

The Enterprise Green Transformation and Supplier Digitization

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Abstract: Clarifying the impact and role mechanism of enterprise green transformation on supplier digitization helps to promote the national supply-side structural reform, supply chain optimization, and high-quality economic development, and to inject a new impetus for the reform of digitization and greening of the global supply chain. Based on the supplier data and green transformation data of listed enterprises in the CNRDS database from 2008 to 2022, a fixed-effects regression analysis model is constructed to explore the role mechanism of enterprise green transformation on supplier digitization. It is found that corporate green transformation significantly promotes supplier digitization, and this conclusion still holds after a series of robustness. The key mechanism suggests that corporate green transformation promotes supplier digitization by increasing supply chain concentration and reducing supply chain risk. Further analysis shows that government subsidies and environmental regulations have different moderating effects. This paper provides a micro-foundation for promoting supplier digitization based on supply chain linkages, which has important implications for global supply chain restructuring and constructing a new pattern.

Keywords: Green Transformation, Supplier Digitization, Government Subsidies, Environmental regulations.

1. Introduction

In today's world, a new round of scientific and technological revolution and industrial change are flourishing, and digital technology is developing rapidly. The world economy has shifted from a stage of high-speed growth to a critical period of high-quality development, and there is an urgent need to take the development of a modern supply chain as the starting point. In this process, the digital development of enterprises, especially suppliers, is an inevitable requirement for modern supply chains.

Under the wave of global digitization, the digital economy has become a key force in restructuring the economic structure and transforming the competitive landscape. In recent years. The added value of the core industries of China's digital economy has continued to rise as a proportion of the gross domestic product and has become an important support and power source for the national economy. At the same time, supply chain digitization, as an important part of the digital economy, is of great significance in improving supply chain efficiency, reducing costs, and enhancing market competitiveness. China is closely connected to the global economy, and the reform of the intricate and highly coordinated supply chain system has received attention from many parties. With the

increase of geopolitical uncertainty and the rise of trade protectionist tendencies, the inherent risks of long-distance and geographically concentrated supply chains have come to the forefront, and the drivers of the digitization of China's supply chains, especially upstream suppliers, have become a focus of attention for all sectors.

Driven by multiple factors, enterprises have actively responded to the national call to accelerate the collaborative transformation, and have gradually promoted the transformation of existing facilities and technological innovation and upgrading, with a view to advancing the in-depth integration of industrial digitization and intelligence with greening. At present, China's ecological civilization construction has entered a new stage, and green development has become the consensus of the whole society. As the micro-body of the social economy, enterprises actively respond to the central policy, emphasizing the implementation of green transformation, and actively play a leading role in contributing to the green transformation of the supply chain. With the historic achievements of the country's green and low-carbon development, the pattern of green transformation of enterprises has been gradually established, bringing new impetus to the digital transformation of suppliers who are limited by factors such as technology, capital, and talent and face a lack of their own dynamism.

In summary, with the gradual promotion of GX of enterprises, the digital transformation of suppliers is facing new opportunities and challenges, and its development is complicated and diversified in terms of influencing factors and functioning mechanisms. Actively playing the role of midstream enterprises in the supply chain to transfer empowerment to upstream and downstream enterprises, and promoting enterprise GX have an important impact on the establishment of the supplier digitalization pattern. This paper attempts to focus on the development pattern of supplier digitization in the context of enterprise GX and actively explores the role of GX affecting supplier digitization from the perspective of supply chain relationships. Compared with existing research, this paper has the following innovations: First, the influence factors of digital transformation of upstream enterprises focusing on supply chain relationships have not been fully studied in the academic community, which helps expand and focus on the GX of enterprises. Secondly, focusing on the supply chain relationship and the transmission mechanism affecting the digital transformation of suppliers not only helps to reveal the interaction mechanism between the behaviors of enterprises within the supply chain but also provides new perspectives and practical paths for the overall digital transformation of the supply chain.

2. Literature Review

The impact of enterprise GX can be divided into the impact on the enterprise itself and the impact on the external environment. Research on the impact on enterprises mainly focuses on enterprise performance. Qi Yunnan believes that GX has a significant positive impact on enterprise performance under the positive regulation of stakeholder orientation[1]; Luo Wenxin focuses on the heavy pollution industry and believes that GX hurts enterprise performance under the regulation of managerial remuneration[2]. On the influence of enterprises on the outside world, Gong Xiaojing argues that corporate GX can significantly improve the quality of information disclosure[3] Jiang Yuanyuan et al. argue that corporate GX promotes audit quality by affecting corporate transparency[4]. In the segment of supply chain, Li Qiang et al. argues that corporate GX realizes the impact on supply chain enterprises through pressure mechanism, knowledge spillover mechanism, and ecological network synergy mechanism[5]. Li Yuanqin et al. argue that supplier and customer GX can improve corporate ESG levels by managing knowledge resources, financial resources, and technology resources sharing channels[6].

Enterprise digitalization is affected by a variety of factors, mainly focusing on two major perspectives: internal factors and external factors. Among the internal factors, Yu Yuanyuan et al[7] pointed out that an entrepreneurial-oriented strategy significantly improves the level of enterprise

digital transformation under the moderation of executive power, average tenure, and educational background. The research on external factors mainly focuses on both environment and policy. In terms of environmental factors, Chen Fang and Zhu Xiaoqian think that trade facilitation helps enterprise digital transformation through cost effect, innovation effect, and risk-taking effect[8]. Other scholars believe that finance is an important factor affecting enterprise digitalization, and Cui Hao et al. show that fintech helps enterprises carry out digital transformation through three paths, including information optimization, risk-bearing capacity leap, and digital innovation vitality enhancement[9]. In terms of policy factors, Liu Kai et al. believe that the pilot policy of the Pilot Free Trade Zone can significantly promote the digital transformation of enterprises by alleviating the financing constraints of enterprises and improving the efficiency of enterprise agency[10]. Of particular interest, scholars have shown that supply chain relationships have a significant impact on enterprise digital transformation, with Li Xiangrong et al. pointing out that both supplier and customer concentration have a single-threshold effect on enterprise digital transformation[11].

In summary, academics have conducted extensive research on the impact of enterprise GX and the influencing factors of digitization, which provides some theoretical support for revealing the relationship between the two. This paper will make supplementary expansion of existing research in the following aspects: first, this paper examines the impact of corporate GX on supplier digitization through the supplier microdata; Second, we empirically test the existence and effect of the mechanism and analyze the moderating effects of government green subsidies and environmental regulations.

3. Theoretical analysis and research hypotheses

3.1. The impact of corporate GX on supplier digitalization

The behavior of midstream enterprises can have an impact on upstream suppliers. Based on the transaction cost theory, to reduce the potential costs due to supplier non-compliance in the transition process[12], enterprises will choose to reduce the number of trading partners, establish long-term cooperative relationships, and realize the influence on supplier behavior through resource sharing. Meanwhile, according to Porter's hypothesis, enterprises, as a key link in the supply chain, are imposing external regulation on suppliers by setting higher standards and purchasing requirements, prompting suppliers to carry out technological innovation and process reengineering to comply with enterprise standards.

Based on this, Hypothesis 1 is formulated.

H1: Enterprise GX has a facilitating effect on supplier digitalization.

Supply chain concentration reflects the transactional relationship and dependence between enterprises and suppliers. From the perspective of the supply chain, the behavior of enterprises often produces a significant "spillover effect" on their suppliers. According to the theory of enterprise reengineering, to meet the needs of downstream enterprises, suppliers have to re-examine their internal processes, improve production efficiency, reduce production costs, and comply with environmental standards. Specifically, with the GX of enterprises, the demand structure of their products or services has shifted greatly, corresponding to the gradual focus of the range of suppliers. Limited market share in the competitive situation between suppliers tends to be fierce, suppliers have to seek new paths of technological innovation and efficiency improvement, and digital transformation becomes a key strategy for suppliers to enhance competitiveness.

Enterprise GX through the introduction of green technology, optimizes production processes to achieve the optimization of the supply chain, not only to enhance the sustainability and stability of the supply chain but also to promote collaboration between the upstream and downstream enterprises. This transformation is conducive to the effective operation of the information and risk-sharing mechanism, thus significantly reducing the uncertainty factors and potential risks in the supply chain,

which creates a more stable environment for enterprises and suppliers. It is conducive to their access to the necessary resources and conditions for digital transformation, and also strengthens the suppliers' confidence and motivation in digital transformation, and helps the exploration of digital transformation.

Based on this, this paper proposes Hypothesis 2.

H2a: Corporate green transformation promotes supplier digitization by increasing supply chain concentration.

H2b: Corporate green transformation promotes supplier digitization by reducing supply chain risk.

3.2. Regulatory effects of government subsidies and environmental regulations

As an external incentive, government subsidies are widely used to promote GX. However, when enterprises rely excessively on government subsidies, it may weaken their endogenous motivation for GX - enterprises reduce their investment in green technology and instead use their resources for other projects with higher short-term returns. When the GX of enterprises mainly relies on government subsidies, the depth and breadth of transformation may be limited, and in the long run, the hidden risks of the supply chain are aggravated, which in turn affects its effect on the digitization of suppliers. At the same time, subsidy-driven transformation often lacks inherent innovation and competitiveness, which leads to the weakening of the enterprise's influence in the supply chain, and thus fails to influence suppliers' transformation effectively.

Environmental regulation can constrain the pollution behavior of enterprises, and force them to carry out GX by increasing their environmental management costs[13]. From the cost-driven point of view, environmental regulations increase the environmental cost, forcing suppliers to seek more efficient, more environmentally friendly production methods, digital transformation has become an important means to reduce costs and improve efficiency. From the policy guidance point of view, government policies have a direct impact on supplier behavior. Government policy incentives and other means can guide the behavior of enterprises, including suppliers, combined with the inherent binding force of the policy, both of which jointly promote the digitalization process. On the other hand, government policies indirectly influence supplier behavior by influencing corporate behavior in the supply chain. The policy requirements of the midstream enterprises will give preference to suppliers with a higher degree of digitization, thus promoting the digitization process of suppliers.

Based on this, this paper proposes Hypothesis 3.

H3a: Government subsidies will negatively regulate the promotion of supplier digitization by enterprises' GX.

H3b: Environmental regulation intensity positively moderates the facilitating effect of corporate GX on supplier digitization.

4. Research Design

4.1. Model Setting and Variable Selection

To test the relevant theoretical research hypotheses, this paper constructed the following panel data model, which was estimated using fixed-effects regression analysis.

$$Dig_supplier_{it} = \beta_0 + \beta_1 GX_{it} + \sum_{j=2}^T \beta_j control_{it}^j + \gamma_i + \mu_t + \varepsilon_{it} \quad (1)$$

Where i denotes the enterprise stock code; t denotes the period; the $Dig_supplier_{it}$ represents the degree of the supplier's digital development, and the number of sentences with digital keywords appearing in the annual report of the supplier is specifically adopted as a proxy for the supplier digitization, and the selection of digital keywords integrates the existing research results. The core

explanatory variable GX_{it} denotes the GX of enterprises, which is expressed by the total amount of green patents granted by enterprises. *Control* denotes a series of control variables, γ_i denotes time fixed effect, μ_t denotes the province fixed effect, and ε_{it} is a random disturbance term.

In order to control the influence, the enterprise size (Size), asset-liability ratio (Lev), the shareholding ratio of the top five shareholders (Top5), the growth rate of operating income (Growth), and degree of industry competition (HHI) are selected.

The descriptive statistics of the variables are shown in Table 1.

Table1: Descriptive statistics of variables

variable	N	mean	p50	sd
Dig_sup	1051,000	34,601	17,000	54,043
GX	1051,000	4,674	0,000	29,779
Size	974,000	22,238	21,968	1,354
Lev	974,000	0,438	0,416	0,203
Top5	974,000	0,547	0,547	0,152
Fixed	973,000	0,249	0,214	0,182
Growth	972,000	0,153	0,100	0,440
HHI	1041,000	0,159	0,112	0,137

4.2. Sample selection and data sources

This paper uses data from the top five suppliers disclosed by Chinese listed companies from 2008 to 2022, and 1052 samples were obtained after cleaning. Supplier digitization data comes from the CNRDS database of listed companies' digital transformation database, and enterprise GX data comes from the CNRDS green patent database. Some of the control variables data originate from sourced from the CNRDS database.

5. Analysis of empirical results

The regression results of the benchmark model are shown in Table 2, in which the coefficients of the core explanatory variables in columns (1)-(5) are all significantly positive, indicating that enterprise GX can significantly promote suppliers' digital development. Among them, column (1) is the result of ordinary OLS estimation, and columns (2)-(5) are the estimation results of year-fixed effects, province-fixed effects, double-fixed effects of year and province, robust standard errors, and clustered standard errors. From the overall regression results of the sample: after controlling for year and province fixed effects, there is a significant positive correlation between supplier digitization and firms' GX, for every 1% increase in the total number of green patents granted by firms, supplier digitization increases by 0.1193%, which is significant at the 1% level is positive. Overall, enterprise GX has a significant contribution to supplier digitization.

Table 2: Baseline regression results

	(1)	(2)	(3)	(4)	(5)
	Dig_sup	Dig_sup	Dig_sup	Dig_sup	Dig_sup
GX	0.1555***	0.1132**	0.1514**	0.1159***	0.1159***
	(2.5830)	(1.9629)	(2.5232)	(2.7260)	(3.4621)
Size	-0.6810	-3.9907**	-2.1839	-5.7720***	-5.7720**
	(-0.3963)	(-2.3803)	(-1.1873)	(-3.4386)	(-2.4816)
Lev	-27.5566**	-6.6978	-21.0071*	-1.1807	-1.1807

Table 2: (continued).

	(-2.5323)	(-0.6323)	(-1.8675)	(-0.1186)	(-0.0947)
Top5	-36.8979***	-26.1461**	-42.8512***	-32.4167**	-32.4167*
	(-3.0077)	(-2.2043)	(-3.3089)	(-2.4093)	(-1.7774)
Growth	2.1714	1.4439	1.4405	0.9509	0.9509
	(0.5403)	(0.3715)	(0.3553)	(0.1639)	(0.1699)
HHI	1.7036	19.1203	5.7436	24.5154**	24.5154
	(0.1336)	(1.5444)	(0.4458)	(2.0568)	(1.2809)
_cons	81.1331**	107.1495**	102.2465***	127.6420***	127.6420***
	(2.3364)	(2.4319)	(2.6720)	(4.2553)	(3.0895)
Year	No	Yes	No	Yes	Yes
Province	No	No	Yes	Yes	Yes
N	964	964	964	964	964
adj. R ²	0.019	0.112	0.052	0.150	0.150

t statistics in parentheses

* p < 0.1, ** p < 0.05, *** p < 0.01(Same below)

In this paper, we first use the replacement variable method to test the robustness, of columns (1)-(2) use the word frequency statistics of digitized keywords in suppliers' annual reports, and the total number of enterprise green patent applications, the results are highly similar to the benchmark regression. Secondly, considering that the enterprise fixed asset ratio is closely related to the production of enterprises, the enterprise fixed asset ratio variable will be added in column (3). Then the sample period is adjusted, and the estimation results are shown in column (4). Considering the accelerated digitization process of the whole industrial chain due to the “promotion of industrial digital transformation” in 2021, the sample is adjusted to the period of 2008-2020, and the results effectively support the conclusion.

Table3: Robustness test

	(1)	(2)	(3)	(4)
	Dig sup	Dig sup	Dig sup	Dig sup
GX	0.1447***	0.1502**	0.1193***	0.1967**
	(2.6888)	(2.0242)	(2.7594)	(2.2164)
controls	Yes	Yes	Yes	Yes
FIXED			-35.0007***	
			(-3.8092)	
_cons	174.8113***	122.8812***	106.1509***	113.4678***
	(4.0613)	(4.1501)	(3.6295)	(2.7397)
N	964	964	963	758
adj. R ²	0.133	0.151	0.160	0.147

6. Analysis of empirical results

To verify whether GX can promote the increase of supply chain concentration, the Herfindahl-Hirschman index is calculated as a proxy variable for supply chain concentration. Column (1) of Table 4 shows that corporate GX can significantly increase supply chain concentration[14]. To verify whether GX can reduce supply chain risk, reference is made to Liu Qiren et al[15] using the deviation

of firms' production fluctuation from demand fluctuation for measurement. Column (2) of Table 4 shows that the GX of enterprises can significantly reduce supply chain risk.

Table 4: Mediation effect test

	(1)	(2)
	SC_concentration	SC_risk
GX	0.0484**	-0.0002*
	(2.3645)	(-1.7820)
controls	Yes	Yes
cons	27.5323**	0.5477***
	(2.3002)	(3.6404)
N	956	895
adj. R ²	0.015	0.026

The percentage of green subsidies divided by total business revenue is taken as a measure of government green subsidies. The regression results are shown in Table 5, column (1) and column (2), the government green subsidies have a significant negative moderating effect on the promotion of corporate GX on supplier digitalization. The amount of money invested in pollution control of waste gas and wastewater in the year in the region where the listed companies are located as a proportion of the industrial output value in that year is used as a measure of environmental regulation intensity. The regression results are shown in Table 5, Column (3) Column (4), the environmental regulation intensity significantly strengthens the promotion effect of enterprise GX on supplier digitalization, and the hypotheses H3a and H3b are verified.

Table 5: Moderating effect test

	Green Subsidies		Environmental regulations	
	(1)	(2)	(3)	(4)
	Dig_sup	Dig_sup	Dig_sup	Dig_sup
GX	0.1493***	0.1557***	0.1326***	0.8781***
	(3.8534)	(3.9112)	(3.4104)	(3.6104)
Regulatory	-2.7783***		-5.2317***	
	(-3.4540)		(-4.6969)	
M1		-0.0765***		0.4381***
		(-4.7352)		(3.2511)
controls	Yes	Yes	Yes	Yes
cons	68.3616**	82.2424***	96.7117***	94.0838***
	(2.2048)	(2.7898)	(3.2803)	(3.0681)
N	964	964	964	964
adj. R ²	0.019	0.018	0.054	0.031

7. Heterogeneity analysis

Based on the National Bureau of Statistics classification standards for the East and West economic zones, suppliers are categorized into three categories. The results of the sequential regression are shown in columns (1)-(3) of Table 6. The core explanatory variables of suppliers in the central and western economic belt did not pass the significance test, and the core explanatory variables of the eastern economic belt had a significant positive coefficient of 0.1314. Given the higher level of

economic development in the eastern economic belt, compared with the central and western economic belt, the supply chain concentration and transparency may be higher, which is highly consistent with the promotion mechanism of enterprise green transformation on suppliers' green transformation; while the supply chain of suppliers in the center and west may be at high risk, and the supply chain transmission mechanism may still be in the stage of development and improvement.

Suppliers are categorized into regulated and non-regulated industries based on the industry, and the regression results are shown in columns (4)-(5) of Table 6. Both of the core explanatory variables through the significance test, the core explanatory variables of the non-regulated industry suppliers coefficient are significant at the 95% confidence level, while the core explanatory variables of the regulated industry suppliers coefficient are significant at the 90% confidence level. The Dig_supplier coefficient of non-regulated industry suppliers is significantly higher than that of regulated enterprises, which is 0.4909, indicating that the green transformation of enterprises has a greater digitalization promotion effect on non-regulated industry suppliers than that of regulated industry suppliers. This may be since the behavior of suppliers in regulated industries is more influenced by policies, and they do not respond adequately to supply chain mechanisms, making it difficult for the green transformation mechanism to work effectively.

Table 6: Heterogeneity Analysis

	(1)	(2)	(3)	(4)	(5)
	West	Middle	East	Non-regulated	Regulated
GX	1.3592	0.5594	0.1314**	0.4909**	0.1311*
controls	Yes	Yes	Yes	(2.4230)	(1.8759)
	(1.1771)	(1.2335)	(2.2593)	Yes	Yes
_cons	178.1352**	118.3044	63.4538	163.8627***	86.4335*
	(2.2074)	(1.4133)	(1.5015)	(3.0746)	(1.6524)
N	128	252	584	538	426
adj. R ²	0.022	0.043	0.018	0.030	0.036
Empirical p-values	Prob > chi2 = 0.0436**			Prob > chi2 = 0.0592	

8. Conclusion and Recommendation

In the current new round of scientific and technological revolution and industrial change in the ascendant, the efficient and high-quality supply chain is an important guarantee for the high-quality development of the industry, as the upstream transformation of the supplier behavior has increasingly become a major impetus to promote the optimization and upgrading of the supply chain. As an important micro-body of society, the supporting role of enterprises should not be ignored. The impact of the green transformation of enterprises on the digitalization of suppliers and its path of action will provide a new perspective for the assessment of the supply chain transmission mechanism, which has theoretical value and can guide the supply chain to optimize and upgrade comprehensively.

To this end, based on the supplier and GX data of listed enterprises from 2008 to 2022, this paper explores the effect of GX on supplier digitization and its path by using fixed-effects regression analysis. The empirical results show that enterprise GX has a significant promotion effect on supplier digitization; the estimation results are still robust after a series of robustness tests. Heterogeneity tests show that GX has a significant incentive effect on supplier digitization for firms located in the eastern economic belt, but not for firms in the central and western parts of the country and that GX is a stronger driver of supplier digitization in regulated industries than in non-regulated industries. The mechanism test finds that GX promotes supplier digitization by increasing supply chain concentration and reducing supply chain risk. The moderating effect shows that government green subsidies can

negatively modulate the promotion effect of regional GX on OFDI, while the opposite is true for the intensity of environmental regulations.

Based on this, this paper puts forward the following three recommendations: First, the government should improve the supply chain transmission mechanism, encourage midstream enterprises to transform, and then drive the digitalization process of upstream and downstream enterprises. Through policy guidance and financial support, the government should promote information sharing and cooperation among supply chain enterprises. Secondly, suppliers should actively respond to the needs of GX of enterprises, improve their digitalization level, explore new modes and paths of green digital transformation with partners, and promote the optimization of the supply chain through information sharing and synergy. Thirdly, enterprise managers should clarify the strategic goal of GX, and promote the innovative practice in supply chain management. At the same time, they should rationally view government subsidies and enhance the endogenous motivation of enterprises.

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