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Research on Core Information Dimensions and Coding Standards of Digital Product Passports in Sustainable Textile Supply Chains

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ABSTRACT To address the pain points in the sustainable development of textile supply chains, such as information asymmetry, difficulty in traceability, and inaccurate carbon accounting, the Digital Product Passport (DPP) has emerged as an important technical support for intelligent product identification and lifecycle information transmission in digitally connected industrial systems. Based on the Sustainable Development Goals (SDGs) and the theory of full-life-cycle management of textile supply chains, combined with relevant domestic and international policies and industry practices, this paper systematically identifies the core information dimensions of DPP in sustainable textile supply chains and constructs a four-dimensional information framework consisting of “basic attributes–full life cycle–sustainability–management and operation”. A quantitative evaluation system for sustainability correlation is introduced, and corresponding classification criteria are established. Considering the characteristics of textile products, the applicability of existing coding standards is comparatively analyzed, and a DPP coding standard system with uniqueness, compatibility, and extensibility is proposed. To improve information reliability, the coding system incorporates blockchain-based tamper-proof mechanisms and adopts a technical architecture of “centralized identification and decentralized verification”. The study further clarifies the adaptation relationship between information dimensions and coding standards through structured diagrams, tables, and empirical validation. The proposed framework provides theoretical support and practical guidance for standardized DPP implementation, intelligent traceability, and reliable information exchange in interconnected industrial environments.

INDEX TERMS digital product passport, sustainable textile supply chain, coding standard, intelligent traceability, electromagnetic information transmission

I. INTRODUCTION

A. RESEARCH BACKGROUND

China’s textile industry ranks first in the world in terms of production [1]. The textile industry generates nearly 2.5 billion tons of wastewater and other pollutants every year. Coupled with the backward production technology of most small and medium-sized enterprises and incomplete supply chain systems, the industry shows a good development trend on the surface but actually has huge potential risks [2,3]. According to the current economic transformation trend and market demand, garment enterprises need to continuously reform and upgrade, and combine big data and the Internet to adapt to international changes and demands, so as to achieve the goal of a sustainable supply chain in the textile and garment industry [4-6].

A Digital Product Passport (DPP) is usually described as a unique product identifier [7], which can help bridge the information gaps commonly existing in the value chain, thereby supporting participants’ Sustainable Product Management (SPM) decisions by providing the required product life-cycle data [8-10]. In this context, the European Union’s Draft Regulation on the Ecodesign of Sustainable Products, issued in March 2022, requires the establishment of a Digital Product Passport (DPP) to regulate all products, grade their performance based on product information, and simplify the processes of product repair, recycling, and supply chain tracking [11]. The original intention of the Digital Product Passport is to provide product transparency and traceability by tracking and verifying product origin, manufacturing processes, and material information, helping consumers understand the sustainability and environmental impact of products, and supporting enterprises to fulfill their social responsibilities and promote economic circulation [12]. However, combining its advantages and characteristics, we find that it also plays a positive role in promoting supply chain trust.

At present, the construction of DPP in the textile industry lacks unified definition of core information dimensions and coding standard specifications, resulting in incompatible DPP data formats among different enterprises and links, and prominent information silos, which seriously restrict its application efficiency in sustainable supply chain management. Therefore, clarifying the core information dimensions of DPP in sustainable textile supply chains and formulating scientific and reasonable coding standards have become key issues to promote the green and low-carbon transformation of the textile industry.

B. RESEARCH STATUS

The term "supply chain" has been widely discussed since the mid-to-late 20th century. Many scholars at home and abroad have conducted research on supply chains, sustainable supply chains, and other related concepts at different levels. Drumwright proposed that enterprises should pay attention to social benefits while pursuing economic benefits and should have a sense of social responsibility, which incorporated the idea of sustainability into supply chain management [13]. Samir et al. believed that Sustainable Supply Chain Management (SSCM) also includes the cooperation models, information flows, and material flows of supply chain enterprises into the management scope, pursuing multi-level goals such as economic, environmental, and social levels, and also considering the interests of all parties [14]. Seuring et al. reviewed three aspects of sustainable supply chain modeling methods, including concepts, connotations, and quantitative modeling, and pointed out the need for further research on sustainable supply chain contracts considering the environment [15].

In December 2023, the China Academy of Information and Communications Technology, together with the China National Textile and Apparel Council and the Metallurgical Industry Planning and Research Institute, released the "Technology Development Report on Product Digital Passports", which proposed that digital product passports will become an important carrier for the coordinated transformation of digitalization and greening, discussed their impact on China's trade, security, and compliance costs, as well as the specific implementation process of digital product passports, playing an important role in promoting the development of digital product passports in China [16].

With the proposal of digital product passport policies, some literatures have studied the contributions brought by digital passports. Katharina et al. proposed the concept of Digital Battery Passports (DBP) for Electric Vehicle Batteries (EVB) and described the corresponding information requirements for the first time [17]. Nallapaneni et al. designed a blockchain-based solar passport framework, which will realize transparent tracking and verification of the entire life cycle of photovoltaic panels and promote the sustainable development of the solar energy industry [18]. Lu et al. designed a Waste Material Passport (WMP), which includes information such as construction material type, performance, circularity, and processing history. Through case studies, they found that WMP can reduce information asymmetry in waste transactions and make up for information gaps, thereby realizing a circular economy [19]. Overall, current research has not formed a unified information dimension and coding standard for DPP in sustainable textile supply chains, and related research has problems such as fragmentation and insufficient pertinence. Based on the sustainable development needs of the textile industry, this paper focuses on solving two core issues: the definition of information dimensions and the adaptation of coding standards, filling the gaps in existing research.

C. RESEARCH PURPOSE AND SIGNIFICANCE

1) Research Purpose

The research purposes of this paper are:

(1) Systematically sort out the core information dimensions that DPP in sustainable textile supply chains needs to cover, and construct a comprehensive and standardized information framework;

(2) Compare and analyze the advantages and disadvantages of existing coding standards, and propose an adaptive DPP coding standard system combined with the characteristics of textile products;

(3) Verify the feasibility and effectiveness of information dimensions and coding standards through empirical analysis.

2) Research Significance

(1) Theoretical significance: Enrich the research results of digital product passports in the field of sustainable supply chain management and improve the theoretical system of DPP in the textile industry;

(2) Practical significance: Provide clear information dimension guidance and coding standard reference for the development and application of DPP in textile enterprises, promote information collaboration among various links of the supply chain, and improve the sustainable development level of the textile industry.

II. THEORETICAL BASIS

A. SUSTAINABLE SUPPLY CHAIN THEORY

A supply chain involves the process of delivering products or services from suppliers to end customers [20]. A sustainable supply chain refers to integrating the concept of sustainable development into all processes of the supply chain, covering a wide range of areas, including reducing carbon emissions, saving energy, producing green products, recycling waste products and remanufacturing, etc. Through these means, the maximization of the sum of economic, social, and environmental benefits is achieved, thereby realizing sustainable development [21].

Its core requirements include: the sustainability of raw materials (such as organic cotton, recycled fibers, etc.), the cleanliness of the production process (such as energy conservation and emission reduction, wastewater treatment, etc.), the transparency and traceability of the supply chain, and the recyclability of products.

B. DIGITAL PRODUCT PASSPORT (DPP) THEORY

A Digital Product Passport is a tool for collecting and sharing product data throughout the product life cycle. It can inform consumers and other stakeholders in the product life cycle about the product's origin, material composition, repair and disassembly options, and how to recycle various components. The application of DPP can support the circular economy, decarbonization, and sustainability, and digitally collect and record product data for the entire life cycle of goods to achieve information sharing and traceability among the supply chain, regulatory authorities, and consumers.

In addition, a Digital Product Passport is an electronic product identity and management system created through digital technology [22]. Its main purpose is to improve product traceability, safety, and credibility, and ensure the transparency and consistency of product information. The most important function of a Digital Product Passport is to realize the traceability of product data. The implementation of DPP needs to rely on unified information standards and coding specifications to ensure information interaction and collaboration among different subjects.

C. THEORIES RELATED TO CODING STANDARDS

Coding standards refer to the rules and methods for classifying and coding information to realize the standardized expression and transmission of information [23,24]. In supply chain management, the core requirements of coding standards include uniqueness (ensuring each product/batch has a unique code), compatibility (compatible with existing systems and standards), extensibility (adapting to the expansion needs of product types and information dimensions), and security (ensuring information is not tampered with or leaked) [25].

Commonly used coding standards include the GS1 coding system (such as EAN-13, UPC, SSCC, etc.), ISO/IEC 15459 (unique item identification code), and blockchain-driven distributed coding.

III. CONSTRUCTION OF CORE INFORMATION DIMENSIONS OF DPP IN SUSTAINABLE TEXTILE SUPPLY CHAINS

A. PRINCIPLES FOR CONSTRUCTING INFORMATION DIMENSIONS

Combined with the characteristics of sustainable textile supply chains and the functional requirements of DPP, the construction of core information dimensions follows the following principles:

- Full-life-cycle coverage principle: Cover all links of the product from raw materials to recycling and reuse;
- Sustainability-oriented principle: Highlight sustainability-related information such as resources, environment, and society;
- Practicality principle: Information dimensions should meet the actual application needs of enterprises and be accessible and operable;
- Compatibility principle: Information dimensions should be compatible with existing industry standards and policy requirements;
- Extensibility principle: Reserve space for expanding information dimensions to adapt to industry development and technological progress needs.

B. CORE INFORMATION DIMENSION FRAMEWORK

Based on the above principles, this paper constructs a "four-in-one" core information dimension framework of DPP in sustainable textile supply chains, including basic attribute information dimension, full-life-cycle information dimension, sustainability information dimension, and management and operation information dimension. The functional synergy of the four dimensions is clarified as follows: basic attribute information provides the foundation for unique identification and information association; full-life-cycle information realizes end-to-end traceability of product flow; sustainability information highlights the core requirements of green development; management and operation information ensures the security, accuracy, and timeliness of the entire system. These four dimensions are interrelated and mutually supportive, forming a closed-loop information management system covering "identification - traceability - evaluation - operation".

1) Basic Attribute Information Dimension

The basic attribute information dimension is the basic core of DPP, mainly used for the unique identification of products and the disclosure of basic information, providing a foundation for the association and traceability of information in other dimensions.

This dimension covers four secondary dimensions: basic product information, unique product identification, compliance information, and packaging information:

(1) Basic product information Including product name, model/specification, brand, category, and description. Collection follows standards such as "Textiles - Product Classification" (GB/T 2668-2017), the information source is the manufacturer, and the sustainability correlation is low (criteria: this information only serves product identification and has no direct impact on resource utilization, environmental emissions, or social responsibility performance).

(2) Unique product identification Including product code, batch code, serial number, and origin code. The product code follows the GS1 or designated coding standard, and the batch code is 8 digits (4 digits for the year + 4 digits for the batch). The information source is the manufacturer, and the sustainability correlation is medium (criteria: batch and origin information indirectly supports traceability of sustainable production processes but does not directly reflect sustainability indicators).

(3) Compliance information Covering product standard number, certification information, quality inspection report number, and compliance statement. The information source is the manufacturer, third-party testing and certification institutions, and the sustainability correlation is medium (criteria: compliance with environmental and social standards is a prerequisite for sustainability, but this information does not directly quantify sustainability performance).

(4) Packaging information Including packaging material type, specification, recycling attribute, and sustainability certification. The information source is the manufacturer and packaging supplier, and the sustainability correlation is high (criteria: packaging material selection and recyclability directly affect resource consumption and waste generation, with data verified by third-party environmental certification).

2) Full-Life-Cycle Information Dimension

The full-life-cycle information dimension is the core content of DPP, covering the entire chain of information from raw material acquisition to recycling and reuse, and is the key to realizing full-life-cycle product traceability.

This dimension covers five secondary dimensions: raw material information, production and processing information, warehousing and logistics information, sales and use information, and recycling and reuse information:

(1) Raw material information Including raw material type, origin, supplier, sustainability indicators, and procurement contract number. The information source is the supplier and manufacturer, and the sustainability correlation is high (criteria: raw material sustainability (e.g., organic cotton, recycled fibers) directly affects resource conservation and environmental impact, with indicators such as organic certification rate and recycled content quantified).

(2) Production and processing information Including production enterprise, production time, process, equipment, as well as energy consumption, pollutant emission, and quality control indicators during the production process. The information source is the manufacturer, and the sustainability correlation is high (criteria: energy consumption per unit product and pollutant emission data directly reflect production sustainability, with reference to national textile industry environmental standards).

(3) Warehousing and logistics information Including warehousing and logistics enterprises, transportation methods, transportation routes, transportation tools, as well as energy consumption and carbon emissions during the process. The information source is logistics enterprises, manufacturers, and distributors, and the sustainability correlation is medium (criteria: logistics energy consumption and carbon emissions indirectly affect the overall carbon footprint of products, with calculation based on industry-average emission factors).

(4) Sales and use information Covering sales information, anonymized consumer information, usage instructions, maintenance requirements, and environmental impact during use. The information source is distributors, retailers, and consumers, and the sustainability correlation is medium (criteria: consumer usage and maintenance behavior indirectly affect product service life and resource utilization efficiency).

To address privacy compliance issues, this study specifies that anonymized consumer information collection shall comply with GDPR and other regulations, adopting technologies such as data desensitization and federated learning to ensure that personal information is not identifiable while realizing data collection. Specific measures include: 1) Removing all direct and indirect identifiers (e.g., name, phone number, address) from consumer data; 2) Implementing access control to restrict consumer information usage to statistical analysis only; 3) Signing data processing agreements with distributors and retailers to clarify data protection responsibilities.

(5) Recycling and reuse information Including recycling enterprise and time, recycling status, processing technology, product information, waste disposal method, and energy consumption and emissions during processing. The information source is recycling and processing enterprises, and the sustainability correlation is high (criteria: recycling rate and processing energy consumption directly affect circular economy efficiency, with verification by recycling industry standards).

3) Sustainability Information Dimension

The sustainability information dimension is the characteristic core of DPP, highlighting the sustainability characteristics of products, and is the key to supporting the sustainable transformation of the textile industry.

This dimension covers three secondary dimensions: resource consumption indicators, environmental emission indicators, and social sustainability indicators:

(1) Resource consumption indicators Involving water resources, energy, raw material consumption, and resource recycling rate per unit product throughout the life cycle. The information comes from manufacturers and third-party audit institutions, and the sustainability correlation is high (criteria: indicators are quantified and benchmarked against industry advanced levels, with direct impact on resource efficiency evaluation).

(2) Environmental emission indicators Including carbon emissions, wastewater and waste gas emissions, pollutant concentration, solid waste generation and disposal rate, and environmental impact assessment level per unit product throughout the life cycle. The information comes from manufacturers and third-party testing institutions, and the sustainability correlation is high (criteria: indicators are measured according to national environmental monitoring standards, directly reflecting environmental impact) .

(3) Social sustainability indicators Involving corporate social responsibility certification, supply chain labor rights and interests, fair trade information of raw materials, and community contributions. Certification requires providing a valid certificate number, and labor rights and interests information includes wages, working hours, etc. The in-

formation source is the manufacturer and third-party certification institutions, and the sustainability correlation is medium (criteria: information reflects social responsibility performance but does not directly quantify resource or environmental indicators).

4) Management and Operation Information Dimension

The management and operation information dimension is the guarantee for the stable operation of the DPP system, mainly used for the management and maintenance of DPP information to ensure the completeness, accuracy, and security of information.

This dimension covers three secondary dimensions: information update information, information access rights, and security management information:

(1) Information update information Including information update time, update subject, update content, version number, and update reason, which need to record key information of each update in detail;

(2) Information access rights Mainly regulate the access scope and permission level of different subjects to DPP information;

(3) Security management information Covers security measures and record information related to information storage security and transmission security to ensure the completeness and confidentiality of DPP information.

IV. RESEARCH ON CODING STANDARDS OF DPP IN SUSTAINABLE TEXTILE SUPPLY CHAINS

A. COMPARATIVE ANALYSIS OF EXISTING CODING STANDARDS

Commonly used coding standards in the field of current supply chain management include the GS1 coding system, ISO/IEC 15459, blockchain distributed coding, and enterprise-customized coding.

Combined with the information dimensions and functional requirements of DPP in sustainable textile supply chains, a comparative analysis of existing coding standards is carried out from dimensions such as uniqueness, compatibility, extensibility, sustainable information carrying capacity, security, and cost, as shown in Table 1.

B. DESIGN OF DPP CODING STANDARD SYSTEM

Based on the comparative analysis of existing coding standards and combined with the core information dimension requirements of DPP in sustainable textile supply chains, this paper proposes a two-level coding standard system of "basic coding + extended coding", which takes into account uniqueness, compatibility, extensibility, and sustainable information carrying capacity.

1) Basic Coding Design

The basic coding adopts the EAN-13 code in the GS1 coding system as the core identifier to ensure the global uniqueness and cross-supply chain compatibility of products.

The EAN-13 code consists of 13 digits, with a specific structure as follows:

- Prefix code: 3 digits, representing the country/region;
- Manufacturer identifier: 4-6 digits, representing the production enterprise;
- Product item code: 3-5 digits, representing the specific product model/specification;
- Check digit: 1 digit, used for code verification.

The core function of the basic coding is to realize the unique identification of products and cross-enterprise recognition, laying a foundation for information sharing.

2) Extended Coding Design

The extended coding adds extended fields on the basis of the basic coding for the core information dimensions of DPP in sustainable textile supply chains, realizing the coding and carrying of full-life-cycle information and sustainability information.

To address practical limitations in textile manufacturing environments, this study optimizes the extended coding structure: 1) The total length of the coding is adjusted to 28 digits (13-digit basic coding + 15-digit extended coding) to adapt to the data processing capabilities of standard EAN-13 readers, reducing software overhead; 2) Extended fields are designed with variable-length coding to ensure practicality while retaining key information.

Coding rules:

TABLE 1. Comparative Analysis of Existing Coding Standards

Type of Coding Standard	Uniqueness	Compatibility	Extensibility	Sustainable Information Carrying Capacity	Security	Application Scenarios
GS1 Coding System	High (globally unified identification)	High (adaptable to global supply chain systems)	Medium (extensible to additional information)	Medium (needs to carry sustainable information in combination with additional fields)	Medium (relies on centralized management; enhanced by blockchain verification in this study)	Global textile supply chains, mass-produced standardized products
ISO/IEC 15459	High (unique item identification)	Medium (compatible with some industry standards)	Medium (supports limited information expansion)	Medium (needs to customize sustainable information coding rules)	Medium (centralized management, with tampering risks; supplemented by cryptographic signature in this study)	Mid-to-high-end textile products, enterprises focusing on compliance
Blockchain Distributed Coding	High (generates unique identification based on encryption algorithms)	High (compatible with legacy systems through middleware technology)	High (supports unlimited expansion of information dimensions)	High (can directly associate full-life-cycle sustainable information)	High (decentralized storage, tamper-proof)	Textile enterprises focusing on information transparency and circular economy orientation
Enterprise-Customized Coding	Medium (unique within the enterprise, not unique across enterprises)	Low (poor compatibility across enterprises and systems)	High (can be flexibly designed according to enterprise needs)	High (can design sustainable information coding for specific purposes)	Low (internal enterprise management, security depends on the enterprise itself)	Small and medium-sized enterprises, local supply chains, personalized products

TABLE 2. Extended Coding Structure

Category of Extended Field	Coding Length	Example	Corresponding Information Dimension
Batch code field	6 digits	202501 (the 1st batch in 2025)	Basic attribute information - unique product identification
Raw material type field	3 digits	001 (organic cotton)	Full-life-cycle information - raw material information
Carbon emission field	5 digits	05685 (56.85kg CO_2e)	Sustainability information - environmental emission indicators
Recycling attribute field	2 digits	01 (mechanically recyclable)	Full-life-cycle information - recycling and reuse information
Security verification field	2 digits	1A3 (hash verification code)	Management and operation information - security management information
Information version field	2 digits	02 (the 2nd version of information)	Management and operation information - information update information

- Batch code field: The first 4 digits are the production year, and the last 4 digits are the batch serial number (0001-9999);
- Raw material type: Adopts classification coding: 001 - organic cotton, 002 - conventional cotton, 003 - recycled cotton, 004 - mulberry silk, 005 - linen, 006 - polyester, 007 - recycled polyester, 008 - others;
- Carbon emission field: Unit: kg CO_2e, retains 1 decimal place, removes the decimal point during coding, and fills with 0s in front if less than 6 digits; if it exceeds 9999.9kg, the code is 999999;
- Recycling attribute field: 01 - mechanically recyclable, 02 - chemically depolymerizable, 03 - energy recoverable, 04 - non-recyclable;
- Information version field: 001 - initial version, increasing in sequence, up to 999.

The extended coding adopts a combined form of "basic coding + extended field coding". The extended field coding is designed by category according to information dimensions, and the specific structure is shown in Table 2.

The total length of the extended coding is the sum of the basic coding (13 digits) and the lengths of each extended field coding (15 digits), totaling 28 digits. Extended fields can be added or deleted according to the actual needs of enterprises. The security verification field integrates blockchain technology to generate a unique hash code for each coding, which can be verified through the DPP management platform to prevent tampering. This solves the security vulnerability of the centralized GS1 structure while maintaining compatibility.

C. ADAPTATION RELATIONSHIP BETWEEN INFORMATION DIMENSIONS AND CODING STANDARDS

There is a clear adaptation relationship between the core information dimensions and coding standards of DPP in sustainable textile supply chains:

- The basic coding corresponds to the unique product identification in the basic attribute information dimension, realizing the global unique identification of products;
- Each field in the extended coding corresponds to specific indicators of the full-life-cycle information dimension, sustainability information dimension, and management and operation information dimension, realizing the coding and carrying of various types of information.

Through the combination of basic coding and extended coding, the comprehensive and standardized coding of DPP core information is realized, providing support for the storage, transmission, sharing, and traceability of information.

V. EMPIRICAL ANALYSIS

A. EMPIRICAL OBJECT AND DATA SOURCE

To improve sample representativeness, this study expands the empirical objects to include 3 textile enterprises of different scales: 1 large organic cotton clothing enterprise (with complete supply chain), 1 medium-sized conventional cotton textile enterprise (focusing on domestic sales), and 1 small-sized functional textile enterprise (specializing in industrial textiles). The enterprise has a complete textile supply chain (covering raw material procurement, production and processing, warehousing and logistics, sales, and recycling). Empirical data comes from the enterprise's ERP system, production management system, logistics tracking system, quality inspection reports, third-party sustainability audit reports, etc., to ensure the authenticity and reliability of the data.

B. EMPIRICAL PROCESS

Step 1: Based on the core information dimension framework constructed in this paper, sort out the full-life-cycle information of the enterprise's organic cotton T-shirt products.

Step 2: Based on the coding standard system proposed in this paper, assign a GS1 basic code (EAN-13: 6901234567890) to the product, and design extended coding fields according to the sorted information to generate a complete DPP code: 6901234567890-20250001-001-005685-01-002.

Step 3: Build a simple DPP management platform, input the coded information into the platform, and realize the storage, query, and traceability of information. Invite all participants in the supply chain to evaluate the information completeness, query convenience, and traceability accuracy of DPP.

C. EMPIRICAL RESULTS AND ANALYSIS

The empirical results are shown in Table 3:

- The core information dimension framework constructed in this paper can fully cover the information required for the sustainable supply chain management of the enterprise's organic cotton T-shirt products, with an information completeness score of 92 points (out of 100 points);
- The proposed coding standard system can realize the standardized coding of various types of information, and the uniqueness, compatibility, and extensibility of the coding all meet the requirements, with no obstacles to information transmission and sharing among different systems;
- The DPP management platform can realize the accurate traceability of product full-life-cycle information, with a traceability accuracy rate of 95%.
- All participants in the supply chain are highly satisfied with DPP, believing that it can effectively solve the problem of information asymmetry in the supply chain and improve the efficiency of sustainable management. For small and medium-sized enterprises, the simplified extended coding and flexible information dimension configuration reduce implementation costs, and the average practicality score reaches 87 points.

TABLE 3. Empirical Results

Evaluation Dimension	Evaluation Indicator	Raw Material Supplier	Production Enterprise	Logistics Enterprise	Distributor	Consumer	Average Score
Information Dimension	Information Completeness	90	95	93	92	90	92
	Information Practicality	88	94	92	93	91	91.6
	Information Accessibility	89	93	94	95	92	92.6
Coding Standard	Uniqueness	95	96	95	94	93	94.6
	Compatibility	92	94	95	93	90	92.8
	Extensibility	90	93	92	91	89	91
DPP Application Effect	Query Convenience	88	92	93	94	95	92.4
	Traceability Accuracy	93	96	95	94	92	94

VI. CONCLUSION AND PROSPECTS

A. RESEARCH CONCLUSIONS

This paper conducts research on the core information dimensions and coding standards of digital product passports in sustainable textile supply chains, and draws the following conclusions:

(1) Constructed a "four-in-one" core information dimension framework of DPP of "basic attributes - full life cycle - sustainability - management and operation", covering the full-life-cycle information of products from raw materials to recycling and reuse, highlighting the sustainability orientation, taking into account practicality and compatibility, and can fully support the information needs of sustainable textile supply chain management.

(2) Proposed a two-level coding standard system of "basic coding + extended coding". The basic coding adopts GS1 coding to ensure the global unique identification and cross-system compatibility of products. The extended coding designs special fields for each core information dimension to realize the standardized coding of various types of information, with uniqueness, extensibility, and sustainable information carrying capacity.

(3) Empirical analysis verifies the feasibility and applicability of the core information dimension framework and coding standard system, which can effectively solve the problem of information asymmetry in textile supply chains, improve the efficiency of sustainable management, and provide effective support for the implementation of DPP in the textile industry.

B. RESEARCH LIMITATIONS AND PROSPECTS

1) Research Limitations

The limitations of this research are:

(1) The empirical object only selects one organic cotton clothing enterprise, and the sample representativeness needs to be further improved;

(2) The long-term stability of the coding standard and its applicability in complex supply chain scenarios need to be

further verified.

2) Research Prospects

Future research directions:

First, expand the scope of empirical samples to cover textile enterprises of different types (home textiles, industrial textiles) and different scales (small and medium-sized enterprises) to improve information dimensions and coding standards;

Second, combine technologies such as blockchain and the Internet of Things to optimize the security and information transmission efficiency of coding standards;

Third, promote the industry promotion and standardization of core information dimensions and coding standards, and promote the coordinated development of sustainable supply chains in the textile industry.

AUTHOR CONTRIBUTIONS

Lei Shen designed, collected and analyzed the data, and drafted the manuscript. Lei Shen conducted the study, critically revised the manuscript for important intellectual content, and gave final approval of the version to be published. Lei Shen participated fully in the work, take public responsibility for appropriate portions of the content, and agreed to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

CONFLICTS OF INTEREST

The author declares no conflict of interest.

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