



# Research on the Influence of CEO's Technical Background Characteristics on the Digital Transformation Effectiveness of Manufacturing Enterprises: Taking the Marketization Process as the Moderating Variable

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## Abstract

**Background and Aims:** The digital transformation of manufacturing enterprises is a critical aspect of modern business dynamics, with CEOs playing a central role in navigating this evolution. This study investigates the influence of CEO technical background characteristics on the effectiveness of digital transformation within manufacturing enterprises, while also considering the mediating role of external environment perception and the moderating impact of marketization processes.

**Methodology:** Drawing on data from Shanghai and Shenzhen A-share listed manufacturing enterprises spanning 2016 to 2021, quantitative research methods are employed to analyze the relationship between CEO technical background characteristics and digital transformation outcomes.

**Results:** The findings highlight the significant impact of CEO technical backgrounds on digital transformation effectiveness, with external environment perception serving as a mediator in this relationship. Moreover, in regions characterized by high marketization processes, CEO technical backgrounds demonstrate a heightened influence on digital transformation outcomes.

**Conclusion:** This study contributes to the understanding of digital transformation dynamics in manufacturing enterprises and offers insights into strategic leadership and organizational change management practices.

**Keywords:** CEO Technical Background Characteristics; Manufacturing Enterprises; Digital Transformation; Marketization Process

## Introduction

From a philosophical standpoint, science and technology have long been recognized as fundamental drivers of productivity. Deng (2001) asserted, "The productive forces of society are first and foremost the power of science." Marx (2004) further expounded that the advent of large-scale industry seamlessly integrated great natural forces and knowledge from natural sciences into the production process, thereby significantly enhancing labor productivity. Digital transformation represents a deliberate effort to harness digital technology and supportive capabilities in constructing dynamic digital business models. This transformation not only digitizes traditional production paradigms but also propels productivity to new heights. Marx's observations in 1867 foresaw that increased productivity would inevitably precipitate changes in production relations.

The rapid surge and proliferation of the digital economy are attributable to three key breakthroughs in scientific and technological advancement. Firstly, computing technology encompasses data processing, computation, and storage, spanning integrated circuitry (chips) and computer technology. Communication technology, another cornerstone of the digital economy, encompasses data transmission, reception, and various network-related technologies. The Internet, a quintessential component of the digital economy, exemplifies the pivotal role of communication technology in facilitating information transmission and interconnectivity. Lastly, big data technology encompasses digitization and mass data processing, exemplified by its capacity to transform physical music records into virtual digital formats

[411]





for computer processing. These three technologies significantly influence the trajectory and potential of digital technology, shaping the developmental trajectory and level of the digital economy.

Digital transformation assumes a pivotal role in propelling the digital economy forward. By seamlessly integrating digital technology with traditional manufacturing practices and fostering innovation, digital transformation emerges as a catalyst in the ongoing global industrial metamorphosis. Scholars, such as Cao (2018), advocate for enhancing the efficacy of manufacturing digital transformation by focusing on core equipment, breakthrough technologies, talent development, and establishing robust industrial information security systems. Wang (2019) emphasizes the paramount importance of human factors among various influencers, while Qian (2017) underscores the complexity and systematic nature of enterprise digital transformation, necessitating steadfast commitment and confidence from senior management. Li (2018) advises enterprises to meticulously evaluate internal and external environments during transformation and advocates for leaders' comprehensive understanding of digital resources. Building upon Hambrick and Mason's (1984) seminal high ladder team theory, subsequent revisions, notably the "multi-theory integration model," have underscored the significance of senior management's strategic acumen and background characteristics in navigating complex market landscapes. Thus, strategic decisions in enterprises often reflect the distinctive traits and insights of senior management, showcasing the critical role of leadership in shaping organizational trajectories.

## Objectives

- 1、 Investigate the influence of CEO technical background characteristics on the effectiveness of digital transformation within manufacturing enterprises.
- 2、 Explore the mediating role of external environment perception in shaping the relationship between CEO technical background characteristics and digital transformation outcomes.
- 3、 Examine the moderating effect of marketization processes on the association between CEO technical background characteristics and the effectiveness of digital transformation initiatives.

## Literature review

### The effect of the digital transformation of manufacturing enterprises

Scholars mainly focus on the following points and study the achievements of the digital transformation of manufacturing enterprises through a large number of literature. First of all, we should evaluate the results of the digital transformation of manufacturing enterprises with productivity. Some scholars conclude that the matching degree between digital communication technology and the labor structure of senior technical employees and long-term employees has a significant impact on improving productivity. Some academics feel that the impact of digital investment on improving productivity is not obvious, but it has a significant intermediate effect on improving productivity. The widespread application of digital technology is not only closely related to the significant productivity increase but also partially mediated to some extent; the transformation of the business model affects improved productivity. Some scholars (He et al, 2019) have pointed out that digital transformation plays an obvious role in improving the productivity of manufacturing enterprises. (Atrostic, 2005) The study found that computer networks have a significant impact on labor productivity in factories. Some academic scholars have made a thorough discussion on this and put forward three forms of digital transformation (Liu, 2020).





Secondly, this paper considers optimizing the organizational structure of enterprises and improving enterprise performance to discuss the benefits of digital transformation of manufacturing enterprises. Through empirical analysis, some scholars found that the extensive application of digital technology has a significant impact on real enterprises, which is manifested in cost reduction, improvement of asset use efficiency, and enhanced innovation ability. Although the application of digital technology varies according to the enterprise situation, it is of great significance to the improvement of the economic benefits of real enterprises (He, 2019). According to Yang Deming's research results in 2018, after the traditional enterprise's use of Internet-related technologies, their enterprise-related benefits have been significantly improved, and this conclusion has been verified by the empirical test. Enterprise informatization investment can not only significantly reduce the manufacturing cost of enterprises, but also shorten the research and development cycle, and affect the profits of enterprises with volatility (Zhan, 2019). Some scholars adopted the case analysis method and chose two manufacturing enterprises Kute Intelligence and Qingdao Haier as the research objects. This paper discusses the impact of digital transformation on the boundaries, operation mode, and business model of manufacturing enterprises, and finds that digital transformation has a significant impact on the production, distribution, exchange, and consumption of enterprises (Lin & Lu, 2019). In general, the empirical results that enterprise digital transformation has a significant positive impact on enterprise performance have been confirmed (Hu, 2020).

Third, considering the perspective of promoting the innovation ability of enterprises, digital transformation is crucial to the effect of manufacturing enterprises. The research of small and medium-sized manufacturing enterprises shows that digital transformation has promoted the efficiency of new product development. Some scholars have used the Tobit model to study the relationship between digital transformation and the intensity of innovation in manufacturing enterprises and concluded that there is a significant positive correlation between the two (Zhao & Yang, 2020).

To sum up, the digital transformation of manufacturing enterprises, as the mainstream trend of the current global manufacturing industry development, improves production efficiency and reduces and optimizes supply chain management through the introduction of advanced digital technology and digital tools. However, there is still controversy about the effectiveness of the digital transformation of manufacturing enterprises, because the evaluation of the effectiveness involves many complex factors. The latest research results show that the digital transformation of manufacturing has had a positive impact, including improving production efficiency, enhancing innovation capacity, improving product quality, and improving customer satisfaction.

### **Relevant studies on the background characteristics of senior executives**

As an important core of enterprise strategic decision-making and business activities, the CEO plays a key role in R&D and innovation activities. The CEO is responsible for making strategic decisions and business activities, aiming to drive continued innovation and development. The research and management community has been discussing the problem that enterprise strategic change is affected by the background characteristics of the CEO. The background characteristics of the CEO play a key role in the operation, management, and decision-making of the company. At present, the academic community has conducted extensive research on the impact of the CEO on corporate strategic decisions and changes, mainly focusing on the CEO's educational background, age, tenure, education, work experience, political relevance, and narcissism. Although existing studies have extensively explored the impact of demographic and psychological characteristics on the digital transformation of enterprises,



the perspective of the technical background characteristics of CEOs is still relatively limited.

In general, studies show that corporate CEOs tend to make more conservative decisions when they are older and that they are more conservative about the opportunities to try out novel and challenging behaviors. As a result, these CEOs have shown a limited willingness to face strategic change. From the perspective of term continuity, if a CEO (CEO) has a long term, then the culture within the enterprise will be more consolidated, making it slower to respond to changes in the external environment, leading to a lack of positive will for strategic change. In terms of gender, women are more inclined to adopt prudent and conservative strategic decisions, while they lack a sense of risk-taking. From the perspective of educational level, there is a certain degree of positive correlation between academic degree and innovation consciousness. Higher-educated senior managers often tend to adopt more risky strategic decisions. CEOs with a political background show a high level of emotional intelligence, being proficient in acquiring information and communicating, and also being more sensitive to environmental changes. Therefore, these capabilities enable it to capture the opportunities brought about by the strategic transformation and gain a first-mover advantage in the competition (Wang, 2017). Narcissistic CEOs have a strong sense of identity and tend to resist strategic advice from other executives during decision-making to demonstrate their excellence. To this end, they often choose aggressive strategies or strategies (Zhu & Peng, 2012).

In general, many scholars at home and abroad have fully confirmed that the background characteristics of the CEO have a significant impact on the strategic decisions and strategic changes of enterprises. As an important change in the enterprise strategy level, the progress of digital transformation is influenced by the personal background characteristics of the company's CEO (CEO). In the context of the widespread spread of the digital economy, to promote the smooth implementation of digital transformation, it is necessary to conduct in-depth research on the technical background characteristics of corporate CEOs (CEOs) to propose customized recommended measures. According to the previous research, this paper ensures the scientific accuracy of the CEO by comprehensively measuring the technical background characteristics of his expertise, work experience, and social capital.

### **Research on the perceived ability of the external environment**

The theory of dynamic capability was first extended in the research of enterprise capability theory, and it is currently a hot issue in the field of strategic management in the world. (Teece, Pisano & Shuen, 1997) published The Dynamic Capabilities of Firms article that defines dynamic capabilities as the ability of enterprises to integrate, build, and reconfigure internal and external capabilities to adapt to rapidly changing environments. This view emphasizes how enterprises can acquire and maintain their competitive advantage by tapping into their existing and external capabilities in the face of a changing environment. (Eisenhardt & Martin, 2000) further defines dynamic capabilities as "the ability to extend, revise, and create fundamental capabilities," and believes that it is extremely important for businesses in dynamic and complex environments. (SubbaNarasimha, 2001) believes that dynamic capability is a kind of universal enterprise capability. In response to the changing external market environment, the organization plans through the development and adjustment of dynamic capability. From the perspective of organizational learning, we explore the mechanism of the formation of dynamic ability, which provides a new perspective for the study of dynamic ability theory. Although scholars have continuously enriched the theory of dynamic competence, its essence is an ability to help organizations adapt to the changing external environment (Winter, 2003). Using the dynamic ability theory of enterprise digital transformation found that there is internal force and external force to promote enterprise transformation,



internal force is mainly reflected in the enterprise under the pressure of rapid cognition and research and development ability of the enterprise, and external force is mainly for the sharp change of the external environment perception and rapid absorption of new technology, learning (Gao and Changmin, 2020).

### **Related research on the marketization process**

The process of marketization is to measure the degree of market resource allocation. In the following, "marketization degree" and "marketization process" are the same concept. Internationally, the degree of economic liberalization is used to describe the degree of marketization, and it is divided into five levels: unfreedom, comparative unfreedom, moderate freedom, comparative freedom, and freedom. The level of these levels depends on the extent of government intervention in the economy (Faccio, 2006). When government intervention in production, consumption, and other areas decreases, the liquidity of production factors increases, which will lead to the improvement of economic liberalization. (Fan Gang, 2003) established an index evaluation system of the marketization degree of China in the Report on the Relative Process of Marketization in Various Regions of China. This system includes five aspects and is further divided into 25 second-level indicators and three-level indicators. The main component analysis method is used to analyze and calculate the above indicators. It should be pointed out that the marketization index provided by it is a "relative index", that is, it does not indicate the absolute degree of marketization, but determines the provinces with the highest and lowest degree of marketization first, while the marketization index of other provinces is relative to the provinces with the highest and lowest marketization index. When the market index is composed of these five dimensions and the value is large, the inferred market degree is high. Given the important impact of the external environment on strategic decisions, the degree of marketization of the business operation area is also critical affecting the development of enterprises (Christensen, 2003).

The digital transformation of enterprises has become an irreversible trend in China's economic environment, so the role of marketization degree in the process of the digital transformation of enterprises needs to be studied in depth. Regions with a high degree of marketization have mature markets and perfect systems. Enterprises communicate more with market entities to reduce financing costs and help enterprises in digital transformation. The advent of the era of the digital economy has aroused consumers' increasing demand for product quality. Many enterprises in regions have high degree of marketization and with innovation ability can meet the needs of consumers. The higher the degree of marketization, the more sensitive the enterprise is to the change in the market environment, and it can get the support needed for strategic transformation.

## **Hypothesis**

### **1. Technical background characteristics of the CEO and the effect of the digital transformation of the manufacturing enterprises**

Through the construction of the digital transformation management capability model, it is found that some personal background characteristics of enterprise managers, such as knowledge, skills, experience and professional education, and human capital are important resources to promote the development of digital transformation of enterprises (Lee et al, 2017). Therefore, this paper selects the CEO of manufacturing enterprises as the research object and selects the professional technical background and digital technology-related work experience from many personal background characteristics to construct the technical background characteristics of the CEO.





According to the above literature review and theoretical basis, the digital transformation of manufacturing enterprises is carried out through a variety of enterprise behaviors such as upgrading products and improving services, and the ultimate goal is to continuously improve the business performance of enterprises and enhance the competitiveness of enterprises. No matter what kind of transformation method an enterprise adopts, the ultimate goal of transformation and upgrading lies in the improvement of enterprise performance. Therefore, this paper defines the effectiveness of digital transformation of manufacturing enterprises as follows: manufacturing enterprises cite or develop digital technologies, and innovate digital business models so that enterprises can create and acquire more value. Referring to the evaluation system of SASAC, this paper uses the empowerment calculation of return on total assets and return on equity, and finally seeks peace to measure the effect of digital transformation. In conclusion, hypotheses

H1: The technical background characteristics of the CEO have a positive impact on the digital transformation effect of manufacturing enterprises.

## 2. The Mediator's role in the perceptual ability of the external environment

External dynamic ability is a keen perception of the external environment, which can help enterprises avoid the solidification of the core ability, break the shackles of the original thinking, let the enterprise develop in a new direction, help enterprises establish a first advantage, and gradually expand the competitive advantage.

First, managers, especially senior managers, need to be aware of the ability to perceive the external environment and detect unexpected conditions that may damage the organization (Helfat & Raubitschek, 2018). By building awareness, companies can use technology to generate and verify multiple assumptions logically, help managers explain unexpected or abnormal events, and assess the impact of unexpected conditions (Dong & Garbuio, 2016). Perceiving new opportunities or threats is largely an ability to perceive, interpret, and create, and can play an important role in analyzing various information about trends in the business ecosystem. Therefore, perception requires keen information and insight about external conditions at the top level (Teece, 2014).

Second, perceptual ability is a sub-ability associated with strategic agility, rapid prototyping, and balanced digital organization. Make profits by scheduling enterprise resources, meeting enterprise needs, and seizing opportunities (Teece, et al, 2014). Perception can help companies respond quickly and adjust their strategies in a competitive market environment to maintain a competitive advantage.

Finally, improving the capacity for digital transformation includes finding the right innovation ecosystem, redesigning the internal structure, and improving digital maturity. The core purpose of the promotion is to manage and balance the internal and external collaboration, and to redesign a flexible and manageable governance structure. This requires senior executives to have a technical background and a keen perception of the external environment of the enterprise, especially in the digital environment. This ability can help senior executives to make the top-level design of enterprise digital transformation in the early stage, and give full play to the first-mover advantage, to achieve greater results.

In conclusion, hypotheses

H2: The technical background characteristics of the CEO have a positive influence on the perception ability of the external environment;

H3: The perception ability of the external environment has a positive impact on the digital transformation effect of manufacturing enterprises;

H4: The external environment perception ability plays an intermediary role in the relationship





between the CEO's technology background characteristics and the effectiveness of the digital transformation of manufacturing enterprises.

### 3. The regulatory effect of the marketization process

The strength of market development will lead to completely different results in the allocation and utilization of market resources of manufacturing enterprises, and then lead to different strategic change paths for enterprises (Li et al, 2022). Differences in the market environment not only determine the demographic and social distribution of senior executives in the region but also have an impact on their strategic decisions (Guo & Zhou, 2020). The influence of the marketization degree is mainly reflected in the following aspects. The first is the ability to obtain resources: a high degree of marketization means that the market competition is more fierce, and enterprises need to have a stronger ability to obtain resources to survive and develop in the competition. The technical background characteristics of the CEO may affect the acquisition ability of the technical resources required by the enterprise in the process of digital transformation, thus affecting the effectiveness of the transformation. The second is innovation-oriented: enterprises with a high degree of marketization usually pay more attention to innovation, because only through continuous innovation can they stand out in the fierce market competition. The technical background characteristics of the CEO may affect the innovation orientation of the enterprise, thus affecting the effectiveness of the digital transformation. Moreover, organizational culture and decision-making mechanism: enterprises with a high degree of marketization tend to have a more flexible and adaptable organizational culture and decision-making mechanism, which helps to promote the implementation and implementation of digital transformation. The technical background characteristics of the CEO may affect the organizational culture and decision-making mechanism of the enterprise, thus affecting the effectiveness of the digital transformation. Finally, market demand and competitive pressure: a high degree of marketization means more diversified market demand and competition is fierce, and enterprises need to constantly adapt to market changes and meet customer needs. The technical background characteristics of the CEO may affect the ability of enterprises to understand and respond to the market demand in the process of digital transformation, thus affecting the effectiveness of the transformation.

In the areas with a high degree of marketization, the government's intervention and marketization factors can control the enterprises less, and the allocation of resources follows the market rules more. Therefore, consumers and external investors have a higher influence on enterprise strategic choices, and enterprises pay more attention to resources related to demand. CEOs with technical background can consider the digital transformation process of the enterprise in the long term from the strategic level, quickly integrate internal and external resources, carry out technological innovation within the enterprise, improve the technical strength, to establish a competitive advantage in resources, and ensure that the enterprise maintains the first-mover advantage and competitive advantage in the fierce market competition.

Accordingly, in areas with a low degree of marketization, manufacturing enterprises are greatly disturbed by marketization factors such as the government. Due to the backward market development level, the poor liquidity of information and resources, and the imperfect systems of patent technology, intellectual property protection, market laws, and regulations, the strategic reform of enterprises is greatly limited. As a result, strategic decisions made by CEOs with technical backgrounds will face huge resistance, hard for boards and corporate employees to accept, and even hard for consumers to be impressed.



To sum up, when the degree of marketization is low, even if the CEO has the technical background characteristics, it may be difficult to promote the digital transformation of manufacturing enterprises. On the contrary, in regions with a high degree of marketization, CEOs with technical background characteristics are more likely to promote the digital transformation of manufacturing enterprises. Therefore, hypotheses are proposed in this paper

H5: The degree of marketization plays a regulatory role in the relationship between the technical background characteristics of the CEO and the effectiveness of the digital transformation of manufacturing enterprises.

To investigate the regulating effect of marketization degree more comprehensively, this paper also includes each subdivision index of marketization degree into the test. Therefore, the hypothesis is proposed

H5a: The relationship between the government and the market plays a regulatory role in the relationship between the CEO's technology background characteristics and the effectiveness of the digital transformation of manufacturing enterprises.

H5b: The development of a non-state economy plays a regulatory role in the relationship between the technical background characteristics of the CEO and the effectiveness of the digital transformation of manufacturing enterprises.

H5c: The development of the product market plays a regulatory role in the relationship between the technical background characteristics of the CEO and the effectiveness of the digital transformation of manufacturing enterprises.

H5d: The development of the factor market plays a regulating role in the relationship between CEO technology background characteristics and the effectiveness of digital transformation of manufacturing enterprises.

H5e: Intermediary organization and legal environment play a regulatory role in the relationship between CEO technology background characteristics and the effectiveness of digital transformation of manufacturing enterprises.

### The conceptual model

Through the above analysis, the conceptual model of this paper is proposed as follows:

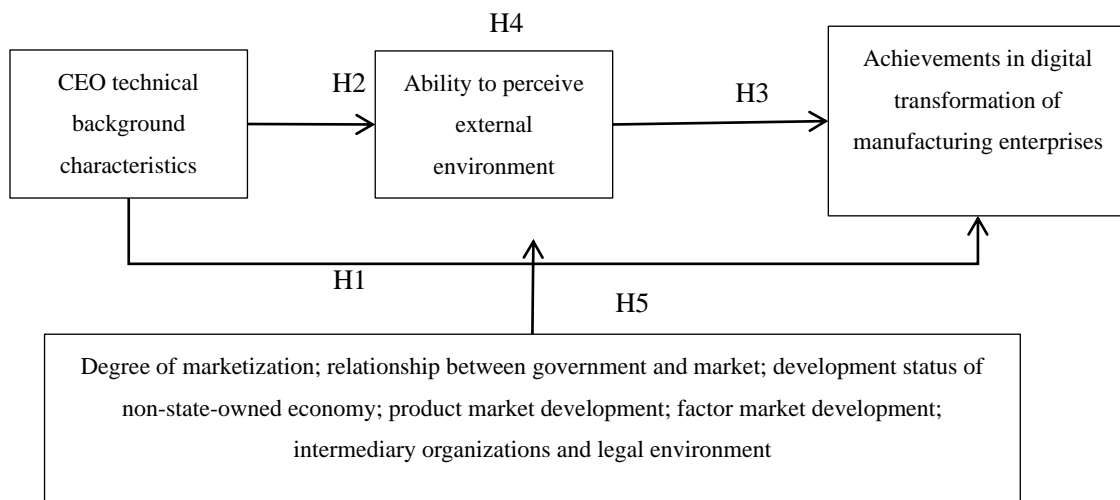


Figure 1: conceptual model





## Methodology

### Data collection and source

Different from the environment in Europe and the United States, China has only launched a market economy for more than 40 years, many systems are not perfect, and the definition of CEO is vague. In China, both the chairman and the general manager can be regarded as the CEO of enterprises, and their responsibilities and powers are almost the same in most cases. Based on this special factor, this article will treat the CEO, president, chairman and general manager disclosed in the annual report of a-share listed enterprises as the CEO. The research data of this paper selects A-share manufacturers in Shanghai and Shenzhen during the five years from 2016 to 2021 as samples and determines whether the CEO will be newly appointed in combination with Juchao Information Network and Sina Finance. He was not CEO, Chairman, general manager, or president before 2016, but he was one of these four positions in 2016 and beyond. Considering some special enterprises, to filter the data to ensure the accuracy of the data:

Eliminate ST or \* ST samples; eliminate the samples with a CEO serving less than two years (unable to reflect the impact of the effect of enterprise transformation); eliminate the samples with less than three years, missing main variables, and incomplete annual report data after listing; since the outliers will affect the empirical results, to eliminate the impact of outlier on the empirical results, the data is 1% of the tail.

The year 2016 is regarded as the first year of China's 13th Five-Year Plan, which requires deepening information construction, promoting the development of information at a higher level, and building a digital market system. The 2022 Digital China Development Report also points out that positive progress has been made in digital construction during the 13th Five-Year Plan period. The data at the beginning of the 14th Five-Year Plan was affected by COVID-19, and the digital construction was also affected. Therefore, the data of this historical stage were selected as data samples.

### Variable setting and measurement

#### 1. Effectiveness of digital transformation

Many scholars do not have a consensus on the measurement of the effectiveness of the digital transformation of manufacturing enterprises. The digital transformation of manufacturing enterprises is a broad business strategy, whose essence is data-driven and intelligent assisted research and development, production, operation, and service improvement, and ultimately promotes the optimization of profit model and the improvement of user experience. Specifically, is simple, direct, reduces the intermediate links, from the product center, to the customer center, face-to-face with the end customer real demand, rapid iterative innovation, reduces communication loss, purpose in solving the traditional business challenges and through the use of technology to create new opportunities, to improve efficiency, reduce cost, enhance the competitiveness of manufacturing enterprises. The effectiveness of digital transformation can be measured through a variety of indicators, such as business growth rate, customer satisfaction, cost reduction, productivity improvement, etc. At the same time, the success of digital transformation can also be evaluated by comparing the real-time simulation of digital twin technology with the actual operation situation, and by using data analysis and visualization to reflect the actual effect of digital transformation. Common measures include:

1. Total return on investment (ROI) : Return on investment is one of the most commonly used KPIs when undertaking a new initiative. It can help measure the economic benefits of the digital transformation.



2. Revenue growth: Revenue growth is an important indicator of whether an enterprise can increase its market share through digital transformation.

3. Customer satisfaction: Customer satisfaction is an important indicator to measure whether an enterprise can improve customer experience through digital transformation.

4. Employee engagement: Employee engagement is an important indicator to measure whether an enterprise can improve employee productivity and productivity through digital transformation.

5. Innovation rate of products and services: The innovation rate of products and services is an important indicator to measure whether an enterprise can accelerate the launch speed of new products and improve product quality through digital transformation.

6. Shortening of production cycle: Shortening of production cycle is an important indicator to measure whether an enterprise can improve production efficiency and reduce production costs through digital transformation.

Combined with the above indicators, some scholars have constructed the evaluation framework and index system for the digital transformation and development of the manufacturing industry. For example, the research of (Wang et al., 2019) is based on the digital transformation of manufacturing enterprises, using AHP and DEMATEL methods to build the digital maturity evaluation model to evaluate the development process of the digital transformation of manufacturing enterprises; this model evaluates the progress of the digital from four aspects (strategy, cultural organization capability, operational technology, and ecosystem). The developed digital maturity models using literature research and expert review, including 19 first-level indicators and 63 second-level indicators for five key process domains.

In addition, some scholars use financial indicators to measure the effect of corporate transformation. For example, the study of (Gu and Yang, 2012) uses the increased rate of marketing expenses in the ratio of enterprise R & D expenses to total costs by measuring the variables of enterprise transformation. (Poon, 2004) believe that transformation and upgrading is a process of improving high-value-added production. Enterprise transformation is divided into three levels: organization, business, and product, and measured by the rate of return on human input, the proportion of research and development expenditure and marketing expenses in the total cost, and the profit margin of sales. It can be observed that the ways and strategies of enterprise transformation are diverse, and the manifestations of different enterprises may be different in the transformation and upgrading. The study (Huang & Deng, 2013) summarizes past practices and concludes that operational financial indicators, such as ROA and ROE, etc.

Screening according to relevant professional background, relevant work experience, and relevant social capital, expressed by variable X, 1,0;

### 3. Ability of external environment

External dynamic ability refers to the enterprise's ability to perceive the external environment, including the enterprise's sensitivity and adaptability to external factors such as market, competitors and technological change. External dynamic capabilities can help enterprises identify market opportunities and threats in time, and flexibly adjust their strategies and resource allocation to maintain their competitive advantage. External dynamic capability refers to the ability of an enterprise to perceive the external environment, which is represented by the variable X2.1. Drawing on the method of Ke (2017), using the extraordinary profit of enterprises to measure the perception ability. Due to the uncertainty of



the environment, there may be deviations in the plans or forecasts of the enterprise. Supernormal profits are the profits obtained by the enterprise by bearing certain risks. However, the stronger the perception ability of the enterprise, the higher the extraordinary profits will be. The calculation formula is as follows:

3.1 Enterprise extraordinary profit = the scale of the industry profit pool of the industry profit pool

3.2 Size of industry profit pool = industry average annual sales unit price of industry average sales profit margin

#### 4. Degree of marketization

(Fan Gang, 2003) have established an index evaluation system of marketization degree in the Report on the Relative Process of Marketization in Various Regions of China. This system includes five aspects and is further divided into 25 second-level indicators and three-level indicators. The "main component analysis method" is used to analyze and calculate the above indicators. It should be pointed out that the marketization index provided by it is a "relative index", that is, it does not indicate the absolute degree of marketization, but determines the provinces with the highest and lowest degree of marketization first, while the marketization index of other provinces is relative to the provinces with the highest and lowest marketization index. The system mainly includes the following five aspects: government intervention in the market, the development of the non-state-owned economy, the development of the product market, the development of the factor market, the market intermediary organization, and the legal environment. In the case of these five major aspects, 25 sub-indicators can be calculated. From the evaluation of the precision of the marketization index, the FanGang building index system is undoubtedly the most comprehensive in the existing research, but it highlights the "relativity", namely each version of the market index report has a different base year, and each index with weight will change over time, lead to data discontinuity, concrete performance for the release of each version of the China market index relative process report all only contains part of the year, and different versions of the report in different regions overlap year market index is not the same. This paper adopts the comprehensive index of provincial marketization (Wang et al., 2017) in China's Provincial Marketization Index Report (2021), as the basis for measuring the strength of the marketization degree.

## Results

After the above analysis and theoretical derivation, this paper puts forward the influence mechanism and theoretical model between the technical background characteristics of CEO and the digital transformation effect of manufacturing enterprises, and constructs a regression model, using the statistical analysis software SPSS of IBM company to conduct statistical analysis of the sample data to verify the theoretical assumptions.

### 1. Descriptive analysis and correlation analysis

This paper makes A descriptive analysis of 7529 data collected from Chinese Shanghai and Shenzhen A-share listed companies. As shown in Table 1. Through descriptive statistical analysis, many characteristics of statistics can be mined, such as minima, maxima, mean, standard deviation, and other data characteristics.





Table 1 describes the analysis table

Name	sample capacity	least value	crest value	average value	standard error	median
Achievements of the digital transformation of manufacturing enterprises	7529	-44.609	2.414	0.041	0.703	0.059
Technical background characteristics of the CEO	7529	0.000	1.000	0.373	0.484	0.000
The perceived capacity of the external environment	7529	0.136	0.594	0.368	0.131	0.368
Total score for the marketization process	7529	-6.800	12.540	9.236	1.965	9.870
Government-market relationship score	7529	-14.290	14.290	6.710	1.593	6.900
Non-state economic development score	7529	-14.290	14.290	7.884	2.202	7.790
Product market development score	7529	-14.290	14.290	7.108	1.640	7.230
Factor market development score	7529	-14.290	19.060	7.168	2.342	7.070
Mediation organization development and legal score	7529	-14.290	29.850	9.178	5.540	7.310

Using related analysis research manufacturing enterprise digital transformation results and CEO digital background, external environment perception, marketization process total score, the government and market relations, non-state economic development, product market development, factor market development, intermediary development, and legal score between a total of nine correlation, using Pearson correlation coefficient to express the strength of the relationship. Specific analysis shows: the effect of digital transformation on manufacturing enterprises and the CEO's digital background, The perceived capacity of the external environment, the Total score for the marketization process, the Government-market relationship score, Non-state economic development score, the Product market development score, All the 7 development scores of factor market are significant, The correlation coefficient values were 0.054, 0.064, 0.038, 0.060, 0.056, 0.059, 0.033, All are greater than 0, It means the effectiveness of digital transformation of manufacturing enterprises and the digital background of CEO, The perceived capacity of the external environment, Total score for the marketization process, Government-market relationship score, Non-state economic development score, Product market development score, There is a positive correlation between the scores of factor market. As shown in Table 2.





Table 2 Correlation analysis table

	1	2	3	4	5	6	7	8	9
Achievements of digital transformation of manufacturing enterprises (1)	1								
CEO Technical Background Characteristics (2)	0.054**	1							
Perception of the external environment (3)	0.064**	0.482**	1						
Total score of marketization process (4)	0.038**	0.432**	0.440**	1					
Government-market relationship score (5)	0.060**	0.374**	0.449**	0.682**	1				
Non-state economic development score (6)	0.056**	0.285**	0.210**	0.368**	0.433**	1			
Product Market Development Score (7)	0.059**	0.432**	0.373**	0.411**	0.450**	0.556**	1		
Factor Market Development Score (8)	0.033**	0.424**	0.315**	0.473**	0.382**	0.503**	0.528**	1	
Inter-Organization Development and Legal Score (9)	0.014	0.205**	0.041**	0.441**	0.256**	0.655**	0.336**	0.472**	1

### 2. Collinearity test

To avoid multicollinearity problems, the variance inflation factor (VIF) was calculated for each explanatory variable before performing the benchmark regression. Examination results showed that the largest VIF was 1.592, much less than 10, indicating that multicollinearity is less likely. As shown in Table 3.

Table 3 Multiple collinearity test table

Variable	VIF	tolerance
The CEO's digital background	1.518	0.659
The perceived capacity of the external environment	1.592	0.628
Total score for the marketization process	1.434	0.697

### 3. Direct effect test and mediation effect test

Considering the effect of the independent variable X on the dependent variable Y, M is called the mediating variable if X affects Y by influencing the variable M. The following regression equation is used to describe the relationship between the variables:

$$Y=cX+e1 \quad (1)$$

$$M=aX+e2 \quad (2)$$

$$Y=c'X+bM+e3 \quad (3)$$

Where the coefficient c of equation (1) is the total effect of the independent variable X on the dependent variable Y; the coefficient a of equation (2) is the effect of the independent variable X on the intermediary variable M; the coefficient b of equation (3) is the effect of the intermediary variable M on the dependent variable Y after controlling the influence of the independent variable X; the coefficient is the direct effect of the independent variable X on the dependent variable Y after controlling the influence of the intermediary variable M; e1~e3 is the regression residual difference.



To test whether the dynamic capability has a significant intermediary role between the CEO's digital background and the digital transformation of manufacturing enterprises, this study adopted the latest mediation effect test procedure proposed by (Wen & Ye, 2014). In this paper, the mediation effect of the perceived ability of the external environment was first examined using SPSS software, and the results are shown in Table 4.

Table 4 Table of direct and mediation effects

	Achievements of the digital transformation of manufacturing enterprises	The perceived capacity of the external environment	Achievements of the digital transformation of manufacturing enterprises
Constant	-0.032 (-0.214)	0.323** (13.218)	-0.114 (-0.750)
The CEO has a technical background	0.075** (4.459)	0.129** (47.237)	0.042* (2.211)
The perceived capacity of the external environment			0.252** (3.571)
sample capacity	7529	7529	7529
R <sup>2</sup>	0.005	0.235	0.007
adjust R <sup>2</sup>	0.005	0.235	0.006
F price	7.977***	463.186***	8.784***

\* p < 0.05 \*\* p < 0.01, t value in parentheses

The technical background of the independent variable CEO has a significant correlation on the effect of the digital transformation of manufacturing enterprises, That is, according to the theory of the mediation role, Found that the second model independent variable with a significance of 0.000, Reject the null hypothesis,  $Y=cX + e1$  is considered significant, It shows that the independent variable has a significant effect on the digital transformation effect of the dependent variable manufacturing enterprises, That is can prove that the CEO technical background can directly predict the effectiveness of the digital transformation of manufacturing enterprises; The second step is to test the regression equation of the perceptual ability of the independent variable on the external environment of the intermediary variable, According to the above coefficient table, The significance of the independent variable on the external environment of the mediation variable was 0.000, That is, to reject the null hypothesis, That is, the independent variables are considered to predict the mediation variables. To test the relationship between the perceived ability of the external environment of the intermediary variable and the effect of the dependent variable manufacturing enterprises, the significance of the perceptual ability of the external environment of the intermediary variable is 0.000, that is, the intermediary variable has a significant impact on the effect of the digital transformation of the dependent variable manufacturing enterprises. To sum up, there is a mediating role in the model, that is, when the technical background of the independent variable CEO has a significant impact on the digital transformation effect of manufacturing enterprises, the perceptual ability of the external environment plays an intermediary role.

After using the process plugin of SSS, the 95% confidence interval of the above variables does not include 0, so assuming H1, H2, H3, and H4 are supported. This arrangement is shown in Table 5 below.

Table 5 Summary table of tests for direct and mediation effects

Item	Symbol	Meaning	The 95% CI		Z-value	p-price	Conclusion
			Lower limit	Superior limit			
CEO technical background => perception of external environment => effectiveness of digital transformation of manufacturing enterprises	a*b	indigo effect	0.033	0.013 0.100	1.585	0.113	
The CEO's technical background => the perceived ability of the external environment	a	X=>M	0.129	0.124 0.135	47.237	0.000	Part of the intermediary
Perception ability of external environment => the effect of digital transformation on manufacturing enterprises	b	M=>Y	0.252	0.114 0.390	3.571	0.000	
CEO technical background => the effect of digital transformation on manufacturing enterprises	c'	direct effect	0.042	0.005 0.080	2.211	0.027	
CEO technical background => the effect of digital transformation on manufacturing enterprises	c	gross effect	0.075	0.042 0.108	4.459	0.000	

#### 4. Test of the Regulatory Effect

The degree of marketization was included in the test, and the results are shown in Table 6.

Table 6 Test table of the adjustment effect of marketization degree

	Achievements of the digital transformation of manufacturing enterprises	The perceived capacity of the external environment
Constant	-0.240 (-1.544)	0.323** (13.218)
The CEO has a technical background	0.282** (3.232)	0.129** (47.237)
process of marketization	0.023** (3.403)	
CEO technical background *	-0.035** (-2.922)	
The perceived capacity of the external environment	0.214** (2.854)	
sample capacity	7529	7529
R <sup>2</sup>	0.009	0.235
adjust R <sup>2</sup>	0.008	0.235
F price □	8.291***	463.186***

Achievements of the digital transformation of manufacturing enterprises

The perceived capacity of the external environment

\*  $p < 0.05$  \*\*  $p < 0.01$ , t value in parentheses

Calculated using mode5, overall, the model boot 95% CI does not include the number 0, implying a mediation role. For the mediation variable of perceptual ability in the external environment, the model boot 95% CI does not include the number 0, implying a regulatory mediation role. Suppose that H5, H5a, H5 b, H5c, H5d, and H5e hold, as shown in Table 7.

Table 7 has the regulatory mediation tests

Item	Effect	BootSE	BootLLCI	BootULCI
Total	0.028	0.013	0.010	0.058
The perceived capacity of the external environment	0.028	0.013	0.010	0.058

Note: BootLLCI refers to the lower limit of 95% interval for Bootstrap sampling, and BootULCI refers to the upper limit of 95% interval for Bootstrap sampling

The specific regulatory effect is shown in the figure below:

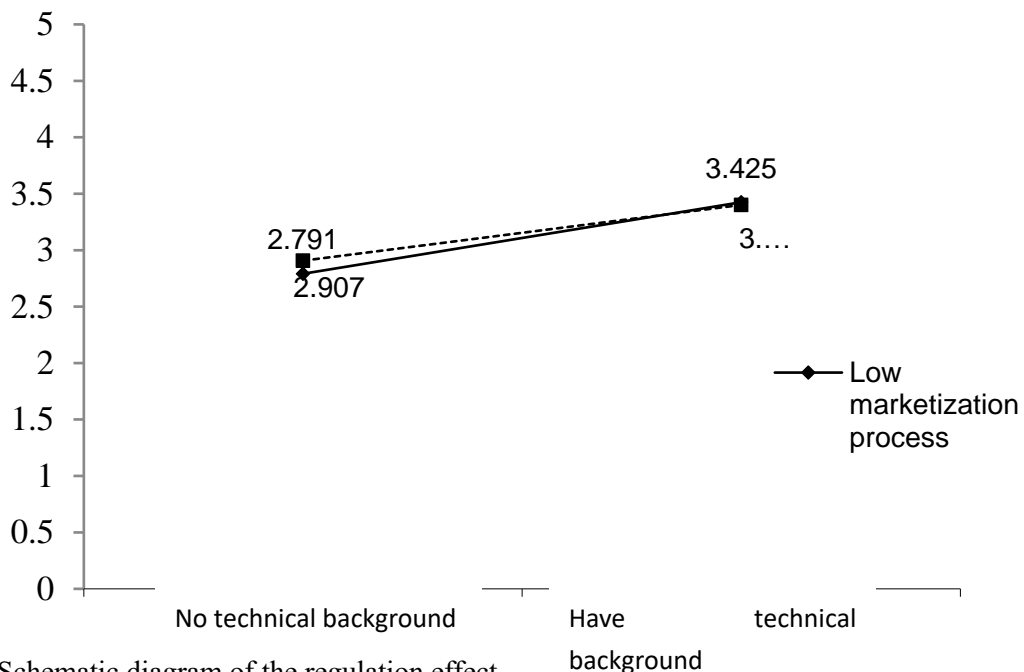


Figure 2: Schematic diagram of the regulation effect

### Conclusions

Assuming that H1, H2, H3, H4, and H5 are supported.

CEOs with a technical background have a significant role in driving the digital transformation of manufacturing enterprises. Compared with CEOs with technical backgrounds, better understand the





importance of digital transformation to the sustainable development of manufacturing enterprises, so they can better unite the internal members of enterprises and reduce the resistance to strategic change. At the same time, because they have accumulated a wide range of social resources, they can help manufacturing enterprises accumulate digital resources, introduce and cultivate digital talents, and help the digital transformation of manufacturing enterprises. CEOs with technical backgrounds are more influential than others in making strategic decisions, so they are more conducive to promoting the digital transformation of manufacturing enterprises and showing the value of CEOs internally and externally, having a broader impact. In the process of digital transformation of manufacturing enterprises, research and development capability is regarded as a crucial element. The CEO has a technical background, which plays a crucial role in improving the R&D capabilities of enterprises through innovation. Because CEOs with technical backgrounds can more deeply understand the great value of digital technology to enterprises, and pay more attention to technological innovation.

In regions with a high degree of marketization in China, CEOs with technical backgrounds play an obvious positive role in the digital transformation of manufacturing enterprises. In the context of the digital economy, consumers' ability to obtain information has been significantly improved, so the requirements for product quality and performance of manufacturing enterprises are increasingly increasing. If the manufacturing enterprises cannot timely capture the changes in consumer demand, the development of the enterprises may be hindered. In the regions with a high degree of marketization in China, the market is important as a prerequisite for resource allocation. The market determines the way manufacturing enterprises obtain production factors and resources. CEOs with technical backgrounds are more sensitive to the external perception of the market, and can quickly acquire and integrate all kinds of information resources, to lead the competitors in the strategic change decisions and gain the first-mover advantage in the market. With the continuous improvement of the marketization degree, the information flow and the intellectual property protection mechanism have been further improved. This trend provides a good market environment for CEOs (CEOs) with technical backgrounds to lead manufacturing companies in their digital transformation.

### Theoretical contributions

1. Extended the research concept of CEO technical background characteristics from the perspective of executive heterogeneity of higher-order theory, and enriched and developed the higher-order theory. The technical background characteristics of the CEO are an important aspect of executive heterogeneity, referring to the expertise and experience of the CEO in the technology field, which affects the digital transformation effectiveness of the manufacturing enterprises in the following aspects.

2. Put the CEO in the focus of research and analysis, and explore the topic of digital transformation from the personal micro level of the CEO. On the one hand, it enriches the research at the micro level of digital transformation, and on the other hand, it provides a general overview of the specific roles and actions that the CEO pursues to realize the digital transformation of enterprises.

3. This paper further discusses the path and mechanism of the influence of the CEO's technical background characteristics on the digital effect of manufacturing enterprises and expands the connotation of the research related to digital transformation. Considering that marketization is a complex factor of a changing market environment, it has a relatively complex impact on the strategic decisions of enterprises. Therefore, it is an extension of the digital transformation model to include the situational factors of marketization degree into the framework of studying the digital transformation of

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manufacturing enterprises.

## Discussion

The study concludes that CEOs with a technical background significantly drive the digital transformation of manufacturing enterprises. They understand the importance of digital transformation for sustainable development, enabling them to unite internal members and reduce resistance to strategic change. Additionally, their accumulated social resources facilitate the accumulation of digital resources, talent introduction, and technological innovation. In regions with a high degree of marketization in China, these CEOs play a more pronounced positive role in digital transformation. They are sensitive to market perceptions, quickly acquiring and integrating information resources to gain a first-mover advantage. The study extends the research concept of CEO technical background characteristics, enriches higher-order theory, and explores the CEO's role in digital transformation at a micro-level. Moreover, it discusses the path and mechanism of the CEO's influence on digital transformation, expanding the research connotation in this field.

## Recommendation

There are still some unsolved problems in this paper. First, while the important role of CEOs with technical background characteristics in the digital transformation of manufacturing enterprises is emphasized, the overall role of the senior executive team has not been fully considered. Future research can focus more on the overall characteristics of the senior management team, especially with AI technology as the background characteristic, to explore the impact of AI technology on the digital transformation of manufacturing enterprises. Secondly, due to the difficulty of data collection, this paper only takes into account whether the CEO has a technical background, but has not yet considered the intensity of the specific background, such as the level of education, the length of employment, the position and the difference in the industry. Future studies can further explore the impact of these factors on the digital transformation of manufacturing enterprises. Finally, digital transformation involves many aspects of the enterprise. At present, there is no authoritative and mature way to measure the effectiveness of digital transformation. Although this paper adopts the acceptance of a relatively high second-hand data analysis method and considers the different keyword selection strategies, but still can't completely avoid keyword selection is not comprehensive, the specific context is difficult to identify, the future research can be comprehensive text analysis and other second-hand data measurement way, expected to further improve the effect of digital transformation measurement validity.

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