally, 100 billion garments are produced annually, with the average carbon emission per garment reaching about 12 kilograms, while carbon emissions from the textile and leather industry account for 0.6% of the global total. As the world's largest producer and consumer of textiles and apparel, China generates a massive total volume of waste textiles annually, but only about 2% is used for industrial recycling, and 1% achieves closed-loop cycling. A large amount of used clothing faces incineration or landfilling, causing both resource waste and increased environmental burden.

Amid the rise of the circular and sharing economy concept and the advancement of the "Dual Carbon" strategy, in 2022, the National Development and Reform Commission and two other ministries jointly issued the "Implementation Opinions on Accelerating the Recycling of Waste Textiles," explicitly setting the target for a 25% recycling rate for waste textiles and a production of 2 million tons of recycled fiber by 2025. This policy direction

drives the industry's transition from the linear model of "resource consumption --- product production --- waste disposal" to the circular model of "resource --- product --- renewable resource." In this process, how enterprises break through the technical bottlenecks of resource reuse and build a multi-party collaborative governance system becomes the core proposition determining the sustainable development of the industry.

In-depth research on resource reuse and collaborative governance innovation of textile and apparel enterprises under the circular and sharing economy holds significant theoretical and practical importance. Theoretically, it can fill the gap in connecting "technological practice --- governance mechanisms --- benefit transformation" in circular economy research for the textile industry, enriching the theoretical system of industrial ecological transformation. Practically, it can provide guidance for enterprises to overcome practical difficulties such as difficult recycling, high costs, and weak collaboration, helping China's textile and apparel industry contribute the "Chinese Solution" in global sustainable governance.

2. Cases of Resource Reuse in Domestic and International Textile and Apparel Enterprises

Resource reuse is the core carrier for textile and apparel enterprises to achieve circular development, requiring full-chain design of "recycling---technology---benefit" to realize the value transformation from "waste" to "resource."

2.1 Bosideng

In the 2022-2023 fiscal year, Bosideng first proposed the concept of "Sustainable Fashion." Regarding the environment, the Anta Group not only reduced operational and production energy consumption and properly disposed of hazardous waste but also focused on investing in the research and development of green products. For example, the "Trained with Plastic" eco-friendly apparel series launched in 2019 in cooperation with suppliers utilized plastic bottle recycled polyester fiber technology to "turn waste into treasure," reducing production costs by 30%-50%. Such green innovations have become a key R&D focus for Anta in recent years, while also bringing long-term benefits to the enterprise.

In the first half of the 2023-2024 fiscal year, Bosideng's operating revenue reached 7.4717 billion yuan, a significant increase of 20.9%. Specifically, Bosideng continuously researches, develops, and promotes the use of new eco-friendly fabrics. For instance, the Polar Extreme Cold series uses GORE-TEX fabric, incorporating GORE-TEX expanded Polyethylene (ePE) membrane, an environmentally friendly technological fabric that is lightweight, thin, and strong, possessing excellent durability. This membrane does not contain Perfluorinated Compounds, and through lighter material weight and new material combinations, it effectively reduces the carbon footprint. Benefiting from material innovation, this product is not only waterproof and windproof but also has a long product lifespan, minimizing the negative impact on the environment and society throughout the product's lifecycle [1].

Considering the low-carbon attributes of products from the raw material stage can drive innovative emission reduction across the entire production chain. Through innovative design, product quality and fashionability need not be sacrificed. Taking the high-end outdoor innovation series B30142230, which won the ISPO Global Design Award in the past year, as an example, this series combines comfortable cuts, advanced color schemes, and fashion technology, achieving a breakthrough in youthful style [2].

2.2 Icicle

In terms of material selection, Icicle's products use historically natural raw materials such as cashmere, wool, linen, silk, and cotton, which are the core materials for the brand's fashion creation. Regarding accessories, Icicle comprehensively replaces ordinary plastic hanging tags with biodegradable bio-based corn hanging tags, effectively reducing the environmental footprint and plastic pollution. The vast majority of buttons are made from natural materials like horn, shell, coconut shell, or metal. When processing metal parts on accessories, Icicle avoids using heavy metals like nickel, common in the electroplating industry, thereby preventing heavy metal pollution. The brand's washable eco-friendly denim label paper synthesis process complies with the Forest Stewardship Council environmentally traceable standard, and the logo embossing process does not involve dyeing or printing, making it more environmentally safe

and possessing good wash resistance.

Furthermore, Icicle's product accessories are also highly eco-friendly. The brand avoids using plastic hangers in stores, reduces the use of solid wood hangers to lower wood consumption, and instead uses biodegradable hangers made from corn starch. Simultaneously, it uses raw cotton cloth instead of non-degradable materials as the main dust prevention tool, and retail outlets also use biodegradable sugarcane pulp packaging boxes, striving to minimize environmental impact.

During the production stage, Icicle focuses on the development and creation of styles using original color fabrics, supports historical traditional textile and dyeing handicraft techniques, and as much as possible adopts production methods that conform to nature, maximizing energy savings and avoiding environmental harm. The brand also places great importance on the recycling and reuse of leftover materials during garment production, establishing a systematic classification and recycling mechanism to ensure effective management and processing of these leftovers [3].

Icicle collaborates with the non-profit environmental organization Canopy and has officially joined the CanopyStyle and Pack4Good forest protection initiatives, working together to promote the green and sustainable development of the fashion industry. The brand actively adopts sustainable fibers and recycled materials recommended by CanopyStyle, ensuring product design reduces the environmental burden from the source. Following the Pack4Good initiative, Icicle will comprehensively review and optimize product packaging, using biodegradable, recyclable, or reusable packaging materials. It promotes circular fashion through various means such as innovation, recycling, and leftover material recovery. At the same time, through close cooperation with Canopy and other industry partners, it continuously explores new technologies and materials, jointly promoting the green transformation of the fashion industry and contributing to low-carbon fashion and biodiversity conservation.

2.3 Anta

Anta has built a comprehensive sustainable product inventory and evaluation system, systematically summarizing the categories and quantities of sustainable products developed by each brand on a quarterly basis, and conducting a comprehensive assessment of the sustainable characteristics of each category. Anta incorporates environmental and health performance as important considerations in product design, focusing on key indicators such as the usage area and weight of sustainable materials, while closely tracking the market sales performance of sustainable products, thereby building a feedback mechanism to continuously optimize sustainable product design and striving to set a benchmark within the industry.

To standardize the criteria for sustainable products, Anta has formulated and clarified specific requirements for sustainable materials, sustainable production processes, sustainable packaging, and sustainable products, establishing the technical and certification standards for sustainable products. Various brands under Anta have planned and implemented targeted ESG strategies, focusing on resource recycling and reuse in the production processes, actively launching sustainable products, and conveying green and low-carbon consumption concepts.

Anta continuously optimizes production processes, prioritizes the selection of eco-friendly materials containing recycled or regenerated content, that are recyclable or biodegradable, steadily increases the proportion of sustainable materials used in products, while expanding the application scope of sustainable packaging and increasing the proportion of sustainable products in the overall product line. Through process innovation, Anta has successfully used eco-friendly materials to create a series of high-quality sustainable products, effectively improving resource efficiency during the consumer use phase, reducing environmental pollution while significantly enhancing product durability and lifespan.

In terms of process innovation, Anta introduces plant dyeing technology, using natural dyes extracted from plant roots, stems, leaves, and fruits to give textiles natural colors, highlighting ecological beauty. Additionally, Anta also employs natural chitin antibacterial technology, reducing the use of chemical auxiliaries, effectively inhibiting bacterial growth, and ensuring clothing maintains a fresh and natural wearing experience.

2.4 Adidas

Adidas launched a 100% recyclable high-performance running shoe, FUTURECRAFT.LOOP. Through nearly a decade of joint research and development with leading global partners, it successfully found an innovative method to make running shoes using only one type of 100% reusable TPU material without the need for glue. This running shoe utilizes SPEEDFACTORY technology, meticulously crafted through multiple processes such as spinning, weaving, and molding. When the shoes are worn out, they can be cleaned, ground into pellets, and remelted into material for new shoes, achieving zero waste, thus completing a closed loop from product design, production, to recycling and reuse [4].

Furthermore, Adidas's "Old Clothes Remade into Eco-Bags" project transforms used clothing through processes like re-fibering, spinning, and weaving into reusable tote bags. These initiatives, through sustainable product design and technological innovation, not only achieve efficient resource reuse but also significantly enhance the brand's environmental image and market competitiveness.

2.5 Uniqlo

Uniqlo initiated the "Fleece Recycling Campaign" in September 2001, and further launched the "All-Product Recycling Campaign" in September 2006. The company continuously expands recycling channels, covering stores, commercial locations outside stores, schools, and online platforms. By the end of 2018, the cumulative number of collected garments had reached 28.97 million items. Additionally, Uniqlo is committed to extending the clothing lifecycle, launching the RE.UNIQLO Clothing Repair Workshop, which gives old clothes new life through repairs and creative redesigns [5].

In terms of material use, Uniqlo's parent company, Fast Retailing, plans to replace approximately 50% of all clothing materials with eco-friendly recycled materials by the 2030 fiscal year. As of the 2023 fiscal year, the usage ratio of recycled materials has reached 8.5%, with its recycled polyester fiber technology being mature, and about 30% of its products use recycled polyester fiber. By building a comprehensive recycling system, promoting technological innovation, and meticulously managing the product lifecycle, Uniqlo successfully balances social and economic benefits.

2.6 Nike

The American sports giant Nike has always adhered to sustainable design concepts, whose active initiatives have not only promoted environmental practices within the industry but also refreshed consumers' understanding of recycling.

Regarding recycling, Nike started its old sneaker recycling program as early as the 1990s, processing old shoes and leftover materials into crumb rubber for paving sports grounds in impoverished areas. Subsequently, Nike cooperated with Ant Group to launch the "Old Shoe, New Life" mini-program, further expanding the scale of recycling. To date, related projects have cumulatively recycled over 30 million pairs of old shoes and over 120 million pounds of shoe factory materials. In the 2024 fiscal year, Nike's "Textile-to-Textile" plan collected 135 tons of high-polyester leftover materials for remanufacturing.

At the technical level, Nike relies on Nike Grind technology to process old shoes and leftover materials into rubber granules and, in cooperation with Tongji University, achieved technological breakthroughs such as the separation of components from waste shoes. In 2012, Nike sportswear made from recycled polyester materials debuted at the London Olympics. Today, the Nike Air Zoom Alphafly Next Nature running shoe has a recycled material content of up to 50%. The "Circularity: Guiding the Future of Design" guide released in 2019 further systematized the standards for material circularity technology.

In terms of benefits, as of 2018, 75% of Nike's shoes and apparel used recycled materials, cumulatively using 115 million recycled polyester bottles to manufacture high-performance jerseys, ranking first in the industry for recyclable polyester material usage for four consecutive years ^[5]^.

3. Comparison and Insights from Circular Economy Practices of Typical Enterprises

To more clearly present the strategic choices and effectiveness of different enterprises under the circular economy model, this paper selects six typical domestic and international brands as cases for systematic comparison. Although these enterprises are in the same industry, their entry points and technological paths for resource reuse have distinct characteristics, covering multiple

dimensions such as material innovation, process innovation, recycling system construction, and full lifecycle management. The table below compiles and compares the practices of these enterprises from the perspectives of their business models from a circular economy angle and the driven economic benefits, to provide diversified references and insights for the industry.

Table 1. Comparison of Circular Economy Business Models and Economic Benefits of Typical Textile and Garment Enterprises at Home and Abroad

Brand	Business Model from a Circular Economy Perspective	Driven Economic Benefits
Bosideng	Uses eco-tech fabrics (GORE-TEX ePE membrane, PFC-free), extends product lifespan through lightweight and innovative design, reduces full lifecycle environmental impact, practices product circularity.	Enhances brand image of "Eco-Tech,"attracts environmentally conscious consumers, increases product premium capability; extended product lifespan reduces repeat purchase demand while fostering user brand loyalty, beneficial for long-term market share stability.
Icicle	Core use of natural materials, accessories use biodegradable, eco-friendly materials (corn-based hanging tags, nickel-free buttons, etc.), retail terminals use eco-friendly packaging and display materials,implements circular environmental practices from product to terminal throughout the chain.	Shapes a "Natural & Eco-friendly" high-end brand image, aligns with the sustainable fashion demands of high-end consumer groups, enhances brand added value; full-chain environmental measures can reduce costs for some material procurement, while gaining favor from eco-conscious consumers, expanding the market.
Anta	Utilizes industrial waste CO2 to produce carbon capture polyester fiber, uses eco-friendly shoe upper materials, biodegradable polyester fiber, etc., promotes green supply chain upgrade, some leather and down obtain authoritative environmental certifications, achieves material cycling and sustainable sourcing.	Reduces reliance on traditional materials like petroleum-based polyester fibers, mitigates risks from raw material cost fluctuations; eco-friendly materials and certifications enhance brand competitiveness in the sports market, attract consumers and partners focused on social responsibility, beneficial for expanding domestic and international markets.
adidas	Over 60% of products use sustainable materials (recycled polyester, sustainable cotton), introduces NTX Cooltrans waterless dyeing technology, achieves resource cycling and emission reduction in production links.	Waterless dyeing technology saves water and dye costs, improves production efficiency; sustainable materials and eco-tech strengthen the brand's "Sustainable Sports" image, enhance product competitiveness in global markets, especially in regions with high environmental requirements like Europe, promoting sales growth
Uniqlo	Achieves high water savings rates for jeans through Nano-bubble and ozone washing processes; fleece, sunscreen clothing, etc., use varying proportions of recycled fabrics, practices production water saving and material cycling.	Water-saving processes reduce production water costs; application of recycled fabrics reduces raw material procurement costs, while attracting mass consumers concerned about sustainable fashion, enhances brand market share, especially establishing differentiated competitive advantages in the fast fashion field.
nike	75% of footwear and apparel use recycled materials, relies on Nike Grind technology to separate components of waste shoes, promotes product material cycling, some running shoes have high recycled material content.	Waste shoe recycling and processing reduce raw material costs, application of recycled materials reduces dependence on virgin materials; strengthens the brand's "Innovative & Eco-friendly" image, attracts consumers seeking technology and environmental protection in the sports running shoe market, promotes high-end product sales, enhances overall brand profitability.

4. Conclusion

Against the backdrop of the global "Dual Carbon" goals and increasingly severe resource constraints, the transition of the textile and apparel industry towards a circular and sharing

economy has become an irreversible trend. By systematically reviewing the resource reuse practices and collaborative governance mechanisms of typical domestic and international enterprises, this paper draws the following conclusions:

First, the diversification of technological pathways is a key support for promoting resource reuse. Innovative means represented by chemical recycling, digital product passports, and recycled fiber technology have effectively broken through the technical bottlenecks of traditional physical recycling, achieving efficient separation and regeneration of complex materials and significantly improving the resource conversion rate of waste textiles.

Second, corporate practices have moved from single-point breakthroughs to full-chain collaboration. From Bosideng's eco-tech fabrics and Anta's carbon capture polyester fiber to Adidas's 100% recyclable running shoes and Uniqlo's full-category recycling system, enterprises are gradually building closed-loop systems in design, production, recycling, and regeneration, promoting the implementation of the "design for recycling" concept.

Third, a collaborative governance mechanism has initially taken shape but still needs deepening. Linkages are forming among the government, enterprises, research institutions, and consumers, with policy guidance, technological R&D, and market incentives acting together. However, challenges such as fragmented recycling systems, high recycling costs, and insufficient internalization of external costs still persist, constraining the scaled development of the circular model.

Fourth, economic benefits and environmental benefits can achieve a win-win situation. Research shows that through resource reuse and green innovation, enterprises can not only reduce energy consumption and carbon emissions but also shape differentiated brand advantages, enhance product premium capability, strengthen market competitiveness, and achieve the unity of sustainable development and commercial value.

In the future, textile and apparel enterprises should continue to strengthen the three-dimensional path of "technological breakthrough --- model reconstruction --- collaborative empowerment," promoting the circular economy from concept to systematic practice. The government needs to further improve the policy system and standard construction, research institutions should accelerate the tackling of key common technologies, and consumers also need to actively participate in green consumption, jointly building a new green, circular, and collaborative development ecosystem for the textile and apparel industry.

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