International Journal of Sustainable Development and Planning
Vol. 18, No. 12, December, 2023, pp. 3703-3711
Journal homepage: http://iieta.org/journals/ijsdp

# Does Digital Transformation Promote Sustainable Development of Enterprises: An Empirical Analysis of A-Share Listed Companies

Gongwen Xu, Dhakir Abbas Ali*, Amiya Bhaumik

Faculty of Business and Accountancy, Lincoln University College, Petaling Jaya 47301, Malaysia

Corresponding Author Email: drdhakir@lincoln.edu.my



https://doi.org/10.18280/ijsdp.181202

**Received:** 15 August 2023
**Revised:** 9 October 2023
**Accepted:** 25 October 2023
**Available online:** 29 December 2023

***Keywords:***
*digital transformation, sustainable development capability, a-share listed companies, total factor productivity*

**ABSTRACT**

This article examines the interplay between digital technology and enterprise development in China, with a specific focus on the efficacy of digital transformation within enterprises. Our research draws on data from A-share listed companies in China between 2012 and 2021 to investigate the influence of digital transformation on an enterprise's capacity for sustainable development and the underlying mechanisms at work. Our findings indicate that digital transformation can significantly enhance an enterprise's sustainable development capabilities. The mechanism testing results reveal that advancements in digital transformation have led to improved internal control quality and boosted total factor productivity, thereby strengthening the capacity for sustainable development. Moreover, our heterogeneity analysis uncovers several intriguing trends. We found that digital transformation more notably improves the sustainable development capacity of non-state-owned enterprises compared to their state-owned counterparts. Similarly, high-tech enterprises experience a more pronounced enhancement in sustainable development capabilities through digital transformation compared to non high-tech enterprises. Furthermore, we discovered that enterprises located in regions with high levels of marketization benefit more significantly from digital transformation in terms of sustainable development capacity than those in regions with lower levels of marketization. Through this study, we provide valuable empirical evidence that aids in evaluating the effectiveness of digital transformation in enterprises and in promoting high-quality sustainable development. Additionally, our findings offer a theoretical foundation for devising relevant policies.

## 1. INTRODUCTION

In various reports from the Chinese government, there has been a proposition to accelerate the build-out of Digital China. To implement the Digital China strategy and drive high-quality economic development, it is crucial to construct a technologically advanced network infrastructure, expedite the release of data resource value, and augment digital technology innovation capabilities [1].

Given that enterprises form the backbone of the economy, it is imperative for them to undergo digital transformation. Technological upgrades often manifest as iterations of enterprise growth and decline, linking digital transformation to their sustainable development capability. This capability is typically constrained by the enterprise lifecycle, but digital transformation offers a potential to transcend this lifecycle and enhance sustainable development capacity [2].

Most existing literature on enterprise digital transformation focuses on the mechanisms, processes, and outcomes of such transitions [3]. Some scholars argue that embedding data elements into the production system transitions traditional systems to digital ones. This process improves internal financial factors and boosts innovation levels within enterprises, either through more efficient human resource allocation or cost reduction [4]. The information diffusion also results in knowledge spillover effects between enterprises, impacting total factor production efficiency.

Other researchers posit that technological updates and changes in production factors trigger a wave of digital transformation, endowing enterprises with new efficiency levels and driving forces for high-quality development [5]. However, these works only offer a glimpse into the issue of digital transformation and do not fully address practical concerns. Specifically, they do not answer whether strategic investment in digital technology can enhance sustainable development capability.

To address this question, this article analyzes data from listed companies in China, investigating the impact of digital transformation on sustainable development capability and its underlying mechanisms. The study's findings endorse the positive effect of digital transformation on sustainable development capability, with the internal control quality and total factor productivity improvements being key influencing mechanisms. The study also reveals that the positive correlation between these factors is influenced by the heterogeneity of property rights, industrial characteristics, and

regional marketization levels.

The potential marginal contributions of this article are as follows: Firstly, by establishing sustainable development ability as the outcome variable, we have uncovered the causality of digital transformation in enterprises. This approach, to some extent, confirms the unique economic logic of digital technology. It has extensively and profoundly transformed production and operation activities in terms of comprehensive technical level and production factors, changed the growth mode and sustainable development ability, and enriched the body of literature on enterprise sustainable development. Secondly, in terms of mechanism research, digital transformation has significantly enhanced the controls of enterprises and increased their total factor productivity. This article uses total factor productivity and internal control as mediating variables to elucidate the underlying principle behind digital transformation and sustainable development capabilities. This method enables easy integration of existing research and theories on the digital transformation of enterprises.

## 2. THEORETICAL MECHANISM AND RESEARCH HYPOTHESES

Enterprises can only formulate specific strategies to continuously improve their competitiveness and achieve the goal of sustainable development when viewed from the perspective of sustainable growth [6]. An essential prerequisite for achieving sustainable development is maintaining a competitive advantage. Resource-based theory posits that acquiring unique resources is key to businesses' success and future development [7]. These resources are characterized by their scarcity, difficulty in imitation, and value. The technology system adopted by enterprises is often regarded as such a resource.

While traditional industrial technology systems cannot break free from the limitations of the enterprise lifecycle, digital technology systems can transcend the law of marginal decline under the industrial technology system, and even achieve a marginal increase [8]. Consequently, enterprises are expected to overcome the limitations of their lifecycle and achieve sustainable development.

Digital technology, which represents information through bits, can help enterprises lower the cost of information storage, computation, and data transmission. This leads to reduced search, replication, transmission, tracking, and verification costs [9].

Traditional digital technology, primarily manifested as informatization, converts businesses into data through IT technology. Previous studies have shown that investing in ERP can significantly increase business performance, and IT capabilities can help improve sustainable development performance [10].

Recently, with the proliferation of mobile internet and the commercialization of Fifth Generation mobile communication technology, the application of underlying techniques such as AI, big data, blockchain, etc., has driven a new round of digital technology burst. Digital transformation based on these new technologies can penetrate information silos, break enterprise boundaries, and establish interconnected business networks. The governance structure and internal management model of enterprises can be innovatively transformed. Enterprises with these new digital resources are conducive to digital transformation, gaining competitive advantages, and enhancing sustainable development capabilities [11].

In summary, we propose Hypothesis 1.

***Hypothesis 1:*** Digital transformation is positively correlated with the sustainable development ability of enterprises, in other words, the higher the degree of digital transformation, the stronger the sustainable development ability.

From the perspective of impact mechanism, digital transformation mainly enhances the sustainable development ability by improving the quality of internal control and improving production efficiency.

Internal control is a significant internal institutional safeguard for achieving sustainable development. However, new business models are transforming internal management models, and the multiple principal-agent relationships under the backdrop of information asymmetry are becoming increasingly complex. Thus, the impact of internal control construction in enterprises is being challenged. Through the application of new techniques such as AI and big data, digital transformation endows enterprises with more efficient, secure, and reliable internal controls [12].

A notable achievement of digital transformation is the promotion of intelligent business process reengineering within enterprises. Intelligent business processes have improved the efficiency of internal control systems, increased the frequency, breadth, and depth of enterprise processing of non-standard and unstructured data, and reduced managerial intervention in internal control [13]. This business process can effectively suppress management's self-interest motivation and reduce agency costs.

The use of blockchain and cloud technology simplifies internal control procedures and ensures data integrity with the support of computing power, thereby increasing the security and reliability of related control activities. Simultaneously, the use of visualization technology in decision-making can enhance business decision-making performance and reduce potential business risks [14].

Modern enterprise internal control emphasizes stakeholder orientation. Digital transformation could enhance the relationship between enterprises and stakeholders by strengthening information disclosure, suppressing earnings management, and improving the relevance of accounting information, thereby establishing an internal governance model with stakeholder participation [15].

In summary, digital transformation can enhance internal control quality in enterprises. Meanwhile, existing empirical research has found a positive correlation between internal control quality and the sustainable development ability of enterprises. Based on this, we propose Hypothesis 2a for this article.

***Hypothesis 2a***: In the enterprises, internal control plays a mediating role between digital transformation and the sustainable development ability.

A major prerequisite for enterprises to achieve sustainable development capability is comprehensive production efficiency that surpasses competitors. Data-based transformation can help enterprises improve total factor productivity in the following ways:

Firstly, the essence of digital transformation is incorporating data as a new element into the enterprise production function. With the development and popularization of digitization, the price of data elements has decreased. This can generate substitution effects and reduce the investment of

other production factors in the enterprise, thereby lowering production costs [16].

Secondly, data elements have technical and economic characteristics such as non-competitiveness and low-cost replication. This feature enables the micro-efficiency improvement mechanism to operate simultaneously on a larger scale and in more scenarios, making it easier to combine with traditional production factors and form new business models. An unreasonable combination of factors is the main reason why the total factor productivity in Chinese companies is relatively lower than in India. With the support of new technologies, enterprises can achieve a re-optimized combination of relevant elements, build a value creation system driven by data at the core, and undergo business model transformation [17].

Thirdly, the use of digital technology can reduce internal and external communication costs and alleviate overcapacity. Digital transformation can also promote information sharing within and outside enterprises, allowing them to timely grasp changes in the market environment, understand market demand, improve information asymmetry among enterprises, increase sales, and alleviate overcapacity [18]. In addition, digital transformation could also ease financing constraints, optimize resource allocation efficiency, and improve production efficiency.

Existing empirical research shows that ICT investment can enhance the production efficiency of enterprises, and digital transformation is positively related to total factor productivity [19]. In summary, digital transformation can improve total factor productivity. The enhancement of total factor productivity is an important guarantee for improving sustainable growth ability. Based on this, we propose Hypothesis 2b.

***Hypothesis 2b***: Total factor productivity plays a mediating role between digital transformation and sustainable development capabilities.

## 3. RESEARCH DESIGN

### 3.1 Data selection

This article starts from 2012 and selects data from A-share listed companies from 2012 to 2021 as the research sample. In order to eliminate the effects of outliers and special industries on the research results, *ST* and *PT* listed companies, as well as financial, insurance, and real estate listed companies, were excluded from the sample. We also excluded some samples with missing data and ultimately obtained annual sample observations for 22719 companies.

### 3.2 Variable definition

(1) The Dependent variables

Both Higgins and Van Horn's sustainable growth models will be used to measure the sustainability of enterprises. But the Higgins model did not consider the factor of stock issuance [20]. Therefore, this article selects Van Horn Sustainable Growth Model, a measure of sustainable development capability. The method is shown in Eq. (1):

$$\begin{aligned}&\text{Sustainable Development Capability Of The Enterprise}\\&= \text{Net Profit From Sales} \times \text{Earnings Retention Rate}\\&\times (1+\text{EquityRatio}) \left(\left(\frac{1}{\text{Total Asset Turnover Rate}}\right) - \text{Net Profit Margin On Sales}\right.\\&\left.\times \text{Earnings Retention Rate} \times (1+\text{Equity Ratio})\right)\end{aligned} \tag{1}$$

**Table 1.** Variables table

| Variable | | Definition |
|---|---|---|
| Dependent variable | SUS | Sustainability, see formula (1) |
| Explanatory variable | DIG | Enterprises Digital Transformation: the feature words frequency with Logarithmic Form |
| Mediating variable | IC | Internal Control Quality: China's listed companies' internal control DiBo index divided by 1000 |
| | TFP | Total Factor Productivity: using the LP function |
| Control variable | LNA | Enterprise Size: with Logarithmic Form |
| | LEV | Asset Liability Ratio |
| | TOP1 | Major Shareholder Shareholding Ratio: the largest one |
| | BS | Board Size: number of directors |
| | SUP | Size of Supervisory Board |
| | CASH | Cash ratio: (cash + securities)/current liabilities |
| | CL | Comprehensive Leverage: ratio of net profit change rate to main business income change rate |
| | ROA | Return on Assets |
| | GROWTH | Enterprise Growth: operating profit growth rate |
| | SOE | Property Right Nature: the nature of the actual controller. If it is state-owned, 1 is taken, otherwise 0 is taken |

(2) The Explanatory variables

In current econometric research, there are three main ways to measure the digital transformation of enterprises. The first method uses the "0-1" dummy variable to indicate whether the companies have undergone digital transformation. The disadvantage of this method is its imprecision and inability to measure the intensity of transformation.

The second method utilizes detailed information on intangible assets. Terms such as "software" and "intelligent platform" within these assets are recognized as digital intangible assets. The ratio of digital technology intangible assets to total intangible assets is used as a proxy variable. However, the application of digital technology by enterprises is not only reflected in intangible assets, so using this method may result in omissions.

The third method uses data mining technology to select specific keywords related to digital transformation, and to extract, filter, and analyze text from annual reports. The frequency of selected keywords is used as an indicator of the level of digital transformation intensity. The advantage of the third method is that the information in annual reports can comprehensively reflect the company's strategy and business philosophy, and word frequency statistics can be used to judge the intensity of digital transformation.

Therefore, this article opts for the third method, designing a feature vocabulary from two levels: "employment of underlying technology" and "practical application of technology", and using the logarithm of the word frequency as

an indicator of enterprise digital transformation [21].

(3) The Control variables

Referring to existing research, this article sets control variables: enterprise size, asset liability ratio, shareholding ratio of the largest shareholder, board size, supervisory board size, cash ratio, comprehensive leverage, asset return ratio, enterprise growth, and property rights nature. At the same time, it also controls the dummy variables of the year and industry.

(4) The Mediating variables

When it comes to the company's internal control in this article, we use the DiBo China listed company's internal control index divided by 1000 as the proxy variable. The semi parametric LP function is applied to construct total factor productivity indicators. The specific variable definitions are in Table 1.

### 3.3 Model settings

To check the influence of digital transformation on the sustainable development ability, we set up the following model (1):

$$SUS_{i,t} = \alpha_0 + \alpha_1 \times DIG_{i,t} + \alpha_i \times \sum Control + \varepsilon_{i,t} \quad \text{model (1)}$$

When $\alpha_1$ is obviously above 0, it implies that digital transformation has improved sustainable development ability of the enterprise.

At the same time, referring to the above principal, digital transformation could enhance sustainable business capabilities via enhancing internal controls. To test this mediation mechanism, we have set up models (2) and (3) respectively:

$$IC_{i,t} = \beta_0 + \beta_1 \times DIG_{i,t} + \beta_i \times \sum Control + \varepsilon_{i,t} \quad \text{model (2)}$$

$$SUS_{i,t} = \chi_0 + \chi_1 \times DIG_{i,t} + \chi_2 \times IC_{i,t} + \chi_i \times \sum Control + \varepsilon_{i,t} \quad \text{model (3)}$$

If the regression coefficient $\beta_1$ and the regression coefficient $\chi_2$ above are significantly greater than 0, we could say internal control has the positive partial mediating effect.

Existing research has shown that digital economy could significantly enhance total factor productivity, and the improvement of factor productivity is vital to improve sustainable growth ability. The improvement of total factor productivity could have a mediating role when digital transformation acts on the sustainable development ability. To test the mediation mechanism above, this article sets up models (4) and (5) respectively:

$$TFP_{i,t} = \beta_0 + \beta_1 \times DIG_{i,t} + \beta_i \times \sum Control + \varepsilon_{i,t} \quad \text{model (4)}$$

$$SUS_{i,t} = \chi_0 + \chi_1 \times DIG_{i,t} + \chi_2 \times TFP_{i,t} + \chi_i \times \sum Control + \varepsilon_{i,t} \quad \text{model (5)}$$

If the regression coefficient $\beta_1$ and the regression coefficient $\chi_2$ above are significantly greater than 0, it indicates that total factor productivity has a positive partial mediating effect.

## 4. EMPIRICAL RESULTS

### 4.1 Descriptive statistical results

They are presented in Table 2.

According to the above table, we discover that in the selected sample of listed companies, the minimum value of the sustainable development ability index is -0.023, the maximum value is 0.44, the mean is 0.09, and the median is 0.07. Among digital transformation indicators, the minimum is 0, the maximum is 6.27, the mean is 2.01, and the standard deviation is 1.411. The digital transformation intensity of the sample enterprises varies greatly. In addition, from the perspective of property rights, state-owned enterprises account for 33% of the sample, while non-state-owned ones account for 67%.

**Table 2.** Descriptive statistics of variables

| Variables | Sample Size | Mean | Standard Deviation | Minimum | Median | Maximum |
|---|---|---|---|---|---|---|
| SUS | 22719 | 0.09 | 0.072 | -0.023 | 0.07 | 0.44 |
| DIG | 22719 | 2.01 | 1.411 | 0.000 | 1.82 | 6.27 |
| LNA | 22719 | 22.36 | 1.284 | 18.026 | 22.15 | 28.61 |
| LEV | 22719 | 0.39 | 0.181 | 0.011 | 0.39 | 0.97 |
| TOP1 | 22719 | 0.32 | 14.723 | 0.026 | 0.309 | 0.885 |
| BS | 22719 | 8.31 | 1.641 | 4.000 | 9.00 | 17.00 |
| SUP | 22719 | 3.51 | 0.999 | 1.000 | 3.00 | 12.00 |
| CASH | 22719 | 0.76 | 1.235 | 0.001 | 0.39 | 24.83 |
| CL | 22719 | 1.99 | 1.739 | 0.951 | 1.47 | 13.62 |
| ROA | 22719 | 0.08 | 0.049 | -0.035 | 0.07 | 0.81 |
| GROWTH | 22719 | 0.68 | 3.875 | -5.683 | -0.08 | 27.13 |
| SOE | 22719 | 0.33 | 0.475 | 0.000 | 0.00 | 1.00 |

### 4.2 Benchmark regression analysis results

(1) Regression results

In Table 3, column (1) presents regression results without control variables, showing a regression coefficient of 0.0027, which is significant at the 1% level. In column (2), the regression results include control variables and display a regression coefficient of 0.0022, also significant at the 1% level. These results indicate a significant positive correlation between digital transformation and the sustainable development capabilities of enterprises. As the intensity of digital transformation increases, so does the sustainable development ability. Therefore, these findings support Hypothesis 1.

(2) Robust test

i. Key variable replacement

When replacing the dependent variable, we used a sustainable development rate that takes account of the benefit

of both sides to replace the sustainability of the enterprise. After replacing the dependent variable, the research conclusion remains robust.

We replaced the explanatory variables in two aspects. On one hand, this article mainly considers intensity of digital transformation, so enterprises with zero frequency of digital transformation feature words were not included in the sample in the previous test. In order to ensure more robust research results, we assigned a value of 0 to enterprises without digital transformation feature words and included them in the sample for re regression. In the second aspect, we have set relevant digital transformation indicators at the 2 levels of "application of underlying technology" and "practical application of technology". The new indicator replaces the original digital transformation indicator. We could find out a significant positive interaction between digital transformation in both the application of underlying technology and the practical application of technology, and the sustainable development ability [22].

ii. Changing research interval

COVID-19 epidemic may extensively affect the sustainable development ability. In order to avoid the potential effect of the epidemic on the conclusions of the paper, 2020 and 2021 samples were excluded from the sample. After re conducting regression analysis using samples from 2012 to 2019, the results showed that the fundamental research conclusions in the article are still robust.

(3) Endogeneity problem

i. Latency and instrumental variable method

Enterprises with strong sustainable development capabilities usually have more resources invested in digital transformation, and the above conclusions may face endogeneity issues that are mutually causal. In order to reduce its impact, this study used digital transformation with a lag of one period as the explanatory variable and re regressed, and the results were still robust [23].

ii. Heckman two-stage model

In the previous main test, this article did not include enterprises with a frequency of 0 digital transformation feature words in the sample, and did not consider the impact of the sample of enterprises that did not undergo digital transformation. This operation will lead to non random selection of samples, resulting in the above research conclusions being affected by sample selection bias. To overcome the above issues, this article used the Heckman two-stage model to conduct regression analysis again [24]. We will use the digital transformation indicators and related control variables from the previous period as explanatory variables for whether a company undergoes digital transformation, and conduct the first stage regression to obtain the inverse miller ratio. Based on this, we will conduct the second stage regression estimation. After using the Heckman two-stage model, the conclusion is that the main regression results are still robust.

iii. Propensity matching scoring method

In addition to the above, whether digital transformation will improve the sustainable development ability could also be affected by self selection bias. The main purpose of digital transformation is to gain competitive advantage, which in turn could improve sustainable development capabilities. However, enterprises that do not participate in digital transformation may already have strong competitiveness and do not need to achieve it through digital transformation. All variables of digital transformation might be non strictly exogenous. To overcome the above problems, this article used propensity score matching method for robustness testing [25]. The specific approach is as follows: control variables such as enterprise size, comprehensive leverage, cash ratio, and asset return rate are selected as covariates, and the samples undergoing digital transformation and those not undergoing digital transformation are matched in a 1:1 neighborhood to examine their processing effects. After matching, the results of parallel trend testing showed that the absolute values of standardized deviations for each covariate were less than 5%. And the results after matching are significantly smaller than before, and matching effect is valuable. The treatment effect after matching is 0.0036, with a T-value of 2.15, significant at 5% level. Then we could conclude that conducting digital transformation would indeed improve sustainable development ability. Furthermore, this article retested the main model using matched samples. The test results give regression coefficient variable 0.002, significant at the 1% level, and we could find out that the research results are robust.

**Table 3.** Regression analysis results

| | (1) SUS | (2) SUS |
|---|---|---|
| DIG | 0.0027***(5.69) | 0.0022*** (6.15) |
| LNA | | -0.000(-1.44) |
| LEV | | 0.14***(23.60) |
| TOP1 | | -0.0002***(-8.57) |
| BS | | -0.0008***(-3.06) |
| SUP | | -0.003***(-7.61) |
| CASH | | 0.001***(2.67) |
| CL | | -0.0004**(-2.01) |
| ROA | | 1.17***(30.65) |
| GROWTH | | 0.00004**(2.39) |
| SOE | | 0.000(1.26) |
| Constant term | 0.07***(65.71) | -0.01(-0.98) |
| Year | NO | YES |
| Industry | NO | YES |
| Adjust-$R^2$ | 0.002 | 0.62 |
| Sample size | 22719 | 22719 |

Note: * indicates significant at the 10% level; ** significantly at the 5% level; *** significantly at the 1% level. Tables below are the same.

### 4.3 Mediation effect test results

(1) The mediating effect of internal control

The mediating results are displayed in Table 4.

According to the results, columns (1) and (2) discover that digital transformation would be significant positive effect on internal control, with a regression coefficient of 0.0038, significant at 1% level. And internal control of enterprises also has a significant positive effect on their sustainable development ability, with a regression coefficient of 0.0034, significant at the 1% level. Meanwhile, it can be seen from column (2) that when internal control is brought in the main model, internal control still has a significant positive effect on the sustainable development ability, with a regression coefficient of 0.015, which is significant at the 1% level. Based on the evidence, it can be concluded that internal control has a partial mediating role in the relationship between digital transformation and sustainable development ability. Results from Sobel's test underscore the significance of this mediating effect at the 1% level [26]. Consequently, these findings corroborate Hypothesis 2a.

**Table 4.** Mediation effect test of internal control

| | (1) IC | | (2) SUS |
|---|---|---|---|
| DIG | 0.0038*** (6.02) | | 0.0034*** (11.08) |
| IC | | | 0.015*** (3.36) |
| Control variable | YES | | YES |
| Constant term | 0.35 (17.221) | | -0.08*** (-0.92) |
| Adjust-$R^2$ | 0.06 | | 0.61 |
| Sobel-Z | | 2.95 | |
| *p*-value | | 0.004 | |
| Sample Size | 22635 | | 22635 |

(2) The mediating effect of total factor productivity

The results of mediating effect of total factor productivity are displayed below in Table 5.

**Table 5.** Intermediary effects of total factor productivity

| | (1) TFP | | (2) SUS |
|---|---|---|---|
| DIG | 0.071*** (17.36) | | 0.0035*** (10.39) |
| TFP | | | 0.002** (2.61) |
| Control variable | YES | | YES |
| Constant term | -5.11 (-44.96) | | 0.0002*** (-0.02) |
| Adjust-$R^2$ | 0.74 | | 0.61 |
| Sobel—Z | | 2.55 | |
| *p*-value | | 0.011 | |
| Sample Size | 21713 | | 21713 |

According to columns (1) and (2), we could conclude that digital transformation has a significant positive impact on total factor productivity, with a regression coefficient of 0.071 and significant at the 1% level. The total factor productivity also has a significant positive effect on their sustainable development ability, with a regression coefficient of 0.0035, significant at the 1% level. Meanwhile, from column (2), it can be seen that when total factor productivity is brought in the main model, it still has a significant positive effect on the sustainable development ability, with a regression coefficient of 0.002 and significant at the 5% level. Our results suggest that total factor productivity serves as a partial mediator in the relationship between digital transformation and sustainable development ability. The significance of this mediating effect, as indicated by Sobel's test results, is upheld at the 5% level. Therefore, these findings provide empirical support for Hypothesis 2b.

## 5. HETEROGENEITY ANALYSIS

### 5.1 Heterogeneity of property rights

The heterogeneity of property rights is mainly reflected in the inconsistence between state-owned and non-state-owned property rights. For the natural connection between the state-owned and the government, they can gain additional competitive advantages and sustainable development capabilities through their state-owned nature. On this premise, if state-owned enterprises continue to undergo digital transformation, the marginal utility of their competitive advantages and sustainable development capabilities may be relatively low [27]. Otherwise, digital transformation of state-owned enterprises is also constrained by insufficient innovation, owner vacancy, multiple agency problems, and lower operational efficiency. The digital transformation process involves business process reengineering, and compared to non-state-owned, state-owned may face upper business inertia and reengineering costs. There would be a negative effect on the effectiveness of digital transformation. On the contrary, fierce market competition will encourage non-state-owned enterprises to adopt new technologies. As an efficient, convenient, and shared digital information technology, digital transformation can reduce costs and improve production efficiency through economies of scale, economies of scope, technological innovation, and management efficiency effects, thereby enhancing the sustainable growth capacity of enterprises. In summary, the digital transformation of non-state-owned ones may have a more significant effect on enhancing their sustainable development capabilities. Therefore, this article carried out a grouping test on the samples based on nature of property rights, and the test results are displayed below in Table 6.

**Table 6.** Grouping regression results of property rights

| | State-Owned-Enterprise Group SUS | | Non-State-Owned-Enterprise Group SUS |
|---|---|---|---|
| DIG | 0.0008 (1.28) | | 0.0023*** (5.06) |
| Control variable | YES | | YES |
| Constant term | 0.01 (0.78) | | -0.01 (-0.85) |
| Adjust-$R^2$ | 0.64 | | 0.62 |
| Intergroup difference test | | 32.41*** | |
| Sample size | 7140 | | 15579 |

From the above results, there exists a significant inter group difference between state-owned group and the non-state-owned ones, with a Chi square value of 32.41, significant at the 1% level. For the state-owned ones, the effect of digital transformation on the sustainable development ability is not significant, while in the non-state-owned enterprise group, the regression coefficient of digital transformation indicators is 0.0023, significant at the 1% level. The above results indicate the improvement impact of digital transformation on sustainable development ability is briefly reflected in the sample of non-state-owned ones.

### 5.2 Heterogeneity of industries

High tech industries typically have a good technological foundation and innovation environment, making it easier to generate synergies with digital technology. Moreover, some high-tech industries themselves rely on information technology as a carrier [28]. At the same time, high-tech industries have the characteristics of valuing capital, human capital, and assets, which reduces obstacles for process reengineering involved in enterprise digital transformation. This will be more conducive to the role of digital technology and enhance sustainable growth capacity. In summary, compared to non-high-tech industries, the digital transformation of high-tech ones may have a more obvious

effect on enhancing the sustainable development ability. Therefore, according to the industry classification standards of the China Securities Regulatory Commission, this article defines aviation transportation, research and experimental development, pharmaceutical manufacturing, and instrument manufacturing as high-tech industries, while other industries are defined as non high-tech industries. We conducted group testing on the samples, and here are the experimental results (Table 7).

**Table 7.** Group regression results of high-tech industries

| | High Tech Industries | Non High Tech Industries |
|---|---|---|
| | SUS | SUS |
| DIG | 0.0038*** | 0.0023*** |
| | (8.61) | (5.87) |
| Control variable | YES | YES |
| Constant term | 0.003 | -0.004 |
| | (0.22) | (-0.41) |
| Adjust-$R^2$ | 0.68 | 0.57 |
| Intergroup difference test | 121.67*** | |
| Sample size | 6128 | 16591 |

As can be seen from the above table, the regression coefficients for digital transformation are obviously positive both high-tech industry and non-high-tech industry group, both significant at the 1% level. However, regression coefficient (0.0038) of the high-tech industry group is larger than the non-high-tech group (0.0023), and the inter group difference test is significant, with a chi square value of 121.67, significant at the 1% level. Then it could be concluded that compared to the non-high-tech industry, the enhancement impact of digital transformation on sustainable development ability is more significant for the high-tech one.

### 5.3 Heterogeneity of marketization degree

The strength of enterprise digital transformation depends on both internal factors and external market environment. One of the ways in which digital transformation affects the sustainable development is by improving internal controls. In addition to relying on reasonable design and effective operation, internal control also requires a sound external legal environment. In high-marketization degree regions, relevant laws and regulations are relatively sound, and the above mechanisms can be strengthened. Another path for digital transformation to affect sustainable development is to improve their total factor productivity. In high-marketization degree regions, the construction of product and factor markets is complete. During the digital transformation process, timely matching of various resources and factors can be achieved, and the effectiveness of digital transformation is strengthened. Therefore, this article uses the regional marketization index of each year to measure the marketization degree. We group based on the median of marketization index, define areas with higher marketization index as high marketization level groups, and vice versa, as low marketization level groups. Then we conducted group testing on the samples, the experimental results are below.

Table 8 shows that the regression coefficients of digital transformation are significantly positive in both high and low marketization groups, and are significant at the 1% level. However, the regression coefficients of the higher ones (0.0022) are greater than those of the lower ones (0.0018). The inter group difference test is significant, with a chi square value of 36.17, which is significant at the 1% level. So we can conclude that compared to regions with low levels of marketization, the improvement impact of digital transformation on the sustainable development ability of enterprises is more significant in regions with high levels of marketization.

**Table 8.** Grouping regression results of marketization degree

| | High Degree of Marketization | Low Degree of Marketization |
|---|---|---|
| | SUS | SUS |
| DIG | 0.0022*** | 0.0018*** |
| | (4.34) | (3.69) |
| Control variable | YES | YES |
| Constant term | -0.039** | 0.017 |
| | (-2.43) | (1.22) |
| Adjust-$R^2$ | 0.63 | 0.62 |
| Intergroup difference test | 36.17*** | |
| Sample size | 12563 | 10156 |

## 6. RESEARCH CONCLUSION AND COUNTERMEASURE SUGGESTIONS

### 6.1 Research conclusion

Nowadays the digital transformation is an vital means for enterprises to gain sustainable development. This article is in view of the data of listed companies (2012-2021), and empirically tests the effect of digital transformation on the sustainable development ability, as well as intermediary mechanisms and heterogeneity. Research has found that digital transformation plays an important role on the sustainable development ability. The higher the degree of digital transformation, the stronger enterprises' sustainable development ability. The test results of intermediary impact indicate that digital transformation has improved quality of internal control, increased total factor productivity, so enhanced the sustainable development ability. The heterogeneity analysis shows that enhancement impact of digital transformation on sustainable development ability is only reflected in the sample of non-state-owned ones. The digital transformation would improve the sustainable development ability of high-tech enterprises more obviously; Compared to regions with lower levels of marketization, regions with higher levels have shown better improvement.

### 6.2 Countermeasure suggestions

The digital transformation for Chinese enterprises is necessary. Digital technology encourages successful individuals to achieve greater success, and economist Brian Arthur calls this phenomenon 'increasing returns'. He believes that "increasing returns mean that the leader will take the lead step by step, while those who lose the opportunity will lose the overall situation". This is the biggest difference between digital economy and industrial economy. For the industrial economy, enterprises follow the principle of diminishing returns, and their development has a mathematical upper limit. The digital economy has become or is about to become a new economic form, and digital transformation is imperative.

Enterprises should apply digital technology and improve their internal control system, establish a sound internal governance mechanism. The active digital transformation of enterprises is conducive to preventing internal control failures such as management fraud from affecting the sustainable development. For example, when applying big data technology in the internal risk assessment process, it can identify more potential risks; The application of enterprise sharing centers can achieve a deep integration of business finance and internal control, expanding the traditional internal control boundary that focuses on finance; The application of blockchain technology makes key internal control processes more secure and reliable.

Enterprises need to make great use of data as a new production factor. Enterprises also should apply digital technology for dual line governance both offline and online. Enterprises should fully collect and use big data resources to improve the timeliness, accuracy of production and operation decisions, in order to achieve high-quality development.

## REFERENCES


[1] Andriushchenko, K., Buriachenko, A., Rozhko, O., Lavruk, O., Skok, P., Hlushchenko, Y., Muzychka, Y., Slavina, N., Buchynska, O., Kondarevych, V. (2020). Peculiarities of sustainable development of enterprises in the context of digital transformation. Entrepreneurship and Sustainability Issues, 7(3): 2255. https://doi.org/10.9770/jesi.2020.7.3(53)

[2] Foroudi, P., Gupta, S., Nazarian, A., Duda, M. (2017). Digital technology and marketing management capability: achieving growth in SMEs. Qualitative Market Research: An International Journal, 20(2): 230-246. https://doi.org/10.1108/QMR-01-2017-0014

[3] Braña, F.J. (2019). A fourth industrial revolution? Digital transformation, labor and work organization: A view from Spain. Journal of Industrial and Business Economics, 46(3): 415-30. https://doi.org/10.1007/s40812-019-00122-0

[4] Khan, S.A., Yu, Z., Umar, M. (2022). A road map for environmental sustainability and green economic development: An empirical study. Environmental Science and Pollution Research, 1: 1-9. https://doi.org/10.1007/s11356-021-16961-1

[5] Tong, T., Rahman, A.A. (2022). Effect of innovation orientation of high-tech SMEs "Small and Mid-Sized Enterprises in China" on innovation performance. Sustainability, 14(14): 8469. https://doi.org/10.3390/su14148469

[6] Saeed, H.S., Hasan, S.I., Nikkeh, N.S., Flayyih, H.H. (2022). The mediating role of sustainable development in the relationship between producer cost expectations and customer desires. Journal of Sustainability Science and Management, 17(10): 13-21. http://doi.org/10.46754/jssm.2022.10.002

[7] Lubis, N.W. (2022). Resource based view (RBV) in improving company strategic capacity. Research Horizon, 2(6): 587-596. https://doi.org/10.54518/rh.2.6.2022.587-596

[8] Castro, G.D.R., Fernandez, M.C. Gonzalez, Colsa, A.U. (2021). Unleashing the convergence amid digitalization and sustainability towards pursuing the Sustainable Development Goals (SDGs): A holistic review. Journal of Cleaner Production, 280(29): 1-40. https://doi.org/10.1016/j.jclepro.2020.122204

[9] Gouvea, R., Kapelianis, D., Kassicieh, S. (2018). Assessing the nexus of sustainability and information & communications technology. Technological Forecasting and Social Change, 130: 39-44. https://doi.org/10.1016/j.techfore.2017.07.023

[10] QSislian, L., Jaegler, A. (2022). Linkage of blockchain to enterprise resource planning systems for improving sustainable performance. Business Strategy and the Environment, 31(3): 737-750. https://doi.org/10.1002/bse.2914

[11] Nayal, K., Kumar, S., Raut, R.D., Queiroz, M.M., Priyadarshinee, P., Narkhede, B.E. (2022). Supply chain firm performance in circular economy and digital era to achieve sustainable development goals. Business Strategy and the Environment, 31(3): 1058-1073. https://doi.org/10.1002/bse.2935

[12] Barr-Pulliam, D., Brown-Liburd, H.L., Munoko, I. (2022). The effects of person-specific, task, and environmental factors on digital transformation and innovation in auditing: A review of the literature. Journal of International Financial Management & Accounting, 33(2): 337-374. https://doi.org/10.1111/jifm.12148

[13] Jarah, B.A., Zaqeeba, N., Al-Jarrah, M.F., Al Badarin, A.M., Almatarneh, Z. (2023). The mediating effect of the internal control system on the relationship between the accounting information system and employee performance in Jordan Islamic Banks. Economies, 11(3): 77. https://doi.org/10.3390/economies11030077

[14] Litvinenko, V., Bowbrick, I., Naumov, I., Zaitseva, Z. (2022). Global guidelines and requirements for professional competencies of natural resource extraction engineers: Implications for ESG principles and sustainable development goals. Journal of Cleaner Production, 338: 130530. https://doi.org/10.1016/j.jclepro.2022.130530

[15] Doni, F., Corvino, A., Bianchi Martini, S. (2022). Corporate governance model, stakeholder engagement and social issues evidence from European oil and gas industry. Social Responsibility Journal, 18(3): 636-62. https://doi.org/10.1108/SRJ-08-2020-0336

[16] Alkaraan, F., Albitar, K., Hussainey, K., Venkatesh, V.G. (2022). Corporate transformation toward Industry 4.0 and financial performance: The influence of environmental, social, and governance (ESG). Technological Forecasting and Social Change, 175: 121423. https://doi.org/10.1016/j.techfore.2021.121423

[17] Khanra, S., Kaur, P., Joseph, R. P., Malik, A., Dhir, A. (2022). A resource-based view of green innovation as a strategic firm resource: Present status and future directions. Business Strategy and the Environment, 31(4): 1395-1413. https://doi.org/10.1002/bse.2961

[18] Demir, F., Hu, C., Liu, J., Shen, H. (2022). Local corruption, total factor productivity and firm heterogeneity: Empirical evidence from Chinese manufacturing firms. World Development, 151: 105770. https://doi.org/10.1016/j.worlddev.2021.105770

[19] Sama, L.M., Stefanidis, A., Casselman, R.M. (2022). Rethinking corporate governance in the digital economy: The role of stewardship. Business Horizons, 65(5): 535-46. https://doi.org/10.1016/j.bushor.2021.08.001

[20] Dhar, B.K., Sarkar, S.M., Ayittey, F.K. (2022). Impact of social responsibility disclosure between implementation

of green accounting and sustainable development: A study on heavily polluting companies in Bangladesh. Corporate Social Responsibility and Environmental Management, 29(1): 71-78. https://doi.org/10.1002/csr.2174
[21] Irfan, M., Razzaq, A., Sharif, A., Yang, X. (2022). Influence mechanism between green finance and green innovation: exploring regional policy intervention effects in China. Technological Forecasting and Social Change, 182: 121882. https://doi.org/10.1016/j.techfore.2022.121882
[22] Gaglio, C., Kraemer-Mbula, E., Lorenz, E. (2022). The effects of digital transformation on innovation and productivity: Firm-level evidence of South African manufacturing micro and small enterprises. Technological Forecasting and Social Change, 182: 121785. https://doi.org/10.1016/j.techfore.2022.121785
[23] Weber, E., Büttgen, M., Bartsch, S. (2022). How to take employees on the digital transformation journey: An experimental study on complementary leadership behaviors in managing organizational change. Journal of Business Research, 143: 225-238. https://doi.org/10.1016/j.jbusres.2022.01.036
[24] Fernandez-Vidal, J., Perotti, F.A., Gonzalez, R., Gasco, J. (2022). Managing digital transformation: The view from the top. Journal of Business Research, 152: 29-41. https://doi.org/10.1016/j.jbusres.2022.07.020
[25] Andreeva, Z.V., Asaliev, A.M. (2023). Exploring the dynamics of labor performance indicators amidst digital transformation. Leadership and Management, 10(1): 343-56. https://doi.org/10.18334/lim.10.1.117380
[26] Siwei, D., Chalermkiat, W. (2023). An analysis on the relationship between ESG information disclosure and enterprise value: A case of listed companies in the energy industry in China. Cogent Business & Management, 10(3): 2207685. https://doi.org/10.1080/23311975.2023.2207685
[27] Jiakui, C., Abbas, J., Najam, H., Liu, J., Abbas, J. (2023). Green technological innovation, green finance, and financial development and their role in green total factor productivity: Empirical insights from China. Journal of Cleaner Production, 382: 135131. https://doi.org/10.1016/j.jclepro.2022.135131
[28] Ma, Q., Tariq, M., Mahmood, H., Khan, Z. (2022). The nexus between digital economy and carbon dioxide emissions in China: The moderating role of investments in research and development. Technology in Society, 68: 101910. https://doi.org/10.1016/j.techsoc.2022.101910