

Weaving the green thread: configurational drivers of sustainable transformation in the textile industry

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ABSTRACT – REZUMAT

Weaving the green thread: configurational drivers of sustainable transformation in the textile industry

Green transformation is a critical strategy for promoting sustainable development in the textile industry. Drawing on the TOE framework, we construct a theoretical model encompassing technological, organisational, and environmental dimensions. Using panel data from Chinese textile enterprises spanning 2016 to 2024, we apply a combination of dynamic Qualitative Comparative Analysis (QCA), Necessary Condition Analysis (NCA), one-way ANOVA, and the Kruskal–Wallis rank-sum test to explore configurational pathways influencing green transformation. The findings reveal that no single factor constitutes a necessary condition for high-level green transformation. However, the necessity of digital transformation and government subsidies has shown a rising trend. Three distinct pathways are identified that facilitate green transformation: technology–environment driven, technology–organisation driven, and hybrid multi-factor driven. Inter-group analysis indicates that the consistency scores of these configurations declined collectively in 2020, followed by a rebound from 2021 onward, with the hybrid pathway demonstrating the greatest stability and effectiveness. Intra-group analysis suggests that the effectiveness of each configuration varies depending on enterprise size. Our study demonstrates that the green transformation of textile enterprises is not the result of a single driving force but emerges from the interplay of multiple factors, offering practical insights for firms pursuing green innovation.

Keywords: textile industry, green transformation, TOE framework, dynamic QCA

Conturând dimensiunea ecologică: factori de configurare ai transformării durabile în industria textilă

Transformarea ecologică este o strategie esențială pentru promovarea dezvoltării durabile în industria textilă. Pe baza cadrului TOE, construim un model teoretic care cuprinde dimensiuni tehnologice, organizaționale și de mediu. Folosind date panel de la întreprinderi textile chineze din perioada 2016-2024, aplicăm o combinație de analiză comparativă calitativă dinamică (QCA), analiză a condițiilor necesare (NCA), ANOVA unidirecțională și testul Kruskal-Wallis pentru a explora căile configuraționale care influențează transformarea ecologică. Rezultatele arată că niciun factor singular nu constituie o condiție necesară pentru o transformare ecologică la nivel înalt. Cu toate acestea, necesitatea transformării digitale și a subvențiilor guvernamentale a înregistrat o tendință ascendentă. Sunt identificate trei căi distincte care facilitează transformarea ecologică: bazată pe tehnologie-mediu, bazată pe tehnologie-organizație și bazată pe factori multipli hibridi. Analiza intragrup indică faptul că scorurile de coerență ale acestor configurații au scăzut colectiv în 2020, urmate de o revenire începând cu 2021, calea hibridă demonstrând cea mai mare stabilitate și eficacitate. Analiza intragrup sugerează că eficacitatea fiecărei configurații variază în funcție de dimensiunea întreprinderii. Studiul nostru demonstrează că transformarea ecologică a întreprinderilor textile nu este rezultatul unei forțe singulare, ci rezultă din interacțiunea mai multor factori determinanți, oferind perspective practice pentru firmele care urmăresc inovarea ecologică.

Cuvinte-cheie: industria textilă, transformare ecologică, cadru TOE, QCA dinamic

INTRODUCTION

As one of the world's oldest industries [1], the textile sector plays a vital role in many developing countries by generating substantial employment and enhancing women's economic status and social participation [2]. However, the rise of fast fashion and its demand for low-cost textiles has led to intensified fabric consumption and shortened garment life cycles, resulting in numerous environmental challenges, including greenhouse gas emissions, global warming, and air pollution [3]. According to the International Energy Agency (IEA), the textile and apparel industry accounts for approximately 10% of global carbon

emissions, making it the second-largest industrial polluter after the petroleum sector. Producing one ton of textiles results in nearly 200 tons of wastewater, while each kilogram of fabric emits around 23 kilograms of carbon dioxide. Some studies predict that, with the global population expected to reach 8.5 billion by 2030, the clothing industry may overtake petrochemicals as the world's largest polluter. In the current global movement toward harmony between humans and nature, addressing the environmental and health challenges posed by the textile industry has become a core agenda of sustainable development [4].

Green transformation is widely regarded as a key pathway for achieving sustainable development in the textile sector, as it enhances resource efficiency and significantly reduces pollutant emissions [5, 6]. However, due to its public-good nature and generally low financial returns, firms often lack adequate incentives to invest in green initiatives [7]. In response, researchers have increasingly sought to identify the driving forces behind green transformation [8, 9]. From a technological perspective, digital technologies provide promising avenues by optimising resource allocation, facilitating knowledge sharing, and supporting innovation to address environmental challenges [10]. Nevertheless, the widespread application of digital tools may lead to increased energy consumption, which could undermine their intended environmental benefits [11]. On the environmental front, regions with stricter regulatory standards tend to experience lower levels of pollution [12]. When formal environmental regulations prove ineffective in certain areas, informal mechanisms based on public environmental awareness can serve as valuable supplements to compensate for regulatory gaps [13].

Although existing studies have provided valuable insights into the green transformation of the textile industry, a core question remains insufficiently addressed: why do the same influencing factors result in markedly different transformation outcomes across enterprises or contexts? This issue partly arises from the methodological limitations of conventional research approaches. Most prior studies rely on linear regression and other traditional quantitative techniques that focus on identifying the “net effect” of individual variables, which refers to the marginal contribution of a single variable while controlling for the influence of others. However, these approaches are based on several assumptions, including the independence of variables, the symmetry of causal relationships, and the constancy of marginal effects. In complex management environments, such assumptions are often unrealistic [14].

In practice, green transformation is a complex process influenced by the dynamic interaction of multiple conditions, which may exhibit complementarity, substitutability, or even mutual inhibition [15]. Qualitative Comparative Analysis (QCA), rooted in set theory, provides a powerful framework for analysing such complexity. It takes a holistic and configurational perspective, viewing each case as a set of interrelated conditions, and systematically compares different combinations across cases to identify multiple causal pathways that lead to a common outcome [16]. Unlike traditional methods that assume variable independence, QCA emphasises the interdependence among factors and the logic of configurations. This makes it particularly effective in explaining why distinct pathways may produce the same result, or why a single pathway might lead to different outcomes depending on the context [14, 17].

China presents an ideal empirical setting for investigating the green transformation of the textile industry.

On one hand, as the world’s largest producer, consumer, and exporter of textiles and garments, China plays a pivotal role in the global textile value chain [18]. According to data from the China National Textile and Apparel Council (CNTAC) and related institutions, the textile and apparel sector emits approximately 230 million tons of greenhouse gases each year, accounting for about 2 per cent of the country’s total emissions. The industry has long been under substantial pressure to improve energy efficiency and reduce pollution, which has generated strong internal momentum for green transformation. On the other hand, the industry has recently been shaped by increasingly stringent environmental regulations and policies promoting industrial restructuring. Since China’s official announcement of its “carbon peak and carbon neutrality” goals at the 75th United Nations General Assembly in September 2020, targeting peak carbon dioxide emissions by 2030 and carbon neutrality by 2060, the textile industry, as a high-emission sector, has become a priority in national policy efforts toward green upgrading.

For instance, the “14th Five-Year Plan for the Development of the Textile Industry”, released in June 2021, explicitly called for substantial progress in energy conservation, cleaner production, and resource recycling, and elevated green development to a strategic level for the sector.

This study makes several contributions. First, it enriches the understanding of green transformation pathways. Previous studies have mainly relied on traditional statistical models to examine the impact of single factors on green transformation [12, 19], while paying limited attention to how different factors interact or substitute for each other under specific conditions to influence corporate green innovation. Drawing on configuration theory [20], this study integrates the Technology–Organisation–Environment (TOE) framework and finds that the green transformation of textile firms is not driven by any single factor, but instead results from the synergistic interaction of multiple conditions. This insight offers managers a new theoretical lens for understanding the complex mechanisms that drive green transition and responds to recent calls in the literature to explore the coupling of ecological elements [20, 21]. Second, by applying one-way analysis of variance and the Kruskal–Wallis rank-sum test, we identify the heterogeneous effects of different configurational paths on green transformation. Our findings emphasise the importance of selecting adaptive, multi-factor strategies based on a firm’s stage of development in order to enhance the feasibility and effectiveness of green transformation.

LITERATURE REVIEW AND THEORETICAL FRAMEWORK

TOE Framework

The TOE (Technology–Organisation–Environment) framework was first proposed by Tornatzky and Fleischer in 1990 [22]. This analytical framework focuses on the factors influencing technological

application conditions from three levels: technology, organisation, and environment. It is essentially a comprehensive analytical framework used to explain organisational behaviour related to technological integration and adoption. The technological dimension often includes factors such as the level of informatisation, technological innovation capability, and technological integration capability [23]. The organisational dimension commonly covers factors such as executive tenure, executive background, organisational climate, and organisational slack [24]. The environmental dimension generally includes factors such as market competition, policy changes, and external pressures [25]. As the TOE framework has been continuously applied, its connotations, sub-dimensions, and application scenarios have been constantly adjusted and refined. Based on its application in technological innovation research, it has now been extended to various fields such as education, e-government, healthcare, and post-pandemic organisational governance [26].

We choose the TOE framework for two reasons: first, according to the existing literature, the influencing factors of green transformation mostly fall within the dimensions of technology, organisation, and environment. Using the TOE framework facilitates the integrated analysis of existing factors. Second, the TOE framework is a highly generalizable theoretical model that can be further refined according to specific research questions and contexts. It has strong flexibility, operability, and broad applicability.

TOE Framework for Construction Green Innovation

(1) Technological conditions

This dimension includes digital transformation and investment in R&D personnel. The widespread application of digital technologies provides crucial support for textile enterprises undergoing green transformation. Specifically, tools such as big data, cloud computing, and the Internet of Things enable precise management of energy, water, and raw materials, which enhances resource efficiency and reduces environmental burdens. In addition, digitalisation improves firms' access to external information on markets, policies, and technologies, thereby strengthening their ability to acquire and apply green production knowledge and reducing uncertainty and cost during the transition [27]. Investment in R&D personnel reflects a firm's technical capacity in developing green technologies and designing environmentally friendly products. According to endogenous growth theory, R&D is a critical driver of sustained innovation and technological progress. In the textile industry, technical staff engaged in R&D often focus on energy conservation, pollution control, and sustainable materials, providing practical green solutions. Higher R&D input is associated with greater progress in green transformation and improved market competitiveness alongside reduced environmental risk.

(2) Organisational conditions

This dimension includes organisational slack and the environmental awareness of top executives.

Organisational slack functions as a resource buffer that enables firms to absorb the costs of green transformation. When facing policy pressure or market uncertainty, companies with available slack are more capable of allocating resources to green R&D, cleaner production, and sustainable product development, thereby enhancing the feasibility and stability of transformation [28]. Nevertheless, excessive slack may lead to inefficiencies, resource misallocation, or even path dependence on high-emission practices, which can undermine responsiveness to environmental challenges and hinder progress [29, 30]. The environmental awareness of executives plays a vital role in guiding strategic decisions related to green transformation. Since this process often requires major strategic shifts and resource realignment, strong support from top management is essential for successful implementation [31]. In the textile sector, environmentally conscious leaders are more inclined to adopt green strategies such as energy reduction, material substitution, and eco-certification, thereby enhancing firms' initiative and execution capacity in green practices [32].

(3) Environmental conditions

This dimension includes market competition and perceived government support. Market competition significantly shapes firms' green strategies. In highly competitive markets, firms may prioritise short-term profit and defer green investment due to intense cost pressures [33]. Conversely, moderate competition can motivate firms to pursue green innovation as a means of differentiation, strengthening their competitive advantage in emerging green markets [34]. Perceived government support refers to firms' awareness of external policy incentives. Given the high upfront costs and uncertainty associated with green transformation in the textile industry [11], firms' perception of stable policy support, such as subsidies, green credit, and tax incentives, can significantly influence their willingness to invest. Nevertheless, some scholars argue that government subsidies may alter firms' innovation behaviour. When innovation costs remain constant, firms may reduce their own investment in R&D, suggesting that subsidies could potentially suppress rather than promote innovation [35].

In conclusion, the TOE framework identifies six key sub-dimensions that influence green transformation in the textile industry. These technological, organisational, and environmental factors do not operate in isolation but interact dynamically as part of a configurational system. To better understand these interdependencies, this study employs a dynamic QCA approach to examine complementary and substitutive relationships across dimensions and to identify distinct configurational pathways that drive green transformation. The overall research framework is presented in figure 1.

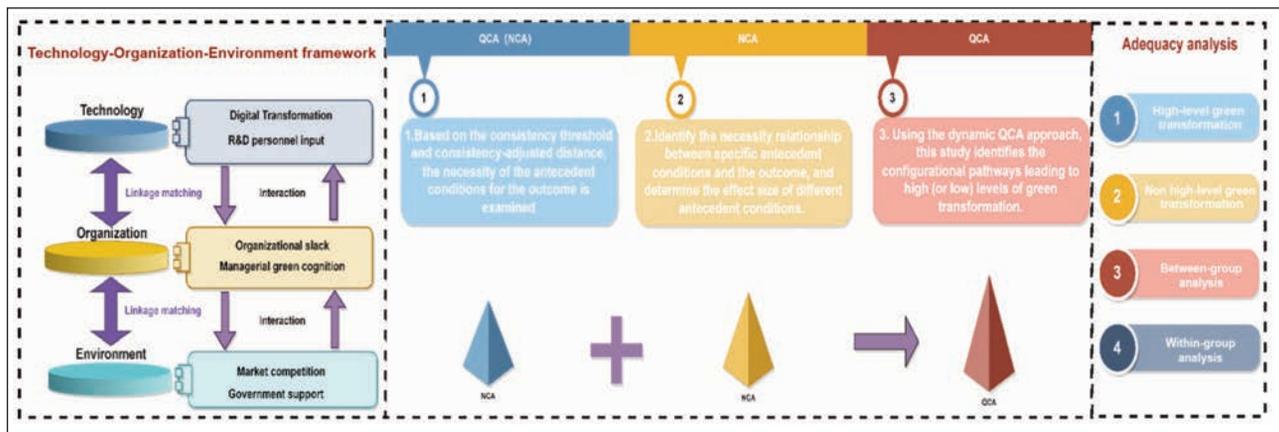


Fig. 1. Theoretical framework

RESEARCH DESIGN

To systematically explore the multiple pathways of green transformation in Chinese textile enterprises, we adopted a two-stage research paradigm integrating Dynamic Qualitative Comparative Analysis (Dynamic QCA) and Necessary Condition Analysis (NCA). This combination of methods allows for a comprehensive and in-depth revelation of complex causal relationships from both sufficiency and necessity perspectives.

Dynamic Qualitative Comparative Analysis (QCA)

Qualitative Comparative Analysis (QCA) is a set-theoretic and Boolean algebra-based configurational method. Its core advantage lies in its ability to identify how multiple antecedent conditions combine to lead to a certain outcome, rather than examining the net effect of individual variables in isolation. However, traditional QCA typically performs static analysis at a single time point, a method with clear limitations when analysing certain industries.

For China's textile industry, the policy environment, market demand, and technological conditions it faces are in continuous flux. For instance, in recent years, the state has successively introduced policies such as "carbon peaking" and "carbon neutrality" targets, the "14th Five-Year Green Development Plan", and "pollution prevention and control battles", guiding enterprises to accelerate their transformation towards low-carbon, efficient, and intelligent operations. This policy orientation not only drives continuous adjustments in corporate strategies but also leads to green practices exhibiting phased characteristics across different periods. Furthermore, the rapid evolution and replacement of digitalisation and green technologies further shorten enterprises' adaptation cycles. Enterprises often need to complete the leap from basic environmental compliance to systematic green innovation within a few years. Therefore, the green transformation of the textile industry is not a one-time, static event, but rather a long-term, cumulative, and phased dynamic process.

Specifically, concerning the result variable defined in this study – "green transformation" – its evolutionary trajectory encompasses multiple levels, from preliminary compliance-based pollution control, gradually progressing to cleaner production, resource recycling, and then establishing a green innovation system. This inherently represents a long-term, cumulative, and phased dynamic process, not a static, singular event. In this process, the combinations of driving conditions required at different stages may differ fundamentally. For example, early transformation might be more influenced by government subsidies and policy pressure, whereas later stages may rely more on internal technical capabilities, organisational slack, and green culture. Static QCA overlooks this longitudinal causal evolution and struggles to reveal the driving logic of enterprise green transformation pathways as they change over time.

Moreover, the sudden COVID-19 pandemic in 2020, as a significant environmental shock, also had a non-linear impact on corporate green practices. Some enterprises faced resource constraints during the pandemic, temporarily reducing green investments, while others seized the opportunity to accelerate their green transformation initiatives. Such episodic and discontinuous event characteristics cannot be fully identified through static QCA.

Consequently, a static analysis at an isolated time point fails to capture the macro-level dynamics of the textile industry, nor can it reveal the staged characteristics and the evolution of driving factors inherent to the "green transformation" process itself. To address this, our study employs Dynamic QCA, as proposed by Garcia-Castro and Ariño (2016) [36], which, through its cross-period analytical capabilities, accurately characterises the true trajectory of enterprise green transformation. This method treats each enterprise's observations across multiple years as independent cases, thereby introducing the time dimension. It systematically examines the influence of different condition combinations on the outcome variable at various time points, and further analyses the consistency, stability, and trend changes of configurational pathways over time. This approach thus extends beyond the explanatory boundaries of static

configurational methods and aligns more closely with the dynamic nature of green transformation.

The technical implementation of Dynamic QCA in this study followed these steps: 1. Data Reorganisation and Calibration: We first organised the panel data from 2016 to 2024. In the R language environment, we used “enterprise-year” as the unit of analysis, converting the condition and outcome values of each enterprise in each year into fuzzy set membership scores (between 0 and 1) to construct the QCA truth table format. 2. Configuration Solving and ESA Method: When solving configurations, we adopted Enhanced Standard Analysis (ESA). ESA is an improved version of QCA standard analysis that produces more robust and credible parsimonious and intermediate solutions by excluding logically contradictory “logical remainders” during the Boolean minimisation process. This ensures the logical rigour of the causal paths we identify. 3. Dynamic Evaluation: We used R packages such as QCA and SetMethods to perform configurational analysis for each annual time slice separately, and calculated the consistency adjustment distance between groups and within groups. This enables us to quantify whether the explanatory power of a specific path changes significantly over time or with enterprise size, thereby capturing the dynamic mechanisms driving green transformation.

It is worth noting that, unlike traditional QCA, Dynamic QCA requires measuring consistency from three dimensions: between-group, within-group, and overall, and captures the trend of consistency changing with time and cases through consistency adjustment distance. Specifically, when analysing with the R language, the system defaults to outputting consistency Euclidean distance, which must be converted into consistency adjustment distance using the following formulas:

$$BECONS \text{ adjusted distance} = \frac{BECONS \text{ distance}}{\sqrt{\frac{n}{n^2 + 3n + 2}}} \quad (1)$$

$$WICONS \text{ adjusted distance} = \frac{WICONS \text{ distance}}{\sqrt{\frac{n}{n^2 + 3n + 2}}} \quad (2)$$

where n in formula 1 represents time (9 in this study), used to calculate BECONS adjusted distance; n in formula 2 represents cases (51 in this study), used to calculate WICONS adjusted distance.

Necessary Condition Analysis (NCA)

Although QCA can identify the necessity of certain conditions, its judgment is primarily qualitative. In management practice, policymakers are often more concerned with quantitative questions, such as: “To what extent must a certain condition be met to provide the necessary assurance for achieving a specific objective?” To address this, we introduced Necessary Condition Analysis (NCA) as a complement to QCA. NCA is a quantitative analytical technique that precisely identifies the minimum threshold

(often referred to as a bottleneck) of each driving factor required to achieve a certain target level. It does this by measuring the effect size of necessary conditions and constructing a ceiling regression line. For fuzzy set membership scores that continuously vary between 0 and 1, NCA can describe the degree of necessity more finely than traditional QCA. For example, NCA can formulate quantitative necessary condition statements such as: “To achieve a certain level of green transformation performance, condition X must reach at least level X_c ”. This provides richer information for analysis, allowing us to explicitly determine the level at which each driving factor becomes a limiting bottleneck for transformation. In this study, we simultaneously employed both the stepped CE-FDH and the smoother CR-FDH methods to estimate the ceiling line, ensuring the robustness of our results. To evaluate the strength of necessity, we further reported the effect size d , which indicates constraint strength, and obtained p-values through 10,000 permutation resamples to assess its statistical significance. The combination of QCA and NCA enables us to gain a more comprehensive understanding of causal relationships from both sufficiency and necessity dimensions.

Case selection and data collection

Based on the 2012 industry classification standard issued by the China Securities Regulatory Commission (CSRC), we select textile companies listed on the Shanghai and Shenzhen A-share markets from 2016 to 2024 as the study sample. During the screening process, we exclude ST and *ST firms as well as companies with significant missing data. The final dataset includes 459 firms with balanced panel data. Annual report information is obtained from the official websites of the Shanghai and Shenzhen Stock Exchanges, while financial data is retrieved from the CSMAR database provided by GTA. Considering the lag in green transformation behaviour, all antecedent variables are lagged by one period.

Outcome Variable

We measure green transformation based on textual information disclosed in firms’ annual reports [37]. Specifically, we identify 113 green transformation keywords from five dimensions: advocacy and initiatives, strategic orientation, technological innovation, pollution control, and environmental monitoring. We calculate the frequency of each keyword appearing in the annual report text of listed companies. The total frequency count, plus one, is then transformed using the natural logarithm to construct the firm’s green transformation score.

Antecedent Variables

Technological conditions include two sub-conditions: digital transformation and investment in R&D personnel. For digital transformation, we follow a textual analysis approach [38]. First, we define digital transformation behaviour based on two categories: the adoption of foundational digital technologies and the implementation of technological practices.

Foundational technologies include four typical types: artificial intelligence (A), blockchain (B), cloud computing (C), and big data (D). Technological practices (E) are categorised based on their real-world applications. Figure 2 illustrates the keyword map. Then, using Python, we extract the annual report texts of sample firms to create a text corpus. Based on the keywords in Figure 2, we perform word matching, frequency counts, and keyword grouping to construct a composite indicator of digital transformation. The final total frequency is log-transformed to produce a quantitative index of each firm's digital transformation level. R&D personnel investment is measured by the proportion of R&D staff (number of R&D employees

divided by total employees), which reflects the firm's input of technical human capital for green innovation. Organisational conditions include two sub-conditions: organisational slack and executives' green awareness. Organisational slack is measured using the quick ratio, which better reflects a firm's short-term solvency and its ability to absorb transformation-related costs. For executives' green awareness, we identify 19 keywords related to environmental strategy, green competitiveness, corporate social responsibility, and sensitivity to external environmental pressure [39, 40]. These keywords include energy conservation, environmental strategy, low-carbon development, and environmental governance. Using Python, we scrape and analyse keyword frequencies

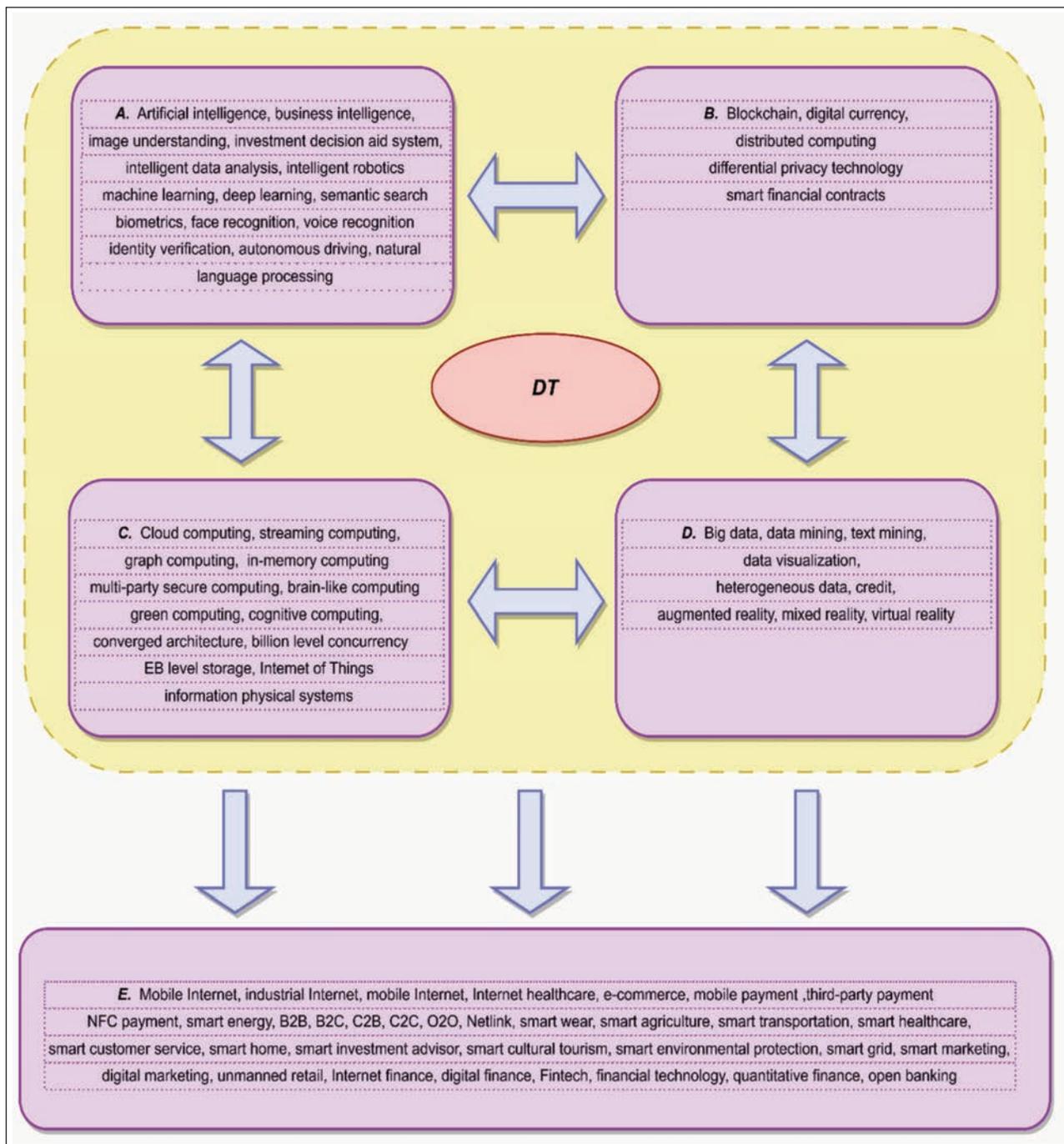


Fig. 2. Characteristic keyword map

from each firm’s annual report texts. The natural logarithm of keyword frequency plus one is used as the indicator of green awareness among executives.

Environmental conditions include market competition and perceived government support. Market competition is measured using the Lerner Index, which effectively captures a firm’s market power relative to peers in the same industry. For government support, we use the natural logarithm of the total amount of government subsidies received, which reflects the firm’s perception of policy incentives for R&D.

RESULTS AND ANALYSIS

Variable calibration

Unlike traditional empirical research, QCA requires variable calibration before analysis. Based on case characteristics and the distribution of raw values, we define three anchor points: full membership, the crossover point, and full non-membership. These anchors are used to convert original values into fuzzy-set membership scores ranging from 0 to 1. Following established practice [14], we apply the direct calibration method, setting the 95th, 50th, and 5th percentiles as thresholds. Since all variables follow a unified quantile calibration rule, listing the specific anchor values for each variable individually does not provide additional information, so the calibration table will no longer be reported separately.

Necessary condition analysis

Qualitative Comparative Analysis (QCA)

In conventional QCA, a condition is deemed necessary if its consistency exceeds 0.9. In dynamic QCA, a condition can also be considered necessary if the consistency is high and the difference in consistency

across groups is less than 0.1. When this threshold is exceeded, further investigation is required.

As shown in table 1, digital transformation, organisational slack, and government support exhibit consistency differences across groups greater than 0.1, suggesting that further analysis is warranted. By examining their consistency and coverage across different cases (table 2), we observe that the consistency scores in Cases A through D remain below 0.9 for all years, indicating that these variables are not necessary conditions [41].

Nonetheless, in Cases A and D, both digital transformation and government support show an upward trend in necessity over time (figure 3). This finding is consistent with previous research that underscores the increasing importance of these two factors in enabling green transformation [42].

Necessary Condition Analysis (NCA)

Since QCA assesses necessity from a qualitative perspective, we complement our analysis using Necessary Condition Analysis (NCA), as recommended by Dul et al. NCA includes two ceiling estimation techniques: Ceiling Regression (CR) and Ceiling Envelopment (CE). We assess necessity using two diagnostic procedures [43].

First, we examine the scatter plots between each antecedent condition and the outcome. A visible space in the upper-left corner suggests potential necessity, with larger empty areas implying stronger constraints. Second, we analyse the effect size and perform a Monte Carlo permutation test. A condition is considered necessary only if it exhibits both a statistically significant effect size and a significant permutation result ($p < 0.05$).

Table 1

NECESSARY CONDITION ANALYSIS								
Causal condition variable	High energy-saving innovation level				Low energy-saving innovation level			
	Overall consistency	Overall coverage	Inter-group adjusted distance	Intra-group adjusted distance	Overall consistency	Overall coverage	Inter-group adjusted distance	Intra-group adjusted distance
Digital Transformation	0.658	0.679	0.114A	0.084	0.395	0.398	0.087	0.091
~Digital Transformation	0.772	0.675	0.083	0.009	0.534	0.625	0.196B	0.037
R&D Personnel Ratio	0.613	0.602	0.085	0.091	0.491	0.495	0.088	0.093
~ R&D Personnel Ratio	0.489	0.484	0.095	0.068	0.605	0.609	0.091	0.013
Organizational Slack	0.607	0.504	0.007	0.036	0.439	0.393	0.153C	0.006
~ Organisational Slack	0.611	0.609	0.091	0.095	0.393	0.401	0.093	0.072
Executives’ Green Cognition	0.592	0.671	0.018	0.062	0.443	0.419	0.093	0.099
~ Executives’ Green Cognition	0.429	0.428	0.091	0.096	0.674	0.693	0.096	0.098
Market Competition	0.515	0.602	0.096	0.049	0.384	0.396	0.093	0.027
~ Market Competition	0.625	0.573	0.096	0.083	0.698	0.506	0.097	0.059
Government Support	0.701	0.605	0.171D	0.066	0.488	0.494	0.094	0.014
~ Government Support	0.578	0.471	0.098	0.047	0.609	0.622	0.094	0.026

Note: “~” denotes the absence of a condition.

INTER-GROUP RESULTS WITH ADJUSTED CONSISTENCY DISTANCE > 0.1										
Causal configuration		Year								
		2016	2017	2018	2019	2020	2021	2022	2023	2024
Case A	Inter-group consistency	0.311	0.326	0.498	0.561	0.637	0.791	0.796	0.875	0.898
	Inter-group coverage	0.862	0.775	0.761	0.656	0.615	0.583	0.635	0.575	0.635
Case B	Inter-group consistency	0.692	0.715	0.664	0.623	0.531	0.469	0.421	0.314	0.409
	Inter-group coverage	0.415	0.392	0.505	0.611	0.606	0.434	0.713	0.665	0.675
Case C	Inter-group consistency	0.623	0.327	0.415	0.526	0.545	0.385	0.255	0.386	0.419
	Inter-group coverage	0.312	0.677	0.315	0.265	0.21	0.345	0.616	0.623	0.406
Case D	Inter-group consistency	0.304	0.329	0.483	0.575	0.657	0.788	0.792	0.838	0.845
	Inter-group coverage	0.825	0.730	0.615	0.585	0.591	0.515	0.482	0.351	0.455

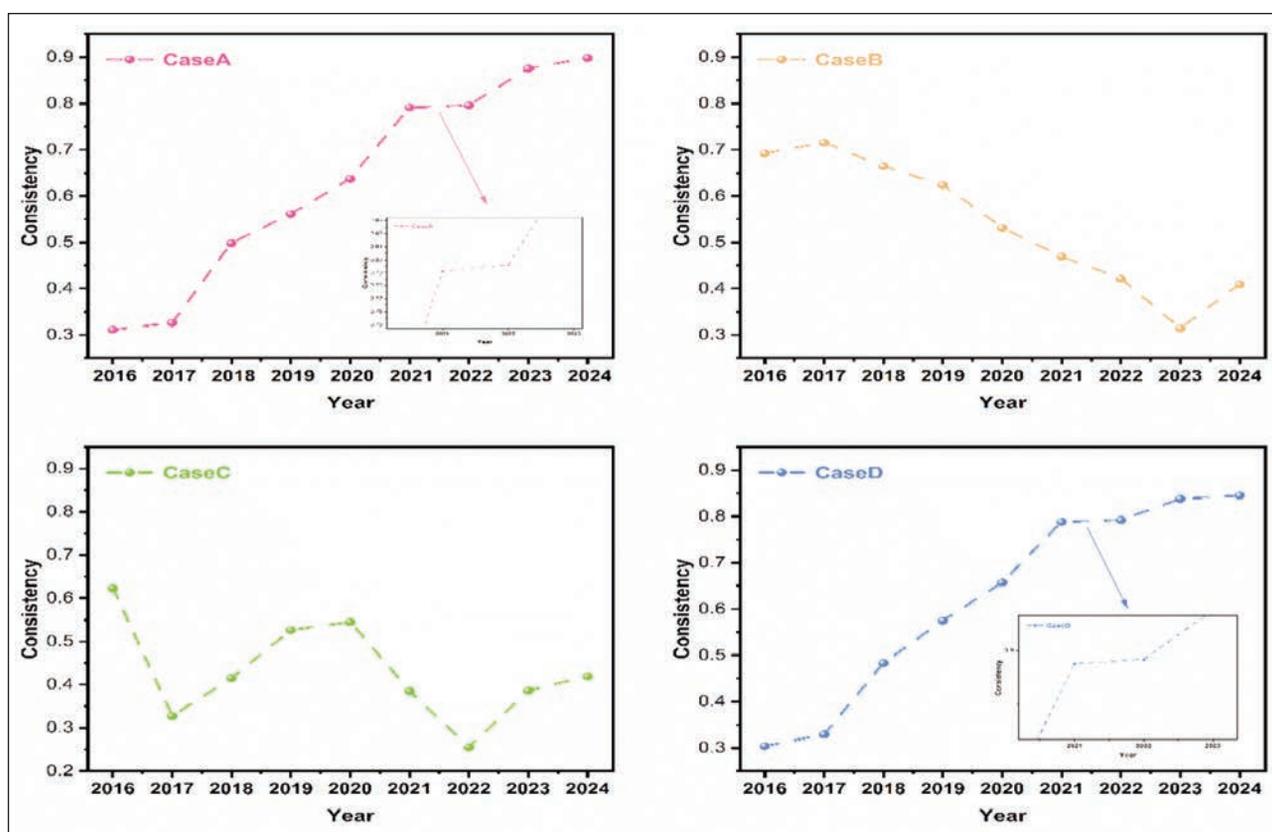


Fig. 3. Trend of inter-group consistency

Based on the scatter plots, no evident empty area is observed in the upper-left region for any of the variables, suggesting preliminarily that they do not constitute necessary conditions for green transformation. Moreover, according to the effect size and Monte Carlo permutation test results, none of the six variables simultaneously meets both the effect size criterion (Effect size > 0.1) and statistical significance in the Monte Carlo simulation permutation test (p -value < 0.05), indicating that none of them satisfies the criteria for being identified as a necessary condition for green transformation.

In summary, the results show that no single antecedent condition is necessary for achieving green transformation. Table 4 further presents the bottleneck thresholds for each condition. To ensure

full green transformation among textile enterprises, the following minimum levels are required: 8.3% for digital transformation, 3.0% for R&D personnel input, 5.8% for organisational slack, and 8.0% for government support. Executive green awareness and market competition do not exhibit bottleneck effects.

Sufficiency analysis of configurational conditions

Configuration analysis constitutes the core of QCA and seeks to uncover how various combinations of antecedent conditions influence the emergence of the outcome. According to established standards, the consistency threshold for sufficiency is typically set at a minimum of 0.75 [41]. In this study, we set the consistency threshold at 0.85, the frequency threshold

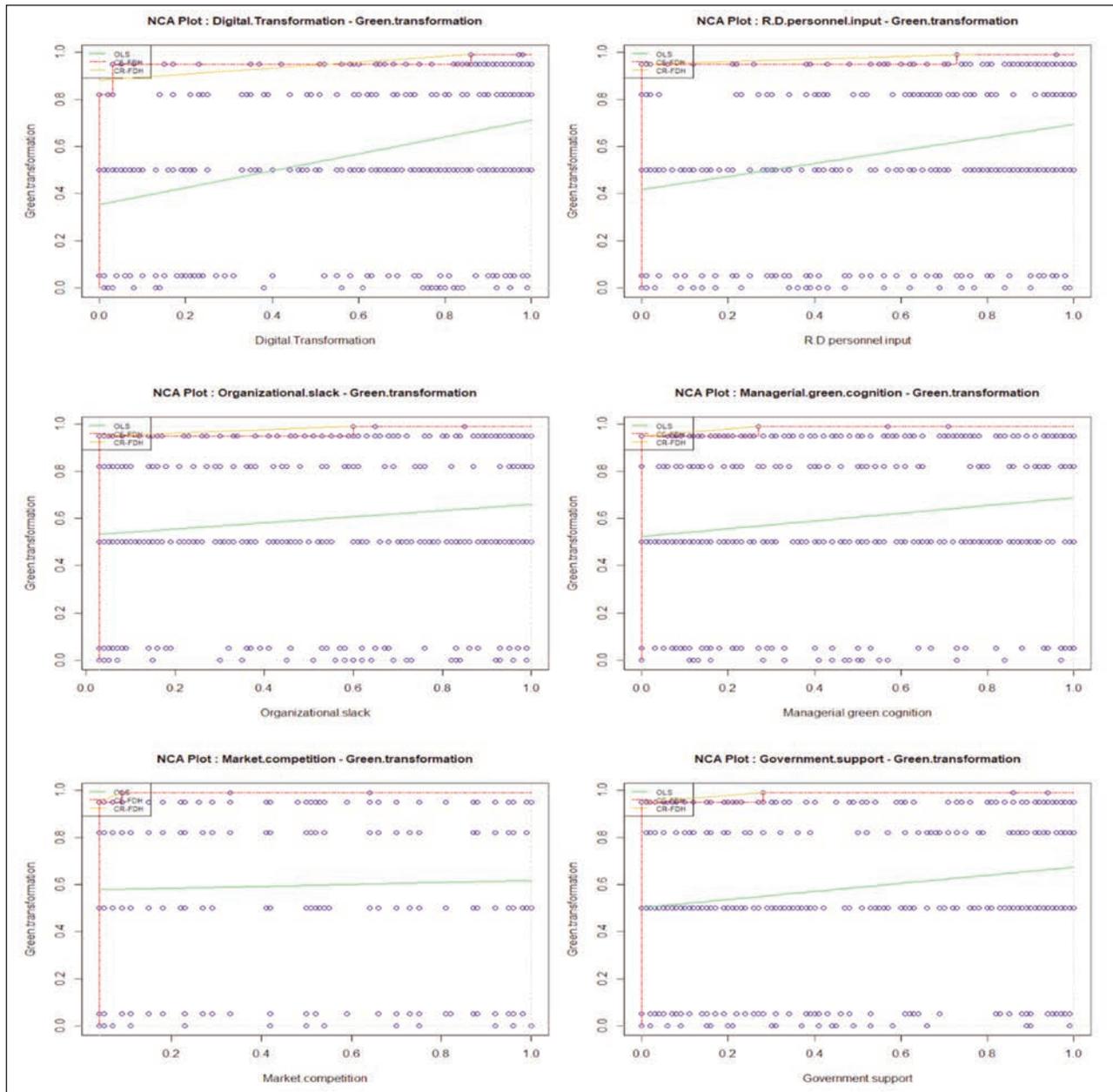


Fig. 4. Scatter plot of influencing factors

Table 3

NECESSARY CONDITION ANALYSIS (NCA)						
Antecedent condition ^a	Methods	Accuracy (%)	Ceiling Zone	Scope	Effect (d)	p value ^b
Digital Transformation	CR	97.4%	0.046	0.99	0.046	0.021
	CE	100%	0.038	0.99	0.039	0.015
R&D Personnel Ratio	CR	100%	0.015	0.99	0.015	0.156
	CE	100%	0.029	0.99	0.029	0.155
Organizational Slack	CR	100%	0.011	0.96	0.012	0.091
	CE	100%	0.023	0.96	0.024	0.091
Executives' Green Cognition	CR	100%	0.005	0.99	0.005	0.195
	CE	100%	0.011	0.99	0.011	0.195
Market Competition	CR	100%	0.001	0.95	0.001	0.622
	CE	100%	0.002	0.95	0.002	0.622
Government Support	CR	100%	0.006	0.99	0.006	0.321
	CE	100%	0.011	0.99	0.011	0.319

Note: ^a – Based on calibrated fuzzy-set data; ^b – Results obtained using permutation testing with 10,000 resamples.

Table 4

BOTTLENECK LEVELS (%) IDENTIFIED BY NCA METHOD						
Green transformation	Digital transformation	R&D staff proportion	Organizational slack	Executives' green cognition	Market competition	Government support
0	NN	NN	NN	NN	NN	NN
10	NN	NN	NN	NN	NN	NN
20	NN	NN	NN	NN	NN	NN
30	NN	NN	NN	NN	NN	NN
40	NN	NN	NN	NN	NN	NN
50	NN	NN	NN	NN	NN	NN
60	NN	NN	NN	NN	NN	NN
70	NN	NN	NN	NN	NN	NN
80	NN	NN	NN	NN	NN	NN
90	7.1	NN	NN	NN	NN	NN
100	8.3	3.0	5.8	NN	NN	8.0

Note: The table uses a CAP regression analysis, CR; NN indicates not necessary.

at 2, and the RPI threshold at 0.75 to enhance the robustness of the results. During counterfactual analysis, we excluded simplifying assumptions that would lead to logical contradictions. Given the heterogeneity in enterprise development, the impact of antecedent conditions on the outcome cannot be uniformly determined. Accordingly, we analysed without preset directional expectations, allowing each condition to appear as either present or absent. As a result, we obtained enhanced parsimonious, intermediate, and complex solutions.

Based on the enhanced intermediate and parsimonious solutions, we identified core and peripheral conditions following the approach proposed by Fiss (2011). Table 5 reports the results of the configuration analysis. Specifically, four configurations were identi-

fied as leading to high-level green transformation, which can be categorised into three types: technology–environment-driven, technology–organisation-driven, and hybrid-driven configurations (figure 5).

Summary of configurations

(1) Technology and Environment Driven

Configuration (H1)

Configuration H1 shows a consistency of 0.907 and a raw coverage of 0.468, explaining approximately 47% of the sample cases. Within this configuration, digital transformation, R&D staffing, and government support are core conditions. This indicates that some textile enterprises advance green transformation by upgrading their technologies and leveraging policy support. For example, through the adoption of smart equipment, the enhancement of technical personnel,

Table 5

CONFIGURATIONAL ANALYSIS				
Causal condition	High-level Green transformation			
	H1	H2	H3a	H3b
	Technology–environment-drive	Technology–organisation-driven	Multi-dimensional driven	
Digital transformation	◆	◆	◆	◎
R&D personnel input	◆	◆	●	◆
Organizational slack	◎	●	◆	◆
Executives' green cognition		◆	●	
Market competition	●			◆
Government support	◆	◎	◆	◆
Consistency	0.907	0.921	0.887	0.912
PRI	0.901	0.802	0.769	0.794
Raw coverage	0.468	0.393	0.297	0.322
Unique coverage	0.101	0.059	0.102	0.125
Inter-group adjusted distance	0.013	0.002	0.054	0.049
Intra-group adjusted distance	0.075	0.082	0.080	0.014
Overall consistency	0.904			
Overall coverage	0.658			

multiple dimensions. Therefore, this configuration is classified as multi-factor hybrid driven.

Inter-group analysis

Although the inter-configuration consistency deviation of the four high-level green transformation configurations does not exceed 0.1, indicating no significant time effects, a closer examination of the temporal trend reveals that all four paths experienced a notable decline in consistency in 2020, followed by a gradual recovery starting from 2021 (figure 6). It should be noted that this fluctuation concentrated in 2020 is a systematic rather than a random disturbance, and thus does not qualify as a benign deviation [36]. This inter-configuration analysis addresses the lack of temporal perspective in previous cross-sectional studies and demonstrates that the four configurations are robust over 2016–2024.

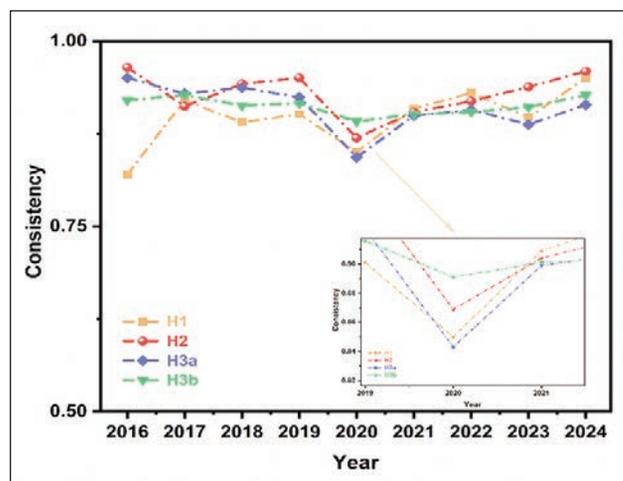


Fig. 6. Variation in inter-group consistency

As for the sharp drop in 2020, it may be attributed to the outbreak of COVID-19 that year, during which enterprises prioritised operational stability over green transformation. Although this short-term disruption occurred, all inter-configuration deviation values remain below 0.1 and do not substantially affect the explanatory power of the model. Therefore, the results remain valid under normal conditions. It is noteworthy that configuration H3b was less affected by the pandemic, indicating that the “Multi-Factor Hybrid Driven Type” exhibits greater stability.

Intra-group analysis

Consistent with the results of inter-configuration deviation, the intra-configuration deviation of all four configurations is also below 0.1, suggesting that the explanatory power of the four configurations does not differ significantly across firm sizes. Given the overall comparability of explanatory power, a further examination of firm size coverage across configurations can help identify their distribution among different firm sizes.

As current QCA methods lack indicators for measuring firm size coverage differences, we rank sample firms by firm size (natural log of total assets) and divide them into small, medium, and large-scale groups based on terciles. Configuration 2 failed the

normality test and was analysed using the non-parametric Kruskal-Wallis rank-sum test. Configurations H1 and H3b passed both the normality and homogeneity of variance tests, making them suitable for one-way ANOVA. Configuration H3a, which barely failed the normality test, was tested using both methods to ensure robustness.

The specific results are shown in tables 6 and 7. The p-values for configurations H1 and H3b are both below 0.1 and are statistically significant, indicating notable differences across firm sizes. The remaining configurations have p-values above 0.1 and are not statistically significant. To further explore configuration preferences by firm size, we calculated the mean firm size coverage for each configuration. As shown in table 8, configuration H1 performs better among large firms, while configuration H3b is more effective for smaller ones (see selected case examples in figure 7).

Table 6

KRUSKAL-WALLIS TEST				
Configuration	Mean	SD	F	P
H2	0.414	0.253	2.147	0.341
H3a	0.331	0.176	1.492	0.476

Table 7

ONE-WAY ANALYSIS OF VARIANCE FOR CONFIGURATIONS				
Configuration	Mean	SD	F	P
H1	0.337	0.172	3.14	0.06*
H3a	0.372	0.216	0.67	0.536
H3b	0.357	0.192	7.02	0.004***

Table 8

MEAN COVERAGE OF CONFIGURATIONAL PATHS				
Category	H1	H2	H3a	H3b
Small-scale	0.322	0.309	0.316	0.489
Medium-scale	0.351	0.354	0.409	0.352
Large-scale	0.502	0.403	0.397	0.245

CONCLUSION AND DISCUSSION

This study investigates the complex driving mechanisms in the green transformation process of China's A-share textile industry. Utilising panel data from 2016 to 2024 and a two-stage method combining Dynamic QCA and NCA, we identified three distinct configurational pathways leading to high-level green transformation: technology-environment driven, technology-organisation endogenously driven, and multi-factor integrated. All identified pathways exhibit high consistency and coverage, suggesting that no single optimal path exists for green transformation, thereby demonstrating the typical characteristic of equifinality. Inter-group analysis further reveals that the

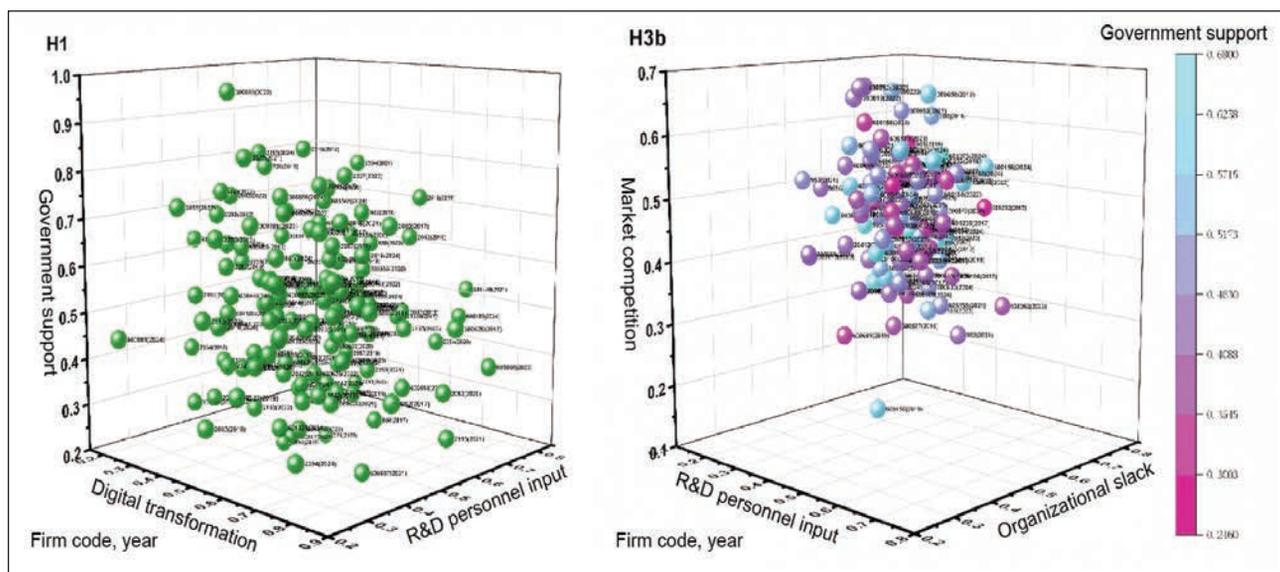


Fig. 7. Representative sample cases of Green transformation

consistency levels of these three configurations significantly declined in 2020 before gradually rebounding in 2021. Notably, the multi-factor integrated pathway demonstrated greater stability and the most effective transformation outcomes amidst these fluctuations. Intra-group analysis, in turn, indicates that the driving effects of these configurations vary to some extent across different enterprise scales. Our research offers several significant contributions. First, we broaden the research perspective on green transformation, moving beyond the existing literature's predominant focus on the linear impact of single variables. From a theoretical standpoint, this study deepens the understanding of the "configurational logic of green transformation". Consistent with Fiss's (2011) three core principles of configurational theory, the three high-performance pathways identified in this paper exemplify equifinality, illustrating that diverse combinations of conditions can lead to superior green transformation performance, thereby responding to recent calls for configurational research [20, 21]. Second, this study elucidates the complex substitution and complementarity relationships among driving factors. For instance, executive green awareness and organisational slack within the technology-organisation endogenously driven pathway can functionally compensate for government support in the technology-environment driven pathway. This vividly illustrates the intricate interplay between internal corporate resources and the external institutional environment in fostering green transformation. Finally, our research substantiates the logic of causal asymmetry prevalent in social sciences. Although digital transformation emerges as a core condition in multiple pathways, NCA analysis demonstrates that it is not a necessary condition for achieving high-level green transformation. This implies that the impact of a single condition on the outcome differs across various factor combinations, challenging the symmetry assumption of variable effects in traditional regression methods and deepening

our comprehension of green transformation's complex causal mechanisms. Furthermore, our findings align closely with China's current green industrial policy orientation, confirming the "green + digital" integrated development logic emphasised in policies such as the "14th Five-Year Plan for the Textile Industry Development", "Industrial Green Development Plan", and "Green Manufacturing System Construction Guide". These insights also offer valuable implications for economies and regions at similar levels of economic development.

From a policy-making perspective, governments should shift from relying on "single tools" to implementing precise policies through a "policy toolbox". For enterprises exhibiting characteristics of the technology-environment driven pathway, policies should extend beyond mere subsidies to include integrated incentive schemes. For example, a fast-track system for green approvals or credit could be established for firms meeting specific standards in digital transformation, R&D personnel proportion, and effective utilisation of government subsidies. Second, supporting digital infrastructure and green finance in the textile industry should not be a one-time investment but rather a long-term, sustained strategic commitment. Moreover, our study indicates that the multi-factor integrated pathway is particularly effective for small and medium-sized enterprises (SMEs) and demonstrates greater stability during external shocks. This suggests that government support for SMEs should not solely rely on direct financial injections (e.g., subsidies) but, more critically, focus on optimising their business ecosystem. For instance, establishing national green textile certification and procurement platforms could strengthen market signals for green consumption, enabling SMEs that pursue green innovation to gain quicker market returns and thus activate their endogenous motivation.

From an enterprise management perspective, managers should act as "resource integrators" rather than "executors of isolated initiatives". Enterprises should

select the most suitable transformation pathway based on their specific conditions. For example, large enterprises with substantial technical and financial strength might prioritise the technology-organisation endogenously driven pathway (H2), with executive green awareness as the core driver, leveraging top-level design and internal culture as the bedrock for transformation. Conversely, SMEs with relatively limited resources should actively seek external support, adeptly utilising external forces such as government subsidies and market competition to pursue a multi-factor integrated compensatory growth strategy (H3b), leveraging external factors to offset internal constraints. Furthermore, the strong resilience demonstrated by the multi-factor integrated pathway during the 2020 pandemic offers a crucial lesson in risk management for all enterprises. This implies that the most robust strategy involves building a diversified capability portfolio: while pursuing technological innovation, maintaining healthy organisational slack (e.g., cash flow) is essential to buffer uncertainty, alongside a keen ability to capitalise on external policies and market opportunities. Finally, our study unequivocally highlights that no single condition offers a permanent solution; managers must regularly review and adjust their resource allocation, perceiving green transformation as a collaborative pro-

cess that necessitates continuous attention and dynamic adaptation.

Despite achieving preliminary results in identifying green transformation pathways and exploring their underlying mechanisms, our study has certain limitations. First, regarding variable selection, we adopted the TOE framework and identified multiple empirically supported antecedent variables from existing literature, aiming to construct a relatively comprehensive explanatory model. However, constrained by data availability and the characteristics of the industry sample, some potentially key factors may not have been included in the analysis, thus failing to fully capture all complex driving mechanisms underpinning green transformation. Future research could explore the inclusion of new, more endogenous variables, such as corporate culture and governance structure, to further refine model construction. Second, this paper's analysis primarily relies on publicly available data, such as corporate annual reports. Future research could integrate qualitative methods, such as interviews or surveys, to delve into the underlying logical mechanisms driving corporate green transformation, thereby further enhancing the theoretical explanatory power and practical relevance of the research.

REFERENCES

- [1] Ma, S., Li, D., Yan, H., *Entangled Value: Actor–Network Configurations and ESG Pathways in China's Textile Value Chain*, In: J. Text. Inst., 2025, 1–13
- [2] Shao, Y., Zheng, M., Xu, X., Ji, X., *Does ESG Performance Have an Impact on Firm Value? Evidence from the Chinese Textile and Garment Industry*, In: Ind. Text., 2025, 76, 2, 249–256, <https://doi.org/10.35530/IT.076.02.2023126>
- [3] Qifeng, L., Jianlei, Z., Dake, Q., Lin, H., *The Impact of Heterogeneous Environmental Regulations on China's Textile Industry CO2 Emissions*, In: Ind. Text., 2023, 74, 419–425, <http://doi.org/10.35530/IT.074.04.202299>
- [4] Yan, H., Yao, X., Li, Y., Xiong, Z., *Capital Market Liberalization and Corporate ESG Rating Divergence: A Quasi-Natural Experiment Based on the Trading System of SSHC*, In: Appl. Econ., 2025, 0, 1–15
- [5] Ulanov, V.L., *The Need for the Green Economy Factors in Assessing the Development and Growth of Russian Raw Materials Companies*, In: J. Compr. Bus. Adm. Res., 2024, 1, 19–26
- [6] Duan, K., Qin, C., Ma, S., Lei, X., Hu, Q., Ying, J., *Impact of ESG Disclosure on Corporate Sustainability*, In: Finance Res. Lett., 2025, 78, 107134
- [7] Yan, H., Li, Y., Zhong, Y., Xia, Z., *Will the 'Government-Court Coordination' of Corporate Bankruptcy Disposal Improve ESG Performance? Evidence from China*, In: Appl. Econ. Lett., 2024, 1–5
- [8] Zhang, X., Liao, Z., *The Influence Mechanism of Digital Technology Empowering Green Innovation of Textile Firms: A Knowledge Search Perspective*, In: Ind. Text. 2024, 75, 359–367, <http://doi.org/10.35530/IT.075.03.202380>
- [9] Li, Y., Jia, Z., Qin, C., Li, Z., Ying, J., *Analysis of Recycling and Emission Reduction Models under Carbon Taxes and Government Subsidies*, In: Int. Rev. Econ. Finance, 2025, 99, 104052
- [10] Zhou, C., Zhang, H., Ying, J., He, S., Zhang, C., Yan, J., *Artificial Intelligence and Green Transformation of Manufacturing Enterprises*, In: Int. Rev. Financ. Anal., 2025, 104, 104330
- [11] Dhar, P., *The Carbon Impact of Artificial Intelligence*, 2020
- [12] Zhang, J., Liang, G., Feng, T., Yuan, C., Jiang, W., *Green Innovation to Respond to Environmental Regulation: How External Knowledge Adoption and Green Absorptive Capacity Matter?*, In: Bus. Strategy Environ., 2020, 29, 39–53
- [13] Shen, Q., Pan, Y., Feng, Y., *Identifying and Assessing the Multiple Effects of Informal Environmental Regulation on Carbon Emissions in China*, In: Environ. Res., 2023, 237, 116931
- [14] Fiss, P.C., *Building Better Causal Theories: A Fuzzy Set Approach to Typologies in Organization Research*, In: Acad. Manage. J., 2011, 54, 393–420
- [15] Wang, X., Zhang, T., Luo, S., Abedin, M.Z., *Pathways to Improve Energy Efficiency under Carbon Emission Constraints in Iron and Steel Industry: Using EBM, NCA and QCA Approaches*, In: J. Environ. Manage., 2023, 348, 119206
- [16] Rihoux, B., Ragin, C.C., *Configurational Comparative Methods: Qualitative Comparative Analysis (QCA) and Related Techniques*, SAGE, 2009, 51, ISBN 978-1-4129-4235-5
- [17] Du, Y., Kim, P.H., *One Size Does Not Fit All: Strategy Configurations, Complex Environments, and New Venture Performance in Emerging Economies*, In: J. Bus. Res., 2021, 124, 272–285

- [18] Hong, Y., Ma, L., Kang, S., Zhang, G., *Decoupling Carbon Emissions from Economic Growth in China's Textile Industry: A Decomposition of Driving Factors*, In: *Front. Environ. Sci.*, 2025, 13, 1587498
- [19] Li, X., Huang, Y., Li, J., Liu, X., He, J., Dai, J., *The Mechanism of Influencing Green Technology Innovation Behavior: Evidence from Chinese Construction Enterprises*, In: *Buildings*, 2022, 12, 237
- [20] Furnari, S., Crilly, D., Misangyi, V.F., Greckhamer, T., Fiss, P.C., Aguilera, R.V., *Capturing Causal Complexity: Heuristics for Configurational Theorizing*, In: *Acad. Manage. Rev.*, 2021, 46, 778–799
- [21] Li, D., Yan, H., Ma, S., *ESG Performance Drivers and Corporate Growth: A Life-Cycle-Based fsQCA–PSM Study of China's Construction and Manufacturing Enterprises*, In: *J. Asian Archit. Build. Eng.*, 2025
- [22] Tornatzky, L.G., Fleischer, M., Chakrabarti, A.K., *The Processes of Technological Innovation; Issues in organization and management series*, Lexington Books, 1990
- [23] Wu, W., Liang, Z., Zhang, Q., Zhang, H., *Coupling Relationships and Synergistic Mechanisms between Technology Management Capability and Technological Capability in Product Innovation: A Simulation Study*, In: *Technol. Anal. Strateg. Manag.*, 2020, 32, 1098–1112
- [24] Walker, R.M., *Internal and External Antecedents of Process Innovation: A Review and Extension*, In: *Public Manag. Rev.*, 2014, 16, 21–44
- [25] Abed, S.S., *Social Commerce Adoption Using TOE Framework: An Empirical Investigation of Saudi Arabian SMEs*, In: *Int. J. Inf. Manage.*, 2020, 53, 102118
- [26] Li, S., Zhu, J., Chen, P., Li, Z., Liao, C., Feng, W., *Exploring High-Performance Green Innovation in China's Logistics Companies: A TOE Framework Based on fsQCA*, In: *Front. Environ. Sci.*, 2025, 12, 1511269
- [27] Mao, Y., Hu, N., Leng, T., Liu, Y., *Digital Economy, Innovation, and Firm Value: Evidence from China*, In: *Pac.-basin Finance J.*, 2024, 85, 102355
- [28] Yuan, B., Cao, X., *Do Corporate Social Responsibility Practices Contribute to Green Innovation? The Mediating Role of Green Dynamic Capability*, In: *Technol. Soc.*, 2022, 68, 101868
- [29] Mishina, Y., Pollock, T.G., Porac, J.F., *Are More Resources Always Better for Growth? Resource Stickiness in Market and Product Expansion*, In: *Strateg. Manag. J.*, 2004, 25, 1179–1197
- [30] Liao, Z., Long, S., *CEOs' Regulatory Focus, Slack Resources and Firms' Environmental Innovation*, In: *Corp. Soc. Responsib. Environ. Manag.*, 2018, 25, 981–990
- [31] Li, Y., Liu, T., Wang, Z., *Do ESG-Conscious Fund Managers Drive Green Innovation? An LLM-Based Textual Analysis of Fund Manager Narratives*, In: *Res. Int. Bus. Finance*, 2025, 102983
- [32] Martin, R., Muûls, M., De Preux, L.B., Wagner, U.J., *Anatomy of a Paradox: Management Practices, Organizational Structure and Energy Efficiency*, In: *J. Environ. Econ. Manage.*, 2012, 63, 208–223
- [33] Porter, M.E., Linde, C. van der, *Toward a New Conception of the Environment-Competitiveness Relationship*, In: *J. Econ. Perspect.*, 1995, 9, 97–118
- [34] Zhu, Q., Sarkis, J., *The Moderating Effects of Institutional Pressures on Emergent Green Supply Chain Practices and Performance*, In: *Int. J. Prod. Res.*, 2007, 45, 4333–4355
- [35] Clausen, T.H., *Do Subsidies Have Positive Impacts on R&D and Innovation Activities at the Firm Level?*, In: *Struct. Change Econ. Dyn.*, 2009, 20, 239–253
- [36] Garcia-Castro, R., Ariño, M.A., *A General Approach to Panel Data Set-Theoretic Research*, In: *J. Adv. Manag. Sci. Inf. Syst.*, 2016, 2, 526
- [37] Loughran, T., McDonald, B., *When Is a Liability Not a Liability? Textual Analysis, Dictionaries, and 10-ks*, In: *J. Finance*, 2011, 66, 35–65
- [38] Yao, L., Liu, D., *Corporate Digital Transformation and Major Shareholder Equity Pledges: An Analysis of Incentive and Constraint Effects*, In: *Int. Rev. Econ. Finance*, 2025, 104666
- [39] Duriau, V.J., Reger, R.K., Pfarrer, M.D., *A Content Analysis of the Content Analysis Literature in Organization Studies: Research Themes, Data Sources, and Methodological Refinements*, In: *Organ. Res. Methods*, 2007, 10, 5–34
- [40] Osborne, J.D., Stubbart, C.I., Ramaprasad, A., *Strategic Groups and Competitive Enactment: A Study of Dynamic Relationships between Mental Models and Performance*, In: *Strateg. Manag. J.*, 2001, 22, 435–454
- [41] Schneider, C.Q., Wagemann, C., *Set-Theoretic Methods for the Social Sciences: A Guide to Qualitative Comparative Analysis*, Cambridge University Press, 2012
- [42] Duan, Y., Xi, B., Xu, X., Xuan, S., *The Impact of Government Subsidies on Green Innovation Performance in New Energy Enterprises: A Digital Transformation Perspective*, In: *Int. Rev. Econ. Finance*, 2024, 94, 103414
- [43] Dul, J., van der Laan, E., Kuik, R., *A Statistical Significance Test for Necessary Condition Analysis*, In: *Organ. Res. Methods*, 2020, 23, 385–395

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