

# How Design for Environment Translates into Competitive Advantage: The Roles of Quality Management Innovation, Green Dynamic Capability, and ESG Performance

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**Abstract**—Driven by global sustainability initiatives and ambitious carbon neutrality targets, Environmental, Social, and Governance (ESG) performance has emerged as a critical measure of corporate value and competitiveness. Yet, translating environmental management investments into tangible and lasting competitive advantages remains a challenge for both scholars and practitioners. Drawing on the dynamic capability perspective and stakeholder theory, this study proposes an analytical framework to explain how Design for Environment (DFE) influences ESG performance in Chinese manufacturing firms. By synthesizing prior research and conceptually mapping the relationships among DFE, Quality Management Innovation (QMI), Green Dynamic Capability (GDC), and stakeholder pressure, the study makes several key arguments: **DFE as a Strategic Starting Point:** DFE serves as a foundation for corporate green transformation, shaping operational improvements and strategic adaptive capabilities. **GDC as a Linking Mechanism:** Green Dynamic Capability bridges environmental practices and ESG outcomes, facilitating the translation of initiatives into measurable performance gains. **QMI as a Capability Enabler:** Quality Management Innovation underpins the capability-building process, helping firms convert DFE initiatives into ESG-related advantages. **Stakeholder Pressure as a Boundary Condition:** External expectations and pressures amplify the value creation potential of environmental strategies, ensuring that green initiatives are aligned with broader stakeholder priorities. By unpacking the “black box” of how DFE evolves into a broader competitive advantage, this study provides a theoretically grounded and practically relevant framework for firms aiming to design and implement effective sustainable development strategies.

**Keywords**—Design for Environment (DFE), Quality Management Innovation (QMI), Green Dynamic Capability (GDC), ESG Performance, Competitive Advantage

## I. INTRODUCTION

In the context of the global sustainability movement and the push for carbon neutrality, Environmental, Social, and Governance (ESG) performance has emerged as a key measure of corporate value and competitiveness [1]. Companies are increasingly seen not just as economic actors but as critical drivers of societal sustainability. Rising pressures from investors, consumers, governments, and the public are pushing firms — especially in the manufacturing

sector, which contributes significantly to environmental impact — to integrate sustainability deeply into their strategies and operations [2].

A persistent challenge for both scholars and practitioners is how to convert environmental management investments into sustainable competitive advantages, rather than treating them solely as compliance costs [3]. Design for Environment (DFE), which intervenes at the earliest stages of the product lifecycle, is widely recognized as a strategic tool to achieve a “win-win” between economic and environmental objectives [4].

While prior studies have documented positive effects of DFE on environmental and financial performance [5], the mechanisms through which these benefits arise remain underexplored. Much of the literature either examines the direct link between DFE and firm performance or considers only a single mediator, such as Quality Management Innovation (QMI) [3], oversimplifying the complex process of value creation. This is particularly relevant in China, the world’s largest manufacturing hub, where firms operate under a unique institutional and competitive landscape. The pathways through which DFE translates into competitive advantage are likely more intricate. This leads to the central research question of this study: How does Design for Environment contribute to ESG performance in Chinese manufacturing firms through multiple interconnected pathways?

To address this question, the study integrates several strands of research. DFE is recognized for improving environmental performance through resource efficiency and pollution reduction [6], yet its implementation often coincides with broader organizational innovations. For instance, QMI acts as a bridge that amplifies the effects of DFE through process improvements and continuous learning [3]. However, these studies primarily focus on operational-level capabilities, paying limited attention to higher-order strategic capabilities.

The Dynamic Capability View (DCV) provides a robust lens for understanding how firms sustain competitive advantage in dynamic environments [7]. Within this framework, Green Dynamic Capability (GDC)—the firm’s ability to integrate, build, and reconfigure resources to

address environmental challenges and capture green opportunities — serves as a critical link between environmental strategy and ESG outcomes [8]. Although recent studies have explored dynamic capabilities in relation to ESG performance [9], few have systematically integrated DFE, QMI, and GDC into a unified framework to examine their cascading effects.

This study seeks to fill this gap. Drawing on dynamic capability and stakeholder theories, we develop an integrated analytical framework to explain how DFE may influence ESG performance. Specifically, the framework examines both independent and sequential roles of QMI and GDC in mediating the DFE – ESG relationship. Rather than relying on resource-intensive survey methods, the study adopts a literature-driven and conceptually structured approach to clarify the underlying logic.

The contributions of this research are threefold:

- **Holistic Outcome Perspective:** Extending the focus from traditional financial or environmental performance to ESG performance, providing a comprehensive lens for evaluating sustainable competitive advantage.
- **Mechanism Elucidation:** Introducing GDC as a key explanatory variable, shedding light on how DFE translates into ESG-related outcomes.
- **Integrated Analytical Framework:** Structuring the relationships among DFE, QMI, GDC, and ESG into a dual-path and sequential framework, deepening understanding of environmental strategy value creation and offering a conceptually accessible foundation for future empirical or archival studies.

## II. LITERATURE REVIEW AND HYPOTHESIS DEVELOPMENT

### A. Design for Environment (DFE)

Design for Environment (DFE), also called eco-design, is a systematic approach that integrates environmental considerations into product and service design throughout the entire lifecycle [10]. The underlying principle is that roughly 80% of a product's environmental impact is determined during its design phase, making early intervention the most effective path to sustainability [11]. DFE practices include selecting recyclable or biodegradable materials, improving energy efficiency, reducing toxic substances, and designing products for easy disassembly and reuse [3].

DFE is recognized not only as an environmental management tool but also as a strategic initiative capable of creating competitive advantage. Early research highlighted its role in improving financial performance by lowering compliance costs, reducing resource consumption, and cutting waste disposal fees [12]. The Porter Hypothesis suggests that well-designed environmental regulations can stimulate innovation, boosting resource productivity to offset — or even exceed — the cost of environmental investment, thereby generating a competitive edge [13]. More recent studies show that DFE can also provide differentiation advantages and access to new revenue streams by enhancing brand image, appealing to green consumers, and tapping emerging green markets [14].

However, the benefits of DFE do not arise automatically; they require organizational capabilities to ensure effective

implementation and channel DFE efforts toward tangible performance outcomes. Understanding this transmission mechanism is a critical area for further research.

### B. Quality Management Innovation (QMI)

Quality Management Innovation (QMI) builds on Total Quality Management (TQM) but emphasizes continuous improvement and innovation in products and processes rather than merely controlling existing quality [3]. Core elements of QMI include top management support, employee engagement, cross-functional teamwork, a culture of continuous improvement, and adoption of advanced quality tools and techniques [15]. Unlike traditional quality management, QMI promotes a proactive, systematic approach to innovation, aiming to enhance organizational efficiency and adaptability through process optimization, waste reduction, and the stimulation of employee creativity.

The synergy between QMI and environmental management has received growing attention. Principles such as continuous improvement, waste reduction, and process optimization align closely with environmental objectives [16]. For example, King and Lenox (2001) found that firms implementing lean production — a typical QMI practice — produced significantly lower pollution levels [17]. Jackson et al. (2016) also demonstrated that QMI mediates the effect of DFE on environmental and financial performance, showing that DFE drives QMI to achieve better outcomes [3].

This suggests that QMI functions as a foundational operational capability that supports DFE implementation and amplifies its impact. Yet, most research treats QMI solely as an operational mediator and has not fully explored its interaction with higher-order strategic capabilities, such as dynamic capabilities, in driving sustainability goals.

### C. Green Dynamic Capability (GDC)

The Dynamic Capability View (DCV), proposed by Teece et al. (1997), defines a firm's ability to integrate, build, and reconfigure internal and external competences to navigate rapidly changing environments [7]. Extending DCV into the sustainability domain gives rise to Green Dynamic Capability (GDC), which refers to a firm's capacity to sense environmental opportunities and threats, seize green market opportunities, and continuously transform organizational structures, processes, and resources to maintain an environmental competitive advantage [18].

GDC acts as a bridge between a firm's environmental strategy and sustainable performance outcomes. It encompasses “green innovation capabilities,” such as developing environmentally friendly products and adopting clean technologies, as well as higher-order strategic skills like adjusting business models, redesigning supply chains, and effectively engaging stakeholders [19]. Recent studies indicate that strengthening GDC—through initiatives such as digital transformation—can enhance ESG performance [20], and that GDC mediates the impact of green innovation on sustainable corporate growth [8].

These findings suggest that GDC is central to transforming operational practices like DFE and QMI into sustained competitive advantage. However, research has yet to systematically integrate DFE (design-level strategy), QMI (operational capability), and GDC (strategic adaptive

capability) to examine whether a hierarchical, cascading relationship exists among them.

#### D. ESG Performance and Research Gaps

ESG performance provides a holistic measure of a firm's sustainable development efforts, extending beyond traditional financial metrics to evaluate long-term value creation and risk management [1]. The Environmental (E) dimension focuses on climate impact, resource use, and pollution control; the Social (S) dimension includes employee relations, supply chain management, product responsibility, and community engagement; and the Governance (G) dimension covers corporate governance, shareholder rights, executive compensation, and business ethics. Strong ESG performance has been linked to higher financial returns, lower cost of capital, and enhanced market competitiveness [21].

Despite research on DFE, QMI, GDC, and ESG individually, the interconnections among them remain unclear. Key gaps include:

- Unclear pathways: Most studies examine direct dyadic relationships (e.g., DFE → performance) and lack an integrative framework showing how DFE influences ESG through the serial mediation of QMI and GDC.
- Lack of capability hierarchy: Few studies differentiate capabilities at design, operational, and strategic levels. Understanding the cascading effects from DFE (design) → QMI (operational) → GDC (strategic) is critical for comprehending environmental strategy implementation.
- Contextual limitations: Much research focuses on developed economies. In China's unique institutional and market environment, motivations, pathways, and effects may differ, requiring localized study. Organizational responses to environmental demands also vary widely, complicating generalization from Western-centric research [22]. Additionally, interactions between green supply chain management and knowledge dynamics influence how environmental practices translate into innovation and performance [23].

To address these gaps, this study develops an integrated framework to systematically examine how DFE, through the independent and serial roles of QMI and GDC, translates into improved ESG performance in Chinese manufacturing firms.

### III. RESEARCH MODEL AND HYPOTHESES

Based on the preceding literature review, we develop a theoretical model illustrating how Design for Environment (DFE) affects corporate ESG performance through multiple mediating mechanisms, including Quality Management Innovation (QMI) and Green Dynamic Capability (GDC). Stakeholder pressure is incorporated as a moderating factor. The framework is depicted in Figure 1.

#### A. DFE, QMI, and GDC

As a proactive environmental management practice, DFE requires firms to systematically integrate environmental considerations at the design stage of product development. This drives not only technological changes but also upgrades in internal processes and organizational capabilities. QMI,

emphasizing continuous improvement, cross-functional collaboration, and employee engagement to optimize processes and reduce waste, aligns closely with DFE goals. Implementing DFE encourages firms to enhance production processes, reduce material consumption, improve energy efficiency, and lower defect rates, thereby stimulating QMI initiatives.

1) *Proposition 1a (P1a)*: DFE is expected to positively influence QMI.

DFE also imposes higher demands on a firm's strategic capabilities. It encourages firms to adopt a lifecycle perspective, sense green market trends, seize opportunities in green technologies, and integrate resources for innovation—the core components of GDC. Consequently, DFE serves as a catalyst for developing a firm's GDC.

2) *Proposition 1b (P1b)*: DFE is expected to positively influence GDC.

QMI lays the operational foundation for strategic capabilities. By embedding continuous improvement into daily operations, firms cultivate routines that enhance their ability to respond to external environmental challenges, thereby strengthening GDC.

3) *Proposition 2a (P2a)*: QMI is expected to positively influence GDC.

#### B. Mediating Variables and ESG Performance

QMI improves operational efficiency, reduces resource waste, and minimizes defective products, contributing directly to ESG performance. For the Environmental (E) dimension, QMI reduces energy use and emissions. For Social (S), it promotes employee engagement and workplace safety. For Governance (G), standardized quality processes support transparency and accountability.

1) *Proposition 2b (P2b)*: QMI is expected to positively influence ESG performance.

GDC, as a strategic capability, has an even broader impact on ESG. Firms with strong GDC can develop green products, adopt clean technologies, anticipate societal expectations, engage stakeholders effectively, and embed sustainability into strategic decision-making, thereby enhancing Environmental, Social, and Governance outcomes.

2) *Proposition 3 (P3)*: GDC is expected to positively influence ESG performance.

#### C. Direct and Mediating Effects of DFE

DFE can also have a direct effect on ESG. By designing safer, environmentally friendly products, firms reduce liability risks (S dimension) and appeal to forward-looking investors, improving governance ratings (G dimension).

1) *Proposition 4 (P4)*: DFE is expected to positively influence ESG performance.

QMI mediates the DFE – ESG relationship by translating operational improvements into sustainability outcomes:

2) *Proposition 5a (P5a)*: QMI may serve as a mediator linking DFE and ESG performance.

Similarly, GDC mediates the DFE – ESG relationship at the strategic level:

3) *Proposition 5b (P5b)*: GDC may serve as a mediator linking DFE and ESG performance.

Furthermore, QMI and GDC can form a sequential mediation pathway, where DFE drives operational-level QMI, which then builds the foundation for strategic-level GDC, ultimately enhancing ESG outcomes:

4) *Proposition 5c (P5c)*: QMI and GDC jointly form a serial pathway linking DFE to ESG performance.

*D. Moderating Role of Stakeholder Pressure*

According to stakeholder theory, firm actions are influenced by the expectations and pressures of key stakeholders (e.g., government, customers, investors, public). Stronger stakeholder pressure encourages firms to implement DFE more rigorously and align outcomes with external expectations, enhancing its impact on ESG performance.

1) *Proposition 6 (P6)*: Stakeholder pressure strengthens the relationship between DFE and ESG performance, making DFE’s influence more pronounced under higher pressure.

IV. RESEARCH DESIGN AND ANALYTICAL APPROACH

*A. Analytical Materials and Research Procedure*

This study examines manufacturing firms listed on China’s A-share market. The manufacturing sector was selected due to its significant economic role and substantial environmental footprint, making it an especially relevant context for ESG transformation. Publicly listed firms are particularly suitable because their annual reports, ESG disclosures, CSR reports, and other publicly available materials are relatively transparent and verifiable, allowing the analytical framework to be applied to information that can be readily examined and revisited.

Accordingly, the study adopts a low-cost, replicable approach centered on publicly accessible materials and a systematic integration of prior literature. Rather than relying on large-scale surveys or resource-intensive fieldwork, the analysis focuses on recurring patterns identified in existing studies and observable firm-level disclosure practices commonly used in sustainability research. This design enhances transparency, reduces implementation barriers, and facilitates replication or extension by future researchers using publicly available data sources.

The scope of the analytical materials and the contextual boundaries of the study are summarized in Table I.

TABLE I. PUBLICLY AVAILABLE ANALYTICAL MATERIALS AND CONTEXTUAL BOUNDARIES

Dimension	Illustrative Scope	Analytical Relevance	Publicly Interpretable Sources
Firm Size	Large / Medium / Small firms	Helps interpret heterogeneity in resource endowment, organizational complexity, and ESG capacity	Annual reports, ESG reports, company profiles
Industry	Electronics / Machinery / Chemical & Pharma / Automotive / Other manufacturing segments	Helps compare differences in environmental intensity, regulatory exposure, and green design pressure	Industry reports, annual reports, ESG disclosures

Region	Eastern / Central / Western China	Helps interpret regional variation in regulation, industrial upgrading, and stakeholder expectations	Corporate disclosures, regional policy documents, statistical yearbooks
Ownership and Governance Context	State-owned, private, mixed, or other governance arrangements	Helps interpret differences in strategic responsiveness, governance structure, and ESG implementation logic	Annual reports, governance disclosures, CSR/ESG reports
Sustainability Disclosure Scope	Environmental, social, and governance related public information	Provides an observable basis for discussing how DFE, QMI, GDC, and stakeholder pressure may be manifested in practice	ESG reports, CSR reports, sustainability sections of annual reports

*B. Core Constructs and Analytical Dimensions*

To enhance practical accessibility and replicability, this study conceptualizes the key variables as analytical constructs rather than survey-based latent measures. Each construct is grounded in established literature and tied to observable organizational practices and publicly interpretable disclosure dimensions:

- **Design for Environment (DFE)**: DFE is treated as a design-stage environmental strategy, reflected in product lifecycle considerations, material selection, energy efficiency orientation, and pollution prevention practices.
- **Quality Management Innovation (QMI)**: QMI is framed as an operational-level capability, reflected in process optimization, employee involvement, continuous improvement routines, and structured quality management practices.
- **Green Dynamic Capability (GDC)**: GDC is conceptualized as a higher-order strategic capability, encompassing the ability to sense green opportunities, integrate resources, adapt organizational structures, and reconfigure strategies in response to environmental changes.
- **ESG Performance**: ESG performance is viewed as a multidimensional sustainability outcome, covering environmental, social, and governance dimensions, consistent with prior literature and mainstream ESG evaluation frameworks [1].
- **Stakeholder Pressure (SP)**: SP is treated as an external contextual force originating from regulators, customers, investors, and public opinion.

Additionally, firm-specific characteristics—such as size, industry type, regional context, and ownership structure—are considered important background conditions that may influence how the proposed framework operates in practice.

V. FRAMEWORK ANALYSIS AND RESEARCH PROPOSITIONS

A. Analytical Overview of the Core Relationships

Table II presents a summary of the key constructs, their analytical roles, and the expected relationships among them. Unlike survey-based tables, it organizes the conceptual links identified in prior research and clarifies how DFE, QMI, GDC, ESG performance, and stakeholder pressure can be interpreted within a unified analytical framework. This approach highlights the logical connections and the role each construct plays in driving sustainable performance, providing a clear roadmap for understanding their interactions.

TABLE II. CORE CONSTRUCTS, ANALYTICAL ROLES, AND EXPECTED RELATIONSHIPS

Construct	Analytical Level	Representative Focus	Expected Relationship	Key References
DFE	Design-level practice	Lifecycle thinking, material selection, energy efficiency, pollution prevention	Expected to influence QMI, GDC, and ESG performance directly and indirectly	[3][4][10][11][12][13][14]
QMI	Operational-level capability	Process optimization, employee involvement, continuous improvement, structured quality routines	Expected to support ESG performance directly and to strengthen GDC as an operational foundation	[3][15][16][17]
GDC	Strategic-level capability	Green opportunity sensing, resource integration, organizational adaptation, strategic reconfiguration	Expected to function as the core bridge linking environmental practice to ESG performance	[7][8][9][18][19][20]
ESG Performance	Outcome construct	Environmental, social, and governance related sustainability outcomes	Expected to reflect the broader competitive implications of DFE, QMI, and GDC	[1][2][21]
Stakeholder Pressure	External contextual condition	Regulatory, customer, investor, and public expectations	Expected to strengthen the practical salience of the DFE – ESG relationship	[1][2][23]

B. Conceptual Clarity of the Core Constructs

To improve accessibility and reproducibility, this study does not rely on questionnaire-based reliability or validity testing. Instead, Table III provides clear conceptual definitions, representative manifestations, and analytical indicators for each core construct based on established literature. This approach maintains conceptual consistency while making the framework more practical and easier to apply in future research using public disclosures, case studies, or secondary datasets.

TABLE III. CONCEPTUAL DEFINITIONS, REPRESENTATIVE MANIFESTATIONS, AND ANALYTICAL INDICATORS OF CORE CONSTRUCTS

Construct	Conceptual Definition	Representative Manifestations	Illustrative Analytical Indicators from Public Disclosures
DFE	A design-stage environmental strategy that integrates lifecycle thinking into product and process design	Recyclable material selection, disassembly logic, energy-efficient design, pollution prevention orientation	Product design narratives, material substitution disclosures, eco-design statements, lifecycle-related descriptions
QMI	An operational-level improvement capability emphasizing continuous improvement and innovation in quality-related routines	Process optimization, employee participation, quality circles, structured problem-solving, waste reduction	Continuous improvement disclosures, process management initiatives, quality management practices, employee involvement mechanisms
GDC	A higher-order capability through which firms sense green opportunities, integrate resources, and adapt strategically to environmental change	Green opportunity sensing, resource orchestration, cross-functional adaptation, strategic reconfiguration	Green innovation initiatives, strategic sustainability adjustment, collaboration with suppliers/customers, capability-building narratives
ESG Performance	A multidimensional sustainability outcome covering environmental, social, and governance dimensions	Emission reduction, employee well-being, governance quality, responsible disclosure	ESG metrics, sustainability performance narratives, governance arrangements, social responsibility disclosures
Stakeholder Pressure	External pressure arising from regulators, customers, investors, and public opinion	Regulatory attention, market expectations, investor demands, reputation sensitivity	Policy compliance disclosures, customer-facing sustainability communication, ESG reporting pressure, public response narratives

C. Mechanism Analysis of the Proposed Relationships

Figure 1 summarizes the mechanism pathways proposed in the analytical framework. Rather than focusing on model

fit statistics, the figure emphasizes the theoretically grounded relationships connecting DFE, QMI, GDC, and ESG performance, illustrating how environmental strategies are transmitted through operational and strategic capabilities to enhance sustainability outcomes.

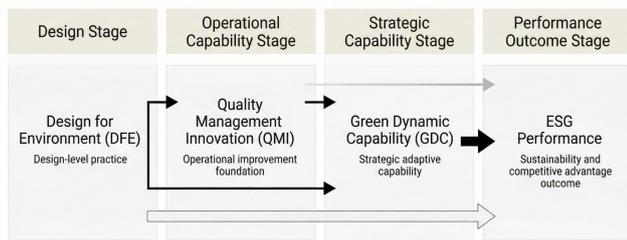


Fig. 1. Layered Mechanism Linking DFE to ESG Performance

The analytical framework positions DFE as a key precursor to both QMI and GDC, with GDC serving as the primary strategic pathway that translates environmental design practices into tangible ESG advantages. QMI, on the other hand, functions mainly as an enabling and foundational capability, supporting operational improvements but not sufficient on its own to drive broad ESG outcomes. This structure suggests a hierarchical logic: DFE initiates operational enhancements, those improvements build strategic adaptation through GDC, and strategic adaptation, in turn, has the most direct influence on ESG performance.

*D. Indirect Mechanisms and Boundary Conditions*

Table IV outlines the indirect mechanisms proposed in this study. The framework indicates that GDC serves as the key bridge linking DFE to ESG performance, while the sequential pathway DFE → QMI → GDC → ESG illustrates how environmental design practices are progressively transformed into broader sustainability outcomes. In comparison, QMI alone functions primarily as a supporting operational foundation, rather than a complete mechanism driving ESG performance.

TABLE IV. ANALYTICAL INTERPRETATION OF INDIRECT MECHANISMS AND BOUNDARY CONDITIONS

Path	Mechanism Type	Analytical Interpretation	Theoretical Implication	Conclusion
DFE → QMI → ESG	Operational supporting path	DFE may stimulate process improvement, employee participation, and quality-oriented routines, which can contribute to ESG-related outcomes, but this path is better viewed as partial and supportive rather than fully sufficient on its own	QMI provides an important operational foundation for sustainability transformation	Supportive but not sufficient as a standalone route

DFE → GDC → ESG	Strategic bridging path	DFE may strengthen the firm's ability to sense green opportunities, integrate resources, and adapt strategically, thereby translating environmental design logic into broader ESG-related advantages	GDC functions as a key strategic bridge between environmental practice and sustainability performance	Core indirect pathway
DFE → QMI → GDC → ESG	Layered serial path	DFE may first stimulate operational improvement through QMI, which then lays the groundwork for higher-order strategic adaptation through GDC, ultimately supporting ESG performance	The framework reflects a progressive capability-building process from design logic to operational improvement to strategic sustainability outcomes	Most conceptually comprehensive pathway

In this study, stakeholder pressure is treated as an important boundary condition in the DFE – ESG relationship. As shown in Figure 2, stronger pressure from regulators, customers, investors, and public opinion encourages firms to more actively translate environmental design initiatives into tangible ESG outcomes. In this way, stakeholder pressure acts as an external force that amplifies both the practical relevance and organizational importance of DFE.

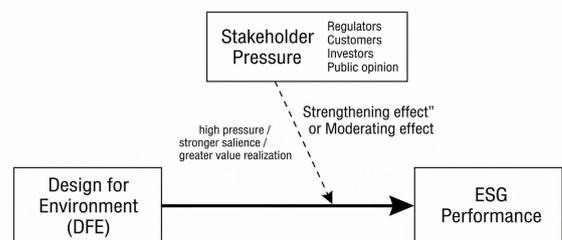


Fig. 2. Illustrative Role of Stakeholder Pressure in Strengthening the DFE – ESG Link

VI. DISCUSSION

A. Interpretation of the Main Analytical Insights

1) DFE as a Strategic Starting Point:

Design for Environment (DFE) serves as the strategic entry point for corporate green transformation. Embedding environmental considerations at the product design stage is not just a technical adjustment — it triggers a cascade of organizational responses, including process improvement, capability reconfiguration, and broader sustainability-oriented transformation.

2) GDC as the Strategic Hub:

Green Dynamic Capability (GDC) functions as the central link connecting environmental practices to ESG outcomes. Whether capability development stems directly from DFE or is gradually built through QMI, the impact on ESG performance is maximized when these efforts are elevated into higher-order capabilities that enable sensing, seizing, and reconfiguring resources to respond to green opportunities and constraints.

### 3) QMI as the Foundational Capability:

Quality Management Innovation (QMI) should be understood as a “foundation stone” rather than a standalone driver of ESG performance. By creating routines around process optimization, employee involvement, and continuous improvement, QMI lays the operational groundwork upon which higher-order green dynamic capabilities like GDC can flourish.

### 4) Stakeholder Pressure as an External Accelerator:

External expectations from regulators, customers, investors, and society amplify the effectiveness of environmental strategy. While firms may initiate DFE based on internal intent, stakeholder pressure enhances the urgency, visibility, and realization of ESG outcomes. This reflects a dual-driver logic: internal capability development provides the base, while external pressure increases the likelihood that environmental efforts are translated into recognized competitive advantage.

## B. Theoretical Contributions

1) Integrates environmental strategy, quality management, dynamic capability, and ESG literature into a multi-level framework, clarifying how DFE can be transformed into sustainable competitive advantage.

2) Expands the application of the dynamic capability view in sustainability by highlighting GDC as the strategic bridge between design-oriented environmental practices and ESG outcomes.

3) Offers a context-sensitive, theory-driven framework for ESG in Chinese manufacturing, providing a structure that is transparent, replicable, and comparable across future research.

## C. Managerial Implications

1) *Prioritize DFE Strategically:* Treat DFE as the “first button to fasten” in building firm-wide green capabilities.

2) *Build a Three-Tiered Capability System:* Position DFE as the catalyst, QMI as the operational foundation, and GDC as the strategic core.

3) *Leverage Stakeholder Pressure:* View external ESG demands not just as compliance requirements but as opportunities to strengthen internal management and generate long-term value.

## VII. CONCLUSION AND FUTURE RESEARCH

### A. Conclusion

By integrating prior research into a coherent, theory-driven framework, this study clarifies how Design for Environment (DFE) can be translated into competitive advantage in ESG performance. The findings suggest that DFE operates through a layered mechanism: QMI provides the operational foundation, GDC acts as the strategic upgrade

pathway, and stakeholder pressure amplifies the translation of environmental initiatives into recognized ESG outcomes. For effective green transformation, firms should develop a multi-level capability system and harness external sustainability pressures to drive internal organizational change.

### B. Limitations and Future Research

This study has several limitations. As a conceptual analysis, it does not provide direct empirical validation; the framework is derived primarily from existing literature and publicly accessible materials rather than original field data. Future research could:

- Test the proposed propositions empirically using case studies, archival data, or other secondary data sources.
- Explore the micro-foundations of GDC across different manufacturing contexts.
- Investigate additional contextual moderators beyond stakeholder pressure.
- Examine the distinct impacts on the Environmental (E), Social (S), and Governance (G) dimensions of ESG performance to refine the model further.

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#### APPENDIX: ILLUSTRATIVE ANALYTICAL INDICATORS FROM PUBLIC DISCLOSURES

##### A. Part 1: Illustrative Contextual Information

- Your company's industry:
- Year of your company's establishment:
- Number of employees in your company:
- Your position in the company:

##### B. Part 2: Illustrative Disclosure Dimensions for Future Research

###### 1) Design for Environment (DFE)

- Our company prioritizes the use of recyclable materials in product design.
- Our company is committed to designing products that are easy to disassemble and reuse.
- Our company considers reducing energy consumption during the production process at the product design stage.
- Our company proactively selects raw materials and components with lower environmental impact.

- Our company strives to reduce or avoid the use of toxic and hazardous substances in product design.

###### 2) Quality Management Innovation (QMI)

- Top management encourages employees to try new quality improvement methods.

- Our company provides systematic training in quality management and innovative thinking for employees.

- Our company has regular quality circle activities to encourage employee suggestions.

- Employee suggestions for quality improvement receive timely responses and adoption from management.

- We systematically use tools like Statistical Process Control (SPC) to analyze and improve processes.

###### 3) Green Dynamic Capability (GDC)

- Our company can quickly identify new market opportunities arising from changes in environmental regulations.

- Our company closely monitors the green strategies and technological dynamics of our competitors.

- Our company can effectively integrate internal and external resources to rapidly develop green products/services.

- Our company is capable of establishing close green innovation partnerships with suppliers and customers.

- Our company is able to continuously adjust its organizational structure and business processes according to sustainability goals.

###### 4) ESG Performance

- Our company has achieved significant results in reducing greenhouse gas emissions.

- Our company effectively manages and reduces water consumption.

- Our company places a high value on employee occupational health and safety.

- Our company provides fair compensation and promotion opportunities for employees.

- Our company's board of directors can effectively oversee management's ESG-related decisions.

###### 5) Stakeholder Pressure (SP)

- Government environmental regulations constitute a strong constraint on our company's business activities.

- Customers are increasingly emphasizing our company's environmental image in their purchasing decisions.

- Investors have put forward higher requirements for our company's ESG information disclosure.

- Environmental NGOs and public opinion closely follow our company's environmental performance.

(Note: The above dimensions are provided only as illustrative indicators to support future archival, case-based,

or disclosure-oriented research, rather than as a finalized survey instrument.)

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Jiaqian Su was responsible for the study design, conceptual development, and original manuscript drafting. Zili Li contributed to the literature collection, theoretical organization, and manuscript improvement. Yuping He contributed to the revision, proofreading, and final validation of the manuscript. All authors contributed to the article and approved the submitted version.

#### COMPETING INTERESTS

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