

Digital Upgrading, Factor Misallocation, and Sustained Eco-Innovation in Enterprises

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Abstract: This paper systematically investigates the ramifications of technological transformation on sustained corporate Eco-innovation. The empirical results show that the estimated parameter between digital transformation and sustained business green innovation is 0.819, positive with statistical significance at the 0.01 alpha level. This paper further lags the digital transformation indicator by one period and re-conducts the regression for sustained corporate green innovation. The test the empirical evidence suggests that the one-period lagged regression coefficient is 1.554 and remains significant at the 1% critical value, that verifies the reliability of the research conclusions. Adopting stepwise regression, this paper examines whether technological transformation can foster the advancement of enterprises' sustained ecological advancement capacity by alleviating resource misallocation. The test results suggest that computer-based upgrading exerts a remarkably negative contribution to resource misallocation at the 5% significance level. After incorporating the resource misallocation variable into the regression model of computer-based upgrading affecting sustained business ecological advancement, the results remain significant. It indicates that computer-based upgrading facilitates sustained green advancement capacity by reducing enterprises' degree of resource misallocation. Finally, the differential examination reveals that the facilitating influence of digital transformation on sustained ecological advancement capacity is more pronounced among state-controlled entities, big conglomerates and low-growth firms.

Keywords: Digital Upgrading; Sustained Business Ecological advancement; Resource Misallocation

1. Introduction

Congratulations! Your paper has been accepted Against the backdrop of the "Dual Carbon" strategic goals, achieving synergistic development between economic growth and ecological conservation has emerged as a critical global issue [1]. As the primary actors in green innovation, enterprises play a critical role in driving exceptional progression through their endurance for sustained ecological advancement. Concurrently, the rapid advancement of cyber technologies—exemplified by algorithmic intelligence, terabyte-scale datasets, and distributed architectures—have catapulted the electronic economy as a significant force powering the environmental upgrading of the productive system and society. In their journey toward sustainable ecological advancement, businesses are demonstrating a growing reliance on digital technologies, with the function of these technologies in ecological advancement becoming increasingly critical. In line with the predictions by the China Research Institute of Digital Communications Technology, digital technologies will contribute 12% to 22% of the carbon emission reductions across various industries by 2030.

As a crucial direction for current corporate strategic transformation, digital transformation not only helps optimize internal resource allocation and alleviate resource misallocation but also enhances operational efficiency and strengthens market competitiveness. Through digital means, enterprises can break through the constraints of traditional production models, enhance the productivity of innovation factor reallocation, and diminish the uncertainties and trial-and-error costs associated with green technology research and development, thereby unleashing their sustained potential in green innovation. Consequently, whether and how digital transformation can effectively enhance

enterprises' capacity for sustained ecological advancement has turned into an urgent and significant issue requiring in-depth exploration. Furthermore, against the backdrop of advancing computer-based upgrading, how to scientifically formulate strategic pathways to guide the continuous development of ecological advancement is also principal to achieving green upgrading under the "Dual Carbon" goals. This study aims to experimentally quantify the impact mechanism of computer-based upgrading on corporate sustained ecological advancement and further examine the intermediary function of resource misallocation therein, toward providing theoretical scholarly foundations and applied directives for enterprises to realize high-quality green transformation.

2. Intellectual Background and a Priori Expectations

2.1 Scholarly Foundations

2.1.1 Explication of corporate computer-based upgrading

In the wake of the rapid ascendance of electronic instrument, computer-based upgrading has emerged as a critical strategic pathway for companies to heighten market standing. Computer-based upgrading denotes the comprehensive optimization of production, management, and organizational processes through the introduction of advanced digital tools such as AI, DLT, virtualized infrastructure, and massive data, ultimately allowing business model innovation and upgrading. Existing literature primarily explores this phenomenon from two dimensions: driving factors and economic consequences [2,3].

Regarding driving factors, studies generally acknowledge that external variables—including industry characteristics, regional disparities, market environment, guideline support, and consumer behavior—serve as significant forces propelling corporate digital transformation [4]. Simultaneously, internal factors such as a firm's technological foundation, digital capabilities, managerial cognition, strategic orientation, and organizational culture also play pivotal roles in the transformation process. Furthermore, some research indicates the presence of "peer effects" in digital transformation, whereby firms' digitalization behaviors are influenced by other enterprises within the same industry or region. [5,6]

In terms of economic consequences, digital transformation has been demonstrated to drive innovation in corporate management mechanisms, facilitate integration into the digital economy ecosystem, and reshape value creation pathways in new market environments. As the transformation process deepens, its operational mechanism evolves from "empowering" to "enabling." Relevant studies show that digital transformation helps reduce corporate financing costs, enhance total factor productivity, improve accounting information comparability, optimize financial performance, and increase investment efficiency. These findings lay a robust theoretical groundwork for this analysis's detailed scrutiny of the relationship between computer-based upgrading and green innovation [7,8].

2.1.2 Research on sustained green innovation capability

Against the backdrop of increasingly prominent global ecological and environmental issues, sustained corporate green innovation has gradually emerged as a central focus of academic research [9]. Sustained green innovation not only reflects a firm's dynamic capabilities but also represents a continuous process where enterprises engage in long-term green activities such as energy conservation, emission reduction, pollution control, and ecological improvement, while simultaneously achieving economic value. This concept integrates both "green" and "sustained" attributes, with existing studies primarily analyzing it viewed through the lens of ecological advancement and sustained advancement [10].

From the green innovation perspective, corporate resource endowment, environmental regulation intensity, and intellectual property protection levels are recognized as key factors influencing green innovation. From the sustained innovation standpoint, technological diversity, ownership structure, working capital, and a firm's embeddedness within innovation networks have all been shown to significantly impact sustained innovation capability. Overall, existing research has predominantly focused on internal management and strategic dimensions, while studies examining sustained green innovation from a resource allocation perspective remain relatively scarce.

In summary, although preliminary explorations have been conducted on the interdependence between computer-based upgrading and

ecological advancement, systematic analysis of the "sustained" characteristic of green advancement remains inadequate, and research investigating the potential mediating role of resource misallocation is still insufficient. Therefore, using a sample of China's A-share listed corporations spanning the 2013–2022 interval, this investigation systematically dissects the repercussions mechanism of digital transformation on business sustained green innovation and evaluates the mediating effect of resource misallocation, with the aim of providing theoretical support for enterprises to realize environmental and sustainable advancement.

2.2 Theoretical Analysis and Research Proposition

2.2.1 The influence of computer-based upgrading on sustained corporate ecological advancement

Sustained corporate ecological advancement indicates the long-term integration of ecological and environmental protection principles throughout a firm's production and operational processes, involving continuous advancement and advancement and proliferation of environmental technologies to achieve synergistic improvement of both economic and environmental benefits. According to Schumpeter's innovation theory, sustained green innovation essentially constitutes a process of dynamic recombination and optimal distribution of green productive inputs. The introduction of computer-based facilities provides technical support for firms to reconfigure their resource allocation systems, hence building a stable groundwork for sustained ecological advancement.

Compared with conventional innovation activities, sustained green innovation typically faces higher technological barriers, greater capital investment, and longer return cycles. These characteristics lead to insufficient motivation for some firms in practical implementation. Digital transformation addresses these challenges by integrating internal information resources and breaking down data silos, effectively reducing energy consumption and resource waste in production processes, thus enhancing the efficiency and sustainability of green innovation. For one thing, computer-based approaches facilitate information transparency and circulation

efficiency, reducing transaction costs and financing difficulties in the green innovation process, thereby providing stable financial support. In the second instance, computer-based strategies enable enterprises to precisely identify market demands, optimize green product design, and integrate green principles throughout the entire product lifecycle, consequently elevating the aggregate standard of sustained corporate ecological advancement

Drawing on the foregoing analysis, we advance the following hypothesis:

H₁: Computer-based upgrading can significantly enhance a firm's capacity for sustained green innovation.

2.2.2 Digital transformation, resource misallocation, and sustained corporate green innovation

Given the inherent disparities among firms in terms of resource endowments, organizational structures, and managerial capabilities, how to efficiently allocate internal resources to support sustained green innovation has become a critical challenge in corporate management. The emergence of the computer-based epoch offers novel possibilities for firms to optimize their resource allocation methods and creates conditions for alleviating resource misallocation. On the one side, computer-based frontier technological modalities including AI and massive datasets possess powerful information processing and data analysis capabilities. These allow enterprises to pinpoint inefficient links in resource allocation, reduce resource redundancy and waste, and improve resource utilization efficiency, thereby providing more substantial factor support for ecological advancement. By contrast, as a highly complex systematic project, sustained ecological advancement accentuates demands on firms' resource integration and coordination capabilities. Digital transformation enhances coordination efficiency among internal departments through the establishment of effective information communication mechanisms, while also facilitating resource sharing and engagement with external supply chain counterparts, and in doing so further expanding the boundaries of breakthrough resources.

Therefore, this study contends that computer-based upgrading not merely straightforwardly influences a firm's capacity for sustained ecological advancement but may additionally implicitly promote the continuous development

of ecological advancement by improving resource allocation efficiency. Drawing on this logic, the following conjecture is put forth:

H₂: Computer-based upgrading indirectly enhances a firm's capacity for sustained green innovation by alleviating resource misallocation.

3. Methodology

3.1 Data Provenance

This investigation draws upon China's A-share listed enterprises throughout the 2013–2022 horizon as the empirical sample. After filtering out observations with incomplete data and those designated as ST or *ST, a last balanced panel of 29,140 firm-year observations is obtained.

The data on sustained corporate green innovation and other control variables are primarily sourced from the CSMAR data repository together with the National Bureau of Statistics. All quantitative attributes are transformed at the 1st and 99th percentiles to attenuate the effect of potential extreme values.

3.2 Variable Definitions

3.2.1 Dependent variable

Sustained Corporate Green Innovation (GPatent): This study measures a firm's capacity for sustained green innovation by examining the intertemporal change in its total green innovation output. Given the lengthy grant process for patent applications, the measure is

constructed as the total application volume of both invention patents for green technologies and utility model patents for green technologies.

$$GP_t = \frac{GP_t + GP_{t-1}}{GP_{t-1} + GP_{t-2}} \times (GP_t + GP_{t-1}) \quad (1)$$

3.2.2 Explanatory variables

Computer-based upgrading (DCG): This evaluation employs a content mining approach. Utilizing the Python programming language, we processed and segmented the textual content of corporate annual reports, deriving quantitative results across five key dimensions. Addressing the pronounced right-skewness observed in the initial data distribution, a logarithmic transformation was applied to construct the final Digital Transformation Index (DCG). Furthermore, the robustness checks section of this paper will delve into a discussion utilizing alternative measurement approaches for digital transformation.

3.2.3 Mediating variable

Resource Misallocation (Overinvest): This variable is measured through a model of corporate investment efficiency. We first estimate the firm's expected optimal investment level and then calculate its deviation, specifically capturing the level of over investment. The actual magnitude of the discrepancies derived by this formulation acts as the barometer of resource misallocation. A larger magnitude suggests a more severe state of resource misallocation inside the enterprise.

3.2.4 Control variables

Table 1. Variable Definitions and Measurements

Variable Type	Variable Name		Symbol	Definition and Measurement
Dependent Variable	Sustained Corporate Green Innovation	GPatent		The intertemporal change in the total application count of green invention patents and green utility model patents
Explanatory Variable	Digital Transformation	DCG		Natural logarithm of (the total word frequency of digital transformation keywords identified through Python-based text segmentation of annual reports + 1)
Mediating Variable	Resource Misallocation	Overinvest		Measured as the absolute value of residuals from the investment efficiency model, calculated using expected optimal investment levels and overinvestment amounts
Control Variable	Business Magnitude	Size		Log of total assets at fiscal year-end
	Inventory Intensity	INV		Net inventory divided by total assets
	Book-to-Market Ratio	BM		Book value divided by market value
	Total Asset Turnover	ATO		Operating revenue divided by average total assets
	investment opportunity proxy	TobinQ		(Market value of equity + number of non-tradable shares × net per-share asset worth together with stated liabilities) / total assets
	Listing Age	ListAge		Natural logarithm of (current year minus IPO year + 1)

	Ownership Balance Ratio	Balance	Shareholding ratio of the second largest shareholder divided by that of the largest shareholder
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To facilitate the interpretability of the regression estimate and adjust for other potential determinants, this study incorporates the following conditioning covariates that may footprint sustained business ecological advancement: firm size (Size), inventory intensity (INV), value premium proxy, operational efficiency proxy, Tobin's Q (TobinQ), listing age (ListAge), and ownership balance (Balance). (Table 1)

3.3 Model Specification

To empirically examine the impact of digital transformation on sustained corporate green innovation, the following baseline regression model is specified:

$$GPatent_{i,t} = \alpha_0 + \alpha_1 DCG_{i,t} + \alpha_2 Controls_{i,t} + Industry + Year + \varepsilon_{i,t} \quad (2)$$

Following the establishment of the baseline model, we next specify the econometric model to scrutinize the influence of computer-based upgrading on resource misallocation as follows:

$$Overinvest_{i,t} = \beta_0 + \beta_1 DCG_{i,t} + \beta_2 Controls_{i,t} + Industry + Year + \varepsilon_{i,t} \quad (3)$$

Finally, to formally test the mediating effect of resource misallocation, the following econometric model is proposed:

$$GPatent_{i,t} = \delta_0 + \delta_1 Overinvest_{i,t} + \delta_2 DCG_{i,t} + \delta_3 Controls_{i,t} + Industry + Year + \varepsilon_{i,t} \quad (4)$$

In the model, GPatent denotes the level of sustained corporate green innovation, DCG represents the degree of corporate digital

transformation, and Controls refers to the full set of control variables.

4. Empirical Analysis

4.1 Descriptive Statistics

Descriptive statistics were conducted on the full sample of firms. The analysis reveals that the dependent variable, Sustained Green Innovation (GPatent), has a mean value of 7.857 and a maximum value of 2,668, while its median is 0 with a dispersion of 59.79. This attests to substantial variation in sustained green innovation capability across firms, reflecting divergent developmental potentials. Regarding the explanatory variable, the Magnitude of computer-based upgrading (DCG) shows a mean of 1.408, with maximum and minimum values of 6.301 and 1.099, respectively. This suggests considerable disparities in the implementation of digital transformation among sample firms, with significant room for strategic improvement in some enterprises, which aligns with the current landscape of digital development in Chinese businesses. The mediating variable, Resource Misallocation (Overinvest), ranges from 0 to 71.07 with a standard deviation of 0.696, demonstrating uneven resource allocation capabilities across the sample. For the control variables, including Firm Size (Size) and Inventory Intensity (INV), notable diversity is observed among the sampled firms. The complete descriptive statistics results are displayed in Table 2.

Table 2. Data Summary of Corporate Measures

Variable	N	Mean	SD	Min	Max	Median
GPatent	29900	7.857	59.79	0	2668	0
DCG	29900	1.472	1.408	0	6.301	1.099
Overinvest	29800	0.0703	0.696	0	71.07	0
Size	29900	22.23	1.305	19.57	26.45	22.04
INV	29900	0.140	0.129	0	0.778	0.109
BM	29800	1.049	1.251	0.0518	10.09	0.652
ATO	29900	0.634	0.429	0.0546	2.891	0.541
TobinQ	29900	2.057	1.400	0.802	16.65	1.620
ListAge	29800	2.100	0.898	0	3.401	2.303
Balance	29900	0.372	0.286	0.00620	1	0.295

4.2 Baseline Econometric Estimation

As observed in Table 3, the estimated coefficient capturing the connection between computer-based upgrading and business sustainable

ecological advancement stands at 0.819, which is statistically significant at the 1% confidence interval. This finding points to the fact that implementing computer-based upgrading strategies can markedly promote the

transformation of corporate sustainable ecological advancement, underscoring its role as a driving force for sustainable corporate development. Consequently, Hypothesis 1 is empirically validated. This demonstrates that computer-based upgrading allows enterprises to leverage the green innovation value inherent in their existing technologies and, building upon this foundation, systematically harness various forms of digital information to explore and develop novel technologies, thereby steadily enhancing their capacity for sustained green innovation.

Table 3 The Imprint of Computer-based Upgrading on Business Advancement Effectiveness

Variable	Dependent Variable: Sustained Corporate Green Innovation
	<i>GPatent</i>
<i>DCG</i>	0.819** (0.368)
<i>Size</i>	2.770*** (0.692)
<i>INV</i>	8.434** (4.161)
<i>BM</i>	-1.814*** (0.385)
<i>ATO</i>	-2.502** (1.220)
<i>TobinQ</i>	0.567** (0.275)
<i>ListAge</i>	-4.396*** (1.595)
<i>Balance</i>	1.932 (1.659)
<i>Constant</i>	-46.08*** (17.19)
<i>Industry</i>	Yes
<i>Year</i>	Yes
<i>N</i>	29140
<i>R²</i>	0.006

4.3 Robustness Tests

Alternative Measure of the Core Variable. This study employs an alternative approach to measure digital transformation by calculating the proportion of computer-based upgrading-the digital-related intangible intensity at the close of the fiscal year, as documented in corporate financial reports. This quantitative metric is used to reconstruct the Enterprise Digital Transformation Index (EDT), and its robustness is rigorously examined. As shown in Column (2)

of Table 4, the positive effect of digital transformation on sustained business ecological innovation continues to be statistically significant, thereby confirming the robustness of the baseline findings and providing further support for Hypothesis 1.

Lagged Explanatory Variable. To account for the time-lagged effects of computer-based upgrading on ecological advancement, and enduring character nature of ecological sustainability, this analysis re-estimates the specification with the lagged specification digital transformation index (Lag1 DCG). As documented in Table 4, Column (3), the parameter estimate endures as statistically significant at the 1% alpha level, with a point estimate of 1.554. These findings confirm that the research conclusions are robust to temporal considerations of the transformation process.

Table 4. Stability Analysis: After Exchanging and Lagging the Explanatory Parameter

Variable	Dependent Variable: Sustained Corporate Green Innovation	Dependent Variable: Sustained Corporate Green Innovation
	(1)	(2)
	<i>GPatent</i>	<i>GPatent</i>
<i>EDT</i>	1.500** (0.726)	
<i>Lag₁ DCG</i>		1.554*** (0.388)
<i>Controls</i>	Yes	Yes
<i>Industry</i>	Yes	Yes
<i>Year</i>	Yes	Yes
<i>N</i>	28587	26316
<i>R²</i>	0.006	0.006

4.4 Mediating Effect Econometric Estimation

In accordance with the mediating effect model formulated previously, the test empirical findings are presented in Table 5. First, the impact of corporate computer-based transformation on resource misallocation manifests a significant negative effect at the 5% threshold, pointing to the fact that computer-based upgrading substantially mitigates resource misallocation. Second, after incorporating the resource misallocation variable into the mechanism by which computer-based upgrading affects sustained corporate ecological advancement, the regression outcomes remain statistically significant. This demonstrates that computer-based upgrading can elevate sustained

ecological advancement, competence by reducing the degree of resource misallocation within firms. In conclusion, resource misallocation operates as an intermediary variable in the interdependence between computer-based upgrading and sustained corporate ecological advancement, thus supporting Hypothesis 2.

Table 5. Empirical Findings of Computer-based Upgrading, Resource Misallocation, and Sustained Business Green Innovation

Variable	Mediating Variable: Resource Misallocation	Dependent Variable: Sustained Corporate Green Innovation
	(1)	(2)
	<i>Overinvest</i>	<i>GPatent</i>
<i>Overinvest</i>		-0.244 (0.339)
<i>DCG</i>	-0.0139** (0.00685)	0.821** (0.368)
<i>Size</i>	0.0699*** (0.0129)	2.798*** (0.694)
<i>INV</i>	-0.229*** (0.0774)	8.384** (4.164)
<i>BM</i>	-0.00661 (0.00718)	-1.816*** (0.386)
<i>ATO</i>	-0.00759 (0.0228)	-2.533** (1.223)
<i>TobinQ</i>	-0.00690 (0.00511)	0.565** (0.275)
<i>ListAge</i>	0.126*** (0.0297)	-4.384*** (1.597)
<i>Balance</i>	0.0524* (0.0309)	1.932 (1.662)
<i>Constant</i>	16.147*** (0.250)	-3.353*** (0.415)
<i>Industry</i>	Yes	Yes
<i>Year</i>	Yes	Yes
<i>N</i>	18566	18566
<i>R²</i>	0.386	0.215

4.5 Heterogeneity Analysis

4.5.1 Heterogeneity in ownership nature

Divergences in management systems, institutional characteristics, and operational mechanisms lead to heterogeneous effects of computer-based upgrading on sustained ecological advancement, across firms across ownership structures natures. This investigation categorizes observed firms into state-affiliated enterprises companies and private-sector companies as per ownership classification for

separate empirical estimation tests. The empirical findings presented according to Columns (1) and (2) of Table 6, the coefficient for computer-based upgrading in SOEs is 1.823, constructive and significant at the 10% standard, while the the estimated parameter of non-SOEs is statistically insignificant. This points to the fact that the implementation of computer-based transformation strategies in SOEs has a more pronounced promoting influence on sustained green innovation capability compared to non-SOEs.

This disparity can be attributed to the following factors. First, as key pillars of the national economy, SOEs possess advantages in resource endowment and demonstrate stronger resource allocation capabilities. They are more inclined to cultivate specialized technical talent and place greater emphasis on leveraging human capital and technological advantages. Second, the inherent nature and functional positioning of SOEs enable them to better fulfill exemplary roles in implementing the requirements for developing the digital economy and Digital China, thereby contributing to the achievement of the "Dual Carbon" strategic goals. These comparative advantages ultimately translate into more steady improvements in sustained green innovation capability.

4.5.2 Firm size heterogeneity

Given the variations in digital transformation implementation across firms of different sizes, their capacity for sustained green innovation may correspondingly differ. This investigation divides the sample into large and small-to-medium-sized enterprise groups based on the central tendency of enterprise size, and conducts separate regressions to examine the differential impact of digital transformation on sustained green innovation. As shown in Columns (3) and (4) of Table 6, the coefficient for digital transformation (DCG) in large enterprises is 1.328, significant at the 5% level, while the coefficient for small-to-medium enterprises is 0.175 and statistically insignificant. This indicates that digital transformation strategies in large enterprises more effectively promote sustained green innovation capability. This can be explained by the inherent characteristics of sustained green innovation activities, which feature high risk, long cycles, and substantial trial-and-error costs. Compared to small-to-medium enterprises, large enterprises possess stronger asset bases and more robust risk

resilience, making them more willing to implement digital transformation strategies and fully leverage digital era benefits, thereby

leading and driving innovation industries toward green and sustainable development.

4.5.3 Growth heterogeneity

Table 6 Heterogeneity Analysis

Variable	Dependent Variable: Sustained Corporate Green Innovation (GPatent)					
	(1)	(2)	(3)	(4)	(5)	(6)
	SOEs	Non-SOEs	Large	SMEs	Low-Growth	High-Growth
<i>DCG</i>	1.823*	0.133	1.328**	0.175	1.856**	0.0601
	(2.58)	(0.31)	(0.648)	(0.181)	(0.803)	(0.281)
<i>Constant</i>	-28.43	-60.73**	-36.87	-26.50***	-112.50**	-42.09***
	(-0.75)	(-3.14)	(-3.14)	(8.71)	(47.90)	(12.13)
<i>Controls</i>	Yes	Yes	Yes	Yes	Yes	Yes
<i>Industry</i>	Yes	Yes	Yes	Yes	Yes	Yes
<i>Year</i>	Yes	Yes	Yes	Yes	Yes	Yes
<i>N</i>	10339	18801	15594	13546	12047	17093
<i>R</i> ²	0.009	0.005	0.008	0.007	0.012	0.005

Both high-growth and low-growth firms prioritize green innovation capability as a key focus for future development. To investigate whether the impact of digital transformation on sustained green innovation varies across firms with different growth levels, this study follows the approach of Tan et al. (2022) by dividing the data-set into above-average expansion and below-average growth firms based on the mean value of firm growth (Tobin's Q). The grouped regression findings are documented in Columns (5) and (6) of Table 6. The digital transformation parameter estimate (DCG) for low-growth firms is significantly positive at the 5% significance threshold, whereas the parameter estimate for the high-growth sample is statistically insignificant. This suggests that the enhancing influence of computer-based upgrading on continuous ecological advancement, capability is more pronounced in low-growth firms compared to their high-growth counterparts. A possible explanation is that low-growth firms, still in the production and manufacturing stage, face both market pressure and transformation opportunities. Consequently, they place greater emphasis on production capabilities and technological advancement, and are more committed to solidly promoting digital transformation to uncover more green development opportunities, thereby enhancing their sustained green innovation capability.

5. Conclusions and Implications

5.1 Research Conclusions

Drawing upon panel data from China's A-proportion listed companies spanning 2013 to

2022, this study systematically investigates the impact transmission of computer-based upgrading on firms' sustained green innovation capability, with particular focus on the mediating role of resource misallocation. The empirical analysis yields the following main conclusions:

Digital transformation significantly enhances firms' sustained green innovation capability. Baseline regression results indicate that higher degrees of corporate digital transformation correspond to more substantial growth in green innovation output. This suggests that the implementation of computer-based instruments can effectively promote continuous investment and innovation in green technology sectors, thereby validating Hypothesis H₁.

Resource misallocation functions as a transmission channel between computer-based upgrading and business ecological advancement. Results from mediation effect tests demonstrate that computer-based upgrading can indirectly strengthen ecological advancement, capability through optimizing resource allocation and reducing resource waste. This finding reveals the intrinsic mechanism through which computer-based upgrading influences ecological advancement, rendering aid for Hypothesis H₂.

The promoting influence of computer-based upgrading on green innovation exhibits significant dissimilarity. Specifically, government-owned corporations, large-scale establishments, and low-growth enterprises demonstrate stronger green innovation responses during digital transformation processes. This pattern may be attributed to these firms' advantages in resource endowment, risk resilience, and transformation motivations.

5.2 Research Implications

First and foremost, it is imperative to harness the digital economy as a dynamic engine to propel green and innovative development. Enterprises should accelerate their digital transformation initiatives, formulating tailored strategies based on their specific contexts to achieve deep integration of digital technologies with green innovation product processes. This synergy will empower firms to advance sustainable green innovation.

Simultaneously, organizations should focus on identifying and leveraging organizational slack to optimize resource allocation efficiency. To effectively alleviate resource misallocation, companies need to conduct comprehensive assessments and analyses of human, material, and financial resources. Achieving effective resource integration and sharing will contribute substantially to the steady enhancement of corporate green innovation capabilities.

Finally, establishing transparent information transmission mechanisms and enhancing green transparency is crucial. Regulatory authorities should strengthen disclosure supervision systems, actively improve information transparency, and accelerate the development of a green data ecosystem. These measures will significantly reduce information asymmetry both within firms and between firms and external stakeholders, thereby providing a solid foundation for sustained corporate green development.

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