

Digital Transformation and Firms' Foreign Direct Investment: Evidence from Chinese Listed Companies

Ziming Lin *

School of Economics, Hefei University of Technology, Anhui 230009, China

* Corresponding Author Email: 1549621902@qq.com

Abstract. Against the backdrop of a new wave of economic globalization, digital transformation empowers firms' foreign direct investment, becoming a key lever for achieving high-quality international circulation. This paper takes A-share listed companies on the Shanghai and Shenzhen Stock Exchanges from 2011 to 2022 as the research sample to explore the effect and mechanisms of digital transformation in promoting firms' FDI. The study finds that digital transformation significantly promotes firms' FDI, and this conclusion holds after a series of robustness and endogeneity tests. Mechanism tests reveal that alleviating financing constraints and incentivizing green innovation are important transmission paths through which digital transformation promotes firms' FDI. Heterogeneity analysis shows that the effect of digital transformation on FDI is more pronounced in large firms and state-owned enterprises. This paper deepens the theoretical understanding of the internal logical relationship between digital transformation and firms' economic behavior, providing valuable insights for driving firms to better expand into overseas markets.

Keywords: Digital transformation, Foreign direct investment, green innovation, Financing constraints.

1. Introduction

The 20th Central Committee of the Communist Party of China, during its Third Plenary Session, emphasized the importance of "promoting high-level opening-up and building a modernized economic system." As a crucial element of the "going global" strategy, firms' foreign direct investment (FDI) not only helps enhance international competitiveness, optimize industrial structures, and introduce advanced business models and technologies but also allows firms to diversify market risks and reallocate international resources and production factors. Regarding the factors influencing firms' FDI, many scholars argue that national characteristics, including geographic scope, political environment, level of economic development, and cultural and institutional frameworks, help attract foreign direct investment (Chen et al., 2020; Han and Huang, 2024; Zhou et al., 2023). Other scholars believe that tax incentives and tax policy reforms can encourage firms to engage in FDI by increasing the liquidity of the parent company's assets and enhancing its innovation capabilities (Sun and Ren, 2023; Yu and Tian, 2023). In the first half of 2024, China's total outward FDI reached \$85.3 billion, a year-on-year increase of 13.2%, accelerating the formation of a new development pattern where domestic and international circulations mutually reinforce each other. Therefore, exploring new opportunities for China's FDI and tapping into the potential of Chinese firms' FDI is of great significance for promoting high-quality development in China's opening-up and fostering smooth domestic and international dual circulation.

Digital transformation refers to the process in which firms comprehensively apply new digital technologies, such as big data, artificial intelligence, and cloud computing, integrating them into their daily operations (Wu et al., 2021). Digital transformation has become a top priority for companies to facilitate information exchange, promote technological upgrades, shift management models, optimize service approaches, and enhance market competitiveness. Existing literature on the role of digital transformation mainly focuses on two areas. First, many studies suggest that firms can increase the efficiency of their resource utilization through digital transformation, thereby expanding profit margins, improving financial performance (Zhai et al., 2022), and enhancing total factor productivity (Zhang and Yin, 2023), which in turn strengthens their competitive advantage. Second, scholars

emphasize the positive role of digital transformation in promoting innovation. Digital technologies enhance a firm's ability to acquire, absorb, and apply external knowledge, fostering openness and innovation (Peng and Tao, 2022). The development of digital platforms facilitates the flow of knowledge and information, significantly improving the synergy within the innovation ecosystem (Urbinati et al., 2020).

There is no consensus on the impact of digital transformation on firms' FDI in existing research. On the one hand, Guo (2024) finds that digital transformation significantly promotes FDI activities of high-tech and technology-intensive firms by enhancing technological innovation capacity and reducing financing constraints. Li and Zhang (2024) point out that digital transformation can overcome geographical distance barriers and optimize the locational distribution of firms' FDI. Liu et al. (2024) highlight how digital transformation, by strengthening firms' ownership advantages and internalization motives, contributes to incremental improvements in FDI. On the other hand, traditional multinational companies face challenges when balancing digital transformation with economic benefits, leading to dilemmas where firms are hesitant or unable to pursue transformation. The "2024 Blue Book on the Digital Development of Chinese Overseas Enterprises (Asia-Pacific)" published by the China Academy of Information and Communications Technology (CAICT) reveals that when enterprises internationalize, they often encounter a lack of overseas digital infrastructure and service markets. Combined with differences in service mechanisms between domestic and foreign telecom operators, Chinese firms face high costs in obtaining digital infrastructure services abroad, and their demand for digital services often goes unmet. Additionally, diverse data security and privacy regulations create pressures for firms to adapt. Wang Ruping and Zhang (2023) also point out that the impact of digital transformation on FDI varies based on firms' ownership structures and geographical locations.

Based on this, this paper adopts a micro-level perspective to explore the relationship between digital transformation and firms' FDI and its mechanisms, aiming to provide a useful supplement to existing research.

The marginal contributions of this paper are threefold: First, this paper integrates digital transformation and firms' FDI into the same analytical framework, attempting to explore the microeconomic consequences of digital transformation from the perspective of FDI, thereby expanding existing research. Second, using A-share listed companies on the Shanghai and Shenzhen stock exchanges from 2011 to 2022 as the sample, the paper provides empirical evidence on the promoting effect and mechanisms of digital transformation on firms' FDI, offering practical insights for firms to adopt differentiated and dynamic strategies in their digital transformation efforts, balancing economic and social benefits. Third, this paper reveals that alleviating financing constraints and providing innovation incentives are key mechanisms through which digital transformation enhances firms' FDI.

2. Literature review and hypothesis development

2.1. Direct Effect

In the current economic environment, foreign direct investment (FDI) is a critical means for enterprises to implement their internationalization strategies and enhance global competitiveness. With the rise of the digital economy, firms' digital transformation has become a key factor in promoting outward investment.

Firstly, from the perspective of transaction costs, digital transformation can promote firms' FDI by mitigating the issue of "cost stickiness" (Zhang et al., 2023). On the one hand, digital transformation helps firms reduce search costs. It facilitates efficient information flows, real-time sharing, and integrated collaboration, thereby lowering search costs. Specifically, the connectivity, openness, and sharing capabilities of digital technologies expand the potential space for firms to search for customer information while alleviating the "bullwhip" effect, reducing the likelihood of information distortion. On the other hand, digital transformation helps reduce decision-making costs. Through digital

technologies and autonomous machine algorithms, intelligent products such as text search, image recognition, and conversational interfaces are created. Based on deep learning and extensive training using machine algorithms, patterns are summarized for scientific decision-making, effectively avoiding cognitive biases in human decision-making, such as the "framing effect," "illusion of control," and "analogical reasoning" (Pang et al., 2023), thereby improving decision-making efficiency and reducing costs.

From the perspective of management efficiency, digital transformation can enhance both production and management efficiency through the upgrading of information technologies, thereby promoting firms' FDI. Specifically, on the one hand, digital transformation helps firms establish a smart, lean, and efficient "information + system" management approach, which further improves management efficiency (Qi and Xu, 2020). In this process, the informational advantages of digital technologies break down operational barriers between domestic and overseas parent and subsidiary companies, improving the timeliness of information transmission and boosting both internal and external operational and management efficiency. This lowers firms' operational costs by integrating various systems such as data mining systems, decision support systems, and business collaboration management systems (Li et al., 2022), achieving specialized division of labor across domestic and international departments and cross-departmental collaboration. On the other hand, during the process of digital transformation, company managers can utilize digital systems to more accurately and promptly grasp operational and management information. After processing and delivering effective information, they can actively communicate this information to market entities worldwide, including investors, creditors, and suppliers, thus mitigating conflicts of interest caused by information asymmetry. This improves supply chain management efficiency and reduces the operating costs and risks of multinational operations (Zhang et al., 2024). Therefore, this study proposes:

Hypothesis 1: Digital transformation can enhance firms' foreign direct investment.

2.2. Literature Review and Theoretical Mechanism

Digital transformation can alleviate firms' financing constraints. On one hand, financing constraints often limit a firm's ability to expand internationally, reducing their foreign investment decisions. This is especially true for small and medium-sized enterprises (SMEs), which, due to limited financing channels, find it difficult to engage in large-scale international investments. Internally, the use of digital technologies enables better allocation of resources, improving resource utilization efficiency and financial performance. Digital transformation can reduce debt costs by mitigating information asymmetry and enhancing profitability (He et al., 2024), allowing firms to make better use of funds and easing financial pressure. Moreover, digital transformation improves firms' economic efficiency and financial condition, thus lowering their financing costs (Xu et al., 2023). It enables firms to specialize and utilize digital technologies to gather the necessary information and data for their production processes, facilitating efficient labor division, reducing costs, and enhancing competitive advantage (Zhao et al., 2021). Improved profitability also strengthens firms' debt repayment ability, reduces the risk of default, and lowers the risk compensation required by creditors, thus decreasing financing costs.

The alleviation of financing constraints facilitates firms' FDI activities. In the capital market, digital transformation enhances firms' reputation ratings by optimizing corporate governance structures and increasing transparency. The capital market's recognition of digitally transformed firms boosts investor confidence, allowing firms to ease financing constraints and gain financial support. When firms have sufficient funds, they are more likely to make FDI decisions. In terms of competition, digital transformation, by easing financing constraints, allows firms to allocate more funds to R&D, which enhances innovation capacity and leads to the accumulation of intangible assets (Li et al., 2021). This, in turn, raises productivity levels, encourages firms to explore overseas markets, and promotes growth in FDI scale. Based on this, the study proposes:

Hypothesis 2: Digital transformation enhances firms' FDI by alleviating financing constraints.

Green innovation is an inevitable choice for promoting economic transformation and achieving environmental sustainability, while firms' digital transformation can systematically enhance green innovation capabilities on multiple levels.

From the perspective of energy consumption, the application of big data in production processes allows companies to collect real-time data on energy flows, reducing unnecessary energy waste. Through the use of "renewable" data as a production factor, digital transformation significantly reduces the energy and resource consumption typical of traditional industries, thereby driving green, high-quality development.

From the perspective of information transmission and resource effects, as digital transformation deepens within companies, the quantity and quality of corporate information disclosure improve, effectively alleviating information asymmetry between firms and stakeholders. This enhances the firm's ability to access diversified information, and the resulting advantages in information flow and resource utilization positively impact all stages of green innovation research and development (Lin et al., 2023).

Considering the entire process of corporate green innovation activities, in the initial stage, digital transformation enhances firms' abilities to search for and integrate resources, mitigates management's short-term focus, and accelerates the generation and refinement of green innovation ideas. In the mid-stage of testing, digital transformation optimizes innovation processes, effectively controls pollution emissions in production, supports green reform in production processes, and provides multi-dimensional support for innovation iterations. In the final stage, digital transformation improves the efficiency of green product manufacturing and helps identify new green innovation opportunities in marketing.

Furthermore, the level of a company's green innovation capabilities will influence its foreign direct investment (FDI). According to the monopolistic advantage theory and the eclectic theory of international production, innovation capabilities are a key source of monopolistic advantage for firms, driving motivation for FDI while also helping firms overcome the "liability of foreignness." The competitive advantage of multinational corporations primarily stems from their technological assets and innovation capabilities; firms with high R&D investment and strong innovation capacities are more likely to evolve into multinationals. Green innovation R&D activities can improve operational efficiency and product quality, enhancing competitiveness in international markets and helping firms strengthen and expand into overseas markets, thereby promoting FDI.

Additionally, green innovation increases firms' willingness to engage in FDI and reduces the negative impacts of FDI. Research shows that green innovation helps improve firms' productivity (Lu and Li, 2023), and according to firm heterogeneity theory, firms with higher productivity are more likely to engage in FDI compared to domestic production and exports. Empirical data also suggests that high production efficiency is an effective way to offset the negative impact of bilateral institutional environment disparities on Chinese firms' FDI (Zhao et al., 2020). Thus, the green technological innovation brought about by digital transformation undoubtedly provides firms with additional advantages for FDI.

At the same time, driven by a desire for advanced foreign green technologies, reverse spillover effects and demonstration learning effects from green technology innovation and improved environmental efficiency (Liu et al., 2021) will motivate firms to "go global" and collaborate with companies in these countries or regions. Based on the above analysis, this study proposes:

Hypothesis 3: Digital transformation promotes firms' FDI through the incentive effects of green innovation.

3. Research design

3.1. Sample selection

3.1.1. Dependent Variable

Corporate Outward Foreign Direct Investment (OFDI): The data for OFDI comes from the annual reports of listed companies and the database of related-party transactions of Chinese listed companies. In cases where the OFDI amount is missing in a company's annual report, following existing research (Wang and Zhang, 2023), this study substitutes the actual registered capital of all subsidiaries of the listed company in different host countries. Additionally, the OFDI data is log-transformed by adding one to the raw value before taking the natural logarithm.

3.1.2. Independent Variable

Corporate Digital Transformation (DIGT): As a core strategy for high-quality development, digital transformation is often highlighted in corporate annual reports, reflecting the company's strategic orientation, business philosophy, and development pathway. Based on the research by Wu et al. (2021), this study measures the extent of digital transformation through word frequency statistics related to digital transformation in the annual reports of listed companies. The specific process is as follows:

First, Python web scraping is used to obtain and organize the annual reports of all A-share listed companies from the Shanghai Stock Exchange and Shenzhen Stock Exchange. Then, the Java PDFbox library extracts all textual content from these reports.

Next, based on two dimensions—"underlying technology usage" (including artificial intelligence, big data, cloud computing, and blockchain technologies) and "technological application practices" (including digital technology applications)—the study identifies five sets of characteristic terms and extracts high-frequency terms related to corporate digital transformation from the annual reports.

Finally, the Jieba tool is employed for text segmentation across all samples to create a data pool. Using the collected characteristic terms, the study performs search, matching, and frequency counting to generate a cumulative word spectrum. The cumulative word spectrum is then log-transformed by adding one to create a digital transformation index for listed companies. The higher the value, the greater the degree of digital transformation.

3.1.3. Mechanism Variables

Green Innovation: Following existing research (Qi et al., 2018; Liu et al., 2023), this study uses the green patent classification list published by the World Intellectual Property Organization (WIPO) in 2010 and matches it with the classification codes from the patent data of the China National Intellectual Property Administration to obtain the green patent data for listed companies. During empirical testing, this variable is log-transformed by adding one to the raw value, with higher values indicating a higher level of green innovation. To account for the effectiveness of corporate green innovation, this study first uses green invention patents (grp) for regression in the mechanism test, and then uses green utility model patents (grp2) for regression to enhance the credibility of the research conclusions.

Financing Constraints: Based on existing research (Xu et al., 2023), this study uses the SA index to represent the level of financing constraints. Compared to the KZ index and WW index, which include endogenous financial variables such as cash flow and leverage, the SA index only uses two exogenous variables—firm size (size) and firm age (age)—which are minimally influenced by external events. The SA index is negative, and the larger the absolute value, the higher the degree of financing constraints. The SA index is calculated as follows:

$$SA = -0.737Size + 0.043Size^2 - 0.04Age \quad (1)$$

To further strengthen the robustness of the mechanism test, the study also uses the FC index for verification. While the SA index focuses on analyzing the degree of information asymmetry within

the firm, the FC index primarily considers the impact of internal cash flow on the firm's financial needs to measure the level of financing constraints faced by the company.

3.2. Methodology

$$OFDI_{it} = \alpha_0 + \alpha_1 DIGT_{it} + \alpha_2 Z_{it} + \mu_i + \theta_i + \delta_t + \varepsilon_{it} \quad (2)$$

In the model, $OFDI_{it}$ represents the firm i 's outward foreign direct investment amount in period t , and $DIGT_{it}$ represents the degree of the firm i 's digital transformation in period t . To more comprehensively analyze the effect of digital transformation on firms' outward foreign direct investment, control variables that might affect OFDI are also included, denoted as Z_{it} . These are:

- Firm size (size), measured as the logarithm of the firm's total assets;
- Firm age (age), measured as the logarithm of the firm's years of establishment;
- Return on assets (roa), calculated as the ratio of annual net profit to total assets;
- Board size (board), measured as the logarithm of the number of board members;
- Ownership concentration (top1), measured as the shareholding ratio of the largest shareholder;
- CEO duality (duality), measured by whether the chairman also serves as the CEO.

To avoid individual heterogeneity in within-group regressions, the model includes fixed effects for individuals, denoted as μ_i , and fixed effects for industries, denoted as θ_i , while δ_t represents time fixed effects, and ε_{it} is the random error term.

3.3. Data Sources and Descriptive Statistics

This study selects A-share listed companies from the Shanghai and Shenzhen stock exchanges from 2011 to 2022 as the research sample, following these filtering steps: exclude financial companies; exclude samples with missing financial data or those that are insolvent; exclude samples marked as ST or *ST during the year.

The sample is subjected to firm-level clustered regression to eliminate interference from intergroup data differences and to reasonably control for heteroscedasticity. The financial data used in the study is sourced from the CSMAR database and Wind database.

Table 1. Descriptive Statistics

Variable	Obs	Mean	Std. Dev.	Min	Max
<i>DIGT</i>	15724	1.432	1.376	0.000	5.037
<i>OFDI</i>	15724	10.640	2.218	-1.139	21.599
<i>size</i>	15724	18.366	5.914	1.000	63.000
<i>age</i>	15724	0.045	0.071	-2.646	0.786
<i>roa</i>	15724	22.372	1.400	17.813	28.615
<i>board</i>	15724	2.131	0.201	1.099	2.890
<i>top1</i>	15724	35.500	15.382	3.000	89.410
<i>duality</i>	15724	0.288	0.453	0.000	1.000
<i>grp</i>	15724	0.253	0.672	0.000	6.328
<i>SA</i>	15724	-3.828	0.288	-5.930	-2.090

4. Empirical Analysis

4.1. Baseline Regression

Table 2 reports the regression results of how digital transformation affects firms' outward direct investment. Columns (1) and (2) present the empirical results using pooled OLS regression. Regardless of whether control variables are included, the estimated coefficient of the key explanatory variable—firms' digital transformation—is significantly positive at the 1% level. Columns (3) and (4) present the empirical results using a fixed-effects model. In both columns, under the conditions of controlling for time and individual effects, the estimated coefficient of the key explanatory variable—

firms' digital transformation—remains significantly positive. After introducing control variables, a 1% increase in the level of digital transformation results in a 0.065% increase in firms' outward direct investment, confirming that digital transformation significantly promotes firms' outward direct investment. This finding supports the conclusions of Wang Ruping and Zhang (2023) as well as Zhang et al. (2023).

Table 2. Baseline Regression

	(1)	(2)	(3)	(4)
	OFDI	OFDI	OFDI	OFDI
<i>DIGT</i>	0.254***	0.232***	0.104***	0.065***
	(0.012)	(0.012)	(0.023)	(0.023)
<i>size</i>		0.457***		0.495***
		(0.013)		(0.055)
<i>age</i>		-0.002		0.058
		(0.003)		(0.078)
<i>roa</i>		3.976***		0.664***
		(0.416)		(0.242)
<i>board</i>		-0.497***		0.077
		(0.085)		(0.156)
<i>top1</i>		0.001		-0.003
		(0.001)		(0.003)
<i>dual</i>		0.227***		-0.017
		(0.037)		(0.057)
<i>_cons</i>	10.277***	0.878***	10.506***	-1.651
	(0.026)	(0.294)	(0.035)	(1.892)
<i>Firm FE</i>	N	N	Y	Y
<i>Industry FE</i>	N	N	Y	Y
<i>Year FE</i>	N	N	Y	Y
<i>N</i>	15724	15724	15418	15418
<i>adj. R²</i>	0.025	0.115	0.599	0.605

Note: ***, **, and * indicate significance at the 1%, 5%, and 10% confidence levels, respectively, with robust standard errors in parentheses. The same applies hereafter.

4.2. Robustness Analysis

4.2.1. Variable Substitution

To account for potential effects of different measurement methods on the research conclusions, a robustness test was conducted by substituting the key explanatory variable. While the previous section used the measurement method from Wu et al. (2021), this section adopts Zhao (2021) approach. This method involves reconstructing the digital transformation index by calculating the frequency of 99 digitalization-related terms across four dimensions: digital technology application, internet business models, smart manufacturing, and modern information systems. As shown in column (1) of Table 3, the key explanatory variable remains significantly positive, validating Hypothesis 1.

4.2.2. Interactive Fixed Effects

In industries with advanced technology or in cities with higher levels of economic development, digital infrastructure may be relatively well-established, providing firms with greater advantages in digital transformation. Based on this, interactive fixed effects for industry-year and city-year were included to control for the impact of industry- and city-level factors that vary over time, thereby mitigating the influence of changes in the macro environment driven by digital economic development (Bai, 2013). The regression results in columns (2) and (3) of Table 3 show that the

estimated coefficients for firms' digital transformation are significantly positive, consistent with the baseline regression results.

4.2.3. Panel Quantile Model

The baseline regression model illustrates the effect of digital transformation on firms' outward direct investment within the mean range but does not specifically examine the variation in the impact across firms with different levels of digital transformation. Drawing on the approach of Chernozhukov et al. (2022), this study further employs a panel quantile regression model. The panel quantile regression model models different quantiles based on the overall data of firms, which compensates for the shortcomings of mean regression and avoids the subjectivity of grouping firm samples. It also captures the overall characteristics of the distribution more comprehensively. The 25%, 50%, and 75% quantiles were selected for the regression, and the results are shown in columns (4) to (6) of Table 3. The results indicate that the coefficients of the key explanatory variable at different quantiles are largely consistent with the baseline regression, further strengthening the credibility that digital transformation promotes firms' outward direct investment.

4.2.4. Double Clustering of Robust Standard Errors

Considering the intrinsic correlation between different firms, we adjusted the standard errors with double clustering at the firm and time levels to overcome the impact of issues such as autocorrelation and heteroscedasticity on statistical inference (Zhang and Li, 2023). The results are presented in column (7) of Table 3. The coefficient of the key explanatory variable remains significantly positive, consistent with the baseline results.

Table 3. Robustness Tests

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	Alternative Variables	Panel Interactive Fixed Effects		Q=0.25	Q=0.5	Q=0.75	Robust Standard Errors with Double Clustering
<i>DIGT</i>	0.048*** (0.015)	0.065*** (0.024)	0.063** (0.025)	0.315*** (0.014)	0.213*** (0.010)	0.141*** (0.008)	0.065* (0.030)
<i>size</i>	0.515*** (0.014)	0.506*** (0.058)	0.390*** (0.060)	0.410*** (0.018)	0.431*** (0.013)	0.504*** (0.012)	0.495*** (0.076)
<i>age</i>	-0.025*** (0.003)	0.050 (0.082)	0.031 (0.093)	-0.009* (0.005)	0.001 (0.003)	-0.003 (0.002)	0.058 (0.045)
<i>roa</i>	3.457*** (0.390)	0.799*** (0.250)	0.557* (0.289)	6.709*** (0.460)	5.046*** (0.365)	2.931*** (0.333)	0.664** (0.242)
<i>board</i>	-0.203** (0.087)	0.014 (0.160)	0.045 (0.174)	- 0.428*** (0.129)	- 0.531*** (0.099)	- 0.572*** (0.072)	0.077 (0.179)
<i>top1</i>	0.002** (0.001)	-0.002 (0.003)	-0.001 (0.003)	0.002 (0.002)	0.004*** (0.001)	0.001 (0.001)	-0.003 (0.005)
<i>dual</i>	0.122*** (0.037)	0.001 (0.059)	-0.036 (0.063)	0.320*** (0.056)	0.203*** (0.032)	0.078*** (0.029)	-0.017 (0.071)
<i>_cons</i>	-0.305 (0.320)	-1.672 (1.988)	1.216 (2.128)	0.661 (0.452)	1.773*** (0.321)	1.683*** (0.256)	-1.651 (1.847)
<i>Firm FE</i>	Y	Y	Y	Y	Y	Y	Y
<i>Industry FE</i>	Y	Y	Y	Y	Y	Y	Y
<i>Year FE</i>	Y	Y	Y	Y	Y	Y	Y
<i>Industry*Year FE</i>		Y					
<i>City*Year FE</i>			Y				
<i>N</i>	15724	15320	14271	15418	15418	15418	15418
<i>adj. R²</i>	0.185	0.609	0.610	0.605	0.605	0.605	0.604

4.3. Endogeneity Analysis

Although this study has controlled for firm-level variables as much as possible and incorporated fixed effects from various dimensions into the model, there may still be issues of omitted variables. To address potential endogeneity problems caused by reverse causality and omitted variables, this study re-estimates the model using the two-stage least squares (2SLS) method with instrumental variables (IV). In selecting the instrumental variable, this study follows the approach of Xiao et al. (2021) and uses the average digital transformation index (IV_Mean) classified by year-province-industry as the instrumental variable to address endogeneity. The overall digital transformation of an industry will improve overall production efficiency and optimize resource allocation, which in turn forces individual firms within the industry to accelerate their digital transformation to adapt to the higher industry production levels (Zhou et al., 2022). Therefore, the overall level of digital transformation in an industry influences the digital transformation performance of individual firms within that industry, satisfying the relevance criterion. At the same time, the industry's digital transformation does not directly affect a single firm's outward direct investment, thus meeting the exogeneity criterion.

Columns (1) and (2) of Table 4 show the estimation results using the instrumental variables. Both models are estimated using 2SLS. As shown, the first-stage estimation results indicate that the instrumental variable significantly and positively affects digital transformation. In the second-stage estimation results, after considering the endogeneity issue, the coefficient of digital transformation remains significantly positive at the 1% level, consistent with the baseline estimation results. Additionally, in the weak instrument identification test, for the null hypothesis of “weak instrument identification,” the p-value of the LM statistic is 0.000, which strongly rejects the null hypothesis. In the weak instrument test, the Wald F-statistic exceeds the critical value at the 10% level of the Stock-Yogo weak identification test. Overall, these tests demonstrate the validity of the instrumental variable used in this study, further validating Hypothesis 1.

Table 4. Endogeneity Test

	(1)	(2)
	IV_MEAN	
DIGT		1.198***
		(0.225)
IV_MEAN	0.275***	
	(0.025)	
size	0.277***	0.197**
	(0.021)	(0.089)
age	0.068***	-0.092***
	(0.004)	(0.024)
roa	0.039	0.562**
	(0.095)	(0.254)
board	0.150***	-0.284
	(0.064)	(0.177)
top1	-0.005***	0.001
	(0.001)	(0.004)
dual	0.001	0.034
	(0.023)	(0.063)
Firm FE	Y	Y
Industry FE	Y	Y
Year FE	Y	Y
KP rk LM		183.418***
KP rk Wald F		119.235***
Stock-Yogo 10%		16.38
F	194.24	
N	15322	15322

5. Further Discussion

5.1. Mechanism Testing

The traditional stepwise method for analyzing mediating effects can reduce statistical testing power, leading to biased estimates. Jiang (2022) suggested that in mediating effect analysis, the conventional stepwise regression method can be discarded. Instead, as long as a theoretically intuitive relationship between the mediating variable and the dependent variable is proposed, and the effects of the independent variable on both the dependent variable and the mediating variable are tested, it can avoid distinguishing between whether there are unexplained direct effects beyond the indirect effects. Therefore, this study draws on existing research and only conducts a regression analysis between digital transformation and the mediating variables, while the effect of the mediating variables on firms' outward direct investment is demonstrated through theoretical literature.

The results shown in columns (1) and (2) of Table 5 indicate that digital transformation can alleviate firms' financing constraints. Generally, digital transformation helps improve firms' economic performance and financial status, reducing financing costs. Lower financing costs provide firms with more funds for R&D investments, which helps enhance their innovation capabilities and accumulate intangible assets, thus improving production efficiency, encouraging firms to expand into overseas markets, and increasing the scale of their outward direct investment.

The results shown in columns (3) and (4) of Table 5 indicate that digital transformation promotes firms' green innovation. Specifically, digital transformation can enhance green innovation by reducing energy consumption, promoting knowledge and technology spillovers, and enabling cross-regional collaboration. The improvement in green innovation can, in turn, raise firms' total factor productivity by improving product quality and reducing the marginal cost of production, thereby boosting firms' motivation for outward direct investment.

Table 5. Mechanism Test

	(1)	(2)	(3)	(4)
	SA	FC	grp	grp2
DIGT	-0.006*** (0.001)	-0.006*** (0.001)	0.057*** (0.005)	0.018*** (0.004)
size	0.049*** (0.002)	-0.174*** (0.001)	0.137*** (0.007)	0.097*** (0.006)
age	-0.039*** (0.000)	-0.004*** (0.000)	-0.004*** (0.001)	-0.005*** (0.001)
roa	-0.044*** (0.015)	0.415*** (0.029)	0.113* (0.061)	0.042 (0.050)
board	-0.046*** (0.007)	-0.027*** (0.007)	0.006 (0.032)	0.011 (0.026)
top1	0.001*** (0.000)	0.000 (0.000)	-0.001* (0.000)	0.000 (0.000)
dual	0.019*** (0.003)	0.014*** (0.003)	0.049*** (0.012)	0.026** (0.010)
_cons	-4.103*** (0.039)	4.490*** (0.031)	-2.845*** (0.153)	-1.950*** (0.121)
Industry FE	Y	Y	Y	Y
Year FE	Y	Y	Y	Y
N	15724	14668	15724	15724
adj. R ²	0.717	0.770	0.189	0.176

5.2. Heterogeneity Test

5.2.1. Firm Size

The impact of digital transformation on foreign direct investment may differ significantly across firms of different sizes. Therefore, this study constructs a dummy variable for firm size, defining firms with total assets above the industry median as large firms, and others as small and medium-sized enterprises (SMEs). The test results are shown in columns (1) and (2) of Table 6. The findings indicate that the estimated coefficient for digital transformation (DIGT) is positive for large firms, with the magnitude and significance slightly higher than for SMEs. This suggests that digital transformation has a more pronounced effect on promoting ODI for large firms compared to SMEs. According to the resource-based theory, large firms have more financial, technological, and human resources, face lower financing barriers, and have stronger market influence. These firms are more sensitive to tariff reductions, have easier access to loans and investments, and thus have more funds to drive innovation, develop high-end talent, and invest in projects that require long-term commitment to yield returns (Gao et al., 2021).

5.2.2. Firm Ownership

Compared to non-state-owned enterprises, state-owned enterprises (SOEs) perform certain government functions, have weaker profit motives, and are more heavily regulated by the government. Therefore, this study conducts grouped regressions based on the ownership type, classifying firms as either state-owned or non-state-owned. The regression results, shown in columns (3) and (4) of Table 6, indicate that the coefficient for the impact of digital transformation is significantly positive at the 1% level for SOEs, while for non-SOEs, it is positive but not statistically significant.

Table 6. Heterogeneity Tests

	(1)	(2)	(3)	(4)
	Large Enterprises	Small and Medium-sized Enterprises	State-owned Enterprises	Non-state-owned Enterprises
<i>DIGT</i>	0.051**	0.046*	0.041**	0.026
	(0.021)	(0.025)	(0.019)	(0.031)
<i>size</i>	0.534***	0.569***	0.457***	0.609***
	(0.041)	(0.023)	(0.020)	(0.023)
<i>age</i>	-0.021***	-0.021***	-0.016***	-0.023***
	(0.004)	(0.005)	(0.004)	(0.006)
<i>roa</i>	2.522***	5.333***	2.896***	3.900***
	(0.397)	(0.510)	(0.429)	(0.613)
<i>board</i>	-0.247**	-0.173	-0.108	-0.148
	(0.121)	(0.123)	(0.112)	(0.146)
<i>top1</i>	0.004**	-0.000	0.005***	0.001
	(0.002)	(0.002)	(0.001)	(0.002)
<i>dual</i>	0.094**	0.104*	0.064	0.038
	(0.046)	(0.062)	(0.041)	(0.092)
<i>_cons</i>	-0.653	-1.795***	0.755*	-2.874***
	(0.892)	(0.555)	(0.452)	(0.584)
<i>Firm FE</i>	Y	Y	Y	Y
<i>Industry FE</i>	Y	Y	Y	Y
<i>Year FE</i>	Y	Y	Y	Y
<i>N</i>	7861	7859	9891	5828
<i>adj. R²</i>	0.186	0.156	0.168	0.242

State-owned enterprises (SOEs) typically have a more centralized decision-making structure, allowing them to implement digital strategies more swiftly and effectively, thereby driving the transformation process forward. Influenced by government objectives, they may take the lead in

actively responding to government mandates for digital transformation. Through the use of government-provided special funds, technical support, or preferential policies, they can accelerate digital development, amplifying the positive effects of digital transformation. SOEs need to continuously enhance their competitiveness, innovation capacity, and influence in their respective sectors to play a strategic supporting role. As a result, during their "going global" efforts, they place greater emphasis on improving their level of digitalization (Yu Jinping and Xia Wenhao, 2024). Additionally, due to their state-owned nature, SOEs have a higher risk tolerance, enabling them to undertake larger-scale and longer-term investments and experiments in the process of digital transformation.

6. Conclusion and Implications

In the current era, with the rapid advancement of a new technological revolution and industrial transformation, the development of strategic plans for digital transformation, the creation of new competitive advantages, and the reshaping of the international landscape have become prevailing trends. Based on data from A-share listed companies in Shanghai and Shenzhen between 2011 and 2021, this study explores the impact and mechanisms of digital transformation on foreign direct investment and analyzes the underlying processes. The findings reveal that digital transformation significantly promotes firms' OFDI, and this effect remains robust even after a series of stability and endogeneity tests. Mechanism tests indicate that alleviating financing constraints and encouraging green innovation are key channels through which digital transformation enhances firms' OFDI. Heterogeneity analysis shows that the effect of digital transformation on OFDI is more pronounced in large firms and state-owned enterprises. Based on these conclusions, the following policy recommendations are proposed:

Government Support for Digital Transformation: Policies should prioritize digital transformation through measures such as tax incentives, financial subsidies, and dedicated funds to encourage firms, especially small and medium-sized enterprises, to pursue digital upgrades in their foreign investments. Additionally, the legal and regulatory framework related to the digital economy should be improved, including aspects such as intellectual property protection, data security, and cross-border data flows. The government should lead the establishment of a digital information-sharing platform and the cultivation of digital talent to support firms' digital transformation and foreign investments.

Encouraging Leading Enterprises to Take Initiative: Leading enterprises should play a proactive role in advancing digital transformation, encouraging the use of digital technologies in overseas investments to enhance operational efficiency and competitiveness, alleviate financing constraints, and better navigate the complex landscape of international markets.

Promoting International Cooperation and Alignment with Digital Standards: Efforts should be made to facilitate the integration of international digital standards and reduce digital barriers to ODI. This can help firms access local markets more effectively and minimize policy and technical obstacles.

References

- [1] Bai, J. S. (2013). Fixed-effects dynamic panel models, a factor analytical method. *Econometrica*, 81 (1), 285 - 314.
- [2] Chen, J., Liu, Y., & Liu, W. (2020). Investment facilitation and China's outward foreign direct investment along the belt and road. *China Economic Review*, 61, 101458.
- [3] Chernozhukov, V., Fernandez-Val, I., & Melly, B. (2022). Fast algorithms for the quantile regression process. *Empirical Economics*, 62 (1), 7 - 33.
- [4] Liu, L. Y., Zhao, Z. Z., & Zhang, M. M. (2021). The effects of environmental regulation on outward foreign direct investment's reverse green technology spillover: Crowding out or facilitation? *Journal of Cleaner Production*, 284, 124689.
- [5] Peng, Y. Z., & Tao, C. Q. (2022). Can digital transformation promote enterprise performance? -From the perspective of public policy and innovation. *Journal of Innovation & Knowledge*, 7 (3), 100198.

- [6] Urbinati, A., Chiaroni, D., & Chiesa, V. (2020). The role of digital technologies in open innovation processes: an exploratory multiple case study analysis. *R & D Management*, 50 (1), 136 - 160.
- [7] Zhai, H. Y., Yang, M., & Chan, K. C. (2022). Does digital transformation enhance a firm's performance? Evidence from China. *Technology in Society*, 68, 101841.
- [8] Zhou, S., Zhou, P., & Ji, H. (2022). Can digital transformation alleviate corporate tax stickiness: The mediation effect of tax avoidance. *Technological Forecasting and Social Change*, 184, 122028.
- [9] Gao, Y., Yin, S., & Huang, H. (2021). Export trade liberalization, firm heterogeneity, and export firm product configuration. *World Economic Studies*, (1), 47 - 61.
- [10] Guo, J. (2024). How does digital transformation affect the OFDI behavior of enterprises: The intrinsic mechanism and empirical evidence. *World Economic Studies*, (2), 63 - 77.
- [11] Han, S., & Huang, M. (2024). The impact of cultural perception differences on China's outward direct investment. *Beijing Social Sciences*, (7), 75 - 89.
- [12] He, Y., Chen, L., & Du, Y. (2024). Can data assetization alleviate the financing constraints of "specialized, refined, and innovative" small and medium-sized enterprises? *China Industrial Economics*, (8), 154 - 173.
- [13] Jiang, T. (2022). Mediating effects and moderating effects in empirical research of causal inference. *China Industrial Economics*, (5), 100 - 120.
- [14] Jiang, G. (2022). The choice of outward direct investment modes by Chinese enterprises. *Economic Perspectives*, (10), 101 - 120.
- [15] Li, M., & Zhang, N. (2024). Can digital transformation optimize the geographical distribution of enterprise OFDI? *Contemporary Finance and Economics*, (2), 111 - 124.
- [16] Li, W., Pan, W., & Yuan, K. (2022). Enterprise digital transformation and the development of China's real economy. *Quantitative Economics*, (9), 5 - 25.
- [17] Li, Y., Ren, H., & Zhu, D. (2021). Digital finance, equity pledge, and corporate innovation investment. *Research Management*, (8), 102 - 110.
- [18] Lin, Y., Yang, C., & Cai, X. (2023). Enterprise digital transformation and the upgrade of green innovation capabilities - An analysis based on network effects. *Modern Finance and Economics (Journal of Tianjin University of Finance and Economics)*, (2), 3 - 19.
- [19] Liu, X., Zhang, H., & Li, Q. (2024). Digital transformation empowers Chinese enterprises' outward direct investment - An analysis based on the eclectic paradigm framework. *International Trade Exploration*, (4), 86 - 101.
- [20] Lu, C., & Li, H. (2023). Carbon pilot policies, green innovation, and corporate production efficiency. *Exploration of Economic Issues*, (4), 38 - 60.
- [21] Pang, R., Liu, L., & Zhang, S. (2023). How does digitalization affect corporate innovation? - From the perspective of human capital and transaction cost transmission mechanisms. *Nankai Economic Studies*, (2), 102-120.
- [22] Qi, D., & Xiao, X. (2020). Corporate management transformation in the digital economy era. *Management World*, (6), 135-152.
- [23] Sun, X., & Ren, J. (2023). Has the resource tax reform promoted corporate outward direct investment? *World Economic Studies*, (7), 47 - 61.
- [24] Wang, R., & Zhang, H. (2023). Digital transformation and corporate outward direct investment - The mediating role of innovation ability and transaction costs. *Finance and Trade Research*, (5), 14 - 24.
- [25] Wu, F., Hu, H., Lin, H., & Ren, X. (2021). Corporate digital transformation and capital market performance - Empirical evidence from stock liquidity. *Management World*, (7), 130 - 144.
- [26] Xiao, H., Yang, Z., & Liu, M. (2021). The effect of corporate digitalization on social responsibility promotion: A test of internal and external dual paths. *Economic Management*, (11), 52 - 69.
- [27] Xu, J., Liu, S., & Wang, Y. (2023). How does digital transformation affect corporate imports? *World Economic Studies*, (9), 29 - 45.
- [28] Yan, Z., Li, R., & Wu, F. (2019). The export effect of Chinese enterprises' outward direct investment - An empirical study from the perspective of firm heterogeneity. *Statistical Research*, (8), 87 - 99.
- [29] Yu, J., & Xia, W. (2024). Has outward direct investment promoted corporate digital transformation? - Empirical evidence from Chinese listed companies. *International Trade Exploration*, (5), 58 - 74.

- [30] Yu, G., & Tian, J. (2023). The growth of corporate outward direct investment scale and the development of digital finance - An empirical study based on listed company samples. *International Business (Journal of University of International Business and Economics)*, (1), 88 - 104.
- [31] Zhang, B., Fan, R., & Meng, L. (2023). Corporate digital transformation, intellectual property protection, and outward direct investment - Empirical evidence from Chinese service industry listed companies. *Issues in International Trade*, (5), 103 - 121.
- [32] Zhang, J., Wu, W., & Yu, D. (2024). Corporate digitalization and the choice of transnational investment patterns. *Journal of Capital University of Economics and Business*, (2), 33 - 47.
- [33] Zhang, T., & Li, J. (2023). Network infrastructure, inclusive green growth, and regional disparities - Causal inference based on dual machine learning. *Quantitative Economics*, (4), 113 - 135.
- [34] Zhang, Y., & Yin, Y. (2023). Digital transformation, corporate governance patterns, and total factor productivity of enterprises. *Journal of Zhengzhou University (Philosophy and Social Sciences)*, (5), 53 - 58.
- [35] Zhao, C., Wang, W., & Li, S. (2021). How does digital transformation affect the total factor productivity of enterprises. *Finance and Trade Economics*, (7), 114 - 129.
- [36] Zhao, Y., Tao, K., Li, Y., & Li, X. (2020). The location choice of Chinese enterprises' outward direct investment - A linkage effect study based on QCA method. *China Industrial Economics*, (11), 118 - 136.
- [37] Zhou, M., Wu, J., Li, Y., & Li, D. (2023). Jointly building the "Belt and Road" and deepening connectivity - From the perspective of countries along the route. *Management World*, (11), 1 - 21.