

Digital Transformation and High-Quality Development of Enterprises: Evidence from China

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Abstract. The swift progression of digital technology is leading to substantial shifts and evolutions within enterprises. In the evolving environment characterized by the integration of digital technologies and the physical market, it's essential to examine the effects of digitalization on the path of enterprises towards attaining superior growth quality. This study utilizes panel data from A-share listed companies in China's equipment manufacturing sector, spanning from 2013 to 2021, to perform an empirical analysis on the influence and mechanisms of digital transformation in fostering the progress of these companies towards high-quality growth. The results reveal that digital transformation plays a significant role in promoting high-quality development among equipment manufacturing enterprises, and these results remain consistent after implementing various tests to mitigate endogeneity and confirm the findings' reliability. The examination of mechanisms suggests that digital transformation significantly contributes to the advancement of equipment manufacturing companies by alleviating financial constraints, improving internal control quality, and facilitating the integration of environmentally friendly innovation technologies. Moreover, the impact of digital transformation on elevating the quality of development within equipment manufacturing companies is notably more pronounced in privately-owned firms, those located in the eastern region, and businesses classified as high-tech. This highlights how the nature of ownership, geographical location, and technological classification further amplify the benefits of digital transformation for high-quality growth in the sector. These findings offer a theoretical basis for assessing the economic implications of enterprises' digital transformation and for shaping relevant governmental policies.

Keywords: Digital Transformation; High-quality Development; Equipment Manufacturing Industry; Green Technology Innovation.

1. Introduction

China's 14th Five-Year Plan underscores the critical goal of deeply integrating digital technology with the tangible economy. This strategic plan advocates for the advancement of digital infrastructure, the refinement of governance frameworks in the digital sphere, the simultaneous fostering of digital industrialization and the digitization of industries, and the modernization and enhancement of conventional sectors. Achieving high-quality development stands as the central ambition for China's economic and social advancement, as outlined in the "14th Five-Year Plan" and its associated policies. This involves prioritizing the exceptional growth and efficiency of businesses as the fundamental factor propelling China's economic advancement. To attain development of superior quality, it is imperative for equipment manufacturing companies to accelerate their digital transformation initiatives, as this is a crucial component of the tangible economy. However, could the journey of digital transformation act as a fresh impetus for the accelerated development of equipment manufacturing enterprises? If so, how is digital transformation facilitated, and in which areas does this enhancement have a more pronounced impact?

To address the aforementioned issues, a significant portion of the current literature commences by evaluating digital transformation indicators. Scholars typically assess the digital transformation of enterprises through three primary methods: the scale method, index method, and text analysis method. For instance, Schumacher et al.[1] devised a scale to gauge the extent of digital transformation in manufacturing firms across six dimensions, incorporating elements such as managerial strategies and customer perceptions regarding the adoption of digital technologies, as well as the extent of product

digitization, to evaluate the extent of Industry 4.0 adoption by manufacturing enterprises. Zhang Yongshen et al.[2] assessed the degree of digital transformation within enterprises by examining the percentage of assets associated with the digital economy and the yearly variation in intangible assets as indicated in the financial records of publicly traded A-share companies. Wu Fei et al.[3] utilized Python to extract 76 digital-related terms from various dimensions in the yearly financial statements of publicly traded corporations for word frequency analysis. Similarly, Zhao Chenyu[4] et al. employed Python to conduct word frequency statistics on 99 digital-related terms. Following the resolution of digital transformation measurement indicators, academics then proceeded to analyze the economic consequences of digital transformation, such as promoting sustainable environmental practices to facilitate a transition towards a more eco-friendly operation[5], enhancing labor income share[6], and fostering supply chain diversification[7]. The impact of digital transformation on advancing businesses towards higher quality benchmarks is complex and layered. Some researchers maintain that digital transformation greatly aids in elevating business development quality through the acceleration of enterprise informatization, the flow of knowledge and data, and collaborative industrial innovation. Conversely, there are arguments suggesting it could hinder advancement by leading to information saturation, resource misallocation [8], and ineffective distribution of labor[9]. As a result, current research thoroughly discusses the metrics and economic impacts of corporate digital transformation, using a variety of approaches to evaluate the extent of digitalization and its economic influence on businesses. Many academics assert that digital transformation is vital in propelling enterprises forward. Nonetheless, there's been an insufficient emphasis on exploring how digital transformation aids in the growth of companies, especially within the framework of integrating the digital and traditional economies. Scholars hold varying perspectives on this matter, necessitating further investigation and analysis.

This study seeks to inquire into how the process of digital transformation influences the progression of businesses towards achieving high-quality development, particularly within the equipment manufacturing firms spanning the years 2013 to 2021, providing a theoretical foundation for the thorough examination of digital transformation and superior growth in this industry. The possible impacts of this study are evident in various significant domains: Firstly, prior research has predominantly concentrated on examining the connection between digital transformation and robust macroeconomic growth. Yet, this research departs from the prevailing approach by investigating the link between digital transformation and the improved growth of micro-companies. This shift in focus broadens the comprehension of the economic impacts of digital transformation in a more comprehensive way. Secondly, by integrating the natural resource-based theory, this study broadens the investigation into the ways in which digital transformation impacts the high-quality advancement of micro-enterprises, introducing an innovative strategy for promoting enterprise expansion. Thirdly, as a pivotal sector of the national economy, the equipment manufacturing industry's development directly influences a country's industrialization level and economic prowess, yet research in this area remains limited. This article investigates the equipment manufacturing sector, extensively examining the relationship between digital transformation and superior development within this field, and offers policy suggestions to promote the sector's future expansion, support the development of a digital China, and boost China's competitiveness on a global level.

2. Theoretical Analysis

2.1. Digital Transformation and High-quality Development of Enterprises

Enterprise digital transformation involves the strategic utilization of digital technology by a business to redefine its vision, operations, and capabilities with the aim of adapting to the digital era and enhance its competitive edge within the digital economy landscape [10]. The advancement of enterprises to a high-quality standard represents a transition from the traditional model of expansive expansion to a strategy that prioritizes innovation and quality, leading to integrated progress across various dimensions including the economy, society, and environment. The significance of digital

transformation in facilitating the high-quality growth of businesses is evident across various critical dimensions.

The process of digital transformation is essential for fostering innovation within firms. Firstly, it enables the expansion of information dissemination channels through the utilization of digital technologies. This facilitates the acquisition of diverse resources, breaks down traditional barriers to information transmission, enables timely access to cutting-edge knowledge, and fosters a culture of innovation[11] to support high-quality development. Secondly, digital transformation facilitates the innovation of enterprise organizational structures and enhances management efficiency. By leveraging data, all departments can establish real-time information exchange networks, fostering collaboration, division of labor, and real-time decision-making processes. This leads to the development of flatter and more networked organizational structures, ultimately enhancing management efficiency[12] and supporting high-quality development. Lastly, the process of enterprise innovation can be expedited through digital transformation. According to innovation diffusion theory, over time, innovations spread within social systems, leading to widespread adoption among enterprises[13]. Technologies such as large-scale data analytics, machine learning, and 5G can catalyze this diffusion process, prompting companies to compete in imitating new products and driving innovation, enhancing enterprise productivity, and ultimately supporting high-quality development.

Digital transformation enhances the efficient distribution of internal resources. As per the resource arrangement theory, organizations leverage their innovation and information capabilities during digital transformation to gain competitive advantages, harmonize diverse resources, optimize internal resource allocation, and enhance production efficiency[14], ultimately leading to high-quality development. The process of digitalization can improve the information gathering capacity of managers within enterprises. Through digital transformation, managers and strategists can comprehensively monitor the growth trajectory of organizations, steer resources towards avenues with greater profitability and promising development prospects[15] and prevent resource misallocation stemming from information imbalances.

Digital transformation leads to a decrease in operational expenses for businesses. Initially, this transformation results in a reduction in transaction costs for enterprises, encompassing expenses related to information gathering and transportation logistics[16]. Through the utilization of digital tools like artificial intelligence and cloud computing, organizations can streamline operations, lower transaction costs, and enhance overall efficiency by consolidating and analyzing data, monitoring real-time logistics and transportation processes, and optimizing routes. Additionally, digital transformation diminishes matching costs for businesses. By leveraging digital technologies, companies can monitor customer behavior patterns, tailor products and services to align with preferences and requirements of the customers, minimize sales-related matching expenses, and foster superior development. Drawing on these observations, this paper proposes the following hypothesis:

H1: The digital transformation process significantly contributes to the advancement of high-quality growth in equipment manufacturing enterprises.

2.2. The Influence Mechanism of Digital Transformation on the High-quality Development of Enterprises

2.2.1. Alleviating Financing Constraints

The adoption of digital transformation is vital in facilitating business growth by easing financial limitations. Through a resource-oriented lens, digital transformation enables companies to access increased external funding. Data resources, as a key production factor, empower enterprises to participate in diverse economic activities. The alignment of enterprise digital transformation strategies with the national "digital China" initiative enhances the likelihood of businesses receiving government incentives[17], thereby reducing financial burdens and fostering superior enterprise development. Furthermore, the adoption of digital transformation can serve as a positive indicator to

external investors, signaling the enterprise's operational health and attracting greater interest and financial backing from external stakeholders. From an information standpoint, digital transformation offers several benefits. Firstly, it can address information imbalances and enhance the transparency of information exchange within enterprises. By facilitating the openness and connectivity of data, digital transformation enables easier access to non-financial information for both financing parties, thereby lowering investors' search costs, supervision expenses, and credit risks[18]. This, in turn, better caters to the requirements of financing parties[19]. Secondly, the adoption of digital transformation can help prevent misconduct within organizations. Through the utilization of digital technologies, companies can gather information more comprehensively, enhancing transparency in various operational aspects like production, sales, and management. Consequently, this reduces the likelihood of short-sighted behaviors such as prioritizing short-term gains, manipulating accounting data, and neglecting employee welfare[20]. Building upon these insights, this paper posits the following hypothesis:

H2: The process of digital transformation facilitates the enhancement of the quality of development within equipment manufacturing enterprises by alleviating financial constraints.

2.2.2. Enhancing the Effectiveness of Internal Control Mechanisms

Enterprise internal control encompasses a set of systems and procedures implemented by an organization to achieve its business objectives, safeguard assets, prevent fraud, and guarantee the precision and promptness of financial reporting. The primary goal is to ensure that the firms' operations adhere to legal requirements, regulations, and enhance operational efficiency. Previous research has mainly focused on the effect of digital transformation on enhancing the internal governance measures of companies. Digital transformation is essential for enhancing internal control mechanisms in various ways. Firstly, it enhances the internal control environment by introducing advanced data analysis tools and technologies during the digital transformation process. This leads to increased transparency in key departments, standardizes operational and transaction processes, and strengthens monitoring and management of internal operations[21]. Secondly, the incorporation of digital technologies into the internal control system enhances the risk control capabilities of enterprises through digital transformation. This transformation significantly alters how enterprises handle data, enabling managers to swiftly identify operational non-compliance, prevent decision-making errors resulting from human factors, and enhance the organization's risk management capabilities[22]. Lastly, digital transformation reduces the supervision costs associated with internal control within an enterprise. By leveraging digital transformation, organizations can facilitate more transparent and efficient information exchange, enhance collaboration among departments, and strengthen internal oversight through digital technologies. This helps mitigate the principal-agent problem between different departments, curb self-interested managerial behaviors, and minimize potential losses to the enterprise. Building upon these insights, this paper posits the following hypothesis:

H3: The enhancement of internal control mechanisms through digital transformation facilitates the advancement of equipment manufacturing enterprises towards high-quality development.

2.2.3. Improving the Capacity for Innovation in Green Technology

The natural resource-based view emphasizes that the adoption of a green innovation strategy enables organizations to acquire distinctive strategic resources or capabilities that are difficult to replicate or substitute, leading to the attainment of sustainable competitive advantages[23]. Hence, the integration of digital transformation holds promise in advancing businesses by fostering innovation in environmentally sustainable technology. Initially, the execution of a digital transformation strategy supports the augmentation of green R&D investments within enterprises. Digital transformation aids in optimizing the allocation of internal resources, allowing organizations to enhance their digital capabilities and allocate more resources towards green R&D, resulting in increased green technology innovation outputs[24] and facilitating high-quality development. Subsequently, digital transformation empowers companies to leverage data effectively to drive green innovation. Through

the collection, analysis, and utilization of extensive data sets, organizations can gain deeper insights into market demands and resource utilization, seize opportunities for environmental conservation and sustainable development, and provide valuable information and perspectives for green technology innovation. Lastly, digital transformation can streamline collaboration between enterprises, other entities, innovation platforms, and societal resources, thereby accelerating the sharing and distribution of environmentally friendly technology and innovation, as well as promote innovation in green technology within corporations. Utilizing digital platforms and tools enables organizations to improve cooperation with external partners and innovation ecosystems, exchange data and assets, speed up the creation and implementation of eco-friendly technologies, and promote sustainable methods. This, in turn, aids businesses in attaining superior development outcomes. Building upon these insights, this paper posits the following hypothesis:

H4: The enhancement of green technology innovation capabilities through digital transformation facilitates the advancement of equipment manufacturing enterprises towards high-quality development.

3. Research Design

The research has selected A-share listed companies in China's equipment manufacturing sector as the main sample for investigation from 2013 to 2021. Following the Industry Classification specified in the 2012 edition by the China Securities Regulatory Commission, eight distinct industries within this sector have been selected for examination. These industries encompass metal product manufacturing, general equipment production, specialized equipment fabrication, automobile production, railway, ship, aerospace, and other transport equipment production, electrical machinery and equipment production, computer communication and other electronic device production, and the manufacture of instruments and meters. The data underwent a selection process where ST or PT company samples were excluded, and companies with substantial missing variable data were removed. Ultimately, a total of 694 listed companies were included in the study, resulting in 6246 observed values. The data on enterprise-level activities and the frequency of terms associated with the extent of digital transformation were extracted from the CSMAR database, and the information regarding the internal control index came from the Dibo database. Additionally, the instrumental variables utilized in the endogenous test were sourced from the China Statistical Yearbook.

3.1. Definition of Variables

The dependent variable is enterprise high-quality development, as measured by total factor productivity (TFP). Based on the research of Lu Xiaodong and Lian Yujun[25], the LP semi-parameter method is employed to establish the TFP of selected enterprises across different time periods. In comparison to alternative TFP measurement techniques, the LP method is preferred for its ability to mitigate endogeneity issues commonly associated with ordinary least square methods. Consequently, the TFP calculated using the LP method is deemed to be more methodologically sound and impactful.

The independent variable is digital transformation (DIG). According to the research of Wu Fei et al.[3], the natural logarithm is employed as a measure for evaluating enterprise digital transformation by aggregating the overall occurrence of pertinent terms associated with enterprise digital transformation and subsequently increasing the total by 1.

Referring to the practice of Deng Chenyi and Wan Yong[22], the variables controlled in this study encompass Enterprise Size (Size), asset-liability ratio (Lev), return on total assets (ROA), Cash holding level (Cash), enterprise Age (Age), shareholding of the largest shareholder (Top1), and proportion of independent directors (Indep). Additionally, the analysis accounts for time fixed effect (Year) and individual fixed effect (Stkcd).

3.2. Research Model

$$TFP_{it} = \alpha_0 + \alpha_1 DIG_{it} + \sum controls + Stkcd + Year + \varepsilon_{it} \quad (1)$$

In model (1), TFP_{it} denotes the high-quality development degree of a specific enterprise i during Year t , DIG_{it} signifies the level of digital transformation of enterprise i in Year t , *controls* encompass a series of control variables, *Stkcd* represents the individual effect, *Year* represents the time effect, and ε_{it} represents the random error term.

4. Empirical Results

4.1. Descriptive Statistics

Table 1 displays the summary statistics for the key variables. Regarding the dependent variables, the average TFP is 8.089, with a maximum of 11.067 and a minimum of 0, suggesting disparities in total factor productivity across enterprises. Regarding the independent variables, the mean DIG is 1.611, with a maximum of 4.97 and a minimum of 0, showing significant variation in digital transformation levels among enterprises, with some entities yet to engage in digital transformation initiatives. The remaining variables fall within acceptable ranges.

Table 1. Descriptive statistics

| VARIABLES | Obs | Mean | SD | Min | Median | Max |
|-----------|------|--------|--------|--------|--------|--------|
| TFP | 6246 | 8.089 | 1.741 | 0.000 | 8.221 | 11.067 |
| DIG | 6246 | 1.611 | 1.350 | 0.000 | 1.386 | 4.970 |
| Cash | 6246 | 0.040 | 0.065 | -0.151 | 0.034 | 0.233 |
| Age | 6246 | 2.136 | 0.791 | 0.000 | 2.197 | 3.296 |
| Size | 6246 | 21.195 | 4.891 | 0.000 | 22.070 | 25.880 |
| Indep | 6246 | 37.629 | 5.639 | 33.330 | 33.330 | 60.000 |
| Lev | 6246 | 0.433 | 0.194 | 0.069 | 0.428 | 0.944 |
| ROA | 6246 | 0.025 | 0.063 | -0.290 | 0.027 | 0.164 |
| Top1 | 6246 | 30.386 | 14.744 | 0.000 | 29.050 | 66.760 |

4.2. Correlation Analysis of Variables

Table 2. Correlation Analysis

| VARIABLES | TFP | DIG | Cash | Age | Size | Indep | Lev | ROA | Top1 |
|-----------|-----------|-----------|-----------|-----------|----------|-----------|-----------|----------|------|
| TFP | 1 | | | | | | | | |
| DIG | 0.117*** | 1 | | | | | | | |
| Cash | 0.183*** | 0.077*** | 1 | | | | | | |
| Age | 0.298*** | 0.090*** | 0.036*** | 1 | | | | | |
| Size | 0.317*** | 0.101*** | 0.161*** | 0.650*** | 1 | | | | |
| Indep | -0.035*** | 0.067*** | -0.018 | -0.022* | 0.007 | 1 | | | |
| Lev | 0.196*** | -0.012 | -0.112*** | 0.321*** | 0.158*** | -0.001 | 1 | | |
| ROA | 0.182*** | 0.044*** | 0.348*** | -0.097*** | -0.001 | -0.056*** | -0.269*** | 1 | |
| Top1 | 0.162*** | -0.072*** | 0.065*** | -0.056*** | 0.051*** | -0.008 | -0.019 | 0.170*** | 1 |

***, **, and * indicate significance of 1%, 5%, and 10%.

Prior to the empirical investigation, it is essential to perform correlation analysis on the primary variables to determine if there exists a relationship between these variables and the level of closeness of their association. The outcomes displayed in Table 2 imply a statistically notable favorable link between TFP and DIG. This outcome provides initial support for hypothesis H1, suggesting that a higher level of digital transformation in an organization is linked to a higher likelihood of achieving high-quality growth. The correlation coefficients for the other variables remain below the significant level. Furthermore, examination of the VIF values for each variable (all below 5) reveals no significant issue of multicollinearity among the primary variables considered in this study.

4.3. Baseline Regression Analysis

Table 3. Baseline regression results

| VARIABLES | (1) | (2) |
|--------------|----------|-----------|
| | TFP | TFP |
| DIG | 0.089*** | 0.070*** |
| Cash | (0.023) | (0.020) |
| Cash | | 0.593*** |
| Size | | (0.183) |
| Size | | 0.080*** |
| Lev | | (0.014) |
| Indep | | -0.006* |
| VARIBLES | | (0.004) |
| Lev | | 0.949*** |
| DIG | | (0.167) |
| ROA | | 1.794*** |
| Age | | (0.221) |
| Top1 | | 0.017*** |
| Indep | | (0.003) |
| Age | | -0.541*** |
| ROA | | (0.109) |
| Constant | 7.541*** | 6.078*** |
| Top1 | (0.050) | (0.262) |
| Year | YES | YES |
| Stkcd | YES | YES |
| Observations | 6,246 | 6,246 |
| R-squared | 0.147 | 0.268 |

Parentheses surround the robust standard errors. ***, **, and * implies significance of 1%, 5%, and 10%. The same below.

Employing panel data from A-share listed firms in the equipment manufacturing industry between 2013 and 2021, this examination utilizes the two-way fixed effect model to conduct regression analysis on the baseline model. The outcomes of the regression are documented in Table 3. It is worth noting that control variables have been excluded from the regression model shown in Table 3 (1). The outcomes imply a significant regression coefficient of 0.089 for digital transformation (DIG) on

enterprises' high-quality development (TFP). Subsequently, column (2) showcases the regression outcomes post the inclusion of all control variables. Noteworthy from column (2) is the regression coefficient of digital transformation, which stands at 0.07 even after the incorporation of control variables, indicating a significant positive correlation. This corroborates hypothesis H1, indicating that the digital transformation process is pivotal in propelling enterprises toward achieving high-quality growth. These results align with the research conclusions drawn by Wang Xi et al.[11] and Wang Fujun and Wu Hao[21].

4.4. Robustness and Endogeneity Tests

4.4.1. Alternative Measures of Digital Transformation

In accordance with the methodology employed by Zhao Chenyu et al.[4], the cumulative count of 99-word frequencies related to digital aspects across four dimensions is incremented by 1, and the natural logarithm is utilized to derive a new variable denoted as DIG2, serving as a substitute for the primary independent variable DIG. The regression outcomes listed in columns (1) to (2) of Table 4 demonstrate the link between this replacement variable and TFP. Specifically, the results reveal a statistically significant regression coefficient of 0.146 for the DIG2 variable in relation to TFP, significant at the 1% level. Upon the inclusion of control variables, the regression coefficient for DIG2 on TFP is calculated as 0.108, remaining statistically significant.

4.4.2. Alternative Measures of High-quality Development

In accordance with the methodology employed by Lu Xiaodong and Lian Yujun[25], the TFP value derived through the OP method was utilized as a substitute variable for the primary dependent variable TFP, and was labeled as TFP_OP. The regression outcomes displayed in columns (3) to (4) of Table 4 highlight the impacts following the change of dependent variables. A notable positive association was discovered between DIG and TFP_OP. Regardless of the method used to measure TFP, digital transformation exhibited a substantial favorable influence on the high-quality advancement of businesses, even after adjusting for other factors. These outcomes are consistent with the findings of Liao Zhichao and Wang Jianxin[26]. The findings obtained from the baseline regression analysis were found to be robust.

Table 4. Outcomes of robustness tests

| VARIABLES | (1) | (2) | (3) | (4) |
|--------------|----------|----------|----------|----------|
| | TFP | TFP | TFP_OP | TFP_OP |
| DIG2 | 0.146*** | 0.108*** | | |
| | (0.031) | (0.026) | | |
| DIG | | | 0.068*** | 0.051*** |
| | | | (0.021) | (0.018) |
| controls | NO | YES | NO | YES |
| Year | YES | YES | YES | YES |
| Stkcd | YES | YES | YES | YES |
| Constant | 7.260*** | 5.879*** | 5.839*** | 4.700*** |
| | (0.094) | (0.277) | (0.042) | (0.237) |
| Observations | 6,246 | 6,246 | 6,246 | 6,246 |
| R-squared | 0.152 | 0.270 | 0.125 | 0.227 |

4.4.3. Endogeneity Test

The internal factors influencing this study might involve the possible bidirectional causality between enterprise digital transformation and high-quality growth, indicating that the evolution of businesses could affect their digital transformation efforts. Additionally, the absence of crucial variables may have been a contributing factor. In tackling issues of endogeneity, this study employs a strategy influenced by Zhao Tao and colleagues [27], utilizing an interaction term derived from the quantity of Internet users per province in the previous year and the quantity of fixed telephone lines per 10,000 people in 1984 at the provincial level as an instrumental variable, labeled IV. The two-stage least square method is applied in analysis. The advancement of businesses through digital means is reliant on the presence of a robust network infrastructure. The Internet, being an advancement of conventional communication technologies, is impacted by the historical progress of telecommunications in each area, which in turn shapes the evolution and adoption of Internet technology in subsequent stages. Consequently, this instrumental variable satisfies the criteria of relevance. Moreover, the influence of conventional communication devices like landline telephones on economic progress diminishes over time as their utilization decreases, aligning with the condition of exogeneity.

Table 5. Results of endogeneity test

| VARIABLES | (1) | (2) |
|---------------------------|---------------------|---------------------|
| | first stage | second stage |
| | DIG | TFP |
| IV | 0.013*** (0.004) | |
| DIG | | 0.464** (0.210) |
| Constant | 0.641*** (0.179) | 6.055*** (0.431) |
| controls | YES | YES |
| Year | YES | YES |
| Stkcd | YES | YES |
| Kleibergen-Paap rk Wald F | | 351.75 {16.38} |
| Observations | 6,246 | 6,246 |
| R-squared | 0.298 | 0.844 |

The endogeneity assessment findings are displayed in Table 5, revealing a notable and favorable link between IV and DIG as demonstrated in the initial regression analysis results (refer to Table 5, column 1). Moreover, the findings from the second-stage regression analysis (refer to Table 5, column 2) demonstrate a notably favorable link between enterprise digital transformation and high-quality growth at the 10% level of significance. This connection is validated by a Kleibergen-Paap rk Wald F statistic of 351.75, exceeding the threshold value of 16.38, thus dismissing the existence of weak instrumental variables. Thus, despite considering internal factors, digital transformation remains a significant driver in facilitating the advancement of high-quality businesses, aligning with the research findings of Deng Chen Yi and Wan Yong[22].

5. Further Analysis

5.1. Mechanism Tests

Drawing from the insights of the previous study, this research seeks to explore further into the mechanisms of digital transformation to aid enterprises in progressing towards high-quality growth. Drawing insights from the works of Jiang Ting[28], Quan Xiaofeng and Li Chuang[29], Wang Xi et al.[11], a two-step methodology is utilized in this paper to perform mechanism testing. The initial phase entails evaluating the impact of digital transformation across three mechanisms. Following this, the study classifies these mechanism variables to more clearly define the process by which digital transformation aids in the high-quality progression of businesses.

5.1.1. Financing Constraint(WW)

Financing constraint (WW), based on the practice of Shi Zhangming et al.[30], was measured by WW index.

$$WW = -0.091 * CF - 0.062 * DivPos + 0.021 * Lev - 0.044 * Size + 0.102 * ISG - 0.035 * SG \quad (2)$$

In model (2), *CF* is the ratio of cash flow to total assets; *DivPos* is the dummy variable of cash dividend payment, which is 1 if cash dividends are paid in the current period, and 0 if not. *Lev* is the ratio of long-term liabilities to assets; *Size* is the natural logarithm of total assets; *ISG* is the industry average sales growth rate; *SG* is the growth rate of sales revenue.

Columns (1) - (3) of Table 6 present the findings from the evaluation of financing constraints mechanism. The findings presented in column (1) demonstrate a statistically significant inverse correlation between DIG and WW. This implies that digital transformation within enterprises can alleviate financial restrictions, thereby initially backing hypothesis H2. Following this, samples were classified into groups with high and low financial constraints according to the degree of financing restrictions faced by the enterprises. Columns (2) and (3) reveal that in the high financing constraint group, digital transformation significantly enhances the high-quality development of enterprises. On the other hand, within the group experiencing low financing constraints, the influence of digital transformation on high-quality growth lacks statistical significance. This difference may stem from the difficulties encountered by businesses in the high financing constraint group in securing extra funds for expansion, making digital transformation essential for improving cost-effectiveness. As a result, the influence of digital transformation is especially prominent in businesses under considerable financial pressure. Conversely, enterprises in the low financing constraint group may already possess adequate financial resources for business growth, diminishing the significance of digital transformation. Additionally, these firms may have already laid a strong digital groundwork, leading to a diminished influence on their high-quality progression. Conversely, companies facing high financial constraints possess a larger scope for enhancement via digital transformation, hence witnessing a more significant effect on their high-quality growth. The outcomes of the two-step analytical approach affirm hypothesis H2.

5.1.2. Internal Control(IC)

Referring to the research results of Liu Jiaorao[31], the internal control index calculated by Dibo Enterprise Risk Management Co., Ltd. is divided by 100 to measure the internal control of enterprises.

Columns (4) - (6) of Table 6 present the findings from the evaluation of the internal control mechanism. As indicated in column (4), a statistically significant positive relationship exists between enterprise digital transformation and internal control. This indicates that integrating digital transformation in businesses can boost the effectiveness of internal control mechanisms, thus supporting the hypothesis presented in this research. Following this, the sample is divided based on the strength of the internal control metric into groups with high and low levels of internal control. The examination of columns (6) and (7) shows that for the group with lower levels of internal control, digital transformation is crucial in generating high-quality growth in enterprises. On the other hand,

for the group with higher internal control levels, the influence of digital transformation on the quality of enterprise development is considered negligible. This difference may stem from the fact that businesses with weaker internal controls typically face greater management and operational risks due to the lack of standardized internal procedures, insufficient oversight, and inadequate risk management strategies. Digital transformation serves to enhance internal processes, bolster supervision, and improve risk management, thereby enhancing operational efficiency, reducing costs, and mitigating risks. As a result, the role of digital transformation becomes increasingly critical in enhancing the superior development of businesses marked by less-than-ideal internal control practices. In contrast, the majority of enterprises in the high internal control level group have well-established internal control mechanisms, standardized internal processes, effective supervision, and risk control practices. Therefore, the influence of digital transformation on the advanced development of businesses possessing strong internal control systems is considered negligible. The outcomes of the two-step analysis method lend support to H3.

5.1.3. Green Technology Innovation(GTI)

This study quantified the volume of patent filings for green technology innovations, drawing upon the findings of Xu Jia and colleagues[32]

Table 6. Results of mechanism tests

| VARIABLES | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) |
|--------------|----------------------|------------------------------------|-------------------------------------|---------------------|-------------------------------|--------------------------------|-----------------------------|--|---|
| | Financing constraint | Low level of financing constraints | High level of financing constraints | Internal control | Low level of internal control | High level of internal control | Green technology innovation | Low level of Green technology innovation | High level of Green technology innovation |
| | WW | TFP | TFP | IC | TFP | TFP | GTI | TFP | TFP |
| DIG | -0.023*** (0.007) | 0.017 (0.017) | 0.095*** (0.037) | 0.087** (0.035) | 0.173** (0.069) | 0.027 (0.017) | 0.485* (0.271) | 0.079*** (0.021) | 0.062** (0.028) |
| Constant | -0.938*** (0.070) | 7.520*** (0.226) | 6.127*** (0.358) | 5.992*** (0.395) | 6.231*** (0.512) | 7.069*** (0.278) | -3.075 (2.347) | 7.319*** (0.319) | 6.376*** (0.369) |
| controls | YES | YES | YES | YES | YES | YES | YES | YES | YES |
| Year | YES | YES | YES | YES | YES | YES | YES | YES | YES |
| Stked | YES | YES | YES | YES | YES | YES | YES | YES | YES |
| Observations | 6,246 | 3,123 | 3,123 | 6,246 | 3123 | 3123 | 6,246 | 3,123 | 3,123 |
| R-squared | 0.484 | 0.908 | 0.845 | 0.466 | 0.888 | 0.964 | 0.691 | 0.888 | 0.878 |

The results related to the green technology innovation mechanism are detailed in columns (7) through (9) of Table 6. According to the data in column (7), a significant and statistically meaningful link exists between the adoption of digital transformation by enterprises and the progress in green technology innovation. This implies that digital transformation within enterprises can enhance innovation in green technologies, thus offering preliminary backing for the hypothesis proposed in this research. Further, the samples were categorized into two groups based on their level of innovation in green technology. Based on the outcomes presented in columns (8) to (9), it is observed that the influence of digital transformation on enhancing the high-quality development of enterprises is more pronounced in the low green technology innovation group when compared to the high green technology innovation group. The possible reasons are as follows: Since the technologies and production methods used by enterprises in the low green technology innovation level group have a greater impact on the environment and lower resource utilization efficiency, these enterprises are usually faced with more environmental protection pressure and resource constraints, resulting in increased environmental compliance risks, rising resource costs, and declining market competitiveness. The adoption of digital transformation can help organizations in promoting their

green technology innovation, improving the efficiency of resource use, and ultimately enhancing their capability for sustainable growth. In contrast, enterprises in the high green technology innovation level group have made great progress in environmental technology innovation and resource utilization efficiency, and their environmental protection and resource utilization management has been relatively standardized and effective. The findings from the two-step approach validate the accuracy of hypothesis H4.

5.2. Heterogeneity Analysis

In reaction to how digital transformation influences the superior development of firms, modifications in corporate governance have been observed across different organizations. This study divides firms into state-owned and privately-owned categories to evaluate their performance concerning the influences of digital transformation on attaining superior growth. The regression findings are demonstrated in Table 7, parts (1) and (2). The evaluation indicates a notably positive impact of digital transformation on the enhanced development of privately-owned companies. This disparity can be traced back to two primary factors. Firstly, privately-owned businesses function within a competitive market environment, where market dynamics play a crucial role[33]. Consequently, to enhance their competitive edge, non-state-owned enterprises are inclined to adopt digital transformation, expedite organizational restructuring, and achieve quality growth. Secondly, Chinese state-owned enterprises exhibit a stable focus on social welfare, with the government relying on them to meet social responsibilities and contribute to economic expansion and employment stability. Consequently, state-owned enterprises encounter greater challenges during the digital transition process due to adjustment costs[29] and potential financial constraints, impeding advancements in quality development.

Table 7. Results of heterogeneity analysis

| VARIABLES | (1) | (2) | (3) | (4) | (5) | (6) |
|--------------|-------------------------|-----------------------------|--------------------|-----------------------------|-----------------------|---------------------------|
| | State-owned enterprises | Non-state-owned enterprises | Eastern regions | Central and western regions | High-tech enterprises | Non-high-tech enterprises |
| DIG | 0.037 (0.029) | 0.067*** (0.025) | 0.053** (0.021) | 0.089* (0.046) | 0.069*** (0.021) | 0.002 (0.034) |
| controls | YES | YES | YES | YES | YES | YES |
| Year | YES | YES | YES | YES | YES | YES |
| Stkcd | YES | YES | YES | YES | YES | YES |
| Observations | 1,935 | 4,311 | 4,610 | 1,636 | 5,786 | 460 |
| R-squared | 0.293 | 0.294 | 0.290 | 0.217 | 0.265 | 0.167 |

Regional disparities significantly influence how digital transformation impacts enterprise development quality, in conjunction with variations in property rights. This study categorizes samples by geographical regions, specifically the eastern region and the central and western regions[34], to explore this phenomenon. This research evaluates the performance of different types of companies regarding the influence of digital transformation on development quality. The regression analysis outcomes, displayed in columns (3) and (4) of Table 7, show a marked enhancement in the quality of enterprise development in the eastern region attributed to digital transformation. In contrast, its impact on companies in the central and western regions appears relatively limited. This difference can be ascribed to two primary factors. Firstly, the eastern region possesses a more advanced information technology infrastructure. Notably, the eastern region of China leads in software and information service technology revenue, with software product revenue and information technology service revenue in 2020 comprising 76.88% and 79.97% of the national total, respectively, significantly surpassing the central and western regions. Moreover, the eastern region harbors a higher

concentration of digital talent. Due to regional economic development and elevated education levels, China's digital workforce predominantly concentrates in key areas like Beijing, Tianjin, the Yangtze River Delta, and the Pearl River Delta. The concentration of digital knowledge and skills in the eastern region provides essential assistance for businesses seeking to engage in digital transformation initiatives and attain high-quality growth.

Furthermore, the research investigates how digital transformation facilitates superior growth in high-tech firms versus non-high-tech firms[35]. The regression outcomes (documented in Table 7, columns 5 and 6) displayed that the effect of digital transformation on boosting high-quality growth is notably stronger in high-tech firms than in non-high-tech ones. This disparity can be attributed to two main factors. Firstly, high-tech enterprises possess strong technological innovation capabilities and abundant data resources, which can be effectively leveraged through digital transformation to enhance production efficiency and product quality, thereby facilitating high-quality development. Secondly, high-tech enterprises often rely on advanced technology and digital platforms for their products and services, and digital transformation enables them to better align with market demands and improve competitiveness, ultimately driving high-quality development within these enterprises.

6. Conclusion and Suggestions

6.1. Conclusion

This research explores the effects of digital transformation on business progression with an emphasis on achieving high-quality results. By analyzing balanced panel data from A-share listed firms in China's equipment manufacturing industry between 2013 and 2021, it uncovers the critical mechanisms involved. The outcomes show that digital transformation substantially boosts the high-quality growth of these companies, a finding corroborated by comprehensive robust analyses. The study uncovers that digital transformation primarily supports high-quality development by easing financial constraints, improving internal control standards, and promoting innovation in green technology. Additionally, the analysis of the variety within the data suggests that digital transformation significantly impacts the promotion of high-quality development in equipment manufacturing companies with non-state ownership, situated in the eastern region, and categorized as high-tech enterprises.

6.2. Suggestions

First, it is imperative for equipment manufacturing firms to comprehensively acknowledge the growth prospects stemming from digital transformation and seamlessly incorporate digital technologies into their operational and managerial frameworks. Concurrently, governmental bodies and pertinent agencies should enhance their backing for equipment manufacturing entities by offering heightened policy backing and resource assurance for their digital transformation endeavors. Collaboratively, they have the potential to drive the digital evolution and advancement of the equipment manufacturing industry. To incentivize enterprises to augment their investments in digital transformation and expedite this process, the government can introduce tax benefits for such initiatives.

Second, the primary focus for equipment manufacturing enterprises in their digital transformation development should be on alleviating financial constraints, enhancing internal control quality, and fostering innovation in green technology. It is essential for digital transformation to be integrated across all facets of the enterprise. To support this endeavor, the government can alleviate the financial burden of digital transformation by offering low-interest loans and encouraging financial institutions to provide increased credit support to equipment manufacturing enterprises. Additionally, enterprises must bolster their internal management and oversight by establishing a robust internal control system, which includes enhancing financial management practices, fortifying data security measures, and implementing information management systems. This will help mitigate risks associated with the digital transformation process and enhance operational efficiency. Moreover, the government can

incentivize businesses to participate in the development of environmentally friendly technology by offering tax incentives, subsidies, and other forms of incentive programs, thereby promoting the amalgamation of digital transformation with environmental conservation principles to achieve sustainable, low-carbon, and high-quality enterprise development.

Third, it is imperative to adhere to the principle of refinement and specialization when devising and executing the digital transformation strategy for equipment manufacturing firms. This involves extending support to non-government-owned equipment manufacturing companies for the broader integration of cutting-edge digital technologies, as well as furnishing additional resources and assistance to aid these entities in enhancing their fundamental competitiveness within the marketplace. Concurrently, in the case of high-tech equipment manufacturing firms, governmental intervention should be directed towards encouraging heightened investments in digital transformation endeavors, thereby fostering advancements in technological innovation and product research and development. Additionally, for equipment manufacturing firms situated in the central and western regions, there ought to be a strategic preference within the digital transformation policy framework towards these areas, designed to offer the necessary external conditions to the full execution of the digital transformation strategy.

Nevertheless, this study is constrained by two limitations. Firstly, the assessment approach employed to gauge high-quality development in enterprises is narrow, focusing solely on total factor productivity. Future research endeavors could be enhanced by integrating supplementary productivity indicators to offer a more thorough assessment of the effective advancement of equipment manufacturing firms from various perspectives. Secondly, the ramifications of digital transformation on management strategies, organizational frameworks, and employee competencies within equipment manufacturing enterprises have not been thoroughly examined. Future research can delve deeper into these aspects.

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