World Journal of Economics and Business Research
Print ISSN: 2960-0073
Online ISSN: 2960-0081
DOI: https://doi.org/10.61784/wjebr3051

THE IMPACT OF DIGITAL TRANSFORMATION ON FIRM EXPORT

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Abstract: This study employs a two-way fixed effects model to analyze the impact of businesses' digital transformation on their exports, using panel data from Chinese A-share listed companies from 2013 to 2023. The results demonstrate that enterprises' digital transformation significantly enhances their export value. Heterogeneity analysis reveals that digital transformation significantly increases export value for firms in technology-intensive sectors and those situated in the eastern region; moreover, advancements in artificial intelligence, cloud computing, and practical applications considerably enhance firms' export value, while the effects of blockchain and big data are minimal. This study enhances the theoretical understanding of digital transformation and export trade, offering practical guidance for business digital strategy, government policy development, and the facilitation of international trade.
Keywords: Digital transformation; Enterprise export; Two-way fixed model; Information factor theory; Transaction cost theory

1 INTRODUCTION

During a period of significant transformations in the global economic framework, the digital economy has emerged as a pivotal element in redefining the competitiveness of national economies. The utilization of digital technology diminishes the expenses associated with international trade, facilitating firms in overcoming geographical barriers and extending their presence in other marketplaces. China's progress in the field of technology is substantial. 2023 In February, the CPC Central Committee and the State Council published the Overall Layout Plan for the Development of Digital China, which expressly seeks to fully improve economic and social development, while also strengthening, optimizing, and expanding the digital economy.This document delineates the pathway for various industries in China to identify their roles within the digital economy and to attain high-quality development.

As the digital economy has emerged, enterprise export has encountered several obstacles in addition to previously unheard-of potential. Through the application of developments such as artificial intelligence and massive data sets, digital evolution empowers enterprises to modify their fundamental business processes, management frameworks, and production and operational systems[1]. However, the international economy is becoming more saturated, and businesses who are not keeping up with digital transformation are losing their advantages in terms of production efficiency, product quality, customer service, etc., and face the risk of a decline in export value (the literature is sourced from: https://www.geega.com/news/772). At the same time, new compliance issues for businesses' exports are brought about by variations in electronic commerce policies and privacy laws among nations and regions.To enhance their global competitiveness, businesses should formulate rational and scientific digital transformation strategies. However, by carrying out a thorough examination of the effects of digital transformation on export volume, the government can support the long-term expansion of China's international commerce as well as the superior development of the economy.

Most of the literature related to digital transformation focuses on the macro level, using cross-country, provincial and industrial samples. Dang Lin et al. [2] studied the impact of digital transformation on the technological complexity of exports based on cross-country data at different industry levels. Fan Xin[3] utilizes provincial data to test the impact of the development of the digital economy on export efficiency. Wang et al.[4] discovered that the advancement of the internet-based economy positively influences the enhancement of production efficiency in China. Research on the micro level of digital evolution is limited, primarily concentrating on corporate export performance[5]. Entrepreneurial innovation[6], organizational effectiveness[7,8], etc., and there is a lack of research on enterprise export turnover.

Additionally, the research of its determining elements is the primary focus of the associated literature on enterprise export volume. A category of literature examines the influence of macroeconomic conditions on the export volume of businesses.Wang Yaqi et al. [9] determine that exchange rate volatility adversely affects exports more significantly for firms with limited imports of intermediate goods and for small-scale exporters, based on a theoretical examination of firm heterogeneity.

2 MARGINAL CONTRIBUTIONS

This paper provides the following marginal contributions derived from present research. This paper extends previous research by examining the influence of digital transformation in firms on export commerce, specifically from the viewpoint of micro enterprises' digital transformation. Existing studies mainly focus on the macro impact of digital

technology and economic effects, using transnational [2] and provincial [3] and Industry [4] samples to explore its impact on export technological sophistication, industrial restructuring, and national competitiveness, etc. Nonetheless, there is a dearth of research investigating the impact of digital change on exports at a smaller scale, which hinders the capacity to meet the specific requirements of firms in practice.The performance, effectiveness, and challenges encountered by enterprises during digital transformation exhibit significant heterogeneity and complexity. Consequently, understanding the impact mechanism of digital transformation on enterprises solely from a macro perspective proves to be difficult. This paper investigates the impact of exports through the lens of digital transformation in micro enterprises, aiming to facilitate sustainable development in the digital age.

Second, this paper further investigates the heterogeneous impact of different dimensions of enterprises' industries, regions, and digital transformation on export volume. Existing studies mainly analyze the heterogeneity based on enterprise size and export destination country [10], and lack the analysis of heterogeneity of industry and digital transformation dimensions. An extensive examination of the impact of digital evolution on the export value of businesses across diverse sectors, along with the effect of specific facets of digital transformation on this export value, can promote the cohesive development of both theoretical and practical elements of enterprise digital transformation. The heterogeneity analysis discussed in this study possesses practical importance.

3 THEORETICAL ANALYSIS AND RESEARCH HYPOTHESES

This study examines the influence of corporate digital shifts on exports, utilizing information factor theory and transaction cost theory to analyze how digital transformation influences the internal dynamics of exports. The following is a comprehensive discussion:

Information factor theory is a modern factor of production theory that analyzes the composition and value transformation of information, and its core view is that information consists of factual elements and value elements in two dimensions [11]. The acquisition and validation of information facilitate trade, and as an inexhaustible resource, information influences costs, prices, and other production aspects in industrial manufacturing and commodities distribution. Investments in information technology (IT) can markedly improve productivity, and this improvement arises from IT capabilities, namely the capacity to utilize IT for resource integration. The essence involves utilizing information and data to facilitate the comprehensive integration of elements such as talent, technology, and capital, thereby maximizing organizational capabilities and enhancing productivity through the optimization of production processes, service levels, and operational efficiency.

Coase introduced the transaction cost hypothesis in his 1937 work, The Nature of the Firm, contending that transaction costs encompass the expenses associated with acquiring precise market information, as well as negotiating and contract costs. In microeconomics, transaction behavior is characterized by three primary attributes: first, the specificity of transaction assets, referring to the illiquidity of invested assets and the challenges associated with recovering costs and repurposing assets post-contract termination; second, the uncertainty risk inherent in transactions, which escalates due to the unpredictability of future outcomes and information asymmetry, consequently increasing execution and oversight costs; and third, the elevated frequency of transactions, which may augment management expenses. Transaction uncertainty significantly influences transaction costs. Prior to and during the export trade, firms will encounter the costs associated with information retrieval for aligning supply and demand, as well as the execution and oversight costs for each stage.

Digital transformation facilitates firms' exports by reducing information costs. Studies have shown that digital platforms can effectively break through geographical distance limitations and reduce information asymmetry [12], and improve export performance. Moreover, employing internet to engage with clients and vendors increases the likelihood of a business participating in exports by 11% [13]. Researchers investigating the impact of the World Wide Web on the global trade operations of companies in Asia and Sub-Saharan Africa found that the the web reduces information-related costs linked to entering international markets, and that the use of electronic mail and web pages enhances the significant margins of both exports and imports for these firms[14]. Accordingly, this paper presents the subsequent theoretical hypothesis.

H1: Digital transformation has a positive effect on firms' export volume.

4 RESEARCH DESIGN

4.1 Variable Selection

Explanatory variable: degree of digital transformation (DCG). The digital transformation degree indicator is derived using text analysis methods. Initially, utilizing Wu Fei's [15] concept, review the pertinent literature regarding digital transformation to summarize its specific keywords. Subsequently, improve these keywords by integrating relevant policy documents and research reports to develop a comprehensive feature thesaurus. Annual reports from all A-share listed companies are extracted using Python to establish a text data pool. Search matching and word frequency statistics utilize feature words to classify and summarize the frequencies of key technical aspects, leading to the final aggregated word frequencies that establish the overall indicators of enterprise digital transformation.

Variable explained: enterprise export amount (QUANTITY). The customs import and export data are aligned with the data of listed companies and compiled by Juchao Information Network. Juchao Information Network serves as the designated information disclosure platform for listed companies, as mandated by the China Securities Regulatory

Commission, ensuring the provision of authoritative and reliable data.
Control variables: (1) The enterprise's age (age), determined by subtracting the year of establishment from the current year, with 1 added prior to taking the natural logarithm (lnage). (2) Capital intensity (lnkl), measured by reference to Dumingway et al. utilizing the ratio ofenterprises' net fixed assets to their staff count, with the natural logarithm applied. (3) The logarithm of the number of employees at the end of the year (lnEmpft) is utilized in this study to represent the firm's labor force, thereby accounting for potential influences of the firm's size. (4) Asset turnover (turnover), assessed by the ratio of the operating revenue of a business to its entirety of assets. (5) Financial leverage (e-verage), which is the firm's gearing ratio, is measured using the ratio of the firm's total liabilities to its total assets. (6) Government grants (lnsubsidy), this paper takes the logarithm of year-end government grants to indicate government grants. (7) Profitability (PROFIT), using the return on net assets of the enterprise.

4.2 Data Processing

This research employs data from A-share publicly traded businesses in Shanghai and Shenzhen spanning the years 2013 to 2023.The primary data sources include the Cathay Pacific database (CSMAR), which provides financial information on publicly traded companies; the China Customs database, which encompasses extensive trade data for all import and export corporations in China, together with textual data from the yearly filings of publicly listed companies. The treatments applied to the consolidated panel data follow established methodologies in the literature. (1) Firms subjected to ST or * ST during the sample period are excluded; (2) Firms that were delisted during the sample period are excluded; (3) Firms with negative firm age are omitted; (4) Samples with significant missing values of the primary variables are discarded; (5) Individual missing value variables are addressed using the mean complementary value method; (6) To reduce the effects of outliers, all continuous variables undergo shrinkage at the 1% significance level; (7). All variables have undergone standardization. Subsequent to the processing described, 1,075 firms were chosen for analysis, resulting in 11,825 valid samples.

4.3 Descriptive Statistics

Table 1 displays the statistical data for the principal variables in this investigation, encompassing 11,825 observations.The mean enterprise export value is 2,923 million yuan, with a minimum of -200 million yuan and a maximum of 210,000 million yuan, indicating significant variability in export values across different years. Additionally, the observations regarding the level of digital transformation reveal considerable differences, with minimum and maximum values of 0 and 6,117, respectively.

Table 1 Descriptive Statistics

Meaning	Variable	Sample size	Mean	Standard deviation	Minimum	Median	Maximum
Digital Transformation	DCG	11825	98.522	183.586	0	34	6117
Exports of products	quantity	11825	2923	10320	-2,000,000	410	210000
Age of the company	age	11825	20.606	6.108	5	21	57
Number of workers employed by enterprises	empft	11825	9129.021	26974.893	58	3317	570060
Asset turnover	turnover	11825	0.66	0.499	0.573	0.573	12.105
Financial leverage	everage	11825	0.446	0.216	0.008	0.008 0.436	8.612
Government subsidies	subsidy	11825	69027478	208493851 .826	-92000000	19000000	5.500e+09
profitability	profit	11825	-0.011	2.496	-235.096	0.059	34.716
Capital Intensity	kl	11825	3.352	37.731	0.083	1.745	2302.072

5 EMPIRICAL RESULTS

5.1 Benchmark Regression

This research utilizes the two-way fixed effects model to examine the impact of digital transformation on firm export volume, with regression outcomes displayed in Table 2.
Lines (1) and (2) display model outcomes devoid of control variables, whereas lines (3) and (4) incorporate c ontrol variables. Columns (1) and (3) do not include person and year fixed effects, whereas columns (2) and (4) include two-way fixed effects. The findings from rows (1) and (2) indicate that digital transformation mar

kedly enhances the export performance of firms. The findings in columns (3) and (4) are significantly positive, suggesting that digital transformation enhances the export performance of enterprises when additional control variables are included. This aligns with the findings of the present research.

Table 2 Benchmark Regression Results

Explained variable: lnquantity	(1)	(2)	(3)	(4)
lndcg	0.163*** (17.93)	0.051*** (5.07)	0.019 ** (2.40)	0.026*** (2.81)
lnage			0.046*** (6.09)	0.103*** (4.34)
lnempft			0.375*** (37.33)	0.15*** (17.15)
turnover			0.054*** (3.52)	-0.066*** (-4.50)
everage			0.130*** (15.32)	0.045*** (5.80)
lnsubsidy			0.170*** (17.35)	0.128*** (18.08)
profit			0.050*** (6.48)	0.022*** (5.07)
lnkl			-0.930*** (-6.05)	-0.237*** (-15.31)
Constant term	0.000*** (0.009)	0.000 (0.004)	0.000 (0.007)	-0.116*** (0.026)
Firm	No	No	N0	Yes
Year	No	No	N0	N0
N	11825	11825	11825	11825
R^2	0.026	0.150	0.403	0.265

Note: t-values are presented in parenthesis; ***, **, and * denote significance at the 1%, 5%, and 10% levels, respectively, as illustrated in the table below.

5.2 Robustness Test

In order to solve the problems of sample selection bias and measurement error in the regression and to ensure the robustness of the regression results, this paper carries out the robustness test from three aspects: adding control variables, changing the sample period, and changing the explanatory variables

5.2.1 Increase control variables

This study incorporates two control variables, specifically the cash flow ratio, defined as the ratio of net cash flow from operational activities to the sum of property.Tobin's Q value (tobinq) denotes the ratio of a firm's market asset value to the replacement cost of such assets, acting as a measure of market resource allocation efficiency. Table 3 presents the analysis of variance, indicating a correlation coefficient of 0.026 for digital transformation, significant at the 1% level, aligning with the benchmark regression findings.The conclusions of this research are shown to be solid.

5.2.2 Excluding the effect of the new crown epidemic

The selected time interval for the benchmark regression in this article is 2013-2023. The detrimental impacts of the COVID-19 epidemic have led to a significant decrease in exports from Chinese companies, potentially skewing the outcomes of the benchmark regression. This study omits all samples from 2020 to 2022 and recalculates them. The estimation findings reveal that the coefficient for digital transformation is 0.028, significant at the 1% level. This discovery corroborates the benchmark regression and reinforces the validity of the arguments articulated in this research.

5.2.3 Replacement of Explained Variables

The quantity_growth denotes the yearly growth rate of export volume. This study replaces quantity_growth with lnquantity as the explanatory variable to evaluate the robustness of the relationship between the primary explanatory variable (the extent of companies' digital transformation) and the explanatory variable (enterprises' export volume). The estimation results indicate that the corresponding coefficient of the explanatory variables is 0.070 and is significant at the 5% level, aligning with the benchmark regression and confirming the robustness of the conclusions presented in this study.

Table 3 Robustness Test Regression Results

Explained Variables	(1) lnquantity	(2) lnquantity	(3) quantity_growth
lndcg	0.026*** (2.80)	0.028*** (2.63)	0.070*** (2.54)
lnage	0.111*** (4.74)	0.136*** (4.66)	-0.214*** (-2.93)
lnempft	0.143***	0.083***	0.022

	(16.43)	(8.40)	(0.87)
turnover	0.076***	-0.069***	0.034
	(-5.21)	(-3.83)	(0.80)
everage	0.044***	0.057***	0.072***
	(5.76)	(6.26)	(3.16)
lnsubsidy	0.122***	0.131***	-0.023
	(17.27)	(16.16)	(-1.11)
profit	0.023***	0.021***	0.086***
	(5.39)	(3.96)	(7.24)
lnkl	-0.257***	-0.233***	-0.066
	(-16.58)	(-12.10)	(-1.48)
cashflow	0.011**		
	(2.44)		
tobinq	0.011**		
	(2.44)		
Constant term	-0.122***		
	(0.026)		
Firm	Yes	Yes	Yes
Year	Yes	Yes	Yes
N	11825	11825	11825
R^2	0.275	0.247	0.019

Note: t-values are presented in parenthesis; ***, **, and * denote significance at the 1%, 5%, and 10% levels, respectively, as illustrated in the table below.

5.3 Heterogeneity Analysis

5.3.1 Heterogeneity analysis based on the industry to which the firm belongs to

Significant variances exist in technology intensity, capital intensity, and labor intensity across industries as China's digital technology revolution progressively influences each sector. Is the effectiveness of digital transformation, and its subsequent impact on firms' export trade, contingent upon the technological levels of the industries in which these firms operate? Enterprises are assigned a value of 1 if they operate within a technology-intensive industry, and a value of 0 if they belong to a capital-intensive or labor-intensive sector. The estimated coefficient for the digital evolution of technology-intensive enterprises is 0.052, demonstrating statistical significance at the 1% level, as indicated in Table 4, column (1), presenting the regression results for these sectors. Figure illustrates the results of digital transformation in technology-intensive sectors. The regression analysis of digital transformation in capital-intensive and labor-intensive sectors yields an estimated coefficient of 0.019, which is not statistically significant. This indicates that digital transformation is more effective in improving the growth of export value for enterprises within technology-intensive industries.

Table 4 Heterogeneity Regression Results Based on the Industry to Which the Firm Belongs to

Explained variable: lnquantity	(1) Technology-intensive industries	(2) Capital-intensive and labor-intensive
lndcg	0.052***	0.019
	(4.11)	(1.37)
Control Variables	Yes	Yes
Firm	Yes	Yes
Year	Yes	Yes
N	11825	11825
R^2	0.302	0.217

Note: t-values are presented in parenthesis; ***, **, and * denote significance at the 1%, 5%, and 10% levels, respectively, as illustrated in the table below.

5.3.2 Heterogeneity analysis based on the region where the firms are located

Significant disparities exist across different locations in terms of policy support, infrastructure, market conditions, and human resources. The eastern regions generally experience more favorable policies and enhanced infrastructure, which attract significant foreign investment and advanced technology, alongside a greater degree of business digital transformation and strong export competitiveness. A firm located in the eastern region of China is assigned a value of 1, while a firm situated in the middle or western regions is assigned a value of 0. Table 5, Column (1), lists the enterprises situated in the eastern region. The estimated coefficient of digital transformation for firms in the eastern region is 0.028, significant and positive at the 5% level. The estimated coefficient for firms in the central and western regions of China, presented in column (2) of table 5, is 0.007, indicating an insignificant result. Significant. The estimated coefficient for digital transformation in firms located in the central and western regions, as shown in Table 5 (2), is 0.007, which suggests it is not statistically significant.

Table 5 Heterogeneity Regression Results Based on Enterprises' Regions

Explained variable: lnquantity	(1) East	(2) Midwest
lndcg	0.028**	0.007
	(2.55)	(0.40)
Control Variables	Yes	Yes
Firm	Yes	Yes
Year	Yes	Yes
N	11825	11825
R^2	0.261	0.291

Note: t-values are presented in parenthesis; ***, **, and * denote significance at the 1%, 5%, and 10% levels, respectively, as illustrated in the table below.

5.3.3 Heterogeneity analysis based on different dimensions of enterprise digital transformation

Enterprise digital transformation represents a spectrum that includes various technological distinctions, each defined by unique structural characteristics. This paper aims to refine the analysis of "digital transformation on enterprise exports" by utilizing the method developed by Wu Fei et al. This method categorizes five indicators: artificial intelligence (AI), blockchain (BD), cloud computing (CC), big data (DT), and application of practice (ADT). It subsequently correlates enterprise data associated with these indicators with word frequency statistics to derive digital transformation indexes. The analysis encompasses data across five indicators and includes word frequency statistics related to enterprise matching within these indicators, aiming to capture the multidimensional aspects of digital transformation. Table 6 illustrates that the estimated coefficients for enterprise digital transformation in the areas of artificial intelligence (AI), cloud computing, and practical application are significantly positive. The estimated coefficients for enterprise digital transformation in the areas of blockchain and big data are not statistically significant. The evidence suggests that digital transformation in artificial intelligence (AI), cloud computing, and practical applications promotes the expansion of corporate exports.

Table 6 Regression Results of Heterogeneity Analysis based on Different Levels of Enterprise Digital Transformation

	(1) lnquantity	(2) lnquantity	(3) lnquantity	(4) lnquantity	(5) lnquantity
lnai	0.033***				
	(6.04)				
lnbd		-0.002			
		(-0.33)			
lncc			0.025***		
			(3.58)		
lndt				-0.004	
				(-0.84)	
lnadt					0.018**
					(1.97)
Indicators	Artificial Intelligence	Blockchain	Cloud Computing	Big Data	Practical Applications
Firm	Yes	Yes	Yes	Yes	Yes
Year	Yes	Yes	Yes	Yes	Yes
N	11825	11825	11825	11825	11825
R^2	0.267	0.264	0.265	0.264	0.264

Note: t-values are presented in parenthesis; ***, **, and * denote significance at the 1%, 5%, and 10% levels, respectively, as illustrated in the table below.

6 CONCLUSION AND POLICY RECOMMENDATIONS

This research assesses the influence of corporate digital transformation on export value, employing a two-way fixed effects model with panel data from China's A-share listed companies in Shanghai and Shenzhen spanning 2013 to 2023. The digital transformation of firms significantly enhances their export value. This finding is robust when control variables are incorporated, the sample period is modified, and explanatory variables are replaced. The industry heterogeneity test indicates that digital transformation significantly impacts the export value of enterprises in technology-intensive sectors. Geographical Variation The analysis reveals that companies in the eastern region get a more significant increase in export value due to digital transformation than those in the central and western regions. Variability Across Different Phases of Digital Transformation The assessment reveals that digital transformation in artificial intelligence, cloud computing, and practical application substantially increases firms' export value, but the influence of blockchain and big data is negligible.

This document outlines the following policy proposals based on the previously stated conclusions: The government ought to strengthen policy support for the digital evolution of enterprises, especially within technology-intensive sectors and the eastern region. This can be achieved through the provision of incentives, including tax benefits, capital subsidies, and technical assistance, to support digital transformation efforts. Enhance infrastructure development for digital transformation in the central and western regions through improved network coverage, optimized data center

configurations, and strengthened cloud computing and big data platforms. This aims to reduce the digital divide in the eastern regions and foster equitable development in national digital transformation. Organizations need to enhance talent development and acquisition in digital transformation, particularly in advanced technological areas such as artificial intelligence and cloud computing, to effectively support their digital transformation efforts. Enhance foundational research and application development for technologies like blockchain and big data, while investigating their potential roles in enterprise digital transformation. Establish a thorough assessment and oversight framework for corporate digital transformation. Regularly assess the progress of digital transformation initiatives, promptly identify and address challenges, and ensure the effective implementation and promotion of digital transformation efforts. Enhance oversight to deter unlawful and irregular activities by businesses during digital transformation, thereby ensuring fair market competition and protecting consumer rights and interests.

COMPETING INTERESTS

The authors have no relevant financial or non-financial interests to disclose.

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