The Impact of Digital Transformation on Financial Performance and Green Development: Evidence from Chinese Manufacturing Companies

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Abstract: Digital transformation, driven by advancements in Artificial Intelligence (AI), Big Data, and the Internet of Things (IoT), has become essential for modern manufacturing companies in reshaping their manufacturing processes and business strategies. While prior research has largely focused on the financial benefits of digital transformation, its environmental implications remain underexplored. This study examines the dual impact of digital transformation on financial performance and green development, using panel data from Chinese A-share listed manufacturing firms between 2010 and 2021. Applying a multiple regression model, the analysis integrates Schumpeterian innovation theory and the Resource-Based View (RBV) to provide a comprehensive understanding of how digitalisation influences both economic and environmental outcomes. The findings reveal that digital transformation significantly enhances financial performance while also promoting sustainable business practices. By bridging the gap in existing literature, this study offers new insights into the broader value of digital transformation, providing practical implications for corporate decision-makers and policymakers seeking to align financial growth with sustainability objectives.

1 INTRODUCTION

The rapid growth of the Internet and digital technologies has significantly transformed the global economy, shifting it from traditional structures to a digital economy. As Liu, Liu, and Ren (2023) note, the world is transitioning into an era of digital business driven by technological advancements. In this context, digital transformation has become a strategic priority for manufacturing companies aiming to enhance competitiveness and achieve sustainable development. By integrating advanced technologies such as Artificial Intelligence (AI), Big Data, and the Internet of Things (IoT), businesses can optimise resource allocation, streamline processes, and adapt to the demands of a changing industrial landscape (Ismail, Khater, & Zaki, 2017; Su et al., 2023).

However, beyond economic gains, an urgent question arises: Can digitalization drive environmental sustainability? Given growing regulatory and stakeholder pressures, understanding how digital transformation supports green development is crucial, especially in the manufacturing sector—a major contributor to environmental impact.

While digital transformation has shown significant potential to improve economic efficiency, its role in supporting green development is increasingly gaining attention. Studies highlight that digitalisation can enhance eco-friendly practices by reducing resource consumption and environmental pollution while improving operational efficiency (Che & Wang, 2022; Wei & Sun, 2021). Moreover, stakeholders now expect corporations to demonstrate greater environmental responsibility, further motivating businesses to align digital initiatives with green objectives (Sui & Yao, 2023). Despite its promise, much of the existing literature focuses primarily on the economic benefits of digital transformation, neglecting its non-economic impacts, particularly in the manufacturing sector.

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To address this gap, this study investigates the relationship between digital transformation, financial performance, and green development in manufacturing enterprises. This research is grounded in Schumpeterian innovation theory and the Resource-Based View (RBV), which together provide a theoretical framework for understanding how firms leverage digital capabilities to enhance both financial and environmental performance. Schumpeterian innovation theory explains how technological advancements drive business transformation and competitive advantage, while RBV highlights the role of firm-specific digital resources in achieving sustainable performance outcomes. The analysis is particularly relevant in the context of China's manufacturing sector, which despite being the world's largest carbon emitter, is undergoing a rapid digital transformation to achieve sustainable growth (Du, Xie, & Ouyang, 2017; Zhang et al., 2023). As China intensifies its commitment to green and intelligent manufacturing, it provides a valuable context for understanding how digitalisation can be leveraged to support both economic and environmental sustainability.

This research seeks to answer the following key questions: What is the impact of digital transformation on the financial performance of manufacturing companies? What is the impact of digital transformation on the green development of manufacturing firms?

Using data from Chinese A-share listed manufacturing companies between 2010 and 2021, this study employs textual and content analysis alongside a panel two-way fixed-effects model to test the hypotheses.

The contributions of this research are twofold. First, it enriches the understanding of digital transformation by exploring its impact on both financial and green development, particularly in the context of emerging markets. Second, by integrating Schumpeterian innovation theory and the Resource-Based View, this study develops a robust theoretical and empirical framework that links digital transformation to financial and environmental outcomes.

The paper is structured as follows: Section 2 reviews the theoretical background and develops the hypotheses. Section 3 outlines the research methodology. Section 4 presents the findings and discussion. Finally, Section 5 concludes with reflections on the study's implications and limitations.

2 LITERATURE REVIEW

2.1 Theoretical Framework

Digital transformation is the process by which businesses integrate advanced technologies, such as Artificial Intelligence (AI), Big Data, and the Internet of Things (IoT), into their operations. This transformation allows companies to improve processes, reduce inefficiencies, and adapt to changing market demands. According to Schumpeterian innovation theory, innovation is the main driver of economic growth. Companies that successfully adopt and implement digital technologies gain a competitive edge by enhancing their productivity and operational capabilities (Anthony, 2021). The Resource-Based View (RBV) theory complements this understanding by focusing on the unique resources that a company can leverage to achieve success. According to RBV, resources that are valuable, rare, and hard to imitate—such as advanced technologies, skilled employees, or specialised knowledge—can help businesses sustain long-term advantages (Abbasi Kamardi et al., 2022). In terms of green development, RBV highlights how firms can use digital tools and innovations to implement sustainable practices, reduce environmental harm, and meet regulatory requirements (Okorie et al., 2023). By combining these two theories, this study aims to explore how digital transformation affects both financial performance and green development, emphasising the unique role of digital technologies in achieving these dual goals.

2.2 Hypotheses Development

2.2.1 Digitisation and Financial Performance

Digital transformation has a significant impact on financial performance by improving efficiency, reducing costs, and enhancing decision-making. Technologies such as AI and Big Data enable businesses to collect and process large amounts of information, leading to better insights and faster responses to market changes (Sun et al., 2022). For example, digital tools help streamline production processes by integrating data across different departments, breaking down information silos, and improving overall productivity (Hanelt et al., 2021).

Moreover, digital transformation allows companies to strengthen relationships with their customers by providing personalised services and

improved communication channels. These advancements enable firms to respond to customer demands more effectively, thereby increasing customer satisfaction and loyalty (Gupta et al., 2020). Additionally, businesses can use digital tools to optimise their supply chains, enhance resource allocation, and achieve cost savings (Bughin, LaBerge, & Mellbye, 2017).

The competitive advantages gained through digital transformation are especially important in uncertain economic environments. By using digital tools, businesses can better adapt to external changes, improve operational flexibility, and maintain their market position (Siachou, Vrontis, & Trichina, 2021).

H1a: Digital transformation in manufacturing companies has a positive link with financial performance.

2.2.2 Digitisation and Green Development

Digital transformation also plays a crucial role in promoting green development. Advanced technologies allow businesses to use resources more efficiently, reduce waste, and minimise their environmental footprint. For instance, AI-driven systems can optimise energy use and identify ways to reduce carbon emissions (Chen, 2022). Similarly, Big Data analytics enables firms to monitor environmental performance in real time, helping them meet sustainability goals and comply with environmental regulations (Wang, Wang, & Chen, 2022).

Furthermore, digital technologies encourage collaboration and resource sharing among organisations. This leads to innovative solutions for green growth, such as shared energy systems or collaborative waste management practices (Shang et al., 2023). The integration of digital tools into business operations creates a "double enhancement" effect, where companies can simultaneously improve production efficiency and achieve energy savings (Chen, 2022).

While digital transformation may involve high initial costs, these investments often yield long-term benefits. Reduced information asymmetry, improved transparency, and lower borrowing costs further enhance the financial and environmental outcomes of digital initiatives (Liu, Liu, & Ren, 2023).

H1b: Digital transformation in manufacturing companies has a positive link with green development.

3 METHODOLOGY

3.1 Sample Selection and Data Sources

This study examines the impact of digital transformation on the financial performance and green development of manufacturing companies. The research focuses on A-share manufacturing companies listed on the Chinese Stock Exchanges between 2010 and 2021. This timeframe was chosen to capture the evolution of digital transformation in China's manufacturing sector, particularly in response to government initiatives promoting digitalisation and sustainability. The sample consists of 2,151 companies, selected due to their diverse representation of the manufacturing sector, operating under competitive market conditions and regulatory oversight, making them well-suited for this analysis.
The data for corporate financial performance and the Digital Transformation Index were obtained from the CSMAR database, a widely recognised source for research on China's capital market. Green development was measured using Green Total Factor Productivity (GTFP), calculated with the Slack-Based Measurement (SBM) model and the Green Manufacturing and Logistics (GML) index, incorporating undesired outputs such as emissions. Data for GTFP were sourced from the China Statistical Yearbook, provincial and city-level yearbooks, company annual reports, and the WIND database.

3.2 Measurement of Variables

Green development in the manufacturing sector reflects a balance between economic and environmental performance, representing a "win-win" situation for firms (Alexopoulos, Kounetas, and Tzelepis, 2018). This study measures green development using Green Total Factor Productivity (GTFP), calculated with the Slack-Based Measurement (SBM) model and the Green Manufacturing and Logistics (GML) index. GTFP evaluates inputs such as capital, labour, and expected outputs, alongside undesired outputs like CO_2 and SO_2 emissions. Capital input is calculated based on capital stock changes, labour input is measured by the total number of employees, and expected outputs are proxied by total revenue. Undesired outputs are estimated using pollutant emissions data, derived from provincial and municipal statistical yearbooks. This comprehensive approach ensures a robust assessment of green development.

Financial performance is assessed using Return on Total Assets (ROA), a widely used indicator in empirical research. ROA captures how efficiently a firm utilises its assets to generate profits, making it a reliable measure of economic performance and facilitating comparisons with prior studies.

Digital transformation, a multifaceted concept, is measured through text analysis of annual reports. Python is used to identify keywords related to digital technologies, such as "big data," "AI," "blockchain," and "cloud computing." A Digital Transformation Quotient is then calculated by determining the frequency of these terms relative to the total word count in each report. To ensure credibility and consistency, pre-compiled metrics from the CSMAR database are also employed.

Following prior studies, several control variables are included: (1) enterprise size, measured as the natural logarithm of total assets; (2) enterprise age, defined as the number of years since the firm's establishment; (3) growth rate, calculated as the year-on-year revenue increase; (4) gearing ratio, representing the ratio of total debt to equity; and (5) equity concentration, expressed as the percentage of shares held by the largest shareholder. These control variables ensure that the analysis accounts for firm-specific characteristics that may influence the relationships among financial performance, green development, and digital transformation.

3.3 Model Specification

Accordingly, the study employed the following regression models to examine the relationships among digital transformation, financial performance, and green development:

$$GD_{i,t} = \beta_0 + \beta Dig_{i,t} + \sum \eta Controls_{i,t} + \varepsilon_{i,t}$$

$$FP_{i,t} = \beta_0 + \beta Dig_{i,t} + \sum \eta Controls_{i,t} + \varepsilon_{i,t}$$

In these models, the dependent variable $GD_{i,t}$ represents the degree of green development exhibited by manufacturing firms, while $FP_{i,t}$ captures the level of financial performance achieved by the firms. The key independent variable $\beta Dig_{i,t}$ reflects the extent of digital transformation undertaken by the firm. Control variables, denoted as $Controls_{i,t}$, account for factors such as enterprise size, age, growth rate, gearing ratio, and equity concentration. Finally, $\varepsilon_{i,t}$ represents the random error term, capturing unexplained variation in the models.

4 RESULTS AND DISCUSSION

4.1 Descriptive Statistics and Univariate Analysis

Table 1. Summary Statistics.

Var.	Obs.	Mean	SD	Min	Median	Max
FP	14550	5.8	30.06	-141.8	6.93	871.5
GD	14550	1.8	0.70	0.00	1.87	4.8
Dig	14550	0.8	0.85	0.00	0.55	14.9
Size	14550	9.5	0.51	8.66	9.52	11.1
Growth	14550	20.3	39.9	-29.36	9.79	245.7
Lev	14550	40.1	19.7	5.08	39.26	88.5
Top1	14550	56.5	14.91	22.19	56.91	87.9
Age	14550	7.8	1.03	4.1	8.1	9.1

Table 1 summarises the descriptive statistics for 14,550 observations of 2,151 listed A-share manufacturing companies. Among the sample firms, financial performance (FP) has a mean of 5.809, a standard deviation of 30.065, and ranges from -1481.865 to 871.503, reflecting substantial variation among firms. Green development (GD) averages 1.846, with a standard deviation of 0.702 and a range of 0 to 4.828, indicating diverse environmental and sustainability efforts. Digital Transformation (Dig) has a mean of 0.844, ranging from 0 to 14.925. This highlights a generally low level of digitalisation, consistent with the early adoption phase of digital transformation in China's manufacturing sector. For control variables, firm size (Size) shows a mean of 9.593 and minimal variation, with values between 8.660 and 11.123. Growth rates (Growth) vary widely, averaging 20.308 with a range of -29.360 to 245.708. The gearing ratio (Lev) averages 40.189, spanning from 5.089 to 88.583, reflecting diverse financial strategies. Equity concentration (Top1) has a mean of 56.585, ranging from 22.190 to 87.970, indicating variations in ownership structure. Firm ages range from 9 to 40 years, showing minimal disparity. These variations across key variables justify their inclusion in the study to understand how digital transformation impacts financial and green performance.

The univariate analysis, in Table 2, shows that the correlation coefficient between digital transformation and financial performance is 0.006, which is not statistically significant with indicating that H1a cannot be confirmed through correlation analysis.

The correlation coefficient between digital transformation and green development is 0.042, significant at the 1% level, indicating a weak positive correlation. Although statistically significant, the low degree of correlation suggests a minimal effect of digital transformation on green development. Advanced analytical methods, such as multiple regression, are required to further explore these relationships while controlling for other variables. Firm size has a correlation coefficient of 0.350 with green development, significant at the 1% level, indicating a moderate positive relationship. This suggests that larger firms are more likely to achieve higher green development scores, presenting a potential confounding variable. Similarly, leverage has a correlation coefficient of 0.141 with green development, also significant at the 1% level, implying that firms with higher leverage tend to perform better in green development. These relationships highlight the need to account for these factors when analysing the impact of digital transformation on financial performance and green development.

Table 2. Correlation analysis results

	FP	GD	Dig	Size	Growth	Lev	Top1	Age
FP	1.000							
GD	0.036***	1.000						
Dig	0.006	0.042***	1.000					
Size	0.044***	0.350***	-0.050***	1.000				
Growth	0.136***	-0.064***	0.003	-0.085***	1.000			
Lev	-0.171***	0.141***	-0.049***	0.480***	-0.157***	1.000		
Top1	0.098***	0.014*	0.052***	0.007	0.210***	-0.192***	1.000	
Age	-0.074***	0.078***	-0.088***	0.436***	-0.431***	0.401***	-0.457***	1.000

Note: *** p<0.01, ** p<0.05, * p<0.1

4.2 Multivariate Regression Analysis

Table 3 presents the findings from the regression analysis investigating the influence of digital transformation on financial performance (columns 1 and 2) and green development (columns 3 and 4). As shown in column 2 of the table, after controlling for variables such as enterprise size, enterprise growth rate, enterprise gearing ratio, equity concentration, and age of the enterprise, the coefficient for digital transformation was 0.5863, significant at the 1% level. This provides evidence for a significant positive correlation between digital transformation and financial performance, supporting Hypothesis H1a, consistent with Schumpeter's theory of innovation, which underscores technological advancement as a driver of economic growth. These findings align with prior empirical research in different contexts. For instance, Ji et al. (2022) and Nasiri et al. (2020) found similar positive effects in Western economies, where digitalisation contributed to financial performance through increased operational efficiency and competitive advantage. However, in emerging markets, the impact of digital transformation varies due to differences in digital infrastructure, regulatory environments, and firm capabilities (Xie et al., 2021; Huang & Wang, 2023). Compared to studies on developed economies, where digital adoption is more advanced, the results of this study suggest that firms in China are still in a transitional phase, with digital transformation providing financial benefits primarily through improved scalability, integration, and efficiency of information flow. Digitalisation enhances internal efficiency and reduces information asymmetry, ultimately boosting performance.

From the results of the control variables, firm size significantly affects financial performance, with a coefficient of 12.8692 (p<0.01), suggesting that larger firms benefit from economies of scale. Leverage has a negative coefficient of -0.5470 (p<0.01), aligning with the "pecking order" theory that higher leverage increases financial risk. The positive coefficient of 5.2561 (p<0.01) for company age indicates that older firms typically exhibit better financial results due to established market positions and customer loyalty.

Table 3. Multivariate regression analysis

VARIABLES	(1) FP	(2) FP	(3) GD	(4) GD
Dig	0.594*** (3.58)	0.586*** (3.55)	0.024*** (14.31)	0.029*** (13.98)
Size	-	12.869*** (6.44)	-	0.514*** (67.76)
Growth	-	0.084 (4.03)	-	-0.001*** (-9.92)
Lev	-	-0.547*** (-7.79)	-	0.005 (0.73)
Top1	-	0.109*** (3.49)	-	-0.008*** (-5.33)
Age	-	5.256*** (7.46)	-	-0.132*** (-8.65)
Constant	4.836*** (19.01)	-148.318*** (-8.65)	2.067*** (10.84)	-1.761*** (-12.51)
Observations	14,550	14,550	14,550	14,550
R-squared	0.00651	0.055	0.082	0.19
Firm FE	YES	YES	YES	YES
Year FE	YES	YES	YES	YES

Note: *** p<0.01, ** p<0.05, * p<0.1

Columns 3 and 4 present the regression results on digital transformation's impact on green development. The coefficient of 0.0296 ($p<0.01$) confirms a significant positive relationship, supporting H1b. Firms adopting digital transformation are more likely to finance eco-friendly technologies and sustainable practices, enhancing resource efficiency and supply chain management, aligning with the Resource-Based View (RBV). This theory suggests that firms with advanced digital resources are better positioned for sustainability, as supported by Gu et al. (2023) and Chen et al. (2023).

Control variables also influence green development. Firm size (0.5141, $p<0.01$) indicates that larger firms allocate more resources to sustainability, consistent with RBV. However, firm growth (-0.0011, $p<0.01$) and firm age (-0.1324, $p<0.01$) negatively impact green development, suggesting resource constraints in fast-growing firms and adaptation challenges in older firms. Comparing digital transformation's effects, its impact on financial performance is numerically stronger, yet the higher R-squared for green development suggests greater explanatory power. While financial gains are immediate, green development offers long-term economic and environmental benefits, reinforcing sustainability's strategic importance.

These findings align with prior research on digitalisation and sustainability. Hart and Ahuja (1996) and Xue et al. (2022) found that digital innovations drive long-term environmental gains, particularly in high-carbon industries. In contrast, studies on developed economies (Porter & van der Linde, 1995; Beier et al., 2020) indicate that financial priorities often overshadow environmental objectives. However, in emerging economies like China, increasing regulatory pressures make digital transformation a more crucial driver of green development. Firms adopting smart technologies enhance efficiency while reducing waste and emissions (Zheng et al., 2023), positioning digital transformation as essential for sustainable growth in manufacturing.

4.3 Robustness Test

To further test the robustness of the main findings, the continuous digital transformation variable (Dig) was replaced with a dummy variable (Dig_dum), as presented in Table 4. This use of alternative measurement enables an examination of the relationship between digital transformation and its effects on financial performance (FP) and green development (GD). It seeks to determine if the impact is not only dependent on the magnitude of digital transformation, but also holds substantial significance, even when digital transformation is considered as a binary condition (i.e., the presence or absence of digital transformation). Table 4 summarises the results of this alternative measurement.

Table 4. Regression results with alternative measure.

VARIABLES	(1) FP	(2) GD
Dig_dum	3.1079*** (3.50)	0.0857** (2.28)
Size	12.8566*** (5.96)	0.5130*** (59.55)
Growth	0.0844*** (3.88)	-0.0011*** (-9.39)
Lev	-0.5468*** (-7.38)	0.0005 (0.72)
Top1	0.1096*** (3.21)	-0.0018*** (-4.89)
Age	5.2921*** (7.37)	-0.1350*** (-8.31)
Constant	-151.0299*** (-8.28)	-1.7894*** (-11.55)
Observations	14,550	14,550
R-squared	0.0511	0.189
Number of groups	2,151	2,151

Note: *** p<0.01, ** p<0.05, * p<0.1

The effect of digital transformation remains strong even after replacing continuous variables with dummy variables. Dig_dum is statistically significant at the 1% level for financial performance (FP) and the 5% level for green development (GD), with control variables showing consistent significance across models. To test robustness, post-2020 data was excluded to account for the COVID-19 shock, which could introduce endogeneity. Regression results in Table 5 confirm that Dig remains highly significant at the 1% level in both FP and GD, with control variables maintaining their influence. Excluding post-2020 data confirms the robustness of the findings, reinforcing H1a and H1b—digital transformation significantly impacts financial performance and green development in the manufacturing sector.

Table 5. Regression results with excluding Covid's effect.

VARIABLES	(1) FP	(2) GD
Dig	1.0235***	0.0274***
	(4.88)	(13.65)
Size	16.2110***	0.5264***
	(4.84)	(78.63)
Growth	0.0685***	-0.0011***
	(4.34)	(-14.03)
Lev	-0.5220***	0.0001
	(-7.95)	(0.14)
Top1	0.0864	-0.0019***
	(1.37)	(-3.63)
Age	4.8707***	-0.1318***
	(6.43)	(-5.77)
Constant	-180.7830***	-2.1689***
	(-6.69)	(-15.95)
Observations	11,477	11,477
R-squared	0.045	0.177
Number of groups	1,745	1,745

Note: *** p<0.01, ** p<0.05, * p<0.1

5 CONCLUSION

This study investigates the impact of digital transformation on financial performance and green development in Chinese A-share manufacturing firms from 2010 to 2021.

This study contributes to academic literature and practice by bridging financial and non-financial outcomes of digital transformation. Its practical and managerial implications are significant. For enterprises, the findings emphasise the need to integrate digital technologies to enhance financial performance and sustainability, particularly in energy-intensive industries where efficiency gains reduce costs and support regulatory compliance. For industry leaders, the study highlights the competitive advantages of digital adoption, urging firms to prioritise innovation to remain resilient in evolving markets. Policymakers can use these insights to design targeted incentives that promote digital transformation, reduce regional disparities in digitalisation, and align corporate sustainability efforts with environmental goals. These findings are especially relevant for economies undergoing industrial restructuring, offering evidence-based guidance on the role of digital technologies in sustainable growth.

Despite its contributions, this study has limitations. Geographic heterogeneity in financial impacts warrants further exploration, and the focus on manufacturing limits generalisability to other industries. Assumed linear relationships may oversimplify complex dynamics, and mediating factors remain unexplored. Future research should examine other sectors, assess specific digital technologies, and consider regional policy and cultural differences to provide a more nuanced understanding of digital transformation's broader implications.

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