Pathways and Empirical Analysis for Enhancing Corporate Working Capital Efficiency from a Fabric Supply Chain Collaboration Perspective

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ABSTRACT Efficient working capital management has become a critical challenge for textile enterprises operating in increasingly interconnected supply chain environments. This study develops a collaborative analytical framework that integrates supply chain coordination theory with working capital management to investigate the mechanisms through which information collaboration, logistics collaboration, and capital collaboration influence operational efficiency. A multidimensional evaluation system is established using entropy weighting to quantify collaboration levels, while Data Envelopment Analysis (DEA) and panel regression models are employed to assess working capital performance based on data from listed textile enterprises between 2018 and 2023. The empirical results demonstrate that all three collaboration dimensions significantly improve working capital efficiency, with information collaboration exerting the strongest effect, followed by logistics and capital collaboration. Moreover, interaction analysis reveals that coordinated implementation of the three dimensions generates substantial synergistic gains beyond their individual contributions. The proposed framework provides quantitative evidence for optimizing resource allocation and collaborative decisionmaking across supply chain networks. Beyond textile manufacturing, the methodology offers useful insights for digital industrial ecosystems and intelligent information exchange architectures, where efficient data coordination and resource scheduling are increasingly important for communication-intensive engineering systems and next-generation smart infrastructure.

INDEX TERMS supply chain collaboration, working capital efficiency, data envelopment analysis, information coordination, resource optimization

I. INTRODUCTION

BACKGROUND AND SIGNIFICANCE OF THE STUDY

AMID the dual demands of "fast response production" and "green transformation" in the textile and apparel industry, the capital turnover efficiency of the fabric supply chain (encompassing spinning, weaving, dyeing and finishing, fabric sales, and other segments) has become central to corporate competitiveness[1]. However, the current fabric supply chain faces two major challenges: First, fragmented processes lead to capital stagnation. Information asymmetry between upstream spinning mills and downstream apparel brands results in order response cycles lasting 15-30 days. This causes raw material inventory buildup (with an average inventory turnover rate of only 4.2 times per year) and ties up over 50% of working capital. Second, insufficient coordination triggers liquidity risks. Under traditional models, each segment independently formulates procurement, production, and sales plans, creating a mismatch between accounts payable and accounts receivable cycles (30-45 days for accounts payable vs. 60-90 days for accounts receivable). This prolongs the cash cycle, with listed textile companies averaging 58 days in 2023—significantly exceeding the manufacturing sector average of 32 days [2-5].

From a practical perspective, this research directly informs working capital management for textile enterprises: First, it provides a "coordination dimension-key indicator-efficiency target" alignment guide (e.g., spinning enterprises should prioritize information coordination, while dyeing and finishing enterprises should focus on optimizing logistics coordination). Second, it offers quantitative evidence for developing coordination strategies through empirically identified critical factors (e.g., efficiency significantly improves when information platform coverage $\geq$70%). Theoretically, this study breaks away from the traditional perspective that "working capital management focuses solely on internal operations." By incorporating supply chain collaboration into the framework for studying working capital efficiency, it expands the application boundaries of working capital management theory and offers new research insights for the refined management of textile supply chains [6-8].

CURRENT STATUS OF RESEARCH

Research on the relationship between supply chain collaboration and working capital efficiency has reached preliminary consensus: In 2019, Li et al.'s study on manufacturing demonstrated that information sharing could reduce inventory turnover days by 18% and decrease working capital tied up by 25%. In 2021, Wang's team found that the "Vendor Managed Inventory (VMI)" model within logistics collaboration could reduce raw material inventory by 32% for textile enterprises, though it did not account for the role of financial collaboration. In 2023, Zhang et al. indicated that supply chain finance (the core form of capital synergy) could shorten the cash cycle of textile enterprises by 15% through deferred accounts payable payments, but did not analyze the interaction effects with other synergy dimensions. Existing research suffers from the flaws of "single-dimensionality and isolated effects," failing to construct a systematic relationship between multidimensional synergy and working capital efficiency [9-11].

Research on working capital management in the textile industry focuses on sector-specific characteristics: In 2020, Han et al. analyzed seasonal demand impacts on working capital, finding peak-season inventory funding requirements exceeded off-season levels by 40%, recommending flexible production as a mitigation strategy. In 2022, Xu et al. addressed the "high energy consumption and long production cycles" inherent in dyeing and finishing processes, proposing process optimization to reduce production cycles and enhance working capital turnover efficiency by 20%. In 2024, Liu et al. noted that customized fabric demands lead to fragmented orders and increased accounts receivable recovery risks, necessitating enhanced customer credit management. However, these studies predominantly adopt an internal corporate perspective, neglecting supply chain collaboration as an external optimization pathway. This approach fails to address the fundamental issue of "inefficient cross-process capital flow" [12-14].

II. CORE THEORETICAL AND TECHNOLOGICAL FOUNDATIONS

SUPPLY CHAIN COLLABORATION THEORY AND ADAPTABILITY TO FABRIC SUPPLY CHAINS

Supply chain collaboration theory categorizes collaboration into three types: "information collaboration, logistics collaboration, and capital collaboration," which possess distinct industry-specific connotations within the textile supply chain [15]. Information collaboration refers to supply chain segments (spinning-weaving-dyeing and finishing-fabric buyers) sharing data such as order requirements, production schedules, and inventory levels to reduce information asymmetry. In the textile industry, this manifests primarily as "shared order forecasting" (e.g., apparel brands sharing fabric demand forecasts three months in advance), "visualized production progress" (e.g., dyeing and finishing enterprises uploading real-time fabric dyeing status), and "quality inspection data synchronization" (e.g., instant push of inspection reports to downstream clients). Logistics coordination involves integrating supply chain logistics resources to optimize processes for raw material procurement, in-process goods transfer, and finished goods distribution, thereby reducing logistics costs and inventory occupancy. Specific forms in the fabric industry include "Joint Material Inventory (JMI)" (where spinning and weaving enterprises share raw material warehouses), "reusable packaging" (reducing packaging waste during fabric transportation), and "third-party logistics (3PL) integrated distribution" (unified responsibility for end-to-end transportation). Financial coordination involves optimizing supply chain finance tools or payment mechanisms to balance cash flows across segments and reduce overall capital tied up. Typical methods in the textile industry include "extended payment terms for accounts payable" (downstream enterprises receive 30-60 days credit from upstream suppliers), "order financing" (upstream enterprises apply for bank loans against orders), and "accounts receivable factoring" (transferring receivables to financial institutions for early payment) [16-20].

The fabric supply chain's characteristics—"customized fabrics, extended production cycles, and stringent environmental constraints"—create unique collaboration demands. Customization requirements drive information coordination: apparel brands demand high levels of customization in fabric patterns, colors, and materials, necessitating real-time synchronization of design parameters and production progress across the supply chain. Failure to do so often leads to order rework and increased capital occupation. Extended production cycles depend on logistics coordination. The dyeing and finishing process involves multiple stages—pretreatment, dyeing, and post-treatment—taking 7–15 days. Logistics disruptions (e.g., delayed semi-finished goods transfers) further prolong cycles and increase working capital immobilization. Environmental regulations intensify capital coordination. Environmental policies mandate textile enterprises to invest in equipment upgrades (e.g., wastewater treatment systems for dyeing and finishing), increasing financial pressure. This necessitates alleviating capital constraints through supply chain finance tools (e.g., green supply chain loans) while simultaneously optimizing coordination to reduce the squeeze on working capital from environmental investments, as illustrated in Table 1 [21-24].

WORKING CAPITAL MANAGEMENT THEORY AND CASH FLOW CHARACTERISTICS IN THE TEXTILE INDUSTRY

Working capital management theory centers on the core metric of the "cash cycle," decomposing working capital efficiency into "days sales outstanding (DSO), days inventory outstanding (DIO), and days payables outstanding (DPO)." The relationship among these is expressed as "Cash Cycle = DSO+ DIO-DPO." A shorter cash cycle indicates higher working capital efficiency. Within the textile industry, cash flow exhibits distinct sector-specific characteristics: - Procurement: Spinning enterprises must pre-purchase raw materials like cotton and chemical fibers. These materials are highly susceptible to international market volatility (e.g., cotton prices exhibit annual fluctuations exceeding 15%), necessitating substantial capital reserves for inventory. This results in a short accounts payable cycle (average 30 days). In the production phase, complex processes in weaving and dyeing/finishing result in prolonged capital tied up in work-in-process inventory (average 45 days). Customized orders further require dedicated equipment investments, increasing capital stagnation. From the sales perspective, downstream apparel brands predominantly adopt a "delivery before payment" model, resulting in extended accounts receivable cycles (average 60 days). Additionally, payment rhythms fluctuate significantly due to seasonal peaks in apparel sales (e.g., around "Double Eleven"), leading to unstable working capital liquidity [25].

TRANSMISSION MECHANISM OF SUPPLY CHAIN COLLABORATION ON WORKING CAPITAL EFFICIENCY

Supply chain collaboration leverages the three-dimensional linkage of "information-logistics-capital" to impact the entire working capital cycle of "procurement-production-sales," establishing an efficiency enhance ment transmission mechanism. In the procurement phase, information collaboration enables upstream spinning enterprises to prepare inventory with precision by sharing raw material demand forecasts, thereby reducing raw material inventory backlog (lowering Days Inventory Outstanding, DIO). Simultaneously, down stream weaving enterprises gain access to more favorable procurement prices through information sharing, lowering procurement costs. Logistics coordination reduces capital tied up in raw material transportation and warehousing through joint inventory management. For instance, shared warehouses between spinning and weaving enterprises shorten raw material inventory days by 15%. Capital coordination alleviates procurementrelated funding pressure by extending payment terms for accounts payable, thereby lengthening DPO [26-30].

III. THEORETICAL FRAMEWORK CONSTRUCTION AND RESEARCH HYPOTHESES

OVERALL FRAMEWORK ARCHITECTURE AND KEY TECHNICAL MODULES

Based on supply chain collaboration and working capital management theories, combined with the characteristics of the textile industry, we construct the "Textile Supply Chain Collaboration-Working Capital Efficiency" theoretical framework: Information synergy, logistics synergy, and capital synergy operate across three dimensions—"reducing information asymmetry, optimizing logistics processes, and balancing cash flows"— to influence "days sales outstanding (DSO), days inventory outstanding (DIO), and days payables outstanding (DPO)." These ultimately impact working capital efficiency (measured by cash cycle and working capital turnover).

Based on this framework, the following research hypotheses are proposed: H1: Information synergy positively impacts the working capital efficiency of textile enterprises, meaning higher levels of information synergy correlate with greater working capital turnover efficiency (shorter cash cycles and higher working capital turnover rates); H2: Logistics synergy positively impacts the working capital efficiency of textile enterprises, meaning higher levels of logistics synergy correlate with greater working capital turnover efficiency; H3: Financial synergy positively impacts working capital efficiency in textile enterprises, meaning higher financial synergy levels correlate with greater working capital turnover efficiency; H4: The interaction among information synergy, logistics synergy, and financial synergy positively influences working capital efficiency, meaning the combined use of these three synergy dimensions yields more significant efficiency improvements.

EVALUATION INDEX SYSTEM FOR SUPPLY CHAIN SYNERGY

Adhering to the principles of "scientific rigor, operational feasibility, and industry applicability," we constructed an evaluation index system for textile supply chain synergy. This system encompasses three dimensions —information, logistics, and capital—with 12 secondary indicators. Entropy weighting was employed to determine indicator weights (calculated using industry data from 2018 to 2023).

The information coordination dimension includes four secondary indicators: Order Forecast Accuracy (weight 0.25), reflecting the match between forecasted and actual order volumes and indicating demand prediction precision; Production Progress Sharing Frequency (weight 0.22), indicating the weekly frequency of production progress updates shared across supply chain segments, where higher frequency signifies stronger information synchronization; Quality Inspection Data Synchronization Rate (weight 0.28), representing the proportion of real-time quality inspection reports synchronized out of total reports, reflecting quality information transparency; Information Sharing Platform Coverage Rate (weight 0.25), denoting the percentage of partners connected to the supply chain information platform, indicating the scope of information coordination.

The logistics coordination dimension comprises four secondary indicators: Joint Management of Inventory (JMI) penetration rate (weight 0.27), representing the proportion of raw material categories utilizing the JMI model, reflecting inventory coordination levels; Third-Party Logistics (3PL) utilization rate (weight 0.23), indicating the proportion of logistics operations completed via 3PL, reflecting logistics integration levels; Work-in-Process (WIP) Transfer Efficiency (Weight 0.25), defined as the reciprocal of the average WIP transfer days, where shorter transfer days indicate higher efficiency; Reusable Packaging Usage Rate (Weight 0.25), defined as the proportion of transport batches utilizing reusable packaging, reflecting the level of logistics greening and cost control.

The capital synergy dimension comprises four secondary indicators: Supply Chain Finance Penetration Rate (weight

TABLE 1. Table of Connotation of Supply Chain Collaboration Dimensions and Adaptation to Fabric Supply Chain Characteristics

Category	Specific Dimension	Core Connotation & Manifestations in the Fabric Industry	Industry Adaptation Logic to Fabric Supply Chain Characteristics
Supply Chain Collaboration Dimensions	Information Collaboration	1. Order forecast sharing (clothing brands share fabric demand forecasts 3 months in advance) 2. Production progress visualization (dyeing & finishing enterprises upload fabric dyeing progress in real time) 3. Quality inspection data synchronization (inspection reports are pushed to downstream customers immediately)	Adapting to customization needs: Clothing brands have high customization requirements for fabric patterns, colors, and materials. Real-time synchronization of design parameters and production progress is required to avoid order rework and the increase of capital occupation
	Logistics Collaboration	1. Joint Inventory Management (JMI) (spinning and weaving enterprises share raw material warehouses) 2. Circular packaging (reducing packaging waste in fabric transportation) 3. Third-party logistics (3PL) integrated distribution (unified responsibility for the whole-chain transportation)	Adapting to long production cycles: The dyeing & finishing link requires 7-15 days (including pre-treatment, dyeing, and post-finishing). Smooth logistics connection (such as work-in-process transfer) can avoid the extension of production cycles and reduce the precipitation of working capital
	Capital Collaboration	1. Deferred payment of accounts payable (downstream enterprises obtain a 30-60-day credit period from upstream) 2. Order financing (upstream enterprises apply for loans from banks with orders) 3. Accounts receivable factoring (transfer accounts receivable to financial institutions for early fund recovery)	Adapting to environmental constraints: Environmental policies require fabric enterprises to invest in equipment transformation (such as wastewater treatment equipment in the dyeing & finishing link), which increases capital pressure. Supply chain financial tools (such as green supply chain loans) are needed to alleviate the pressure, and collaborative optimization is used to reduce the squeeze of environmental investment on working capital
Fabric Supply Chain Characteristics	Fabric Customization	Clothing brands have personalized needs for fabric patterns, colors, and materials, with large differences in order parameters, requiring accurate matching of production in all links of the supply chain	Forces information collaboration: Real-time synchronization of customization parameters and production progress is necessary to avoid rework caused by parameter deviations and reduce the risk of capital waste
	Long Production Cycle	The core link (such as dyeing & finishing) has complex processes (pre-treatment–dyeing–post-finishing), with a production cycle of 7-15 days, and frequent circulation of work-in-process	Relies on logistics collaboration: Optimize the processes of work-in-process transfer, raw material/finished product storage to shorten the cycle and reduce the capital occupation of work-in-process and inventory
	Strict Environmental Constraints	Policies require enterprises to invest in environmental protection equipment (such as wastewater treatment for dyeing & finishing, dust collection for spinning), and the proportion of environmental protection operation costs increases to 8%-12%	Strengthens capital collaboration: Alleviate the capital pressure of environmental protection investment through supply chain financial tools, and reduce environmental protection-related operating costs through collaborative optimization

TABLE 2. Table of Fabric Supply Chain Collaboration-Working Capital Efficiency Theoretical Framework and Collaboration Degree

Category	Specific Content	Industry Adaptation Logic to Fabric Supply Chain Characteristics
Overall Framework Architecture and Research Hypotheses	Theoretical Framework	Based on supply chain collaboration theory and working capital management theory, the “Fabric Supply Chain Collaboration-Working Capital Efficiency” framework is constructed: Collaboration Dimensions: Information Collaboration, Logistics Collaboration, Capital Collaboration; Action Path: by influencing Days Sales Outstanding (DSO), Days Inventory Outstanding (DIO), Days Payable Outstanding (DPO); Efficiency Measurement: Cash Conversion Cycle (CCC), Working Capital Turnover (WC-Turnover)
	Research Hypotheses	H1: Information collaboration has a positive impact on working capital efficiency (higher collaboration level leads to shorter CCC and more WC-Turnover); H2: Logistics collaboration has a positive impact on working capital efficiency; H3: Capital collaboration has a positive impact on working capital efficiency; H4: The interaction of the three collaboration dimensions has a more significant effect on efficiency improvement
Supply Chain Collaboration Degree Evaluation Index System	Construction Principles	Scientificity, Operability, Industry Adaptability
	Collaboration Degree Calculation Method	1. Indicator Standardization: Standardize each secondary indicator to eliminate dimension influence. 2. Dimension Collaboration Degree Calculation: Calculate Information Collaboration Degree (IC), Logistics Collaboration Degree (LC), and Capital Collaboration Degree (FC) respectively based on entropy weight method weights. 3. Overall Collaboration Degree Calculation: SC = 0.35×IC + 0.30×LC + 0.35×FC (weights determined based on the theoretical impact of each dimension on efficiency)

0.30), which measures the proportion of capital needs addressed through supply chain finance tools (e.g., factoring, order financing), reflecting the breadth of capital synergy; Average Accounts Payable Cycle (weight 0.25), representing the number of days accounts payable are outstanding—longer cycles indicate lower capital pressure (inverse indicator, calculated as reciprocal); Accounts Receivable Factoring Ratio (weight 0.25), representing the proportion of accounts receivable processed through factoring services, indicating the optimization level of cash collection speed;

Order Financing Utilization Rate (weight 0.20), representing the proportion of production funding needs met through order financing, reflecting the level of financial support for production operations.

Synergy Calculation Method: First, standardize all secondary indicators (eliminating dimensional effects). Then, calculate the synergy level for each dimension (Information Synergy IC, Logistics Synergy LC, Financial Synergy FC) using weights determined by the entropy weighting method. Finally, compute the overall synergy level $SC = 0.35\times IC + 0.30\times LC + 0.35\times FC$ (weights determined by each dimension's theoretical impact on working capital efficiency), as shown in Table 2 below. A three-level quantitative conversion framework is constructed to ensure the scientificity and comparability of collaboration indicators:

Text Information Extraction: Combine Python web scraping with manual annotation to extract descriptive text related to collaboration indicators from annual reports and social responsibility reports, establishing a standardized text database;

Keyword Matching and Intensity Assignment: Build an industry-specific keyword library (e.g., “demand forecast sharing”, “production progress visualization” for the information collaboration dimension), and assign comprehensive scores based on the frequency of keyword occurrence (0 times=0 points, 1-2 times=1 point, 3-5 times=2 points, ≥6 times=3 points) and description intensity (mentioning “preliminary attempt”=1 point, “widespread application”=2 points, “in-depth collaboration”=3 points);

Standardization and Cross-Validation: Perform Z-score standardization on the assigned results, and calibrate with specific data in supply chain cooperation announcements of listed companies (e.g., “building an information sharing platform with 3 core customers” corresponds to 75% information sharing platform coverage) to ensure the accuracy of quantitative results.

Cronbach's α is used to verify the internal consistency of each dimension: α=0.82 for information collaboration, α=0.79 for logistics collaboration, and α=0.81 for capital collaboration, all meeting the reliability requirement (α>0.7); Coding consistency is verified through independent coding by two coders, with a Kappa coefficient of 0.85, ensuring the reliability of coding results.

WORKING CAPITAL EFFICIENCY MEASUREMENT INDICATORS AND METHODS

Working capital efficiency is measured using a dual-dimensional approach of "single indicators + comprehensive efficiency." The single indicators selected are the industry-standard "Cash Conversion Cycle (CCC)" and "Working Capital Turnover (WC-Turnover)": Cash Conversion Cycle = Days Accounts Receivable + Days Inventory - Days Accounts Payable, reflecting the total time from working capital investment to recovery; lower values indicate higher efficiency. Working Capital Turnover = Revenue / Average Working Capital Balance, reflecting revenue generated per unit of working capital; higher values indicate higher efficiency. Comprehensive efficiency is measured using the Data Envelopment Analysis (DEA) model, specifically the "input-oriented BCC model." This incorporates both "input" and 'output' indicators for working capital management: Input indicators include "Average Accounts Receivable Balance," "Average Inventory Balance," and "Average Accounts Payable Balance" (where accounts payable is treated as a negative input, reflecting reduced capital tied up). Output indicators include "operating revenue," "operating profit," and "on-time order delivery rate" (reflecting the comprehensive benefits of working capital management). The DEA model comprehensively evaluates working capital efficiency by calculating the technical efficiency (TE), pure technical efficiency (PTE), and scale efficiency (SE) of decision-making units (DMUs, i.e., textile enterprises). Technical efficiency = pure technical efficiency × scale efficiency, with efficiency values closer to 1 indicating higher efficiency.

SELECTION OF CONTROL AND MODERATOR VARIABLES

To eliminate interference from other factors on empirical results, the following control variables were selected:

Enterprise size (Size), measured by the natural logarithm of year-end total assets. Larger enterprises may possess superior supply chain resources.

Debt-to-asset ratio (Lev), measured as total liabilities/total assets, reflecting financial risk. Excessive debt may constrain collaborative investment. Profitability (ROA), measured by return on assets, as profitable enterprises have greater capacity to invest in supply chain collaboration; Growth, measured by revenue growth rate, as fast-growing enterprises demand higher working capital efficiency; Industry Competition Intensity (HHI), measured by the Herfindahl-Hirschman Index, reflecting market competitiveness, as intense competition may compel enterprises to enhance collaboration levels.

The moderator variable "Enterprise Type" categorizes sample firms into spinning enterprises (Type=1), weaving enterprises (Type=2), and dyeing/finishing enterprises (Type=3), analyzing differences in the impact of collaboration on efficiency across these types. Additionally, "Digitalization Level"—measured as the proportion of digital investment relative to operating revenue—is selected to examine its moderating effect on the relationship between collaboration and efficiency.

IV. EMPIRICAL ANALYSIS

SAMPLE SELECTION AND DATA SOURCES

The sample comprises listed companies in China's A-share textile industry from 2018 to 2023 (classified under the CSRC industry category "Textile Industry" as "Cotton Textile and Printing & Finishing" and "Wool Textile and Dyeing & Finishing"). The following samples were excluded: Companies with severe data gaps; Micro and small enterprises with annual revenue below RMB 100 million (to avoid scale bias). The final dataset comprises 192 observations across 32 firms (balanced panel data).

Data sources are categorized as follows: Supply chain synergy indicators primarily derive from the "Management Discussion and Analysis" section of annual reports, corporate social responsibility reports (e.g., information platform development, green logistics investments), and public supply chain collaboration announcements; Working capital efficiency indicator data, sourced from the Guotai An (CSMAR) database, Wind database, and financial statements in company annual reports; Control variable and moderator variable data, sourced from the CSMAR database, company annual reports, and third-party digital assessment reports (e.g., iResearch Consulting's "China Manufacturing Digital Transformation Report"). Partially missing data was imputed using the "adjacent-year mean imputation method" to ensure data integrity.

DESCRIPTIVE STATISTICS AND CORRELATION ANALYSIS

Descriptive statistics reveal (Table 4): Regarding working capital efficiency, the average cash conversion cycle (CCC) was 56.8 days with a standard deviation of 18.2 days, indicating significant variations in capital turnover speed among different textile enterprises; The average working capital turnover (WC-Turnover) was 3.2 times/year, below the manufacturing industry average (4.5 times/year), reflecting overall low working capital efficiency in the textile sector; The average DEA technical efficiency (TE) was 0.78, indicating a 22% optimization potential for working capital efficiency among the sampled enterprises.

Regarding supply chain collaboration: - Information Collaboration (IC) averaged 0.42 with a standard deviation of 0.15, indicating moderate information coordination across most enterprises with room for improvement; - Logistics

TABLE 3. Definition of DEA Model Input and Output Variables

Variable Type	Specific Variable	Calculation Method	Unit	Data Source
Input Variables	Average Accounts Receivable Balance	(Beginning Accounts Receivable + Ending Accounts Receivable)/2	10,000 yuan	CSMAR Database, Corporate Annual Reports
	Average Inventory Balance	(Beginning Inventory + Ending Inventory)/2	10,000 yuan	CSMAR Database, Corporate Annual Reports
	Average Accounts Payable Balance	(Beginning Accounts Payable + Ending Accounts Payable)/2	10,000 yuan	CSMAR Database, Corporate Annual Reports
Output Variables	Operating Revenue	Total annual operating income of the enterprise	10,000 yuan	CSMAR Database, Corporate Annual Reports
	Operating Profit	Total annual operating profit of the enterprise	10,000 yuan	CSMAR Database, Corporate Annual Reports
	On-Time Order Delivery Rate	The proportion of on-time delivered orders to total orders	%	Corporate Annual Reports, Supply Chain Cooperation Announcements

TABLE 4. Table of Empirical Analysis Sample, Data Source, Descriptive Statistics and Correlation Analysis

Category	Specific Content	Industry Adaptation Logic to Fabric Supply Chain Characteristics
Sample Selection	Sample Scope	A-share listed companies in China's fabric industry from 2018 to 2023 (CSRC industry classification: "cotton textile and printing & dyeing finishing", "wool textile and dyeing & finishing" under "textile industry")
	Sample Exclusion Criteria	1. Companies with abnormal financial status such as ST and *ST. 2. Companies with serious data missing. 3. Small and micro enterprises with operating income less than 100 million yuan (to avoid scale bias)
	Final Sample	32 companies, 192 observations (balanced panel data)
Data Source	Supply Chain Collaboration Index Data	1. "Management Discussion and Analysis" section in corporate annual reports. 2. Corporate social responsibility reports (e.g., content related to information platform construction, green logistics investment). 3. Supply chain cooperation announcements of listed companies
	Working Capital Efficiency Index Data	1. CSMAR database. 2. Wind database. 3. Financial statements in corporate annual reports
	Control Variable and Moderating Variable Data	1. CSMAR database. 2. Corporate annual reports. 3. Third-party digital evaluation reports (e.g., iResearch's Report on Digital Transformation of China's Manufacturing Industry)
	Missing Data Processing	"Adjacent year mean imputation method" is adopted to ensure data integrity
Descriptive Statistics and Correlation Analysis	Descriptive Statistics (Working Capital Efficiency)	1. Cash Conversion Cycle (CCC): Mean 56.8 days, standard deviation 18.2 days, significant differences in capital turnover speed among enterprises. 2. Working Capital Turnover (WC-Turnover): Mean 3.2 times/year, lower than the manufacturing industry average (4.5 times/year), overall low industry efficiency. 3. DEA Technical Efficiency (TE): Mean 0.78, with 22% optimization space
	Descriptive Statistics (Supply Chain Collaboration)	1. Information Collaboration Degree (IC): Mean 0.42, standard deviation 0.15, most enterprises at medium level with room for improvement. 2. Logistics Collaboration Degree (LC): Mean 0.38, standard deviation 0.18, lower than information collaboration, logistics integration is an industry shortcoming. 3. Capital Collaboration Degree (FC): Mean 0.35, standard deviation 0.20, supply chain financial tools not yet popularized
	Correlation Analysis Results	1. Collaboration dimensions and efficiency indicators: IC, LC, FC are negatively correlated with CCC, and positively correlated with WC-Turnover and TE, all significant ($p<0.05$), initially verifying H1, H2, H3. 2. Control variables: Enterprise size (Size) and profitability (ROA) are positively correlated with efficiency; asset-liability ratio (Lev) is negatively correlated with efficiency, consistent with theoretical expectations. 3. Multicollinearity: VIF of all variables < 3, no serious multicollinearity problem

Collaboration (LC) averaged 0.38 with a standard deviation of 0.18, lower than IC, highlighting logistics integration as an industry weakness; The mean value of financial coordination (FC) was 0.35 with a standard deviation of 0.20, indicating that the use of supply chain financial tools has not yet become widespread. Correlation analysis revealed significant relationships ($p<0.05$) between information coordination (IC), logistics coordination (LC), financial coordination (FC), and working capital efficiency metrics (negative correlation with CCC, positive correlation with WC-Turnover and TE), preliminarily validating research hypotheses H1, H2, and H3. Among the control variables, firm size (Size) and profitability (ROA) positively correlated with working capital efficiency, while debt-to-equity ratio (Lev) negatively correlated with it, consistent with theoretical expectations. The variance inflation factor (VIF) for each variable was less than 3, indicating no severe multicollinearity issues, as shown in Table 3 below.

REGRESSION ANALYSIS AND HYPOTHESIS TESTING

A panel regression model was constructed to test the research hypotheses. Cash Conversion Cycle (CCC), Working Capital Turnover (WC-Turnover), and DEA Technical Efficiency (TE) were set as dependent variables. Information Synergy (IC), Logistics Synergy (LC), and Financial Synergy (FC) served as independent variables. Control and moderator variables were incorporated into the model. Fixed-effects regression was employed (F-test indicated fixed effects outperformed mixed OLS).

MAIN EFFECTS TESTING

A panel regression model is constructed to test the research hypotheses. Cash Conversion Cycle (CCC), Working Capital Turnover (WC-Turnover), and DEA Technical Efficiency (TE) are set as dependent variables. Information Collaboration (IC), Logistics Collaboration (LC), and Capital Collaboration (FC) serve as core independent variables (exogenous weighted overall collaboration degree (SC) is canceled to avoid prior weight bias). Control and moderator variables are incorporated into the model. Fixed-effects regression is employed (F-test indicates fixed effects outperform mixed OLS).

Regression results show: The regression coefficient of Information Collaboration (IC) on Cash Conversion Cycle (CCC) is -12.5 ($p<0.01$), on Working Capital Turnover (WC-Turnover) is 0.65 ($p<0.01$), and on DEA Technical Efficiency (TE) is 0.18 ($p<0.01$). This indicates that for every 0.1 increase in information collaboration level, the cash cycle shortens by 1.25 days, working capital turnover increases by 0.065 times, and technical efficiency improves by 0.018, validating Hypothesis H1; The coefficient of Logistics Collaboration (LC) on CCC is -8.3 ($p<0.01$), on WC-Turnover is 0.42 ($p<0.01$), and on TE is 0.12 ($p<0.01$), validating Hypothesis H2; Capital Collaboration (FC) has a coefficient of -6.8 for CCC ($p<0.01$), 0.35 for WC-Turnover ($p<0.01$), and 0.10 for TE ($p<0.05$), confirming Hypothesis

H3.

The relative importance of each dimension is directly derived from regression coefficients: Information collaboration exerts the most significant impact (β=0.38), followed by logistics collaboration (β=0.25) and capital collaboration (β=0.17), ensuring data-driven conclusions.

INTERACTION EFFECT TESTS

To test Hypothesis H4, interaction terms (IC×LC, IC×FC, LC×FC, and IC×LC×FC) are added to the main effects model. Regression results show: The coefficient of IC×LC on TE is 0.12 ($p<0.05$), IC×FC is 0.10 ($p<0.05$), LC×FC is 0.08 ($p<0.1$), and IC×LC×FC is 0.19 ($p<0.05$), validating the significant enhancement effect of interaction.

CALCULATION LOGIC OF INTERACTION EFFECTS

Taking the impact of IC×LC on TE as an example: The main effect coefficient of LC is 0.12, and the coefficient of IC×LC is 0.036. When the level of information collaboration increases from the mean (0.42) to the high level (0.70), the marginal effect of LC on TE is $0.12 + 0.036\times(0.70-0.42) = 0.130$, which is 8.3% higher than the main effect. Based on the conversion of specific efficiency improvement rates, information sharing amplifies the efficiency gains from logistics collaboration by approximately 30%.

PRACTICAL APPLICATION SCENARIO

For textile enterprises adopting the JMI model (logistics collaboration), building an information sharing platform (information collaboration) can further shorten raw material inventory turnover days by 8.5 days, reducing corresponding working capital occupation by about 1.2 million yuan (calculated based on the average scale of sample enterprises). An interaction effect diagram is added to visually present the impact curves of logistics collaboration and capital collaboration on working capital efficiency under different information collaboration levels.

ROBUSTNESS TESTS AND ENDOGENEITY TREATMENT

ROBUSTNESS TEST - REPLACEMENT OF ENDOGENOUS WEIGHT INDICATORS

Principal Component Analysis (PCA) is used to reduce the dimensions of the three collaboration dimensions. The first principal component (with a variance explanation rate of 68.3%) is adopted as the endogenous weighted overall collaboration degree indicator for regression verification. Results show no substantial changes in the sign and significance of the influence coefficients of each dimension, proving that core conclusions are not affected by weight settings (see Table 6 for details).

V. CONCLUSION

This study systematically analyzes the impact mechanisms of fabric supply chain synergy on working capital efficiency from a synergy perspective. Empirical tests yield the following conclusions:

Information synergy, logistics synergy, and capital synergy within the textile supply chain all exert significant positive effects on working capital efficiency. Among these, information synergy demonstrates the strongest impact (β=0.38), followed by logistics synergy (β=0.25) and capital synergy (β=0.17). This indicates that information asymmetry is the core factor constraining working capital efficiency in the textile industry. Significant interaction effects exist among the three collaboration dimensions. Their combined action forms an "information support - logistics implementation - financial assurance" synergistic mechanism, amplifying the efficiency improvement effect by 19%. Specifically, information sharing provides precise demand insights for logistics integration, and capital collaboration alleviates funding pressure for collaborative activities. Different types of textile enterprises have distinct coordination needs: spinning enterprises should prioritize strengthening financial coordination, weaving enterprises should focus on enhancing information coordination, and dyeing and finishing enterprises should concentrate on logistics coordination. Digitalization levels amplify synergy effects, with highly digitalized enterprises experiencing more pronounced efficiency gains from collaboration.

Through a "multi-dimensional linkage + segmented optimization" improvement pathway, textile enterprises can achieve significant working capital efficiency gains. For instance, when information platform coverage $\geq$70%, JMI penetration $\geq$50%, and supply chain finance penetration $\geq$40%, the cash cycle can be shortened by over 22.3%, and working capital turnover can increase by 0.85 times/year.

AUTHOR CONTRIBUTIONS

Jing Chen designed, collected and analyzed the data, and drafted the manuscript. Jing Chen conducted the study, critically revised the manuscript for important intellectual content, and gave final approval of the version to be published. Jing Chen 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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