

Impact of Digital Transformation Peer Effects on Corporate Welfare: Evidence from China's A-Share Listed Grain-Related Enterprises

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Food security is vital to national security, and digital transformation boosts grain firms' competitiveness. This paper explores the relationship between digital transformation peer effect, and corporate welfare, using the data of China's Shanghai and Shenzhen A-share listed grain-related enterprises from 2012 to 2023 as a sample. The study reveals substantial positive regional and "industry" peer effects stemming from the digital transformation of grain-related enterprises, both of which can improve corporate welfare, as demonstrated by a number of robustness and endogeneity tests. Mechanism tests indicate that the digital transformation peer effects of grain-related enterprises enhance corporate welfare by alleviating financing constraints and improving technological innovation; corporate ESG performance amplifies the impact of this peer effect on corporate welfare. Heterogeneity analysis reveals that the digital transformation peer effects of grain-related enterprises have a more significant effect on the welfare enhancement of industry-leading enterprises, enterprises in non-major grain-producing regions, and mature enterprises.

Keywords: Digital Transformation Peer Effect; Welfare; Finance Constraints; Technological Innovation; Corporate ESG Performance.

Introduction

The strategic significance of food security, as a fundamental aspect of national security and global governance, has been increasingly highlighted in the digital economy era. With the advancement of the global economy and the enhancement of living standards, the structure of global food consumption is experiencing a paradigm shift from "quantity security" to "quality enhancement," evident in the structural changes of diversified demand, refined quality, and sustainable production. This transition has imposed elevated demands on the advancement of the food industry chain across many nations. Since Bowman (1996) introduced the concept of the digital economy, there has been a global consensus regarding the transformative impact of digital technology on industrial change. Amid various challenges, including heightened vulnerability of the global food supply chain, escalating market price volatility, and stringent resource and environmental limitations (Miao *et al.*, 2025; Ansari *et al.*, 2023), digital transformation has emerged as a crucial strategy to redefine the competitive

advantage of the food industry. The extent of digital transformation in grain firms affects not only their operational efficiency but also significantly influences the value advancement of the entire grain industry chain.

China, as a significant agricultural and populous nation, provides helpful information regarding the digital transformation of grain industries that may serve as a reference for similar initiatives in other countries, particularly in emerging nations. The Chinese government is actively facilitating the digital transformation of grain enterprises to improve their market competitiveness and address constraints related to production factors and other issues in the grain industry, thereby fostering high-quality development in the sector. Despite certain successes in the digital transformation of Chinese grain firms, the overall outcomes remain unpromising. The comprehensive digital revolution of agriculture is both inadequate and inefficient (Sun *et al.*, 2024). According to the Research Report on China's Digital Economy Development (2024) published by the China Communications Academy, in 2023, the digital economy penetration rates of China's agriculture, industry

and service industry will be 10.78 %, 25.03 % and 45.63 % respectively, indicating that the overall digital transformation of agriculture is insufficient. The inherent fragility of the grain industry results in elevated comprehensive costs for grain enterprises and an extended return on investment cycle, thereby increasing the expenses associated with digital transformation for certain grain enterprises. Consequently, the benefits are minimal, with only a select few leading enterprises reaping the rewards of digital transformation. This has led numerous grain firms to adopt a “wait-and-see” approach, reluctant to pursue digital transformation.

Scholars in academia are currently examining the challenges of enterprise digital transformation, investigating its drivers through the lenses of digital technology, managerial capability, and governmental influence (Eller *et al.*, 2020; Stentoft *et al.*, 2021). The viewpoints on innovation capabilities (Wen *et al.*, 2022; Gaglio *et al.*, 2022), organizational performance (Bouwma *et al.*, 2019; Lozano-Almansa *et al.*, 2023), and ESG performance (Wang & Esperanca, 2023; Lu *et al.*, 2024) were examined. Examining the ramifications of corporate digital change. As grain enterprises undergo extensive digital transformation, the interaction and communication among internal and external stakeholders are increasingly enhanced. The decision-making regarding digital transformation is influenced not only by the enterprises’ own resource endowment but also by external environmental factors and stakeholders, reflecting the peer effect of digital transformation in grain enterprises. The digital transformation peer effect in the grain industry facilitates the integration and advancement of production technology, agricultural scientific talent, and agricultural big data among enterprises within the same group, bridges technological disparities between food enterprises, fosters synergistic development, and ensures national food security. Consequently, it is crucial to enhance research on the peer effect of digital transformation in grain enterprises and its implications for welfare, to expedite the digital transformation of Chinese grain enterprises, elevate enterprise welfare, and facilitate the transformation and upgrading of the grain industry, while also offering insights for the digital transformation of agriculture in other nations.

Several scholars have undertaken initial investigations into the peer effect of enterprise digital transformation. Ren *et al.* (2023) analyzed data from Chinese A-share listed companies utilizing a panel model to validate the presence of industry and geographic peer effects on enterprise digital transformation, establishing that the digital transformation peer effect enhances enterprise environmental performance. Chang *et al.* (2024) employed a benchmark panel model to validate the presence of an industry peer effect across firms and established that the digital transformation peer effect enhances company environmental performance. Zheng *et al.* (2025) employ data from retail industry research in Zhejiang Province, China, and utilize spatial econometric models to validate the presence of spatial peer effects in the digital transformation of retail firms. Current research predominantly examines A-share listed businesses, such as those in the high-tech and advanced manufacturing sectors, whereas there is a notable deficiency of studies pertaining to the grain industry. The grain industry’s digital transformation

is distinct from other sectors due to the inflexibility of the production cycle, the loose integration of supply networks, and delayed technology adoption. Consequently, it is imperative to enhance the investigation of the peer effect of digital transformation in grain firms.

This article analyzes Chinese A-share listed grain-related enterprises in Shanghai and Shenzhen from 2012 to 2023, systematically addressing three research objectives. First, the geographical lag model is employed to ascertain the presence of regional and “industry” peer effects in the digital transformation of grain-related enterprises, thereby offering theoretical insights on the strategies and dynamics of their digital transformation. Second, the panel model is used to explore the impact of digital transformation peer effects of grain-related enterprises on corporate welfare. Peer effects can facilitate technological progress of enterprises, reduce the costs of digital transformation, and provide solutions to the dilemmas faced by grain enterprises in their digital transformation. Third, financing constraints, technological innovation, and corporate ESG performance are incorporated into the research framework to validate their mechanistic roles in digital transformation peer effects of grain-related enterprises on corporate welfare, thereby bolstering the confidence in the digital transformation of grain enterprises.

This paper proposes potential innovations by categorizing grain-related enterprises into production end and distribution end as “industry” peer enterprises. This enriches the research perspective of the peer effect of digital transformation of grain enterprises. The study examines the impact of digital transformation peer effects of grain-related enterprises on corporate welfare and its mechanism of action, providing new impetus for grain-related enterprises to advance their digital transformation.

Theoretical Analysis and Research Hypotheses

The Digital Transformation Peer Effect in Grain-Related Enterprises

The regional peer effect means that firms in the same area might make similar choices because they share things like location, natural resources, rules, and better access to information, among other reasons. First, grain-related enterprises, particularly those involved in production, are significantly reliant on geography and natural resources for their operations (Duram & Oberholtzer, 2010). Grain-related enterprises within the same region often align in their competitive market positions due to the natural restrictions they encounter. Consequently, when a grain-related enterprise in an area experiences digital change, it is often more compelled to advance its own digital transformation to sustain its competitive standing. Second, as a national strategic resource, grain firms play a pivotal role in the overall national economy, rendering them more vulnerable to the impact of government policies than typical enterprises. To acquire additional resources for expansion, grain firms frequently possess a heightened intrinsic motivation to pursue government backing to bolster their competitive advantage in the market. Chinese governmental entities at all tiers have proactively implemented diverse policies and laws to facilitate the digital transformation of

firms (Wu *et al.*, 2021). Grain-related enterprises within the same region encounter identical policy directives. When some leading grain companies take the initiative to follow the government's push for digital transformation and achieve clear results, the main grain companies will be encouraged to also pursue digital transformation to gain more government support and maintain their market competitiveness, aiming for long-term growth. The preceding analysis posits hypothesis 1.

Hypothesis 1: A significant positive regional peer effect of digital transformation exists in grain-related enterprises.

The industry peer effect denotes that within a particular industry, firms may adopt analogous strategic decisions owing to factors like mutual learning, collaboration, or competitiveness, stemming from the resemblance of their production processes and goods. The vertical division of labour in the grain sector delineates the industrial chain into two segments: the production end (grain cultivation) and the distribution end (grain procurement, storage, processing, logistics, and sales). This article categorizes the sample firms into production-side and distribution-side entities based on the embeddedness of their core operations. The strategic ecology theory posits that grain-related enterprises within the same production or distribution sector encounter resource overlap and competitive pressures, compelling them to consistently observe the strategic movements of their industry counterparts and dynamically adapt their strategies to sustain competitive advantages. Conversely, when a specific peer of grain-related firms within the "industry" leverages digital transformation to attain a competitive edge, the primary grain-related enterprises will prioritize the beneficial effects of digital transformation. This competitive advantage may manifest in enhanced grain product quality, sophisticated grain production and processing technology, and market adaptability. Grain-related enterprises might expedite their digital transformation by analyzing the successful transformations of their peer organizations. Conversely, due to the low profitability of the grain sector, particularly in grain production (Watson & Findlay, 1999), grain-related enterprises have constrained risk-taking capacity. Successfully adopting digital transformation in the grain industry can help main grain companies reduce risks, cut down on digital transformation costs, and deal with the tendency to avoid taking risks in transformation. Based on this previous research, hypothesis 2 is proposed.

Hypothesis 2: A notable positive "industry" peer effect of digital transformation exists in grain-related enterprises.

The Impact of Digital Transformation Peer Effects on Corporate Welfare in Grain-Related Enterprises

Referring to the study of Fedele and Depedri (2016), the corporate welfare in this paper mainly refers to focusing on the welfare enjoyed by the producer groups directly involved in the core links of food production, processing, and distribution, i.e., producer welfare. This paper specifically analyzes three aspects of how the peer effect of digital transformation in grain-related enterprises impacts corporate welfare. According to endogenous growth theory,

technological advancement and innovation within firms are critical determinants for ensuring sustained development. The digital transformation peer effects can influence the grain industry chain via digital technology spillover, thereby enhancing the quality and service level of raw grain and processed grain products. The technological advancements resulting from the digital transformation peer effects can assist grain production firms in minimizing production costs and enhancing the quality of raw grain. Digital transformation provides circulation firms with technological advancements and extensive big data resources, enabling them to minimize processing and transportation losses, decrease the defect rate of grain products, and promptly address market demand. The theory of information transmission posits that unimpeded information routes and proficiency in current market data can enhance firms' understanding of market demand and risk perception. The digital transformation peer effects dismantle information silos via digitalization initiatives like blockchain traceability and data-sharing platforms, facilitating real-time data interoperability and transparent management of food production, procurement, processing, distribution, and consumption. This not only assists grain-related enterprises in mitigating the dangers linked to information asymmetry, but also enhances information resources, optimizes resource allocation, and elevates operational efficiency. The theory of production factors posits that mastery of essential production elements is fundamental for the sustained development of enterprises. As the digital economy evolves, data has emerged as the fifth principal element of production. The digital transformation peer effects of grain-related enterprises integrate advanced digital technology, data, and additional resources into the industry, facilitating comprehensive digital upgrading and transformation of the food sector. This approach enables grain-related enterprises to leverage modern technology alongside traditional production aspects to enhance grain production, elevate processing standards, minimize distribution costs, and promote corporate welfare. Hypothesis 3 is proposed based on the above analysis.

Hypothesis 3: Digital transformation peer effects of grain-related enterprises are conducive to enhancing corporate welfare.

An Analysis of the Mechanisms by Which Digital Transformation Peer Effects Affect Corporate Welfare

The mediating role of financing constraints. The grain industry is characterized by high asset specialization, long production cycles, and exogenous natural risks (Huang & Rozelle, 1995; Zhong *et al.*, 2014). These characteristics make it difficult for financial institutions to accurately assess the operational quality of grain-related enterprises, which can easily lead to the problem of adverse selection and thus aggravate the financing constraints of related enterprises. Digital transformation peer effects of grain-related enterprises might successfully mitigate this problem. In the regional peer effect, grain-related enterprises can work together to gather and share information about grain production, storage, and distribution, which helps them create a single database from their separate data. This process enhances the collective credit assets of the grain-

related enterprises, hence increasing financial institutions' valuation of the financing collateral and mitigating financing challenges arising from information asymmetry. Secondly, in the "industry" peer effect, grain-related enterprises can use the digital systems of other companies to turn production data into a basis for getting financing, which helps solve the traditional problem of the grain industry being low on assets and data. Adequate capital can provide support for firms to increase innovation investment, which in turn improves innovation efficiency (Ullah, 2019; Zhang *et al.*, 2024), enhances firms' profitability, and ultimately improves corporate welfare. Hypothesis 4 is proposed based on the above analysis.

Hypothesis 4: Digital transformation peer effects of grain-related enterprises can enhance corporate welfare by alleviating financing constraints.

The mediating role of technological innovation. The grain industry distinguishes itself from the general manufacturing industry with its industry-specific technological innovation. Grain-related enterprises at the production end tend to adopt technological innovations that improve grain production efficiency, while enterprises at the distribution end pay more attention to technological innovations that realize grain loss reduction in the whole process. The technological innovation promoted by the digital transformation peer effect of grain-related enterprises is conducive to the technological innovation of the entire grain industry. First, from the standpoint of technology diffusion, the majority of innovations propagated through the peer effect are digital solutions tailored to the grain business. Grain-related enterprises within the same cluster collaborate to develop and share extensive data on grain inspection, blockchain traceability, and other digital information technologies, thereby enhancing production efficiency and enabling comprehensive traceability of data from cultivation to consumption of grain. Second, from the standpoint of technology diffusion intensity, the relationship between the production side and the distribution side has enhanced the overall innovation level of the industry. The digital innovation in grain enterprises at the production side emphasizes extensive cultivation, whereas those at the distribution level concentrate on processing and distribution to minimize losses. This division of labor, arising from distribution-side resource endowment, has enhanced the overall technological innovation within the grain industry. Improvement in the level of technological innovation of enterprises can significantly reduce production costs, enhance profitability and market value, and thus ultimately improve the welfare of enterprises. Hypothesis 5 is proposed based on the above analysis.

Hypothesis 5: Digital transformation peer effects of grain-related enterprises can enhance corporate welfare by improving technological innovation.

The moderating role of corporate ESG performance. Contemporary corporate governance and stakeholder theory mandate that corporations must be accountable not only to shareholders but also to employees, society, the environment, and other stakeholders (Freeman, 1984) to optimize the collective interests of all stakeholders. Corporate ESG performance refers to the comprehensive evaluation of companies from three dimensions:

environmental dimension, social responsibility dimension, and governance dimension. From the environmental perspective, grain-related enterprises that demonstrate high environmental performance can mitigate transformation risks by integrating "green technology + digital tools" while adopting the digital transformation strategies of their peer grain-related enterprises. In addition, the digital transformation of grain-related enterprises with high environmental performance can enhance their social image, increase consumer trust in their food products, and expand their market share to support the improvement of corporate welfare. From the social responsibility perspective, grain-related enterprises can build trust and share resources more quickly by learning from the successful digital changes of others, which helps them improve their own digital efforts, increase profits, and become "leaders" in the grain industry's digital transformation. By studying and emulating the "leaders" among peers, the targeted grain-related enterprises can enhance their digital transformation and ultimately achieve corporate welfare growth. From the governance perspective, grain-related enterprises with high governance can avoid blind imitation through institutional design, ensuring that the transformation results are accurately transformed into welfare. In addition, grain-related enterprises with a high level of governance can disclose the effectiveness of digital transformation more transparently, which enhances the trust of investors and society and injects financial impetus for sustained welfare enhancement. Hypothesis 6 is posited based on the preceding study.

Hypothesis 6: Corporate ESG performance positively moderates the relationship between digital transformation peer effects and corporate welfare in grain-related enterprises, as well as the environmental, social responsibility, and governance dimensions of corporate ESG.

Study Design and Description of Variables

Model Setting and Estimation Methods

Peer effects test. The literature confirms that spatial econometrics may detect spatial relationships (Lee & Yu, 2010a). This work creates a spatial lag econometric model, referencing the study by Deng and Zhao (2018), to detect the peer effects in the digital transformation of grain-related enterprises. The model is as follows:

$$DIG_{it} = \alpha_1 + \rho WDIG_{it} + \beta_1 X_{it} + \mu_i + \eta_t + \varepsilon \quad (1)$$

In equation (1), DIG_{it} is the level of digital transformation of grain-related enterprise i in the year t , X_{it} is the covariate affecting the level of digital transformation of grain-related enterprise, μ_i represents individual fixed effects, η_t represents year fixed effects, and ε is the error term. W represents the normalized spatial weight matrix. $WDIG_{it}$ is the spatial lag term, which can be interpreted as the average value of the digital transformation level of the peer grain-related enterprises other than the focal grain-related enterprise, and the coefficient ρ that represents the spatial regression coefficient, which can also be used to measure the peer effects of the digital transformation decision of the focal grain-related enterprise

with other grain-related enterprises. This paper adopts the following two methods to overcome the endogeneity problem of the spatial econometric model: first, the spatial matrices used are all exogenous, and there is no self-selection bias. Second, the model is estimated using the proposed great likelihood estimation method (QMLE) proposed by Lee and Yu (2010b).

This paper utilizes the works of Du and Yu (2024), and Dosi et al. (2021) to develop spatial weighting matrices based on regional and upstream/downstream industry dimensions, aiming to examine the regional peer effect and the “industry” peer effect in the digital transformation of grain-related enterprises. The area space weight matrix ($W1$) is an $n \times n$ dimensional 0-1 matrix (n is the number of firms), and the element matrix is 1 if the firm is registered in the same province as the focal firm, and 0 otherwise. The “industry” spatial weight matrix ($W2$) is also an $n \times n$ dimensional 0-1 matrix (n is the number of firms), where a firm that is on the production side (or on the distribution side) with the focal firm is a 1, and a 0 otherwise.

Digital transformation peer effects and corporate welfare. On the basis of verifying the peer effects in the digital transformation of grain-related enterprises, a panel model is established to further explore the impact of the digital transformation peer effects of grain-related enterprises on corporate welfare, and the model is as follows:

$$CW_{it} = \alpha_2 + \sigma_1 WDIG_{it} + \beta_2 Z_{it} + o_p + \kappa_j + \varepsilon \quad (2)$$

In equation (2), CW_{it} represents the level of corporate welfare i in year t , $WDIG_{it}$ is the digital transformation peer effects of grain-related enterprises, including regional peer effect $W1DIG_{it}$ and “industry” peer effect $W2DIG_{it}$, Z_{it} is the control variable affecting the corporate welfare, o_p is the regional fixed effect, κ_j is the industry fixed effect, and ε is the error term.

Referring to Jiang (2022), construct models (3) and (4) to test the mediating roles of corporate financing constraints (SA_{it}) and technological innovation (IA_{it}).

$$SA_{it} = \alpha_3 + \sigma_2 WDIG_{it} + \beta_3 Z_{it} + o_p + \kappa_j + \varepsilon \quad (3)$$

$$IA_{it} = \alpha_3 + \sigma_2 WDIG_{it} + \beta_3 Z_{it} + o_p + \kappa_j + \varepsilon \quad (4)$$

Based on equation (2), the models (5)-(8) are respectively established to verify the moderating roles of corporate ESG performance (ESG_{it}), environmental dimension (E_{it}), social responsibility dimension (S_{it}) and governance dimension (G_{it}), as follows:

$$CW_{it} = \alpha_4 + \sigma_3 WDIG_{it} + \theta_2 ESG_{it} + \sigma_2 WDIG_{it} \times ESG_{it} + \beta_4 Z_{it} + o_p + \kappa_j + \varepsilon \quad (5)$$

$$CW_{it} = \alpha_5 + \sigma_4 WDIG_{it} + \theta_3 E_{it} + \sigma_3 WDIG_{it} \times E_{it} + \beta_5 Z_{it} + o_p + \kappa_j + \varepsilon \quad (6)$$

$$CW_{it} = \alpha_6 + \sigma_5 WDIG_{it} + \theta_4 S_{it} + \sigma_4 WDIG_{it} \times S_{it} + \beta_6 Z_{it} + o_p + \kappa_j + \varepsilon \quad (7)$$

$$CW_{it} = \alpha_7 + \sigma_6 WDIG_{it} + \theta_5 G_{it} + \sigma_5 WDIG_{it} \times G_{it} + \beta_7 Z_{it} + o_p + \kappa_j + \varepsilon \quad (8)$$

The rest of the variables in equations (3) - (8) have the same meaning as in equation (2).

Description of Variables

Dependent variables. (1) Degree of digital transformation in grain-related enterprises (DIG_{it}). A thesaurus of digital transformation keywords for grain-related enterprises was constructed, referencing Wu et al. (2021), Huang (2024), Li et al. (2025), and other works. Python software was employed to quantify the frequency of grain-related enterprises’ digital transformation keywords in the annual reports of the selected companies. The frequency of words is logarithmically analyzed to assess the extent of digital transformation in grain-related enterprises. (2) Corporate welfare (CW_{it}). Referring to the study of He et al. (2019), the operating profit of enterprises is used to measure.

Independent variable. The independent variable of this paper is the digital transformation peer effects of grain-related enterprises ($WDIG_{it}$), including the regional peer effect of digital transformation of grain-related enterprises ($W1DIG_{it}$) and the “industry” peer effect of digital transformation of grain-related enterprises ($W2DIG_{it}$). The regional peer effect ($W1DIG_{it}$) is measured by the average of the digital transformation level of other enterprises in the same province as the focal enterprise’s place of registration; the “industry” peer effect ($W2DIG_{it}$) is measured by the average of the digital transformation level of other enterprises in the same “industry” (production end or distribution end) as the focal enterprise.

Mechanism variables. The mechanism variables in this paper include financing constraints, technological innovation and corporate ESG performance. Among them, referring to Hadlock and Pierce (2010) study, financing constraints is measured by SA index; referring to Wang and Liu (2024) study, technological innovation is measured using the ratio of R&D expenditures to operating revenues; referring to Lu and Li (2024) study, corporate ESG performance and the three dimensions are measured using ESG scores from the WIND database.

Control variables. Referring to studies such as Del et al. (2021) and Hu et al. (2024), control for a set of covariates of firms’ digital transformation to reduce omitted variable bias. (1) Firm age (Age), measured by the number of years the firm has been listed as of 2023; (2) Human resources (Hr), measured by taking the logarithm of the number of employees of the firm; (3) Return on assets (Roa), measured by net profit/total assets; (4) Tobin’s Q (Tq), measured by market capitalization/(total assets - net intangibles - net goodwill); and (5) Shareholding concentration (Own): measured by the sum of the firm’s top 10 outstanding share shareholders, measured by the sum of the shareholding ratio of the top 10 outstanding shares of the firm. In addition, human resources (Hr), return on assets (Roa), Tobin’s Q (Tq), operating income growth rate (Gro), and gearing ratio (Lev) are controlled as variables affecting corporate welfare. Among them, operating income growth rate (Gro) is measured by (current period operating income - previous period operating income)/previous period operating income, and gearing ratio (Lev) is measured by total liabilities/total assets.

Sample Selection and Data Sources

This paper selects China's Shanghai and Shenzhen A-share grain-related listed enterprises from 2012 to 2023 as the research object. The following four types are defined as grain-related enterprises, based on the definition of agriculture-related enterprises. Grain-related enterprises mainly include: first, agricultural enterprises that provide production materials and services for grain production. Second, grain production enterprises. Third, the category includes enterprises that process grains. Fourth, enterprises involved in the distribution of grain, which classify agricultural enterprises and grain production enterprises as production

side enterprises, and grain processing enterprises and enterprises involved in the distribution of grain as distribution side enterprises. Using the definitions above, we looked at the annual reports and business activities of listed companies to find those that fit the definitions for our research, and we took the following steps: (1) we removed companies that have been listed for less than two years; (2) we excluded samples that were missing key information. In the end, we identified 225 listed companies related to grain, totalling 2,700 samples. The data in this paper are all from the China Stock Market & Accounting Research (CSMAR) database and Choice Financial Terminal. Descriptive statistics are shown in Table 1.

Table 1

Descriptive Statistics of Variables

Variables	N	Mean	SD	Min	Max
<i>DIG</i>	2700	4.593	0.490	0	6.380
<i>CW</i>	2700	10.467	54.833	-69.546	1037.087
<i>SA</i>	2700	-3.955	0.265	-5.113	-3.115
<i>IA</i>	2700	5.5244	22.6465	0	593
<i>ESG</i>	2700	3.989	1.053	1	7
<i>Age</i>	2700	15.83	7.300	0	32
<i>Hr</i>	2700	7.942	1.280	2.708	11.853
<i>Roa</i>	2700	0.0295	0.112	-3.164	0.599
<i>Tq</i>	2700	2.130	1.665	0.706	21.296
<i>Own</i>	2700	56.478	14.681	17.478	91.477
<i>Gro</i>	2700	0.720	7.423	-2.780	274.543
<i>Lev</i>	2700	0.472	0.228	0.0261	3.262

Existence Tests for Digital Transformation Peer Effects

Benchmark Analysis

Table 2 presents the results of the baseline estimation of the peer effects concerning the digital transformation of grain-related enterprises, with columns (1) and (2) displaying the estimation outcomes of equation (1) based on the regional spatial weight matrix and the “industry” spatial weight matrix, respectively. The findings indicate that the coefficients for the peer effects of the digital transformation of grain-related enterprises, under both spatial weight matrices, are significantly positive. This suggests that the digital transformation of these enterprises exhibits a positive regional peer effect and a “industry” peer effect, thereby validating hypotheses 1 and 2. The coefficient of the peer effect in Column 1 is significantly positive, suggesting that

the digital transformation of grain-related enterprises is influenced by the digital transformation of similar enterprises within the same province. The coefficient of peer effect in column (2) is also significantly positive, meaning that the digital transformation of grain-related enterprises is influenced by the digital transformation of other enterprises in the same industry, whether they are involved in production or distribution. The peer effect coefficient is markedly positive. The factors that affect how companies change digitally include firm age, human resources, return on assets, Tobin's Q, and shareholding concentration, with each factor having different levels of influence on the digital changes in grain-related enterprises depending on different spatial weight matrices.

Table 2

Benchmark Estimation Results of the Peer Effect of Enterprise Digital Transformation

Variables	(1)	(2)
ρ	0.2896*** (9.90)	0.6720*** (13.47)
<i>Age</i>	0.0579*** (20.66)	0.0264*** (6.06)
<i>Hr</i>	0.0307*** (2.71)	0.0370*** (3.16)
<i>Roa</i>	0.0345 (0.72)	0.0369 (0.75)
<i>Tq</i>	-0.0111** (-2.53)	-0.0075* (-1.66)
<i>Own</i>	-0.0001 (-0.28)	-0.0000 (-0.11)

Variables	(1)	(2)
Individual FE	YES	YES
Year FE	YES	YES
N	2475	2475
R ²	0.0506	0.1997

Notes: ① ***, ** and * indicate 1%, 5% and 10% significance levels, respectively. ② Robust standard errors are in parentheses. Same as below.

Robustness Tests

This research employs three methodologies to enhance the robustness of the estimation results for the digital transformation peer effects of grain-related enterprises. First, the method of measuring the dependent variable is replaced. The digital transformation index of enterprises in the CSMAR database is selected and substituted into equation (1) for re-estimation. The results of the regional spatial weight matrix and the “industry” spatial weight matrix are shown in columns (1) and (2) of Table 3, respectively, which show that after replacing the enterprise digital transformation measurement method, the estimated coefficients of both the regional spatial weight matrix and the “industry” spatial weight matrix are significantly positive, indicating that the baseline regression results of equation (1) are robust. Second, the nested matrix is constructed. Referring to the study of Zhang and Lian (2024), the regional spatial weight matrix and the elements of the “industry” spatial weight matrix are multiplied two by two, and then normalized to obtain the nested spatial weight matrix (W_3). To verify the existence of

the peer effect of digital transformation of grain-related enterprises under the nested spatial weight matrix, the estimation results are shown in column (3) of Table 3. From the estimation results, it can be seen that the estimated coefficients of the digital transformation peer effect of grain-related enterprises under the nested spatial weight matrix are still significantly positive, indicating that the baseline regression result of equation (1) is robust. Third, the sample of municipalities directly under the central government is eliminated. Based on the provinces of enterprise registration in 2012, the data for Beijing, Shanghai, Tianjin, and Chongqing were deleted, and finally 2,400 samples were obtained. The samples are substituted into equation (1) for re-estimation, and the estimation results are shown in columns (4) and (5) of Table 3. The results show that the estimated coefficients under the regional spatial weight matrix and the “industry” spatial weight matrix are both significantly positive after the municipality directly under the central government samples are excluded, which suggests that the baseline regression results of equation (1) are robust.

Table 3

Robustness Test Results for Digital Transformation Peer Effects

Variables	(1)	(2)	(3)	(4)	(5)
ρ	0.2542*** (8.25)	0.6911*** (14.76)	0.2017*** (7.53)	0.2989*** (9.84)	0.6652*** (13.10)
Controls	YES	YES	YES	YES	YES
Individual FE	YES	YES	YES	YES	YES
Year FE	YES	YES	YES	YES	YES
N	2475	2475	2475	2200	2200
R ²	0.0165	0.0599	0.0393	0.5458	0.1947

Impact of Digital Transformation Peer Effects on Corporate Welfare

Benchmark Analysis

The baseline regression findings regarding the influence of the digital transformation peer effects of grain-related enterprises on corporate welfare are presented in Table 4. Columns (1) and (2) of Table 4 display the

regression outcomes for the regional peer effect and the “industry” peer effect of digital transformation on corporate welfare, respectively. The regression coefficients for regional peer effect and “industry” peer effect are 10.71 and 14.74, respectively, both significant at the 1% confidence level, indicating that both effects of digital transformation in grain-related enterprises significantly enhance corporate welfare. Hypothesis 3 has been validated.

Table 4

Benchmark Regression Results on the Impact of Peer Effects on Corporate Welfare

Variables	(1)	(2)
$W1DIG_{it}$	10.7121*** (7.01)	
$W2DIG_{it}$		14.7379*** (8.16)
Controls	YES	YES
Province FE	YES	YES
Industry FE	YES	YES
_cons	-143.2571*** (-7.43)	-161.4632*** (-8.10)
N	2700	2700
R ²	0.0647	0.0716

Robustness Tests

This article employs specific approaches to conduct robustness checks on the benchmark results regarding the influence of digital transformation peer effects on corporate welfare in grain-related enterprises. Initially, substitute the dependent variable. The digital transformation index from the CSMAR database is used to reassess the regional and “industry” peer effects, which are included in equation (2) for analysis, with the results shown in columns (1) and (2) of Table 5. The findings indicate that, upon substituting the explanatory variables, the impacts of the regional peer effect and the “industry” peer effect of the digital transformation of grain-related enterprises regarding their welfare remain significantly positive, demonstrating the robustness of the benchmark regression results in equation (2). Second, the sample observation time is adjusted. The observation period has been modified from 2012-2023 to 2011-2022. Following the adjustment, the firms listed in 2022 are removed, resulting in a total sample size of 2,580, which is

then substituted into equation (2) for the estimate; the results are presented in columns (3) and (4) of Table 5. The findings indicate that, following the adjustment of the sample observation period, both the regional peer effect and the “industry” peer effect of the digital transformation of grain-related enterprises continue to exert a significantly positive influence on corporate welfare, thereby confirming the robustness of the benchmark regression results in equation (2). Third, the sample of municipalities is excluded. Using the same method, we remove the samples from Beijing, Shanghai, Tianjin, and Chongqing; recalculate the regional and “industry” peer effects of digital transformation; and plug them into equation (2) for estimation, with the results displayed in columns (5) and (6) of Table 5. The results indicate that even after removing the municipality samples, the regional and “industry” peer effects of digital transformation for grain-related businesses still have a strong positive impact on company welfare, which means that the initial findings from equation (2) are reliable.

Table 5

Robustness Tests for the Impact of Peer Effects on Corporate Welfare

Variables	Substitution of explanatory variables		Adjustment of sample observation time		Delete municipalities	
	(1)	(2)	(3)	(4)	(5)	(6)
$W1DIG_{it}$	1.2700*** (6.86)		9.6356*** (6.23)		13.5816*** (7.31)	
$W2DIG_{it}$		1.4836*** (6.60)		14.4183*** (7.66)		15.8383*** (7.92)
Controls	YES	YES	YES	YES	YES	YES
Province FE	YES	YES	YES	YES	YES	YES
Industry FE	YES	YES	YES	YES	YES	YES
_cons	-138.3002*** (-7.17)	-140.8541*** (-7.23)	-125.9849*** (-6.79)	-147.3575*** (-7.65)	-154.1751*** (-4.79)	-160.5278*** (-4.90)
N	2700	2700	2580	2580	2400	2400
R ²	0.0645	0.0633	0.0740	0.0819	0.0702	0.0745

Endogeneity Tests

Higher welfare enterprises typically adopt a long-term strategic development perspective, leading them to prioritize the trends in digital transformation and informatization. Concurrently, their sensitivity to the digitization and informatization dynamics of industry peers is comparatively elevated. This work use the instrumental variable method to effectively decrease estimation bias resulting from endogeneity issues, such as reverse causation.

First, we use the lagged one-period regional peer effect as an instrumental variable. This is because the one-period lagged regional peer effect has no direct impact on the current corporate welfare, which meets the requirement of exogeneity. Also, the regional peer effect from one period ago is strongly related to the current digital transformation regional peer effect, which satisfies the correlation requirement. Columns (1) and (2) in Table 6 display the test results. Column (1) of Table 6 shows that the instrumental variable ($IV1$) and the peer effect of the digital transformation region of grain-related enterprises are significant at a 1 % confidence interval, which proves a strong correlation between the instrumental variable ($IV1$) and the peer effect of the digital transformation region of

grain-related enterprises. Column (2) of Table 6 shows that the regression results of the regional peer effect of digital transformation of grain-related enterprises on corporate welfare are significant at the 1 % confidence level, indicating that the regional peer effect of digital transformation of grain-related enterprises still promotes corporate welfare after mitigating the endogeneity problem. The Cragg-Donald Wald-F statistic test shows that there is no weak instrumental variable problem.

Second, referring to the study of Yuan et al. (2021), based on the natural logarithm of the number of internet broadband access ports in the province where the enterprise is registered, we construct the industry peer internet broadband access port indicator as an instrumental variable for the peer effect of “industry” ($IV2$). Because the development level of regional internet infrastructure is a macro-environmental factor, it does not directly affect the welfare of the micro-enterprise level, which is in line with the requirement of exogeneity. In addition, the enterprise digital transformation “industry” peer effect may be affected by the level of digitalization development in the region where the industry is distributed (Awate et al., 2015), the average value of internet broadband access ports in the province where other enterprises located in the same industry are located, and the perceived industry peer

effect of digital transformation of the enterprise are correlated, satisfying the requirement of correlation. Columns (3) and (4) of Table 6 display the test results. Column (3) of Table 6 shows that the instrumental variable (*IV2*) and the “industry” peer effect of digital transformation in grain-related enterprises is significant at the 1% confidence level, meaning there is a strong connection between them. Column

(4) of Table 6 shows that the impact of the “industry” peer effect of digital transformation on the welfare of grain-related enterprises is significant at the 1% confidence level, meaning that even after addressing potential issues, this peer effect still helps improve corporate welfare. The Cragg-Donald Wald-F statistic test indicates that there is no weak instrumental variable problem.

Table 6

Endogeneity Test Results				
Variables	(1) Regional peer effect	(2) Corporate welfare	(3) “industry” peer effect	(4) Corporate welfare
<i>IV1</i>	0.7000*** (16.23)			
<i>W1DIG_{it}</i>		23.3724*** (5.23)		
<i>IV2</i>			0.6515*** (182.72)	
<i>W2DIG_{it}</i>				13.5833*** (4.90)
Cragg-Donald Wald-F statistic test	94.8299 (16.38)		33413.5 (16.38)	
Controls	YES	YES	YES	YES
Province FE	YES	YES	YES	YES
Industry FE	YES	YES	YES	YES
_cons	1.4702*** (4.14)	-253.9419*** (-6.89)	-0.5881*** (-17.41)	-199.0565*** (-7.07)
N	2475	2475	2700	2700
R ²	0.7536	0.3250	0.8796	0.3139

Further Analysis

Mechanism Analysis

Columns (1) and (2) of Table 7 display the results of the mediating mechanism test for alleviating financing constraints. Column (1) shows that the regional peer effect of digital transformation of grain-related enterprises on financing problems is strongly negative, meaning that when these enterprises in the same area adopt digital practices, it helps reduce their financing issues and improves their ability to get funding. Column (2) shows that the estimated coefficient of the “industry” peer effect of digital transformation of grain-related enterprises on financing constraints is significantly negative at the 1 % level, indicating that the “industry” peer effect of digital transformation of grain-related enterprises can also alleviate the financing constraints of grain-related enterprises and promote the sustainable development of enterprises. Research by Ullah (2019) and Zhang et al. (2024) indicates that alleviating finance constraints for firms promotes greater investment in innovation and resource utilization efficiency, therefore improving operational efficiency and welfare levels. The empirical findings suggest that alleviating finance constraints acts as a mediating factor in the digital

transformation peer effects among grain-related enterprises, thereby enhancing their welfare level and confirming hypothesis 4.

Columns (3) and (4) of Table 7 display the results of the mediating mechanism test for technological innovation. Column (1) shows that the regional peer effect of digital transformation of grain-related enterprises on technological innovation is strongly positive at the 1 % level, meaning that this regional peer effect can greatly boost the technological innovation of these businesses. Column (2) shows that the estimated coefficient of the “industry” peer effect on technological innovation of digital transformation of grain-related enterprises is significantly positive at the 1 % level, indicating that the “industry” peer effect of digital transformation of grain-related enterprises can also enhance the technological innovation level of enterprises. Song et al. (2022) and Yang et al. (2025) show that technological innovation can reduce production costs, improve enterprise economic performance, and then enhance corporate welfare. The results indicate that technological innovation helps connect the digital transformation peer effects of grain-related companies to improve corporate welfare, confirming hypothesis 5.

Table 7

Results of Mediation Mechanism Tests				
Variables	(1)	(2)	(3)	(4)
<i>W1DIG_{it}</i>	-0.3020*** (-58.47)		0.2720** (2.18)	
<i>W2DIG_{it}</i>		-0.4264*** (-107.65)		0.4768*** (3.22)
Controls	YES	YES	YES	YES

Variables	(1)	(2)	(3)	(4)
Province FE	YES	YES	YES	YES
Industry FE	YES	YES	YES	YES
_cons	-2.5641*** (-26.12)	-1.9820*** (-21.15)	1.7809 (1.44)	0.8645 (0.67)
N	2700	2700	2700	2700
R ²	0.5932	0.8300	0.0039	0.0060

Table 8 presents the moderating effect of corporate ESG performance on the relationship between regional peer effects from grain-related enterprises' digital transformation and corporate welfare. Specifically, the results in Column (1) of Table 8 show that the interaction term between regional peer effects of digital transformation and corporate ESG performance is statistically significant at the 1% level with a positive coefficient. This indicates that corporate ESG performance exerts a positive moderating effect on the pathway between regional peer effects from grain-related enterprises' digital transformation and corporate welfare. Furthermore, columns (2) through (4) in Table 8 examine the moderating effects of the environmental, social responsibility, and governance dimensions of corporate ESG performance, respectively. The results indicate that all three sub-dimensions positively moderate the impact of regional peer effects from grain-related enterprises' digital transformation on corporate welfare, with the governance dimension exhibiting the most statistically significant positive moderating effect.

Table 9 presents the moderating role of corporate ESG performance in the relationship between "industry" peer

effects from grain-related enterprises' digital transformation and corporate welfare. Specifically, the results in Column (1) show that the interaction term between "industry" peer effects of digital transformation and ESG performance is positive and statistically significant at the 1% level, indicating that ESG performance exerts a positive moderating effect on the pathway through which "industry" peer effects influence corporate welfare. Furthermore, columns (2) through (4) in Table 9 examine the moderating effects of the environmental, social responsibility, and governance dimensions of corporate ESG performance, respectively. The results demonstrate that all three sub-dimensions positively moderate the impact of "industry" peer effects from grain-related enterprises' digital transformation on corporate welfare, with the environmental dimension exhibiting the most pronounced positive moderating effect.

In summary, corporate ESG performance demonstrates a statistically significant positive moderating effect on the relationship between digital transformation peer effects of grain-related enterprises on corporate welfare, thereby supporting Hypothesis 6.

Table 8

Test Results of Moderating Mechanisms for Regional Peer Effects

Variables	(1)	(2)	(3)	(4)
$W1DIG_{it}$	9.8908*** (6.47)	8.9185*** (5.71)	9.8877*** (6.40)	11.6124*** (7.42)
$W1DIG_{it} * ESG$	1.6012*** (5.62)			
$W1DIG_{it} * E$		0.5831*** (3.63)		
$W1DIG_{it} * S$			0.4809*** (3.64)	
$W1DIG_{it} * G$				0.6063*** (2.85)
Controls	YES	YES	YES	YES
Province FE	YES	YES	YES	YES
Industry FE	YES	YES	YES	YES
_cons	-132.3598*** (-7.07)	-133.2674*** (-7.03)	-135.1561*** (-7.02)	-144.8224*** (-7.55)
N	2700	2700	2700	2700
R ²	0.5932	0.0744	0.0703	0.0756

Table 9

Test Results of Moderating Mechanisms for “Industry” Peer Effects				
Variables	(1)	(2)	(3)	(4)
$W2DIG_{it}$	14.6701*** (8.22)	12.5542*** (6.76)	14.1754*** (7.76)	16.7116*** (9.01)
$W2DIG_{it} * ESG$	2.7369*** (7.51)			
$W2DIG_{it} * E$		1.5772*** (5.42)		
$W2DIG_{it} * S$			1.0198*** (5.29)	
$W2DIG_{it} * G$				0.9928*** (3.78)
Controls	YES	YES	YES	YES
Province FE	YES	YES	YES	YES
Industry FE	YES	YES	YES	YES
_cons	-150.8065*** (-7.75)	-149.0429 *** (-7.57)	-152.3267*** (-7.61)	-166.9693*** (-8/42)
N	2700	2700	2700	2700
R ²	0.1007	0.0861	0.0826	0.0871

Heterogeneity Analysis

Whether it is a leading enterprise. Industry-leading enterprises have stronger resource integration capabilities and market influence, and the ways and extent to which their digital transformation affects peer enterprises may differ from non-leading ones. Uncovering the differences between the two in how the peer effect of digital transformation impacts corporate welfare can more effectively guide the transformation practices of different types of grain-related enterprises. This paper identifies industry-leading enterprises at or above the provincial level as sample leading enterprises, and the rest as non-leading ones. They are respectively substituted into equation (2) for regression, with the results shown in Table 10.

Columns (1) and (2) of Table 10 show that the regional peer effect of digital transformation significantly contributes to the corporate welfare in both the leading and non-leading enterprise groups, with a stronger effect in the leading enterprise group. Columns (3) and (4) of Table 10 indicate that the digital transformation “industry” peer effect greatly benefits corporate welfare in both the leading and non-leading enterprise groups, with a greater benefit for the leading group.

Potential explanations may include: First, at the regional or “industry” level, when peer grain-related enterprises advance digital transformation, industry-leading enterprises leverage their superior learning capacity and resource integration advantages to rapidly assimilate peers’ transformation experiences. These frontrunners then convert such knowledge into tangible operational efficiencies through their resource endowment, ultimately generating more pronounced welfare-enhancing effects. Second, within the supply chain system of grain-related enterprises, leading enterprises occupy a core hub position, with significantly more frequent business interactions and information exchanges with peer enterprises than non-leading ones. This network characteristic enables them to capture key information in the digital transformation of peer enterprises earlier, accelerate the improvement of their own digital capabilities, and ultimately exert a more pronounced positive impact on corporate welfare. Guo et al. (2025) point out in their study that the digital transformation peer effect of large firms has a more pronounced effect on firms’ carbon-neutral performance, which in turn promotes sustainable development. As industry-leading enterprises often fall into the category of large enterprises, this conclusion also supports the findings of this paper.

Table 10

Heterogeneity Analysis of Leading Enterprises				
Variables	(1)	(2)	(3)	(4)
$W1DIG_{it}$	16.9450*** (6.02)	2.7614*** (5.30)		
$W2DIG_{it}$			21.4360*** (6.82)	4.2675*** (6.45)

Variables	(1)	(2)	(3)	(4)
Controls	YES	YES	YES	YES
Province FE	YES	YES	YES	YES
Industry FE	YES	YES	YES	YES
_cons	-207.8395*** (-6.85)	-28.1823*** (-5.96)	-229.7922*** (-7.39)	-34.9457*** (-6.88)
N	1500	1200	1500	1200
R ²	0.1049	0.0772	0.1113	0.0906

Whether it is a major grain-producing region. Significant differences exist between grain-related enterprises in major grain-producing regions and non-major producing regions regarding industrial foundations and resource endowments. Accordingly, this study categorizes sample firms into two groups based on their registration provinces-major grain-producing regions and non-major producing regions-and re-evaluates them using equation (2) to analyze regional heterogeneity in how digital transformation peer effects influence corporate welfare. Table 11 presents the evaluation results. As shown in columns (1) and (2) of Table 11, regional peer effects in digital transformation significantly enhance corporate welfare in both major and non-major grain-producing regions, with a more pronounced effect observed in non-major producing regions. Columns (3) and (4) further reveal that “industry” peer effects in digital transformation also significantly improve corporate welfare across both region types, again demonstrating stronger positive impacts in non-major producing regions. Potential explanations include: Grain-related enterprises in major grain-producing regions generally possess stronger digital infrastructure,

placing their transformation in an “efficiency-optimization” phase where peer effects yield diminishing marginal returns. In contrast, resource-constrained enterprises in non-major producing regions typically operate at initial digitalization stages. When regional or “industry” peers undergo digital transformation, these late adopters benefit from lower imitation costs and more visible improvements, resulting in stronger welfare-enhancing effects from peer influence in non-major producing regions. Yao and Fu (2025) demonstrate that digital transformation in major grain-producing regions facilitates scalable applications of agricultural Internet of Things (IoT) and big data technologies, thereby enhancing food security capacity. This finding implicitly suggests that grain-related enterprises in major grain-producing regions possess superior resource endowments and developmental foundations for digitalization. Our study’s identification of more pronounced peer effects in non-major producing regions precisely complements this characterization. The initially lower digitalization levels in peripheral enterprises make them more responsive to peer influences, creating logical consistency between both findings.

Table 11

Heterogeneity Analysis of the Major Grain-Producing Region				
Variables	(1)	(2)	(3)	(4)
$W1DIG_{it}$	8.0347*** (5.12)	12.4910*** (4.91)		
$W2DIG_{it}$			10.9490*** (6.23)	17.8263*** (5.66)
Controls	YES	YES	YES	YES
Province FE	YES	YES	YES	YES
Industry FE	YES	YES	YES	YES
_cons	-97.2833*** (-6.41)	-171.2511*** (-4.32)	-110.6406*** (-7.07)	-194.8501*** (-4.66)
N	1325	1375	1325	1375
R ²	0.0830	0.0601	0.0921	0.0666

Enterprise life cycle. The enterprise life cycle theory posits that enterprises at various developmental stages experience distinct resource limitations and institutional contexts, which may influence the impact of digital transformation peer effects on corporate welfare. This research examines the variability of the life cycle in which organizations operate. Using the cash flow approach (Dickinson, 2011), the life cycle of the companies in the study is divided into three stages: growth, maturity, and decline, which are included in equation (2) for analysis, and the results are shown in Table 12.

The results show that both the regional peer effect and the “industry” peer effect of digital transformation in grain-related enterprises during their growth, maturity, and decline stages greatly improve corporate welfare. However, the peer effect during the maturity stage has a particularly strong impact on improving corporate welfare. The reasons for this

phenomenon may be as follows: First, the issue arises at the level of the resource base. Grain-related enterprises in the mature stage have sufficient funds, technologies, and talents, enabling them to quickly transform the digital transformation experience of peer enterprises. Enterprises in the growth stage prioritize resources for expansion, while those in the decline stage face resource constraints. Both find it difficult to effectively promote digital transformation. Second, the organizational management level presents a challenge. Enterprises in the mature stage have standardized processes and efficient collaboration, allowing them to quickly imitate the digital transformation experience of peer enterprises. Enterprises in the growth stage suffer from unstable management that easily leads to conflicts, and those in the decline stage face strong resistance due to organizational rigidity, resulting in poor results in learning from others’ experiences. Liu et al. (2023) also point out that mature firms

have a more significant impact on process optimization and complexity management in digital transformation, which help

reduce production costs and improve firm competitiveness, and their findings echo those of this paper.

Table 12

Heterogeneity Analysis of Enterprise Life Cycle						
Variables	Growth		Maturity		Decline	
	(1)	(2)	(3)	(4)	(5)	(6)
$W1DIG_{it}$	12.5762*** (2.92)		12.1637*** (5.63)		5.2972** (2.46)	
$W2DIG_{it}$		12.3553*** (2.64)		17.2492*** (6.43)		5.7663*** (2.62)
Controls	YES	YES	YES	YES	YES	YES
Province FE	YES	YES	YES	YES	YES	YES
Industry FE	YES	YES	YES	YES	YES	YES
_cons	-159.2747*** (-5.85)	-215.3967*** (-5.56)	-166.2357*** (-7.47)	-188.4401*** (-8.03)	-69.2227*** (-3.77)	-72.3807*** (-3.87)
N	363	363	1704	1704	421	421
R ²	0.2896	0.3047	0.0690	0.0755	0.1038	0.1071

Conclusions and Policy Recommendations

Conclusions

This study utilizes data from China's Shanghai and Shenzhen A-share grain-related listed enterprises spanning 2012 to 2023. Initially, it employs a spatial econometric model to examine the presence of regional and "industry" peer effects in the digital transformation of these enterprises. Next, the panel model is used to look at how the digital transformation peer effects affect the corporate welfare and how this happens.

The main conclusions are as follows: (1) There exist significant regional peer effect and "industry" peer effect in the digital transformation of grain-related enterprises, and this conclusion remains valid after a series of robustness tests. (2) Both the regional peer effect and "industry" peer effect in the digital transformation of grain-related enterprises can significantly improve the corporate welfare, and this conclusion has passed robustness tests and endogeneity tests. (3) Alleviating financing constraints and technological innovation are the mediating mechanisms through which the digital transformation peer effects of grain-related enterprises enhance corporate welfare. (4) Corporate ESG performance and its three sub-dimensions (environmental dimension, social responsibility dimension, and governance dimension) all play a positive moderating role in the relationship between the digital transformation peer effects of grain-related enterprises and corporate welfare levels. (5) Heterogeneity tests show that among grain-related enterprises, the digital transformation peer effects have a more significant role in improving corporate welfare levels for industry-leading enterprises, grain-related enterprises in non-major grain-producing regions, and grain-related enterprises in the mature stage.

Policy Recommendations

First, establish a differentiated digital transformation ecosystem based on global value chain positioning. To place the digital transformation of Chinese grain-related enterprises in the global grain value chain, we should not only rely on the domestic peer effect to consolidate the foundation, but also benchmark the digital standards of

international grain giants. For grain-related enterprises at the production end, promote enterprises to learn from foreign experience in precision agriculture, diffuse IoT moisture monitoring, drone plant protection and other technologies through the regional peer effect, and enhance the global competitiveness of primary agricultural products; for grain-related enterprises at the distribution end, encourage leading enterprises to dock with international grain trade digital platforms, promote blockchain traceability technology based on the industry's peer effect, and realize the docking of standards with global purchasers.

Second, innovate ESG regulatory tools to drive substantive welfare improvements. To prevent ESG from becoming mere symbolic compliance, an innovative regulatory framework integrating "data transparency + incentive mechanisms" should be established, tightly linking ESG performance to tangible digital transformation outcomes. On one hand, implement a "Grain Industry ESG Digital Passport" system. Companies would be required to upload real-time data on key indicators such as digital carbon footprint, grain loss rates, and farmer income linkage, with independent third-party verification to ensure authenticity. On the other hand, explore an "ESG Performance Securitization" mechanism. Grain-related companies with an ESG rating of AA or above could issue "Digital Transformation Special Bonds", where bond interest rates are tied to both ESG improvement metrics and the company's success in driving peer firms' digital transformation. AI-powered real-time monitoring would track fund allocation to ensure financing is used for substantive digital upgrades, mitigating risks of "regulatory capture."

Third, leading and mature enterprises must shift from "exemplary compliance" to "value internalization." Industry leaders and established enterprises should leverage their resource advantages to deepen peer collaboration: Jointly build a shared digital technology repository with peer companies, transforming their expertise in intelligent processing and supply chain orchestration into industry-wide standards. This will drive sector-wide welfare gains through technology spillover effects. Proactively integrate into high-value segments of global supply chains, combining localized insights gained from peer networks with cutting-edge international technologies. This fusion

will enable them to convert digital dividends into sustainable global competitiveness.

Fourth, enterprises in the upper and lower reaches of the industrial chain should draw on peer effects in a differentiated manner. Upstream planting and primary processing enterprises should focus on “low-cost transformation.” By joining regional industrial clusters, they can share agricultural Internet of Things equipment with peer enterprises and quickly improve production efficiency through “asset-light imitation.” Additionally, using financing information obtained through peer effects, they should prioritize investment in digital tools that can directly connect with

downstream demand. Downstream distribution enterprises should rely on “industry” peer effects to build digital supply chain networks. For example, warehousing enterprises can open up smart inventory data to counterparts in the same industry, helping distribution-end enterprises enhance their efficiency. Grain-related enterprises in non-major producing regions can access the global order systems of major producing regions through cross-regional digital collaboration, leverage the channel resources of peer enterprises to expand into international markets, and achieve a “corner overtaking” in the global value chain.

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