Impact of common institutional ownership on enterprise digital Transformation—Collaborative governance or collusion fraud?

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A B S T R A C T

As a crucial external capital force of enterprises, common institutional ownership plays an essential role in enterprise innovation and development. However, few studies have focused on the impact and underlying impact mechanisms of common institutional ownership on the digital transformation of enterprises. Hence, this study uses Python to analyse the annual reports of listed companies from 2007 to 2021 and constructs measures of enterprise digital transformation. Then, based on panel fixed effects Poisson regression, this study examines the influence of common institutional ownership on enterprise digital transformation by using theoretical logic and empirical evidence. The results reveal that common institutional ownership significantly inhibits enterprise digital transformation; this result remains valid after a series of endogeneity and robustness tests, thereby indicating that common institutional ownership exerts a collusion fraud effect. The mechanism analysis shows that common institutional ownership hampers enterprise digital transformation mainly by increasing monopoly power within the market, aggravating information asymmetry between enterprise insiders and outsiders, and intensifying executive self-dealing. Further analysis reveals that the inhibitory effect of common institutional ownership on digital transformation is more significantly negative in the case of non-state-owned enterprises versus state-owned enterprises. This study expands the research on the factors influencing enterprise digital transformation. The results provide a helpful reference for further improving institutional investors' ownership structures and promoting high-quality enterprise development.

1. Introduction

With the rapid development and popularisation of digital technology, the digital economy has become an essential driving force for national economic growth. Enterprises are the basic units of the economy and society, and promoting digital transformation is a vital policy for cultivating new economic dynamics [1]. In December 2021, the State Council issued the 'Fourteen Five-Year Plan for Digital Economy Development', emphasising the need to guide enterprises to strengthen their digital mindset and comprehensively and systematically promote digital transformation.[1] Therefore, the digital transformation of enterprises has become a key topic of concern among both practical and theoretical communities. Digital transformation generally requires that enterprises integrate, reconstruct, and innovate their products, business processes, organisations, and business models through digital technologies, such as information,

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calculation, and communication, which causes the existing models of enterprises to undergo digital system evolution [2,3]. Studies have found that promoting enterprise digital transformation can effectively enhance an enterprise's ability to resist risks [4], improve its organisational structure and operational processes [5], and improve its innovation capabilities and performance [6,7]. Enterprise digital transformation can also promote the integrated development of the advanced manufacturing and modern service industries, thus improving the enterprise's total factor productivity [8,9]. The continuous penetration of digital technology would also improve the enterprises' dynamic ability to obtain information and integrate resources [10]. Although digital technology has become a new kinetic energy source for promoting high-quality economic development, the development of China's real economy still faces severe challenges. Enterprises still have problems such as low production efficiency, weak product competitiveness, and key core technologies being 'stuck'. According to Accenture's China Enterprise Digital Transformation Index Study 2021, only 16 % of Chinese enterprises have achieved significant digital transformation.[2] Therefore, the goal of this study is to further explore the external factors that affect the digital transformation of enterprises based on the previous literature, and to help enterprises better realise digital transformation.

In the past, most studies focused on the economic consequences of enterprise digital transformation; few scholars focused on the influencing factors of enterprise digital transformation. Scholars have thoroughly discussed the economic implications of digital transformation, and most believe that it can positively affect enterprise management, change, and innovation. Smith et al. [11] found that enterprise digitisation could improve human capital, reduce research and development costs, and thus, enhance technological innovation capabilities. Hänninen and Smedlund [12] found that the digital transformation of enterprises could help expand their markets and increase their value. Digital transformation can also support the development of business models [13] and reduce pollution emissions from enterprise operations [14]. Compared to studying economic consequences, exploring the factors influencing enterprise digital transformation is more important to help enterprises enter a new stage of digital efficiency. The literature has mainly discussed the factors influencing enterprise digital transformation from the perspectives of new digital technology, digital talents, business and institutional environments, and corporate governance [15–18]. These studies all agreed that the better the external factors of the enterprise was, the higher was the degree of enterprise digital transformation. However, previous research on the causes of corporate digitalisation does not go far enough. The factors that inhibit enterprise digital transformation have not been analysed and the research lacks analysis from the perspective of common institutional ownership. As an essential part of the capital market, common institutional investors are a vital driving force for the capital market to serve the real economy and, at the same time, potentially influence the development direction of enterprises significantly. It can be said that common institutional investors should be an essential factor affecting enterprise digital transformation. Therefore, this study aims to determine whether common institutional ownership significantly affects enterprise digital transformation, and if so, through what mechanisms?

Common institutional ownership refers to an ownership model formed by institutional investors who hold more than 5 % of two or more listed companies in the same industry [19]. Common institutional ownership is prevalent in capital markets as a hub of competition and economic contact among enterprises in the same industry. In 1990, only 17 % of S&P 500 companies owned common institutions, and this ratio increased to 81 % by the end of 2015 [20]. In China, more than one-third of the top ten shareholders of listed companies had common institutional investors as of 2020 [19]. However, it remains unclear whether common institutional investors influence company behaviour and performance. As shown in Fig. 1, common institutional ownership not only can exert a collusion fraud effect and trigger anti-competitive behaviour, but also play a synergistic governance effect, realise the coordinated development of product markets, and even promote cooperation among enterprises, which is conducive to the growth of enterprise market value. In other words, there is no academic consensus on the influence of common institutional ownership on enterprise behaviour and development. While this necessitates that the academic community discuss the economic impact of common institutional ownership more carefully, there is an urgent need for more research to provide evidence to fully understand the influence of common institutional ownership on enterprise behaviour and development.

Research on this issue can help stimulate common institutional investors to play an active role as factors of production, and provide supporting evidence and practical recommendations for the digital transformation of enterprises. Considering the controversy surrounding the economic impact of common institutional ownership, we make logical extrapolations through two competing pro and con scenarios. On the one hand: (1) Common institutional ownership promotes the development of market monopoly power among enterprises, which curbs their potential innovation, thereby decreasing their degree of digital transformation. (2) Common institutional investors tend to disclose low-quality accounting information to create an 'information barrier' effect against enterprises not held by common institutional investors. Information asymmetry increases as the quality of enterprises' accounting disclosures deteriorates, making it challenging to link companies' digital transformation resources to capital markets. (3) Furthermore, if the benefits of common institutional investors' collusion with executives outweigh their supervision costs, they are more likely to conspire with the executives, thus exacerbating the possibility of emptying digital resources.

On the other hand: (1) As hubs of communication and liaison between enterprises, common institutional investors have clear comparative advantages in accessing information resources and coordinating the interests of multiple parties. Thus, they are more likely to promote enterprise digital transformation through synergistic effects. (2) Concurrently, common institutional investors can transfer their experience and knowledge gained from supervising enterprises to other enterprises, thereby supervising them at a lower cost. This implies that common institutional investors are more likely to promote enterprise digital transformation through the supervisory governance effect.

Based on the above theory, this study uses data from Chinese A-share listed companies from 2007 to 2021 to assess the influence of
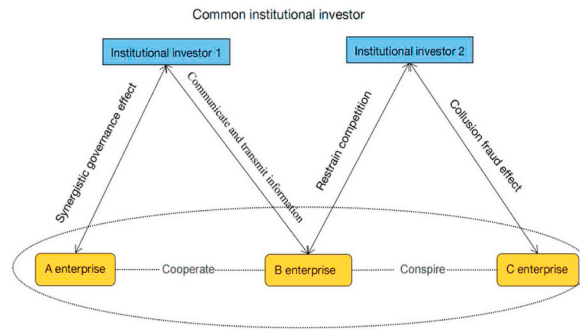

Fig. 1. Diagram of two effects of common institutional ownership.

common institutional ownership on enterprise digital transformation using a panel fixed effects Poisson model. The empirical results show that common institutional ownership has a significantly negative relationship with enterprise digital transformation. This result persists after a series of endogenous treatments and robustness tests, confirming that common institutional ownership has a 'collusion fraud' effect on enterprise digital transformation. Common institutional ownership inhibits the digital transformation of an enterprise mainly by (1) increasing market monopoly power, (2) aggravating information asymmetry between enterprise insiders and outsiders, and (3) intensifying executive self-dealing. Heterogeneity analysis revealed that the impact of common institutional ownership on enterprise digital transformation was significantly negative in non-state enterprises.

Compared to the literature, the contributions of this study are as follows: First, we questioned the research of Gao et al. [21] who believed that common institutional ownership could promote enterprise innovation. Conversely, this study finds that common institutional ownership inhibits enterprise digital transformation (a higher level of enterprise innovation). Our results further support the findings of previous literature [19,22] that common institutional ownership distorts corporate behaviour by exerting the effect of collusion fraud rather than that of collaborative governance. Second, based on the research framework of the benchmark regression (mechanism analysis) heterogeneity test, this paper discusses the impact of common institutional ownership on enterprise digital transformation, which adds to the literature [15,16,23] on the factors influencing enterprise digital transformation, expands research boundaries, and has specific policy implications.

2. Literature review and hypothesis development

2.1. Economic consequences of common institutional ownership

The literature generally states that common institutional ownership strengthens daily contact between peer enterprises and can have an essential impact on micro-enterprise behaviour [23,24]. However, there is ongoing debate on whether common institutional investors exert a 'collaborative governance' or a 'collusion fraud' effect among peer enterprises. Some scholars believe that common institutional investors focus on maximising the value of their portfolios. Such investors have incentives to encourage peer companies to collude in the product market in order to improve their bargaining power and profitability. This theory is supported in the US aviation industry [25]. The friction and competition between enterprises decrease with the intensification of collusion, distorting the investment enterprises' behaviour and the industry price mechanisms [19,22]. Other scholars have concluded that common institutional investors have strong supervisory capabilities and rich private information. They can play a synergistic and governance role in promoting enterprise capacity utilisation [26], corporate innovation [21], and the completion of M&A transactions [27].

2.2. Influencing factors of enterprise digital transformation

For enterprises, digital transformation is not only a process of technological change but also involves the planning and adjustment of enterprise strategy, innovation, production, and management mechanisms. Previous studies show that enterprise digital transformation is driven by many factors including new digital technology, digital talent, business and institutional environments, and corporate governance.

Digital technology is undoubtedly a critical factor in digital transformation. The deep integration of emerging digital technologies, such as 5G, big data, cloud computing, and artificial intelligence (AI), with the real economy has had a significant impact on economic development and transformation, industrial structure upgrading, market demand models, and enterprise value creation, which can help enterprises develop dynamic capabilities in a rapidly changing environment. Emerging digital technologies have brought about a series of innovations in the product market, spawned new models and formats, and become an essential factor in promoting enterprise digital transformation [15,28]. In addition, digital technology is constantly updated and iterated. Only by combining digital technology with human capital can we effectively promote enterprise digital transformation. Therefore, labour protection and high-end digital talent reserves are necessary for enterprise digital transformation [16]. Business and institutional environments are critical factors in enterprise digital transformation. A high-quality business and institutional environment can serve as a regional digital technology platform and collaboration system for enterprises, increase government subsidies and enterprise investment in digital

technology, and promote enterprise digital transformation to some extent [17]. Digital transformation is a critical management and investment decision for an enterprise, which cannot be separated from the supervision and governance of shareholders and strong support from executives. Therefore, corporate governance factors have a significant impact on enterprise digital transformation [23]. Yan et al. [18] reported that shareholders of non-state-owned enterprises played an active role in the digital transformation of state-owned enterprises. At the same time, if enterprises want to fully promote digitalisation, the government should strengthen supervision over the excessive allocation of the enterprises' financial assets and force them to undertake digital transformation through low-carbon and environmental protection policies [29,30].

In summary, although many scholars have studied the economic consequences of common institutional ownership and the factors influencing enterprise digital transformation, the influence and influence mechanism of common institutional ownership on enterprise digital transformation have not been systematically studied. As common institutional ownership is an essential part of the capital market, it affects the development direction of enterprise digital transformation to a great extent. Hence, further research on this topic is crucial. Against the background of the digital economy, this study analyses the strategic choice of enterprise digital transformation from the perspective of common institutional ownership, which can provide empirical evidence for enterprises to better implement digital transformation strategies.

2.3. Hypothesis development

Common institutional ownership has attracted considerable attention in the financial field, and its relationship with enterprise operations and development has gradually been revealed. Unfortunately, scholars have not had a unanimous perception of the economic consequences of common institutional ownership. Especially in enterprise innovation and investment activities, common institutional investors may cooperate with peer enterprises to gain market power and restrain enterprise investments and innovation activities through collusion fraud or collaborative governance to help enterprises improve their investment efficiency and innovation ability.

As a highly innovative activity, there must exist some relationship between common institutional ownership and enterprise digital transformation. Compared with other shareholders with dispersed shares, common institutional investors play an essential role in company governance because of their shareholding advantage. They have a strong motivation to monitor executives, but may also do so for personal benefit. The common goal of institutional investors in the investment decision-making process is to maximise their portfolio value. This means that they cannot help a single company make long-term strategic decisions, and may even sacrifice the long-term profits of some companies for short-term gains. Therefore, common institutional investors may use cooperative networks to create comparative advantages in resource endowment for enterprises, promote digital transformation, and achieve a win-win situation with enterprises. At the same time, they may ignore the internal supervision of the company and even collude with executives to avoid the risk of transformation and achieve short-term profit goals. This study clarifies the theoretical relationship between these two factors and proposes the following two hypotheses.

2.3.1. The 'collusion fraud' hypothesis

(1) At the market level, connections with common institutional ownership creates market monopoly forces that inhibit enterprise digital transformation. Competition is often considered an external mechanism that encourages enterprises to eliminate backward technologies and traditional projects, and capture investment opportunities. Moreover, competition can help enterprises improve product quality, corporate governance, and operational efficiency. However, with an increase in common institutional ownership, the market power formed by the collusion of peer institutions inhibits competition between enterprises [31]. Furthermore, in a competitive product market, if an enterprise's market share increases at the expense of the interests of other enterprises in the industry, it is not conducive to maximising the industry's overall profit. Classical financial and investment theory holds that when an investor owns shares in multiple companies, the investment goal is to maximise the portfolio profit rather than the value of a single asset. Therefore, common institutional investors could encourage peer enterprises to establish collusion alliances and act in unison under the influence of the market power formed by the collusion alliance, thereby decreasing the level of friction and competition among enterprises [32]. In the long term, developing a mentality of being content with the status quo and making cautious investments in a lower competition environment becomes easy [33], which is not conducive to improving enterprise innovation ability and hinders the digital transformation process.

(2) At the firm level, common institutional ownership aggravates information asymmetry between enterprise insiders and outsiders. Common institutional investors hold many shares in their peer enterprises, meaning that they have substantial information collection and processing capabilities. Thus, it was easier to access corporate boards or executives [34]. According to Hansen and Lott's [32] portfolio value maximisation theory, all common institutions have the dual need of 'working inside' and 'bustling outside'. That is, they must face not only adverse competition from portfolio enterprises, but also competition from non-common shareholding enterprises. When faced with foreign enemies, common institutional investors tend to disclose low-quality accounting information to create 'information barriers' against external competitors and to distort external competitors' investment decisions [35]. With the decreased quality of disclosed accounting information, the information asymmetry and agency problems between internal and external enterprises are aggravated. In this situation, it is challenging to maintain a stable production and operation environment, and enterprises focus less energy and resources on digital transformation. In an environment of profound information asymmetry, enterprises struggle to promptly obtain the information elements required for digital growth, and production decisions and processes cannot be optimised. Furthermore, the poor quality of accounting

information disclosure makes investors more pessimistic, leading the company to spend more energy on maintaining investor relations and reducing investment in enterprise digital transformation. Moreover, once the media capture investors' pessimism regarding bad news in the capital market, the public opinion basis of enterprise digital transformation also deteriorates.

(3) At the management level, common institutional ownership increases executive self-dealing. In its early stages, digital transformation requires strong support from human and material resources, and enterprises must reasonably allocate limited digital resources to their daily operations and to various digital projects. The transformation process faces high risks and achieving profits in the early stages is difficult. Digital transformation is both an opportunity and a challenge for management. When common institutional investors can fully use their advantages in information collection and resource acquisition, and actively supervise the self-dealing of controlling shareholders and executives, the enterprise should be able to complete organisational restructuring and digital transformation, and step up to a new level of high-quality development. However, by nature, capital is profit-seeking, and the supervision and governance of common institutional investors are not always 'absolutely good' [36]. Common institutional investors may play a positive supervisory role in enterprises. However, they may also play a negative supervisory role, depending on the relationship between supervision costs and collusion benefits. The cost-benefit principle states that if conspiring with executives provides more significant benefits than that from supervising executives, common institutional investors may ignore the in-service consumption of senior executives and the building of a corporate empire [37, 38], and increase the control of the internal resources of the enterprise, making the enterprise's digital transformation of resources and strategic layout challenging to implement. Considering the demand for short-term returns, Chinese institutional investors pay more attention to the enterprise's short-term performance [36]. However, enterprise digital transformation is a long-term innovation activity, and the transformation process faces the difficulties of high risk and high investment, which is inconsistent with the investment expectations of China's common institutional investors. Therefore, to pursue short-term returns and maximise their interests, common institutional investors may collude with controlling shareholders and executives after weighing their advantages and disadvantages. This approach increases the possibility of emptying enterprise resources, thus making the digital transformation process challenging. Therefore, we propose the following hypothesis:

H1a. Common institutional ownership inhibits enterprise digital transformation.

2.3.2. The collaborative governance hypothesis

(1) From the perspective of institutional synergies, common institutional investors are critical nodes of information and resource transmission between enterprises, and have rich practical experience in obtaining private information about enterprises and realising coordinated development between them [24]. They can influence the management and controlling shareholders by appointing directors to promote coordinated development among enterprises. With an increase in common institutional ownership, the formal boundaries of enterprises become blurred and strategic alliances are established. In a strategic alliance, investors of common institutions play the role of coordinating organisations, and their multiparty coordination ability is enhanced so that they can supervise listed companies more effectively and promote enterprise digital transformation. When the decision made by an enterprise adversely affects its peers, common institutional investors can vote against it through an exit threat. Once a strong information cooperation network is formed among peer enterprises, not only does the bargaining power of enterprises improve, but enterprises can also gain advantages in acquiring new technologies, knowledge, and information, which is conducive to accelerating the digitalisation of physical components and business processes and further improving enterprise digital transformation. Enterprise digital transformation is a complex and high-level innovation activity; however, the transformation process also faces high risks. Common institutional investors who have been engaged in peer management for a long time and have rich knowledge and management experience can ably identify the factors of innovation failure to reduce the possibility of enterprise innovation failure to some extent [39]. According to the incomplete contract theory, the cooperation of enterprises in the same industry is at a low level and low efficiency [19]. To maximise their portfolio value, common institutional investors will ease competition among portfolio enterprises through informal communication, thus promoting technology and R&D exchanges and cooperation between enterprises, and providing an excellent external environment foundation for enterprise digital transformation [21].

(2) From the perspective of supervision and governance, the cost of supervising the digital structure of enterprises by common institutional investors decreases with an increase in connections between enterprises. Therefore, there is stronger motivation to oversee peer enterprises and discover and expose executive self-dealing, such as excessive executive salaries and on-the-job consumption. With increased common institutional ownership, the formal boundaries of enterprises become blurred, and strategic alliances are established. In a strategic alliance, common institutional investors play the role of coordinating organisations, and their multiparty coordination ability is enhanced so that they can supervise listed companies more effectively and promote enterprise digital transformation. When the decision made by an enterprise adversely affects its peers, common institutional investors can vote against it through an exit threat. Under the supervision of common institutional investors, enterprises investing more resources to improve their internal governance structure and optimise business processes can thus seize the opportunity to realise the transformation from physical hardware to digital resources, ultimately accelerating digital transformation [40]. Common institutional investors also play an active role in tracking a company's production and

commercial operations and can supervise executive self-dealing [34], thus reducing the hollowing out of digital resources by management and promoting enterprise digital transformation. Based on this analysis, we hypothesise the following:

H1b. Common institutional ownership promotes enterprise digital transformation.

3. Research design

3.1. Data source and sample selection

This study employs data on A-share listed companies in China from 2007 to 2021. This period was selected for several reasons. First, China adopted new accounting standards in 2007; therefore, starting no earlier than 2007 ensured consistency in the accounting standards of the sampled enterprises. Second, the society was gradually exposed to the concept and technologies of enterprise digital transformation after 2007. We constructed our measures of common institutional ownership using the portfolios disclosed by institutional investors. We used the frequency of related keywords in the annual reports of a listed company to reflect its digital transformation. These keyword frequencies were obtained using a Python crawler. To ensure the reliability of our sample, we performed the following steps. (1) We omitted missing observations and dropped observations of ST and ST* companies. (2) We excluded companies in the financial industries. (3) Continuous variables were winsorised at the 1 % level to avoid the influence of outliers. Ultimately, a sample comprising 35,587 observations were obtained. All the original data in this study were obtained from the CSMAR database.

3.2. Definition of variables

3.2.1. Common institution ownership (CIO)

Following previous literature [19,26], we refer to an institutional investor as a common institutional investor if it simultaneously holds ownership stakes of 5 % or more in two or more enterprises within the same industry. We constructed the following two measures to reflect the status of common institutional ownership of a company in a given year.

(1) CIO abundance (CIO1). We recorded the logarithm quantities of common institutional investors among shareholders at each quarter end throughout the year and then calculated the mean of the four logarithm quantities.
(2) CIO completeness (CIO2). We recorded the proportion of shares held by common institutional investors at each quarter end throughout the year and then calculated the mean of the four proportions.

Remarkably, 5 % is set as the threshold because the China Securities Regulatory Commission (CSRC) refers to an investor who holds 5 % or more shares of a firm as a major shareholder, and previous studies also indicate that such institutional investors have significant influence. In the robustness test, we used 7 % as an alternative threshold.

3.2.2. Digital transformation (DT)

Wu et al. [41] pioneered the research on measurement of enterprise digital transformation based on text analysis. They published the 'Research Report on the Evaluation of Digital Transformation Index of Chinese Listed Companies in 2022' online,[3] and the study data can be freely downloaded by the public. Thus far, many scholars have used these data to draw valuable results that are published in influential journals [41–44]. Following Wu et al. [41], we categorise digital transformation technologies into 'fundamental techniques' and 'extended application of digital technology'. The fundamental techniques include 'ABCD', where A stands for AI, B stands for blockchain, C stands for cloud computing, and D stands for big data. Various types of ABCD technologies have been applied in various practical scenarios. Based on the above two categories, we summarise the exact keywords of digital transformation in Table 1. We first used a Python crawler tool to download the annual reports of A-share listed companies on the Shanghai and Shenzhen Stock Exchanges from the Juchao Information Network. We then used the Java PDFbox database to count the frequency of the digital transformation keywords. Finally, our core independent variable, DT, is the logarithm of 1 plus the frequency, since the distribution of the keyword frequency was right-skewed.

3.2.3. Control variables

Following the research methods in the literature [42–45], this study adopts a series of firm-year level control variables to address the endogeneity issue of omitted variables. The control variables include the company's age (Age), company growth (Growth), company size (Size), leverage (Lev), return on assets (Roa), proportion of management shareholdings (Mana), size of the board of directors (Directors), proportion of independent directors on the board (Independent), dummy variable for the duality of COB and CEO (Dual), and dummy variable for state-owned enterprise (Soe). Remarkably, common institutional investors have shareholding preferences that are related to the age (Age) and size (Size) of a company. Hu et al. [42] and Yan et al. [43] showed that financial metrics are related to enterprise digital transformation; therefore, we add enterprise growth (Growth), leverage (Lev), and firm performance

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[3] https://www.gduf.edu.cn/info/1036/10625.htm.

Table 1

Keywords of five dimensions of enterprise digital transformation.

Index	keywords
Artificial intelligence	Artificial intelligence, business intelligence, image understanding, investment decision assistance systems, intelligent data analysis, intelligent robotics, machine learning, deep learning, semantic search, biometrics technology, face recognition, speech recognition, authentication, autonomous driving and natural language processing
Cloud computing technology	Cloud computing, flow computing, graph computing, memory computing, secure multiparty computing, brain-like computing, green computing, cognitive computing, fusion architecture, 100 million level concurrency, EB level storage, internet of things and information physics system
Big data technology	Big data, data mining, text mining, data visualisation, heterogeneous data, credit investigation, augmented reality and virtual reality
Blockchain technology	Blockchain, digital currency, distributed computing, differential privacy technology and smart financial contracts
Digital technology application	Mobile internet, industrial Internet, mobile Internet, Internet medical, e-commerce, mobile payment, third-party payment, NFC payment, intelligent energy, B2B, B2C, C2B, C2C, O2O, snatched, intelligent wear, intelligent agriculture, intelligent transportation, intelligent medical, intelligent customer service, intelligent household, intelligent interest, intelligent brigade, intelligent environmental protection, smart grid, smart, intelligent marketing, digital marketing, no retail, internet finance, fintech, financial technology, quantitative finance and open bank

(Roa) to the model. The diversity of directors and involvement of independent directors can improve internal governance, alleviate agency problems, and promote enterprise digital transformation. Therefore, we added the size of the board of directors (Directors) and the proportion of independent directors on the board (Independent) to the model. We added the proportion of management shareholding (Mana) and a dummy for the duality of COB and CEO (Dual) to the model because executive self-dealing will hollow out resources and inhibit enterprise digital transformation. In China, the decision-making logic of state-owned enterprises is very different from that of other companies; therefore, we added a dummy variable (Soe) for such enterprises. Table 2 presents the notations and descriptions used in this study.

3.3. Model setting

Following the research methods of the literature [42–47], this study constructed a fixed effects Poisson regression to test the influence of common institutional ownership on enterprise digital transformation. The regression model was as follows:

$$DT_{i,t} = \alpha_0 + \alpha_1 CIO_{i,t} + \gamma Controls_{i,t} + Year_t + Firm_i + \varepsilon_{i,t} \tag{1}$$

In Eq. (1), DT is the explained variable. A CIO can be any of the two measures of common institutional ownership. Controls refer to the control variables, as mentioned above. *Year_t* is the time-fixed effect, *Firm_i* is the individual fixed effect, $\varepsilon_{i,t}$ is the random error term. As this study uses panel data, heteroscedasticity and other problems may arise; thus, we adopted robust standard errors for the fixed effects estimation.

4. Empirical research

4.1. Descriptive statistics

As shown in Table 3, the mean value of DT was 1.162, minimum value was 0, maximum value was 4.956, and standard deviation

Table 2

Main variables, notations and descriptions.

Variable type	Variable name	Notation	Detailed description
Explained variables	Digital transformation	DT	Logarithm of 1 plus the frequency that keywords of digital transformation show in an annual report
Explanatory variables	CIO abundance	CIO1	First record the logarithm quantities of CIO among shareholders at each quarter-end throughout a year, and then calculate the mean of the four logarithm quantities
	CIO completeness	CIO2	First record the proportion of shares held by CIO at each quarter-end throughout a year, and then calculate the mean of the four proportions.
Controlled variables	Company's age	Age	Years since IPO
	Company's growth	Growth	Annual growth rate of total assets
	Company's size	Size	The logarithm of the year-end value of the company
	Leverage	Lev	Total assets/total liabilities at year-end
	Return on assets	Roa	Annual return/total assets
	Board size	Directors	The number of directors in the board
	Proportion of management shareholding	Mana	The portion of shares held by executives
	Proportion of independent directors	Independent	The proportion of independent directors in the board
	COB-CEO duality	Dual	A dummy that equals 1 if one person acts as COB and CEO simultaneously and 0 otherwise
	SOE dummy	Soe	A dummy that equals 1 if the company is state-owned and 0 otherwise

was 1.349. The mean values of CIO1 and of CIO2 were 0.063 and 0.026, respectively. The remaining variables aligned with situations in the previous literature. The mean values of enterprise DT with and without CIO were 1.009 and 1.179, respectively, with a difference of −0.170 that was significant at the 1 % level. The coefficient between either of CIO measures and DT of enterprises was negative and significant at the 1 % level. Such preliminary descriptive statistics support the hypothesis that common ownership suppresses DT among enterprises.

4.2. Correlation coefficient analysis

Table 4 presents the results of the Pearson correlation tests for the primary variables. A significant negative correlation existed between DT and both measures of common institutional ownership. This finding suggests that CIO1 and CIO2 reduced DT. A significant positive correlation was observed between Size and DT, indicating that companies with greater overall strength were more likely to invest in digital transformation. Furthermore, the results show that independent directors played an active role in enterprise digital transformation. The preceding data provided a preliminary assessment of the correlation between the variables; however, this must be empirically confirmed in conjunction with the regression model. In terms of the VIF and 1/VIF test results, the VIF values were less than 10 and the 1/VIF values exceeded 0.1, indicating no multicollinearity among the variables in this study.

4.3. Benchmark regression

To further test the marginal impact of common institutional ownership on enterprise digital transformation, we conducted a regression analysis, as shown in Table 5. Columns (1) shows that the estimated coefficient for CIO1 is −0.110 and significant at the 5 % level. Columns (2) shows that the estimated coefficient for CIO2 is −0.438 and significant at the 1 % level. These results show that companies with common institutional investors pay more attention to enterprise digital transformation, and the probability of finding keywords related to digital transformation in their annual reports is greater. Every 1 % increase in the average number of common institutional investors among the shareholders of an enterprise reduces the frequency of digital transformation keywords by 0.110 %. Every 1 % increase in the average percentage of stocks held by common institutional investors reduces the frequency of digital transformation keywords by 0.438 %. And for every standard deviation increase in CIO abundance, the digital transformation decreases by 1.827 %. For every standard deviation increase in CIO completeness, the digital transformation decreases by 3.506 %. Furthermore, without the control variables, as shown in columns (3)–(4) of Table 5, the coefficients of the CIO measures remained significantly negative. This result further proves that common institutional ownership suppresses enterprise digital transformation, thereby supporting H1a. This result can be explained by the collusion-fraud effect of common institutional ownership. That is, common institutional ownership affects enterprise digital transformation by strengthening market monopoly power, aggravating information asymmetry, and intensifying executive self-dealing. The results of this study are consistent with those reported by He and Huang [19] and Wang and Barrese [22]. That is, we believe that common institutional ownership distorts enterprises' investment behaviour by exerting a collusion effect.

4.4. Endogeneity tests

4.4.1. Two-step heckman regression

Since enterprises with a high degree of digital transformation have better development prospects and may better attract common institutional investors, our sample does not evenly represent all enterprises, and many small- and medium-sized enterprises are

Table 3
Descriptive statistics of the main variables for the entire sample.

Variable	Obs	Mean	Std	Min	Med	Max	Corr (DT)
DT	29,975	1.162	1.349	0.000	0.693	4.956	
CIO1	29,975	0.063	0.193	0.000	0.000	0.693	−0.035***
CIO2	29,975	0.026	0.093	0.000	0.000	0.535	−0.047***
Age	29,975	11.218	7.659	0.000	11.000	28.000	0.017***
Growth	29,975	0.179	0.426	−0.407	0.089	3.061	0.023***
Size	29,975	22.100	1.373	19.118	21.941	26.179	0.120***
Lev	29,975	0.469	0.221	0.059	0.463	1.136	−0.098***
Roa	29,975	0.029	0.080	−0.406	0.033	0.211	0.008
Directors	29,975	8.705	1.737	5.000	9.000	15.000	−0.089***
Mana	29,975	0.083	0.156	0.000	0.000	0.638	0.136***
Independent	29,975	0.372	0.053	0.300	0.333	0.571	0.106***
Dual	29,975	0.251	–	0.000	–	1.000	0.106***
Soe	29,975	0.114	–	0.000	–	1.000	−0.086***
Variables	Have common institutional ownership		No common institutional ownership		Mean difference		
	Mean value		Mean value				
DT	1.009		1.179		−0.170***		

Note: * * * indicate significant coefficients at 1 %, respectively. The SD and median of the dummy variables were not reported. Data source: the results are calculated by the sum command of Stata software.

Table 4
The VIF values and Pearson's correlations coefficient of main variables.

Variable	DT	CIO1	CIO2	VIF	1/VIF
DT	1				
CIO1	−0.036***	1		1.10	0.908
CIO2	−0.048***	0.870***	1	1.10	0.908
Age	−0.025***	0.140***	0.140***	1.54	0.649
Growth	0.031***	−0.028***	−0.028***	1.10	0.910
Size	0.126***	0.241***	0.230***	1.60	0.625
Lev	−0.098***	0.102***	0.105***	1.58	0.633
Roa	0.002	−0.009	−0.013**	1.33	0.752
Directors	−0.089***	0.148***	0.136***	1.47	0.682
Mana	0.161***	−0.105***	−0.115***	1.46	0.686
Independent	0.071***	−0.002	0.000	1.29	0.773

Note: * * and * * * indicate significant coefficients at 5 % and 1 %, respectively. VIF and Pearson's correlations do not make sense for dummy variables; thus, we did not report the VIF and Pearson's correlation coefficients for the dummy variables. Data source: calculated by the author.

Table 5
The estimation results of common institutional ownership and digital transformation of enterprises.

Variable	(1)	(2)	(3)	(4)
CIO1	−0.110**		−0.132***	
	(−2.110)		(−2.985)	
CIO2		−0.438***		−0.560***
		(−3.183)		(−4.532)
CVs	Yes	Yes	Yes	Yes
Year fe	Yes	Yes	No	No
Firm fe	Yes	Yes	No	No
N	33,106	33,106	27,499	27,499
Pseudo R^2	0.3601	0.361	0.361	0.361

Note: The estimation method is the fixed effects Poisson regression. The robust SE is clustered at the firm level, with the t-value of the coefficient in parentheses. * * and * * * indicate significant coefficients at 5 % and 1 %, respectively. The regression results for the control variables (CVs) were omitted. Data source: the results are calculated by the ppmlhdfe command of Stata software.

Table 6
The estimation results of the endogenous test on benchmark regression.

Variable	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Two-step Heckman regression		PSM test		More control variables		IV test	
	DT	DT	DT	DT	DT	DT	CIO2	DT
CIO1	−0.198*		−0.299***		−0.113**			−7.413***
	(−1.924)		(−3.369)		(−2.174)			(−3.400)
CIO2		−0.369***		−0.913***		−0.424***		
		(−2.815)		(−4.835)		(−3.091)		
Is300							0.021***	
							(4.134)	
IMR	0.748***	0.731***						
	(3.402)	(3.329)						
Topints					−0.002***	−0.002***		
					(−2.942)	(−2.755)		
Tunnel					0.239*	0.243*		
					(1.721)	(1.751)		
Ocf					0.017	0.015		
					(0.283)	(0.239)		
Year fe	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Firm fe	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
N	27,382	27,382	4077	4077	27,499	27,499	31,077	23,945
Wald chi2	1042.830	1052.330						
Pseudo R^2			0.347	0.347	0.361	0.361		
Adj R^2							0.090	0.274

Note: The estimation method is the fixed effects Poisson regression. The robust SE is clustered at the stock firm level, with the t-value of the coefficient in parentheses. *, * * and * * * indicate significant coefficients at 10 %, 5 % and 1 %, respectively. Limited to the article length, the regression results of IV test based on CIO abundance(CIO1) are not shown. Data source: the results are calculated by the heckman, psmatch2, ppmlhdfe, ivregress commands of Stata software.

omitted. Therefore, our sample selection process was not perfectly random, which may have led to sample selection bias. We conducted a two-stage Heckman regression to alleviate the endogeneity problem of sample selection bias. In the first stage, we used model (1), regressing the CIO measures on the lag terms of all control variables, and testing the influence of the common characteristics of peer enterprises on common institutional ownership through the inverse Mills ratio. In the second stage, we added the inverse Mills ratio to the benchmark regression model (1) to alleviate the influence of sample selection bias. The regression results are shown in columns (1) and (2) of Table 6. The coefficient of inverse Mills was significantly negative, consistent with the benchmark regression results, indicating that the result is robust after controlling for the influence of sample-selection bias.

4.4.2. Propensity score matching (PSM) test

Since common institutional investors have a specific preference for holding shares, the size of common institutional ownership may be affected by some common characteristics of the company; these company characteristics may also affect enterprise digital transformation. To alleviate the endogeneity problems caused by deviations in the model setting, we adopted the PSM model for further testing. We considered enterprises with common institutional investors as the processing group and the control variables described previously as the matching variables of the PSM. We tested the enterprise digital transformation average processing effect (ATT) for the 1-to-1 nearest neighbour matching method. The results showed that the ATT value was −0.109 and significant at 1 %, indicating that the average degree of digital transformation of companies with common institutional investors was 0.109 lower than that of other companies with similar characteristics. We regressed the matched sample, and the results are shown in columns (3) and (4) of Table 6, respectively. The coefficient of CIO1 is −0.299 and significant at the 1 % level. The coefficient of CIO2 is −0.913 and significant at the 1 % level. It is consistent with the benchmark regression results.

4.4.3. Additional control variables

Following Hu et al. [42], to consider the endogeneity problems caused by missing variables, we added the largest shareholder shareholding (Topints), other receivables (other receivables divided by average total assets, Tunnel), and operating cash flow (operating cash flow divided by average total assets, Ocf) to Model (1). Columns (5) and (6) of Table 6 show that the coefficient of common institutional ownership was significantly negative; thus, the results are robust.

4.4.4. IV test

Considering the endogeneity issue of reverse causality, we referred to Gao et al. [21] to test the impact of common institutional ownership on enterprise digital transformation, that is, we used whether or not an enterprise was listed on the CSI 300 index as an instrumental variable for common institutional ownership. The increase and decrease in the CSI 300 index can change the ownership of common institutions; however, it does not directly affect enterprise digital transformation, which somehow alleviates the endogeneity issue of reverse causality. Specifically, the instrumental variable Is300 is a dummy variable that equals 1 if the company is listed on the CSI 300 index and 0 otherwise.

The instrument variable method was performed using the two-stage least-squares method; the results are shown in columns (7) and (8) of Table 6. In the first stage, Is300 was significantly positive, indicating that whether or not a company was listed on the CSI300 affected the degree of the CIO. In the second stage, the estimated coefficient of common institutional ownership on enterprise digital transformation was significantly negative, indicating that the benchmark regression results were robust. The F-statistic was greater than the cut-offs for each significance level, rejecting the hypothesis of weak instrumental variables. The P-value was less than 1 %, thereby rejecting the hypothesis of the endogenous explanatory variables, and indicating that the two-stage IV regression is valid.

4.5. Robustness tests

To ensure the robustness of our results, we performed robustness tests as follows.

Table 7
The estimation results of the robustness test on benchmark regression.

Variable	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	DT measure adjusted		More stringent identification of CIO		Years of CN stock crash excluded		Long-term consequences	
CIO1	−0.110**		−0.148**		−0.104***		−0.102**	
	(−2.110)		(−2.320)		(−2.843)		(−2.036)	
CIO2		−0.438***		−0.429***		−0.323**		−3.233**
		(−3.183)		(−3.082)		(−2.127)		(−2.543)
Cvs	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year fe	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Firm fe	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
N	27,499	27,499	26,457	26,457	20,891	20,891	21,261	21,261
Pseudo R^2	0.361	0.361	0.360	0.360	0.348	0.348	0.340	0.340

Note: The estimation method is the fixed effects Poisson regression. The robust standard error is clustered at the firm level, with the t-value of the coefficient in parentheses. * * and * * * indicate significant coefficients at 5 % and 1 %, respectively. The regression results for CVs were omitted. Data source: the results are calculated by the ppmlhdfe command of Stata software.

(1) We replaced the variable, DT by extracting the related keywords from four dimensions: digital technology application, Internet business model, intelligent manufacturing, and modern information systems. These four dimensions included 99 digitally related word frequencies. The regression results are shown in columns (1) and (2) of Table 7. The coefficients of CIO measures were significantly negative, consistent with the benchmark regression results.

(2) We adjusted the identification of CIO to be more stringent by raising the threshold from 5 % to 7 %. The adjusted measures, calculated under a 7 % threshold, were used in the DT regression analysis. The results are shown in columns (3) and (4) of Table 7. The coefficients of CIO measures remained significantly negative, which further enhances the reliability of our results.

(3) We excluded observations from the years of the Chinese stock crash. Considering the large liquidity shock during a stock crash, the status of common institutional ownership may result from collective panic and the selling of institutional assets, which cannot reflect real institutional collusion. Therefore, we regressed the samples after excluding those from 2007, 2008, 2015, and 2016. The results are shown in columns (5) and (6) of Table 7; the common institutional ownership coefficient was significantly negative, indicating that our results are robust.

(4) We also considered long-term effects. To determine whether common institutional investors can promote enterprise digital transformation in the long run, we lagged CIO by three years in the regression. Columns (7) and (8) of Table 7 show that the coefficient of common institutional ownership remained significantly negative at the 5 % level, which shows that even in the long run, common institutional investors played the role of 'collusion fraud' and hindered enterprise digital transformation.

5. Further analysis

5.1. Mechanisms of CIO influencing DT

(1) Market monopoly power expanded. Common institutional ownership intensifies the market monopoly formed through collusion among enterprises, thus increasing their bargaining power and profitability. As critical shareholders of a company, common institutional investors can earn considerable profits, thus having an incentive to restrain competition and friction between enterprises. With the easing of enterprise competition, enterprises will be used to seeking monopoly profits through collusion alliances. In the long run, it would be easy for executives not to make progress, and it may be difficult to capture development opportunities from digital transformation, thus inhibiting enterprises' potential innovation and digital transformation. Gradually, it becomes difficult for enterprises to capture the development opportunities created by digital transformation, thereby restraining it. To test whether the market power generated by the common institutional ownership inhibits enterprise digital transformation, we proxy the market power of common institutional ownership with the logarithm of one plus the keyword frequency in the annual reports of other peer companies (Group_num). Based on the benchmark regression model, we tested the impacts of market power and the product of market power and common institutional ownership on enterprise digital transformation. The regression results in columns (1) to (2) of Table 8 indicate that the product of market power and common institutional ownership are significantly negative. This result shows that the greater the power of the 'collusion alliance' bound by common institutional ownership, the more unfavourable it is for enterprises to carry out digital transformation activities. Market monopoly power can reduce competition among enterprises and inhibit potential innovation.

(2) Information asymmetry aggravated. In the context of two-right separation, common institutional investors must rely on some intermediate channels to intervene in corporate investment decisions and digital transformation. The theory indicates that

Table 8
Expand the market monopoly power mechanism of enterprises.

Variable	(1)	(2)
CIO1	−0.165**	
	(−2.236)	
CIO2		−0.723***
		(−3.908)
CIO1*Group_num	−0.104***	
	(−2.747)	
CIO2*Group_num		−0.432**
		(−2.437)
Group_num	0.032**	0.030**
	(2.060)	(1.967)
CVs	Yes	Yes
Year fe	Yes	Yes
Firm fe	Yes	Yes
N	27,499	27,499
Pseudo R^2	0.361	0.361

Note: The estimation method is the fixed effects Poisson regression. The robust SE is clustered at the firm level, with the t-value of the coefficient in parentheses. * * and * * * indicate significant coefficients at 5 % and 1 %, respectively. The regression results for CVs were omitted. Data source: the results are calculated by the ppmlhdfe command of Stata software.

information asymmetry of enterprises may become an effective way for common institutional investors to suppress enterprise digital transformation.

We adopt Kim and Verrecchia's [48] method and use corporate information transparency (Kv) to reflect the comprehensive level of mandatory and voluntary information disclosure. Kv is measured as follows:

$$\ln\left|\frac{\Delta P_{i,k,t}}{P_{i,k-1,t}}\right| = \alpha + \beta_{i,t}\left(Vol_{i,k,t} - Vol_{i,t}\right) + \mu_{i,t} \tag{2}$$

$$KV_{i,t} = 10,000\beta_{i,t} \tag{3}$$

In **Eq. (2)**, $P_{i,k,t}$ represents the closing price of stock i on day k of year t. *$Vol_{i,k,t}$* represents the number of shares traded on day k of stock i in year t, $Vol_{i,t}$ represents the annual average daily number of shares traded in stock i in year t, β is the regression coefficient. In **Eq. (3)**, Kv represents information asymmetry. A large Kv value indicates lower information transparency and greater information asymmetry.

We then tested the enterprise's intermediate mechanism of information asymmetry using the mediation effect model. The results of the model are shown in columns (1)–(4) of Table 9. Columns (1) and (3) show that the correlation coefficient between common institutional ownership and corporate information transparency was significantly positive. Columns (2) and (4) show that common institutional ownership and information transparency were added to the regression equation. The mediation variable, Kv, was significantly negative, initially supporting the mediation effect. The Sobel test showed that the Z-values obtained by the two models were −3.290, and −3.199, all of which were significant at 1 %. The mediation effect was further tested and the results showed that common institutional investors were more inclined to disclose low-quality accounting information, which aggravated information asymmetry and hampered their digital transformation.

(3) Enterprise executive self-dealing intensified. The supervision and governance of common institutional investors are not motivated from a place of 'absolute goodness' but a balance between collusion benefits and supervision costs. Suppose the collusion profit is greater than the supervision cost. In that case, common institutional investors are less willing to participate in corporate governance and executive self-dealing is not well restrained, leading to a decline in the enterprise's digital transformation. The exit threat is the core content and an important way for institutional investors to participate in corporate governance. If the exit threat is limited, executives are more likely to self-deal and hollow out the digital transformation resources of enterprises. Referring to the research methods adopted in the literature [49], we took the product of the competition degree of common institutional investors and stock liquidity as the proxy variable of the exit threat of common institutional investors (Exit). The smaller the exit threat was, the lower was the willingness of common institutional investors to participate in corporate governance through the exit threat. Columns (1) to (4) of Table 10 presents the regression results based on the mediation effect models. The common institutional ownership coefficient of columns (1) and (3) was significantly negative; columns (2) and (4) introduced CIO and Exit into the regression. The results showed that the coefficient of the mediating variable Exit was significantly positive, which proves its mediation effect. Sobel Z-values obtained by the two models were −4.295 and −4.030, all of which were significant at 1 %, further in line with the above mediation effect. The results show that common institutional investors had a low willingness to participate in corporate governance through the 'exit threat', so they would not promptly expose and stop the occupation of the digital transformation resources by the executives or control enterprise shareholders.

Table 9
Information asymmetry aggravated.

Variable	(1)	(2)	(3)	(4)
	Kv	DT	Kv	DT
CIO1	0.026**	−0.020**		
	(5.562)	(−2.262)		
CIO2			0.066**	−0.062**
			(6.500)	(-2.361)
Kv		−0.214***		−0.220***
		(−4.300)		(−4.425)
CVs	Yes	Yes	Yes	Yes
Year fe	Yes	Yes	Yes	Yes
Firm fe	Yes	Yes	Yes	Yes
N	29,706	29,451	29,706	29,526
Adj R²	0.108	0.305	0.108	0.305
Z-values Sobel test	−3.290***		−3.199 ***	

Note: The estimation method is the fixed effect regression. The robust SE is clustered at the stock level, with the t-value of the coefficient in parentheses. * * and * * * indicate significant coefficients at 5 % and 1 %, respectively. The regression results for CVs were omitted. Data source: the results are calculated by the xtreg command of Stata software.

Table 10
Mechanisms for intensifying self-dealing.

Variable	(1)	(2)	(3)	(4)
	Exit	DT	Exit	DT
CIO1	−0.162***	−0.115**		
	(−4.142)	(−2.249)		
CIO2			−1.099**	−0.430***
			(−2.207)	(−3.124)
Exit		0.009***		0.009***
		(4.605)		(4.558)
CVs	Yes	Yes	Yes	Yes
Year fe	Yes	Yes	Yes	Yes
Firm fe	Yes	Yes	Yes	Yes
N	29,582	27,375	29,582	27,375
Pseudo R^2	0.250	0.361	0.250	0.361
Z-values Sobel test	−4.295***		−4.030***	

Note: The estimation method is the fixed effects Poisson regression. The robust SE is clustered at the firm level, with the t-value of the coefficient in parentheses. * * and * * * indicate significant coefficients at 5 % and 1 %, respectively. The regression results for CVs were omitted. Data source: the results are calculated by the ppmlhdfe command of Stata software.

5.2. Heterogeneity analysis based on property rights

Both state-owned enterprises and other companies are essential parts of the Chinese economy. However, the two types of enterprises may differ largely in terms of corporate governance and operational modes [50].

From the perspective of corporate governance, the decision-making processes of state-owned enterprises are vulnerable to the influence of local administrations. Some executives of state-owned enterprises could even be quasi-government officials; therefore, the impact of common institutional ownership on state-owned enterprises is limited. For non-state-owned enterprises lacking administrative intervention, common institutional ownership can significantly affect enterprises' investments and decision-making through competition and the manipulation of enterprise accounting information disclosure.

From the perspective of operations, the controlling shareholder or actual controller of state-owned enterprises is the government; hence, besides paying attention to economic interests, it will also serve social interests, such as paying more taxes, providing more jobs, and undertaking more political tasks for the government. However, non-state-owned enterprises aim to maximise their interests and are not subject to such administrative constraints. Institutional barriers will lead to a significant impact of common institutional ownership on non-state-owned enterprises' investments and decision-making, and the degree of digital transformation of non-state-owned enterprises will be relatively lower.

This study divided the research sample into two groups, state-owned enterprises and other companies, and conducted grouped regression analyses. Columns (1)–(4) of Table 11 present the results. The coefficient of CIO was significantly negative for non-state-owned enterprises. In contrast, the coefficient was insignificant for state-owned enterprises. This result reveals the distinctiveness of state-owned enterprises in the CIO-DT relationship. Common institutional investors will significantly restrain enterprise digital transformation only in non-state-owned enterprises. As state-owned enterprises often have to undertake more political tasks for the government, they are more susceptible to administrative constraints from the government, whereas non-state-owned enterprises are not politically sensitive and are more susceptible to common institutional ownership.

Table 11
The estimation results of the heterogeneity test based on property rights.

Variable	(1)	(2)	(3)	(4)
	State	Non-state	State	Non-state
CIO1	−0.114	−0.138**		
	(−0.867)	(−2.357)		
CIO2			−0.074	−0.535***
			(−0.293)	(−3.184)
CVs	Yes	Yes	Yes	Yes
Year fe	Yes	Yes	Yes	Yes
Firm fe	Yes	Yes	Yes	Yes
N	2783	24,005	2783	24,005
Pseudo R^2	0.387	0.351	0.387	0.352

Note: The estimation method is the fixed effects Poisson regression. The robust SE is clustered at the firm level, with the t-value of the coefficient in parentheses. * * * indicate significant coefficients at 1 %, respectively. The regression results for CVs were omitted. Data source: the results are calculated by the ppmlhdfe command of Stata software.

6. Conclusions and discussion

The rapid development of digital technologies represented by artificial intelligence, blockchain, cloud computing, and big data is leading a new round of industrial transformation [51]. Digital transformation helps enterprises occupy a favorable position and firm competitiveness in the new round of technological change. Based on the context of China, this study provided a new perspective for analysing enterprise digital transformation. Furthermore, we shed light on how common institutional ownership affects enterprise digital transformation. The theoretical section of this paper analysed two competing situations in which common institutional ownership affected the digital transformation of enterprises and proposed two separate research hypotheses. The empirical section tested the impact and impact mechanism of common institutional ownership on enterprise digital transformation using data from A-share listed companies from 2007 to 2021.

We found that common institutional ownership significantly inhibited enterprise digital transformation. In other words, the greater the common institutional ownership, the lower the degree of enterprise digital transformation. This result supports the results of Azar et al. [25], He and Huang [19], and Wang and Barrese [22], whereby common institutional ownership exerts a collusion fraud effect rather than a collaborative governance effect. This result held for the two-step Heckman regression, PSM, and instrumental variable methods to deal with endogeneity issues. There are also differences between this study and that of Gao et al. [21]. While they examined the relationship between common institutional ownership and enterprise innovation, we analysed enterprise innovation as a potential mechanism underlying the impact of common institutional ownership on enterprise digital transformation. They believed that common institutional ownership promoted enterprise innovation, while we reported that it would aggravate the monopoly power within an industry and inhibit potential enterprise innovation.

Common institutional ownership can be considered an external factor that influences enterprises. Previous studies like Chen et al. [15], Luo et al. [17], Yan et al. [18], and Zhao et al. [29] often focused on the facilitative effect of external factors on enterprise digital transformation, while our study investigates the inhibitory effect. We find that common institutional ownership affects the behaviour of enterprises from three aspects: industry, enterprise, and management: (1) Common institutional ownership increases monopoly power within the industry, making enterprises easily content with the status quo and not inclined to undertake high-level innovation activities; (2) Common institutional ownership intensifies information asymmetry between enterprise insiders and outsiders, making it difficult for enterprises to obtain exogenous resources and inhibiting digital transformation; (3) Common institutional investors do not effectively participate in corporate governance and restrain the management team, and conversely, may collude with executives, aggravating self-dealing and hollowing out the resources that could have been used for enterprise digital transformation.

The inhibitory effect of common institutional ownership on enterprise digital transformation is more significant in non-state-owned enterprises. Compared to state-owned enterprises, non-state-owned enterprises are not strictly bound by government administrative orders, and common institutional owners are thus more likely to act on the digital transformation of the enterprise.

Based on the above results, we provide the following suggestions for authorities and common institutional investors.

(1) Governmental decision-making departments should be alert to common institutional ownership because it may hinder China's economic transformation and upgrading, as well as the progress of a free and competitive market. China's economy has entered a stage of high-quality development, and the digital economy is an essential consideration in the current market. This study finds that the market collusion force caused by common institutional ownership can inhibit the improvement of enterprise digital transformation, which is obviously not conducive for the easy flow of value along the chains in the economy and hinders economic transformation and upgrading. Therefore, to mitigate the adverse effects of common institutional ownership, authorities should pay attention to common institutional ownership in the subsequent revision and implementation of the anti-monopoly law and related regulations, thus reducing the possibility of enterprises linked by common institutional owners from forming a market monopoly. The government should continue to expand the opening of capital markets and establish a corporate information disclosure system that is aligned with international standards. Relevant authorities should increase penalties to curb executive self-dealing. Considering that common institutional ownership has a relatively insignificant inhibitory effect on the digital transformation of state-owned enterprises, more attention should be paid to regulating market collusion among non-state-owned enterprises when overseeing market operations.

(2) Common institutional investors should improve their collaborative governance levels rather than conspire with listed companies to hinder digital transformation. The empirical results of this study show that, driven by the interests of collusion, common institutional investors encourage the monopoly power of enterprises and condone executive self-dealing, leading to a decline in enterprise digital transformation. However, the behaviour of common institutional investors is very short-sighted. In an *anti*-globalisation environment, companies must accelerate the digitisation of their physical components and production processes as well as drive reforms in their management processes to cope with intensifying market competition and ensure that they are not phased out of the market. In the long run, enterprises can improve their total factor productivity through digital transformation, and common institutional investors can also benefit from this.

Although this study provides valuable results and suggestions by examining the impact of common institutional ownership on enterprise digital transformation, there are still shortcomings which necessitate further in-depth research. This study finds that the market collusion forces formed by enterprises linked by common institutional investors inhibit enterprise digital transformation; however, it does not discuss the governance effect of the ownership of common institutional. How to guide common institutional owners to exert a collaborative governance effect rather than a collusion fraud effect is an essential issue for future consideration. For example, future studies can discuss the incentive and supervision mechanisms of common institutional ownership based on the

relationship between the compensation of common institutional investors and the synergistic governance effect. Second, this study uses the text analysis method to measure enterprise digital transformation, which is an ex-ante measure that may not accurately describe the results of digital transformation. Future research could, for example, evaluate the information on digital projects implemented in companies' annual reports through factor analysis or expert evaluation, which can distinguish between projects that will be implemented in the future and those that have already been implemented. In addition, a set of indicators can be formulated to measure the digital transformations of companies after changes in ownership.

Data availability statement

All data is publicly available and correctly cited in the text. Data associated with this study has been deposited at annual reports of listed companies available online: http://www.szse.cn/disclosure/listed/notice/index.html; Shanghai Stock Exchange is available online: http://www.sse.com.cn/disclosure/listedinfo/announcement; The data for the control variables comes from the CSMAR available online: https://www.gtarsc.com/#/index. Data are however available from the authors upon request.

Additional information

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Wennanxiang Wang: Writing – original draft, Visualization, Software, Methodology, Formal analysis, Data curation, Conceptualization. **Ridong Hu:** Visualization, Supervision, Resources, Project administration, Funding acquisition. **Cheng Zhang:** Writing – review & editing, Writing – original draft, Validation, Methodology, Conceptualization. **Yang Shen:** Writing – review & editing, Supervision, Resources, Methodology, Conceptualization.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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