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The digital transformation of manufacturing enterprises has an important impact on both the economy and society and the enterprise itself, and the CEO has an important impact on the effect of the digital transformation of manufacturing enterprises. The 20-Shenzhen A-share listed manufacturing companies from 2016 to 2021 are used as research subjects. The effect of the CEO's technical background on the digital transformation of these companies is studied empirically, and the dynamic capability is broken down into external perception capability and internal research and development capability to test their mediating effect. The research found that the technical background characteristics of the CEO significantly affect the effectiveness of digital transformation in manufacturing enterprises; the technical background characteristics of the CEO can influence the strategic decision and implementation of manufacturing enterprises; and the research conclusion enriches the related research on digital transformation and high-order theory in manufacturing enterprises and also provides theoretical reference for the training of the CEO of Chinese manufacturing enterprises.

Keywords: CEO technical background characteristics; manufacturing enterprises; digital transformation; dynamic capabilities

Introduction

According to data released by China's National Bureau of Statistics, the value added of China's manufacturing sector accounted for 27.4 percent of GDP in 2021, with a total of 31.4 trillion yuan, meaning that China's manufacturing industry has maintained the top position in the world for 12 consecutive years.

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China's economy will long rely on manufacturing, which is crucial to the country's economic growth. Nevertheless, Chinese manufacturing enterprises still face extremely severe survival challenges. Chinese manufacturing enterprises are facing development difficulties, and some of them are still facing problems of insufficient demand and overcapacity with diversified business forms, mature markets, and competitive advantages (Lin et al., 2015).

In addition, the rapid development of information technology has provided strong support for the rise of Internet giants but also brought unprecedented challenges to manufacturing enterprises. Promoting the transformation and upgrading of manufacturing enterprises is an important means to consolidate China's competitive advantage. This will not only provide a valuable market for emerging industries and advanced technologies but also provide strong support for the development of high-tech enterprises.

Therefore, Chinese manufacturing enterprises need to adopt digital technologies such as big data, cloud computing, and the Internet of Things to promote the implementation of the digital transformation strategy. Many manufacturing enterprises in China have used digital technology to build smart factories and an industrial ecosystem with the help of cloud platforms.

Haier, BYD, Midea, and other enterprises have made great achievements in using digital technology to improve traditional physical products or innovate smart home products. They are the pioneers in the digital economy and are highly competitive. However, at present, there are still many manufacturing enterprises facing various difficulties and challenges in the process of digitalization, which cannot fully benefit from the advantages brought by digital development and even lead the enterprise into a crisis situation. Digital transformation is not only a choice for manufacturing enterprises but also a survival strategy that must be implemented.

The rapid development of digital technology has brought development opportunities, but also to the development of manufacturing enterprises. In the face of these challenges, manufacturing enterprises have to increase their investment in digital technology and enhance their ability to use information technology in order to realize the digital transformation and enhance their core competitiveness.

Executives within manufacturing companies have had an important impact on strategic decisions. Leaders of manufacturing enterprises have great management power in the company; they must be responsible for allocating resources, responding to changes in the external environment, and assuming the ultimate responsibility for formulating and implementing corporate strategy. In addition, digital transformation is a long-term process. To successfully implement this transformation, resources must be redistributed, organizational structure adjusted, and culture and institutions changed.

Without a strong organization and impetus, achieving digital transformation will be very difficult. At present, many companies have carried out large-scale digital transformation experiments, but usually limited to some specific areas; sometimes they even just do it on the surface, unable to obtain the benefits of digital transformation. Therefore, this article is to discuss: "What background characteristics of manufacturing enterprise executives can help the digital transformation of manufacturing enterprises?"

Although there have been extensive discussions in the fields of "background characteristics" and "digital transformation", which have laid a solid foundation for this study, there are still the following research gaps: First, there is a lack of in-depth discussion
on the impact of the CEO (CEO of manufacturing enterprises) on the effect of digital transformation.

Secondly, the current research mainly focuses on the macro level, exploring the understanding of specific concepts and their impact on enterprise performance, but there is a lack of micro-level research from the perspective of the CEO of manufacturing enterprises.

The purpose of this paper is to look into the technical background of the CEO (CEO) of a manufacturing company, as well as how and when it affects the success of digital transformation in the company. This is done to help the growth of research areas that are related to digital transformation.

Third, the research on the background characteristics of senior executives only focuses on the basic characteristics without fully considering the special factors of the digital situation in China. This study systematically constructed the conceptual connotation of the technical background characteristics of the CEO (CEO), which covered key elements such as technology-related work experience, expertise, and tenure, and established corresponding measurement methods. This is not only conducive to enriching the research of higher-order theories on the personal characteristics of executives but also allows for a deeper understanding of the impact of executive digital technology background on the digital transformation of enterprises from multiple perspectives.

Finally, the introduction of dynamic capability as the intermediary variable into the study of the relationship between the technical background characteristics of the CEO of manufacturing enterprises and the effectiveness of the digital transformation of manufacturing enterprises will contribute to the dynamic capability theory and further enrich its research perspective.

To sum up, first, this paper selects the technical background characteristics of senior executives as the independent variable. On the basis of previous research on higher-order theories, we will focus on the background characteristics of senior managers and their impact on the digital transformation of enterprises, combined with the specific manufacturing enterprise situation. According to the previous research results of other scholars, the technical background characteristics of senior executives are divided into two aspects: professional level and work experience, and a more comprehensive study are conducted from multiple perspectives.

Secondly, this paper selects the degree of digital transformation in manufacturing enterprises as the dependent variable. Previous scholars on the digital transformation of enterprises discuss the factors affecting the degree of digital transformation of manufacturing enterprises and the methods of measuring these factors. Finally, dynamic capability is selected as the intermediary variable to sort out the related studies of previous scholars on dynamic capability theory and to discuss the intermediary role of dynamic capability in the technical background characteristics of senior executives and the degree of digital transformation of manufacturing enterprises.

Theoretical analysis and research hypotheses

The technical background characteristics of the CEO and the effect of the digital transformation of manufacturing enterprises

Senior executives play a crucial role in the formulation and implementation of corporate digital transformation strategies.
HOW CEO TECHNICAL BACKGROUND

With the improvement of enterprise digitalization degrees, the importance of digital literacy among senior executives is becoming more and more prominent. Successful digital transformation of enterprises depends on the IT governance ability of the organization, which is closely related to the CEO.

The CEO's knowledge and ability in that particular area will have an important impact on the implementation of strategic changes. In addition, CEOs have more power, which enables skilled executives to have a more comprehensive understanding of digital transformation and development trends, let alone blindly resist them. Or even, they can empower background executives, board members, and middle managers to understand the strategy of digital transformation, together to accelerate the pace of innovation in digital transformation, and to develop effective strategies.

Through the construction of the digital transformation management ability model, it was found that some personal background characteristics of enterprise managers, such as knowledge, skills, experience, professional education, and human capital, are important resources to promote the development of digital transformation in 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.

Professional quality is the educational process received by individuals in the process of growth and gradually formed by the individual's unique cognition. In the face of major strategic decisions, it helps individuals to make better decisions (Yang et al., 2021).

The technical professionalism of the CEO has an important impact on the digital transformation effect of manufacturing enterprises, as follows:

First, formulate a strategic direction: as the top leader of the enterprise, the CEO's main responsibility is to formulate and promote the development strategy of the enterprise. CEOs with technical expertise can better understand the importance and potential of digital transformation and develop strategic directions accordingly. They are able to identify opportunities for digital technology in the manufacturing process and lead companies toward digital development. CEOs with computers and other related technologies will be more familiar with digital technologies such as cloud computing, big data, AI, and 5G, more aware that these technologies can create value for the company, and more willing to participate in the strategic decisions of future enterprises (Barker & Mueller, 2002; Hu et al., 2018).

Second, investment decisions: digital transformation requires a lot of investment, including the purchase of new technologies and the training of employees. CEOs with technical expertise can more accurately assess the ROI of the digital transition and make informed investment decisions. They can understand the trends and market demands of digital technology to avoid the risk of blind investment or overinvestment.

Third, organizational change management: digital transformation usually requires major adjustments to the organizational structure, process, and culture of an enterprise. CEOs with technical expertise are able to better understand and respond to the challenges of these changes and effectively manage and guide organizational change. They are able to build a digital culture, develop employee digital skills, and drive organizational innovation and adaptability.
Fourth, partnership building: digital transformation usually requires close partnerships with external partners, including suppliers, customers, technology companies, etc. CEOs with technical expertise can better identify and select suitable partners and establish win-win cooperative relationships. They are able to use digital technologies and platforms to promote supply chain collaboration, product innovation, and market expansion.

CEOs with technology-related work experience have more experience in information processing ability, problem-solving ability, and strategic decision-making ability and can better integrate the business experience of the underlying employees and better allocate the internal and external resources of the enterprise (Singh & Hess, 2020).

First, understand and promote digital transformation. CEOs with technical work experience can have a deep understanding of the importance and potential of digital transformation and can effectively promote the digital transformation of enterprises. They understand the application and value of digital technology and can integrate digital thinking into the strategic planning and decisions of enterprises.

Second, establish a digital culture. Digital work experience enables the CEO to better establish and promote a digital culture. They are able to convey the meaning and goals of digital transformation to organizations and stimulate employees’ interest in and participation in digitalization. By developing digital skills and awareness, CEOs can help companies build a working environment and culture that adapts to the digital age.

Third, lead innovation and technology application: CEOs with technical work experience usually have a sharper insight into new technologies and innovation. They are able to identify innovative opportunities for digital technology in the manufacturing process and lead enterprises to innovate and apply them to their products, services, and processes. This helps to improve the competitiveness and market share of enterprises.

Fourth, partnership building: technical work experience enables the CEO to better understand and utilize the digital resources and capabilities of external partners. They are able to work closely with technology companies, suppliers, and other interested parties to drive the digital transformation. Through partnerships, companies can share resources, knowledge, and experience to accelerate the process of digital transformation.

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 their competitiveness. 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 in 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. To sum up, it is proposed that hypothesis H1: The technical background characteristics of the CEO have a positive impact on the digital transformation of manufacturing enterprises.
HOW CEO TECHNICAL BACKGROUND

Mediating role of dynamic capacity

According to the above theoretical basis, external dynamic ability is the keen perception of the external environment, which can help enterprises avoid the solidification of their core ability, break the shackles of their original thinking, and let the enterprise develop in a new direction so as to establish their first advantage and gradually expand their 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 (Helfa & Raubitschek, 2018).

By building awareness, companies can use technology to generate and verify multiple assumptions in a logical way, help managers explain unexpected or abnormal events, and assess the impact of unexpected conditions (Dong et al., 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, 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 internal and external collaboration and to redesign a flexible and manageable governance structure. This requires senior executives to have a technical background and have a keen perception of the external environment of the enterprise, especially in the digital environment. This ability can help senior executives make the top-level design of enterprise digital transformation in the early stages and give full play to the first-mover advantage so as to achieve greater results.

Internal dynamic capabilities are also critical because their value networks are becoming increasingly complex and large. Internal dynamic capabilities enable enterprises to deal with these complex problems effectively and to achieve higher returns by integrating internal resources and strengthening R&D capacity building. The internal dynamic ability pays attention to the internal adjustment ability of the enterprise, and the technical background characteristics of the senior executives will have an impact on the construction of the internal dynamic ability and then affect the effectiveness of the digital transformation of the enterprise.

The flexible use of the rapidly changing business environment and management resources is an important basis for the digital transformation of enterprises. As the key decision-maker in enterprise development, the CEO has the key resources for formulating and implementing enterprise strategic decisions. Digital transformation is crucial for enterprises (Weritz et al., 2020).

With its own professional knowledge and cognitive ability, the CEO can keenly sense the external environment and carry out digital top-level design as soon as possible. In addition, they are committed to improving the building of internal dynamic capabilities and increasing investment in digital research and innovation.
Finally, the R&D and innovation results are applied to the business operations of the enterprise, bringing competitive advantages to the enterprise. Finally, effective digital transformation has brought remarkable results for enterprises.

To sum up, the background characteristics of senior executives, especially CEOs, not only directly affect the effectiveness of digital transformation of enterprises at the decision-making level and digital technology selection level, but also indirectly affect the effectiveness of digital transformation of enterprises by affecting the dynamic ability of enterprises.

Therefore, the hypothesis is:

H2: CEO technical background characteristics have a positive impact on the dynamic ability;

H2a: CEO technical background characteristics have a positive impact on the perceptual ability of the external environment.

H2b: The technical background characteristics of the CEO have a positive impact on the internal R&D capabilities.

H3: dynamic capability has a positive impact on the digital transformation of manufacturing enterprises;

H3a: external environment perception capability has a positive impact on the digital transformation of manufacturing enterprises.

H3b: Internal research and development capabilities have a positive impact on the effectiveness of the digital transformation of manufacturing enterprises.

H4: Dynamic capability plays an intermediary role in the relationship between CEO technology background characteristics and the effectiveness of digital transformation in manufacturing enterprises;

H4a: External environment perception capability plays an intermediary role in the relationship between CEO technical background characteristics and the effectiveness of digital transformation in manufacturing enterprises.

H4b: Internal R & D capability plays an intermediary role in the relationship between the CEO's technology background characteristics and the effectiveness of the digital transformation of manufacturing enterprises.

**Controlled variable**

Since there are many factors affecting the effectiveness of digital transformation of dependent variables, to ensure the accuracy and comprehensiveness of the study, they are added to the control variables in the study. Using the studies of Liu Shuchun et al. (2021) and Wang Mo et al. (2022), this paper selected the control variables from the perspectives of the CEO level, enterprise level, and industry level.

- CEO age. The older you are, the more conservative and less receptive the risk is, and the more motivated and adventurous you are. You also have a strong desire to make strategic change. In this paper, the actual age of the first year of the CEO is selected as the age measure of the CEO.

- CEO gender. Male and female executives often show different management styles and different risk preferences in corporate strategic decisions. Men are good at taking risks; women prefer taking risks; men prefer to make strategic change decisions; and vice versa (Stinerock et al., 1991).
HOW CEO TECHNICAL BACKGROUND

- Enterprise size: Companies of different sizes have different strategies because of their different sizes. Large enterprises have strong technology and invest a lot of R&D funds, while small enterprises respond faster to changes in the market environment. Therefore, the scale of an enterprise will have an impact on its R&D investment and thus affect the results of digital transformation. This paper refers to the study of Wu & Gong (2018), which measures the log value of the total number of employees in the first year of the CEO.

- Nature of property rights: There are differences between the responsibilities and goals of state-owned enterprises and non-state-owned enterprises: the goal of non-state-owned enterprises is to maximize value, while in addition to maximizing value, state-owned enterprises also need to undertake non-economic goals such as social services and employment. The different property rights of enterprises will not only affect the appointment and removal of CEOs and the choice of strategy, but also the CEO's resource allocation ability and the motivation for strategic change. Referring to the research of Dong et al. (2021), this paper divides enterprises into central state-owned enterprises, local state-owned enterprises, private enterprises, foreign-funded enterprises, collective enterprises, public enterprises, and other enterprises.

Research methods

This study used a literature survey, secondary data collection, and empirical research. Hypotheses were tested using the SPSS software.

Sample selection and data source

In October 1992, China held the 14th National Congress of the Communist Party of China in the capital of China. At the congress, it was clearly stated that the goal of economic restructuring is to establish and improve the socialist market economy on the basis of upholding public ownership and distribution according to work as the main body and other economic components and modes of distribution as the supplement.

Thus, it formally established China's socialist market economic system. 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 obviously vague.

In China, both the chairman and the general manager can be regarded as the CEO of a company, 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 companies as CEOs. The research data in 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 was in one of these four positions in 2016 and beyond. Considering some special enterprises, to ensure the accuracy of the data, filter the data: excluding ST or *ST samples; excluding the samples with CEO tenure less than two years (which cannot reflect the impact of the effectiveness of the enterprise transformation); excluding the samples with listing time less than three years;
the main variables are missing and the annual report data is not complete; in view of the outliers that will affect the empirical results, the data was reduced to eliminate the impact of the outlier on the empirical results of this paper.

The year 2016 is regarded as the first year of China's 13th Five-Year Plan, which clearly 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 pointed out that positive progress has been made in digital construction during the 13th Five-Year Plan period. COVID-19 had an impact on both the digital construction and the data at the beginning of the 14th Five-Year Plan. Therefore, the data from this historical stage were selected as data samples.

**Variable measure**

Table 1 - Summary table of variable measures

<table>
<thead>
<tr>
<th>type of variable</th>
<th>variable name</th>
<th>variable symbol</th>
<th>measuring method</th>
</tr>
</thead>
</table>
| dependent variable | Effectiveness of digital transformation            | Y               | Y=ROA*41% + ROE*59%
To measure the effectiveness of digital transformation, it is expressed by the variable Y. |
| argument         | Background of the CEO's technical characteristics | X1              | According to the relevant technical professional background, relevant professional technical work experience and relevant social capital, selected by variable X, there is 1, no is 0; |
| metavariable      | The ability to perceive the external environment  | X2.1            | Enterprise extraordinary profit = the scale of the industry profit pool of the industry profit pool
Size of industry profit pool = industry average annual sales unit price of industry average sales profit margin |
|                   | research and development ability                   | X2.2            | The r & D ratio is a measure of enterprise r & D capabilities, which means the proportion of enterprise r & D personnel in the total number of employees |
| controlled variable | CEO age                                           | B1              | Age in the first year of the CEO |
|                   | CEO sex                                            | B2              | Gender of CEO |
|                   | scale                                              | B3              | A log value of the total number of corporate employees in the first year as a CEO |
|                   | property nature                                    | B4              | 1 for state-owned enterprises; 0 for non-state-owned enterprises |

**Empirical analysis**

Descriptive analysis and correlation analysis

This paper makes a descriptive analysis of 7529 data points collected from Chinese Shanghai and Shenzhen A-share listed companies.

As shown in Tab. 2, through descriptive statistical analysis, many characteristics of statistics can be mined, such as minima, maxima, mean, standard deviation, and other data characteristics.
Table 2 - Descriptive analysis table
(made by the author)

<table>
<thead>
<tr>
<th>Name</th>
<th>Sample</th>
<th>Least Value</th>
<th>Crest Value</th>
<th>Average Value</th>
<th>Standard Error</th>
<th>Median</th>
</tr>
</thead>
<tbody>
<tr>
<td>Achievements of the digital transformation of manufacturing enterprises</td>
<td>7529</td>
<td>-44.609</td>
<td>2.414</td>
<td>0.041</td>
<td>0.703</td>
<td>0.059</td>
</tr>
<tr>
<td>The CEO has a technical background</td>
<td>7529</td>
<td>0.000</td>
<td>1.000</td>
<td>0.373</td>
<td>0.484</td>
<td>0.000</td>
</tr>
<tr>
<td>The perceived capacity of the external environment</td>
<td>7529</td>
<td>0.136</td>
<td>0.594</td>
<td>0.368</td>
<td>0.131</td>
<td>0.368</td>
</tr>
<tr>
<td>Enterprise RESEARCH and development capabilities</td>
<td>7529</td>
<td>0.000</td>
<td>0.924</td>
<td>0.195</td>
<td>0.131</td>
<td>0.159</td>
</tr>
<tr>
<td>CEO sex</td>
<td>7529</td>
<td>1.000</td>
<td>2.000</td>
<td>1.937</td>
<td>0.244</td>
<td>2.000</td>
</tr>
<tr>
<td>CEO age</td>
<td>7529</td>
<td>29.000</td>
<td>81.000</td>
<td>51.509</td>
<td>6.871</td>
<td>52.000</td>
</tr>
<tr>
<td>Property nature</td>
<td>7529</td>
<td>1.000</td>
<td>7.000</td>
<td>5.080</td>
<td>1.602</td>
<td>6.000</td>
</tr>
<tr>
<td>scale</td>
<td>7529</td>
<td>8.736</td>
<td>11.964</td>
<td>10.062</td>
<td>0.702</td>
<td>10.110</td>
</tr>
</tbody>
</table>

Related analysis was used to study the correlation between the effect of digital transformation, CEO technical background characteristics, external environment perception, enterprise research and development ability, CEO gender, CEO age, property rights, and enterprise size.

The Pearson correlation coefficient was used to indicate the strength of the correlation relationship. In this study, we looked at the relationship between the digital transformation of a manufacturing company and its CEO's technology background, how they see the outside world, and the company's ability to do research and development.

We found that all four properties were significant, with correlation coefficient values of 0.054, 0.064, 0.055, and 0.050, which means that the relationship between the digital transformation of a manufacturing company and its CEO's technology background, how they see the outside world, and the company's ability to (Tab. 3).

**Collinearity test**

To avoid multicollinearity problems, the variance inflation factor (VIF) was calculated for each explanatory variable before performing the benchmark regression.

The test results showed that the largest VIF was 1.634, much less than 10, indicating that multicollinearity is less likely.
Table 3 - Correlation analysis
(made by the author)

<table>
<thead>
<tr>
<th>Achievements of digital transformation of manufacturing enterprises (1)</th>
<th>1</th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>CEO Technical Background Characteristics (2)</td>
<td>0.054**</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Perception of the external environment (3)</td>
<td>0.064**</td>
<td>0.482**</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Enterprise R &amp; D capability (4)</td>
<td>0.055**</td>
<td>0.491**</td>
<td>0.527**</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CEO sex (5)</td>
<td>-0.008</td>
<td>-0.039**</td>
<td>-0.035**</td>
<td>-0.003</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CEO age (6)</td>
<td>0.002</td>
<td>-0.055**</td>
<td>-0.050**</td>
<td>-0.035**</td>
<td>0.022</td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Property nature (7)</td>
<td>0.050**</td>
<td>0.052**</td>
<td>0.077**</td>
<td>-0.003</td>
<td>-0.062**</td>
<td>-0.085**</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Enterprise size (8)</td>
<td>-0.010</td>
<td>-0.003</td>
<td>0.001</td>
<td>-0.021</td>
<td>0.022</td>
<td>-0.008</td>
<td>-0.024*</td>
<td>1</td>
</tr>
</tbody>
</table>

Table 4 - Multiple collinearity test
(made by the author)

<table>
<thead>
<tr>
<th>variable</th>
<th>VIF</th>
<th>tolerance</th>
</tr>
</thead>
<tbody>
<tr>
<td>The CEO has a technical background</td>
<td>1.518</td>
<td>0.659</td>
</tr>
<tr>
<td>The perceived capacity of the external environment</td>
<td>1.592</td>
<td>0.628</td>
</tr>
<tr>
<td>Enterprise R &amp; D capability</td>
<td>1.634</td>
<td>0.612</td>
</tr>
<tr>
<td>CEO sex</td>
<td>1.007</td>
<td>0.993</td>
</tr>
<tr>
<td>CEO age</td>
<td>1.011</td>
<td>0.989</td>
</tr>
<tr>
<td>Property nature</td>
<td>1.034</td>
<td>0.967</td>
</tr>
<tr>
<td>scale</td>
<td>1.002</td>
<td>0.998</td>
</tr>
</tbody>
</table>

Test of direct effects and mediation effects

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 cis 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.

In order to test whether the dynamic capability has a significant mediation role between the CEO's digitalization background and the digital transformation of manufacturing enterprises, this study adopted the latest mediation effect test procedure proposed by Wen & Ye (2014).
HOW CEO TECHNICAL BACKGROUND

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 Tab. 5.

Table 5 - Test of the mediation effect of external environment perception ability

<table>
<thead>
<tr>
<th></th>
<th>Achievements of the digital transformation of manufacturing enterprises</th>
<th>The perceived capacity of the external environment</th>
<th>Achievements of the digital transformation of manufacturing enterprises</th>
</tr>
</thead>
<tbody>
<tr>
<td>constant</td>
<td>-0.032 ( \text{(0.214)} )</td>
<td>0.323**</td>
<td>-0.114 ( \text{(-0.750)} )</td>
</tr>
<tr>
<td>CEO sex</td>
<td>-0.010 ( \text{(-0.287)} )</td>
<td>-0.007( \text{(-1.234)} )</td>
<td>-0.008 ( \text{(-0.236)} )</td>
</tr>
<tr>
<td>CEO age</td>
<td>0.001 ( \text{(0.786)} )</td>
<td>-0.000 ( \text{(-1.836)} )</td>
<td>0.001 ( \text{(0.862)} )</td>
</tr>
<tr>
<td>Property nature</td>
<td>0.021** ( \text{(4.112)} )</td>
<td>0.004** ( \text{(4.880)} )</td>
<td>0.020** ( \text{(3.908)} )</td>
</tr>
<tr>
<td>Scale</td>
<td>-0.009 ( \text{(-0.778)} )</td>
<td>0.001 ( \text{(0.364)} )</td>
<td>-0.009 ( \text{(-0.794)} )</td>
</tr>
<tr>
<td>The CEO has a technical background</td>
<td>0.075** ( \text{(4.459)} )</td>
<td>0.129** ( \text{(47.237)} )</td>
<td>0.042* ( \text{(2.211)} )</td>
</tr>
<tr>
<td>The perceived capacity of the external environment</td>
<td></td>
<td></td>
<td>0.252** ( \text{(3.571)} )</td>
</tr>
<tr>
<td>sample capacity</td>
<td>7529</td>
<td>7529</td>
<td>7529</td>
</tr>
<tr>
<td>( R^2 )</td>
<td>0.005</td>
<td>0.235</td>
<td>0.007</td>
</tr>
<tr>
<td>adjust ( R^2 )</td>
<td>0.005</td>
<td>0.235</td>
<td>0.006</td>
</tr>
<tr>
<td>( F ) price</td>
<td>7.977***</td>
<td>463.186***</td>
<td>8.784***</td>
</tr>
</tbody>
</table>

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

The technical background of the independent variable CEO has a significant correlation with 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, rejecting 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, which 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 to the external environment of the intermediary variable. According to the above coefficient table, the significance of the perceptual ability of the independent variable to detect 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 perceptual ability of the external environment of the intermediary variable and the digital transformation 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 digital transformation effect 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.

With the process plugin of SPSS, the 95% confidence interval of the above variables does not include 0, assuming that H1, H2a, H3a, and H4a are supported. This arrangement is shown in Tab. 6 below.

Table 6 - Table of direct and mediation effects, mediated by the perceived ability of the external environment (made by the author)

<table>
<thead>
<tr>
<th>Item</th>
<th>symbol</th>
<th>meaning</th>
<th>The effect value is the Effect</th>
<th>95% CI</th>
<th>Z-value / t-value</th>
<th>p price</th>
<th>conclusion</th>
</tr>
</thead>
<tbody>
<tr>
<td>CEO technical background =&gt; perception ability of external environment =&gt; effectiveness of digital transformation of manufacturing enterprises</td>
<td>a*b</td>
<td>indigo effect</td>
<td>0.033</td>
<td>0.013 0.100</td>
<td>1.585</td>
<td>0.113</td>
<td></td>
</tr>
<tr>
<td>The CEO technical background =&gt; the perceived ability of the external environment</td>
<td>a</td>
<td>X=&gt;M</td>
<td>0.129</td>
<td>0.124 0.135</td>
<td>47.237</td>
<td>0.000</td>
<td></td>
</tr>
<tr>
<td>Perception ability of external environment =&gt; the effect of digital transformation of manufacturing enterprises</td>
<td>b</td>
<td>M=&gt;Y</td>
<td>0.252</td>
<td>0.114 0.390</td>
<td>3.571</td>
<td>0.000</td>
<td></td>
</tr>
<tr>
<td>CEO technical background =&gt; the effect of digital transformation of manufacturing enterprises</td>
<td>c'</td>
<td>direct effect</td>
<td>0.042</td>
<td>0.005 0.080</td>
<td>2.211</td>
<td>0.027</td>
<td></td>
</tr>
<tr>
<td>CEO technical background =&gt; the effect of digital transformation of manufacturing enterprises</td>
<td>c</td>
<td>gross effect</td>
<td>0.075</td>
<td>0.042 0.108</td>
<td>4.459</td>
<td>0.000</td>
<td></td>
</tr>
</tbody>
</table>

Then SPSS software is used to test the intermediary effect of enterprise R&D capability (Tab. 7).
Table 7 - Intermediation effect table of enterprise R&D capability

<table>
<thead>
<tr>
<th>Achievements of the digital transformation of manufacturing enterprises</th>
<th>Enterprise RESEARCH and development capabilities</th>
<th>Achievements of the digital transformation of manufacturing enterprises</th>
</tr>
</thead>
<tbody>
<tr>
<td>constant</td>
<td>-0.032</td>
<td>0.189**</td>
</tr>
<tr>
<td>CEO sex</td>
<td>-0.010</td>
<td>0.008</td>
</tr>
<tr>
<td>CEO age</td>
<td>0.001</td>
<td>-0.000</td>
</tr>
<tr>
<td>Property nature</td>
<td>0.021**</td>
<td>-0.002**</td>
</tr>
<tr>
<td>scale</td>
<td>-0.009</td>
<td>-0.004*</td>
</tr>
<tr>
<td>The CEO has a technical background</td>
<td>0.075**</td>
<td>0.133**</td>
</tr>
</tbody>
</table>

Enterprise RESEARCH and development capabilities

<table>
<thead>
<tr>
<th>sample capacity</th>
<th>7529</th>
<th>7529</th>
<th>7529</th>
</tr>
</thead>
<tbody>
<tr>
<td>$R^2$</td>
<td>0.005</td>
<td>0.243</td>
<td>0.006</td>
</tr>
<tr>
<td>adjust $R^2$</td>
<td>0.005</td>
<td>0.242</td>
<td>0.006</td>
</tr>
<tr>
<td>$F$ price</td>
<td>7.977***</td>
<td>482.930***</td>
<td>8.115***</td>
</tr>
</tbody>
</table>

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

Judging from the above table, the technical background of the independent variable CEO has a significant correlation with the effect of the digital transformation of manufacturing enterprises.

That is, according to the theory of the mediation role, the significance of the second model independent variable was 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. It can prove that the digital background of the CEO can directly predict the effect of digital transformation on manufacturing enterprises.

The second step is to test the regression equation of the independent variable with the intermediary variable. According to the above coefficient table, the significance of the independent variable on the enterprise research and development capacity of the intermediary variable was 0.000, that is, to reject the null hypothesis. That is, the independent variables are considered to predict the mediation variables.

Finally, the relationship between the R&D ability of the intermediary variable and the digital transformation effect of the dependent variable in manufacturing enterprises is tested. It is found that the significance of the R & D ability of the intermediary variable is 0.000; that is, the intermediary variable has a significant impact on the digital transformation effect of the dependent variable manufacturing enterprises.

To sum up, there is an intermediary 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 research and development ability of enterprises plays an intermediary role.

With the process plugin of SPSS, the 95% confidence interval of the above variables does not include 0, assuming that H1, H2b, H3b, and H4b are supported.

This sorting out is shown in Tab. 8.

Table 8 - Test table of direct effect and intermediary effect, with the R&D ability of enterprises as the intermediary

<table>
<thead>
<tr>
<th>Item</th>
<th>symbol</th>
<th>meaning</th>
<th>The effect value is the Effect</th>
<th>95% CI</th>
<th>Z-value</th>
<th>t-value</th>
<th>p price</th>
</tr>
</thead>
<tbody>
<tr>
<td>CEO technical background =&gt; enterprise R &amp; D capability =&gt; effectiveness of digital transformation of manufacturing enterprises</td>
<td>a*b</td>
<td>indigo effect</td>
<td>0.028</td>
<td>0.014</td>
<td>0.080</td>
<td>1.744</td>
<td>0.081</td>
</tr>
<tr>
<td>CEO technical background =&gt; enterprise R &amp; D capability</td>
<td>a</td>
<td>X=&gt;M</td>
<td>0.133</td>
<td>0.128</td>
<td>0.139</td>
<td>48.967</td>
<td>0.000</td>
</tr>
<tr>
<td>Enterprise R &amp; D capability =&gt; Effect of digital transformation of manufacturing enterprises</td>
<td>b</td>
<td>M=&gt;Y</td>
<td>0.210</td>
<td>0.071</td>
<td>0.349</td>
<td>2.961</td>
<td>0.003</td>
</tr>
<tr>
<td>CEO technical background =&gt; the effect of digital transformation of manufacturing enterprises</td>
<td>c'</td>
<td>direct effect</td>
<td>0.047</td>
<td>0.009</td>
<td>0.085</td>
<td>2.430</td>
<td>0.015</td>
</tr>
<tr>
<td>CEO technical background =&gt; the effect of digital transformation of manufacturing enterprises</td>
<td>c</td>
<td>gross effect</td>
<td>0.075</td>
<td>0.042</td>
<td>0.108</td>
<td>4.459</td>
<td>0.000</td>
</tr>
</tbody>
</table>

**Study conclusions and prospects**

**Study conclusions**

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

CEOs with a technical background have a significant role in driving the digital transformation of manufacturing enterprises. Compared with CEOs with technical backgrounds, they 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 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 in manufacturing enterprises, research and development capability is regarded as a crucial element.
HOW CEO TECHNICAL BACKGROUND

The CEO has a technical background, which plays a crucial role in improving the R&D capabilities of enterprises through innovation. CEOs with a technical background can more deeply understand the great value of digital technology to enterprises and pay more attention to technological innovation.

**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 CEO technical background characteristic is an important aspect of executive heterogeneity, referring to the expertise and experience of the CEO in the technology field, which affects the effectiveness of the digital transformation of manufacturing enterprises.

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 extends the research model for the digital transformation of enterprises. In the process of promoting digital transformation, determining what factors can accelerate success is one of the most concerning issues for enterprises. In this paper, the CEO is taken as the research object to study the influence mechanism between the CEO's technical background characteristics, dynamic capabilities, and the digital effectiveness of manufacturing enterprises. A CEO with technical background characteristics can provide resources and continuous competitive advantages for manufacturing enterprises by building research and development capabilities to promote the digital transformation of manufacturing enterprises. 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 the digital transformation.

**Research limitations and future perspectives**

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 differences 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 a relatively high acceptance of second-hand data analysis methods and considers different keyword selection strategies, it still cannot
completely avoid keyword selection because it is not comprehensive and the specific context is difficult to identify.

Future research can include comprehensive text analysis and other second-hand data measurement, which is expected to further improve the validity of digital transformation measurement.

References:


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